Module 6

Mapping and Monitoring

Dr. Priyadharshini. B

Assistant Professor,

Centre for Disaster Mitigation and Management,

Vellore Institute of Technology.

✉ bpriyadharshini@vit.ac.in

Module 6: Mapping and Monitoring

Modelling, risk analysis and loss estimation–Natural disaster risk Reduction Strategies- Prevention and mitigation-Applications of Space Technology (Satellite Communications, GPS, GIS and Remote Sensing and Information / Communication Technologies (ICT) in Early warning Systems-Disaster Monitoring and Support Centre–Information Dissemination– Mobile Communications-Social Media etc through case studies

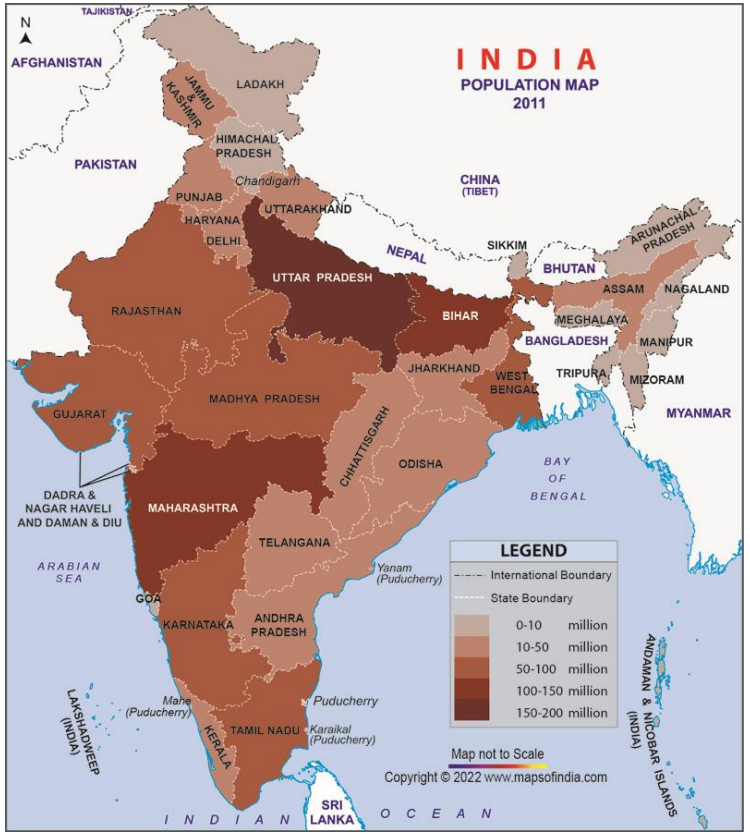
What is mapping?

Disaster mapping is a tool for assessing, storing, and conveying information on the geographical location of a disaster occurrence and the spread of the effects or probable effects of disasters.

Map

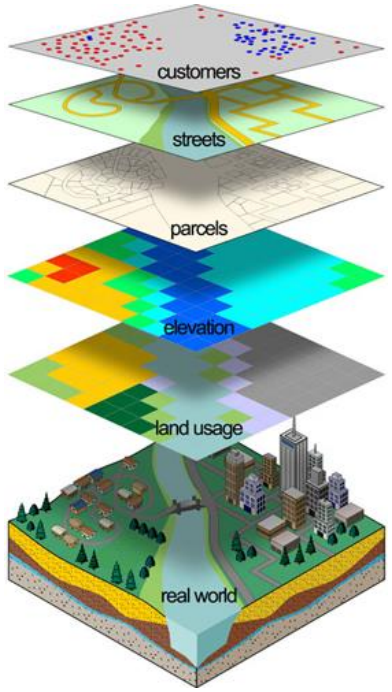
A map is defined as a representation of a portion of the earth's surface in a two-dimensional depiction.

- Maps are geo-referenced
- Latitude, longitude, and altitude
- It is made by physical surveying
- Legend (color-coded)
- Scale – dimension proportionate to actual area, e.g., 1: 20000

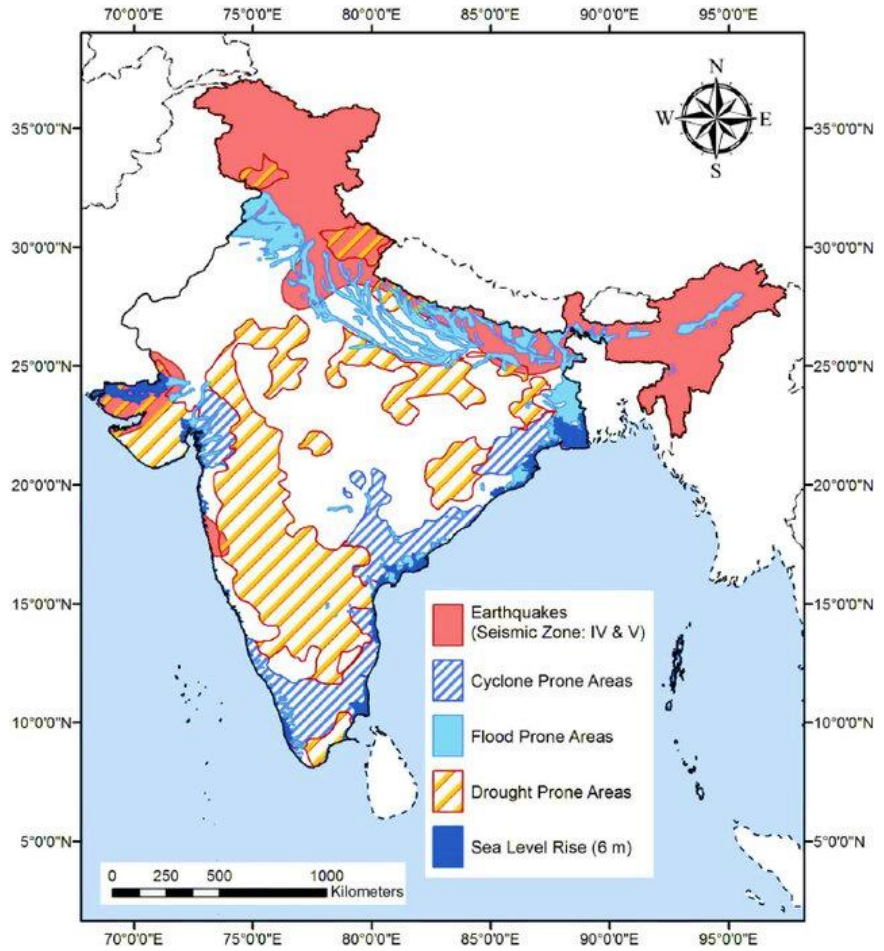


Disaster mapping

Disaster maps usually show **risk zones or disaster impact zones**. These could include flood zone maps, seismic zone maps, industrial risk zone maps, etc.

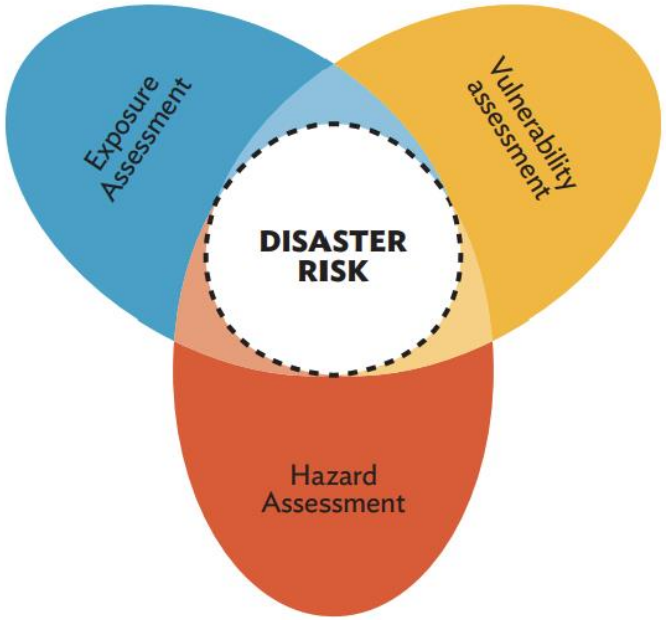


Overlaying in GIS

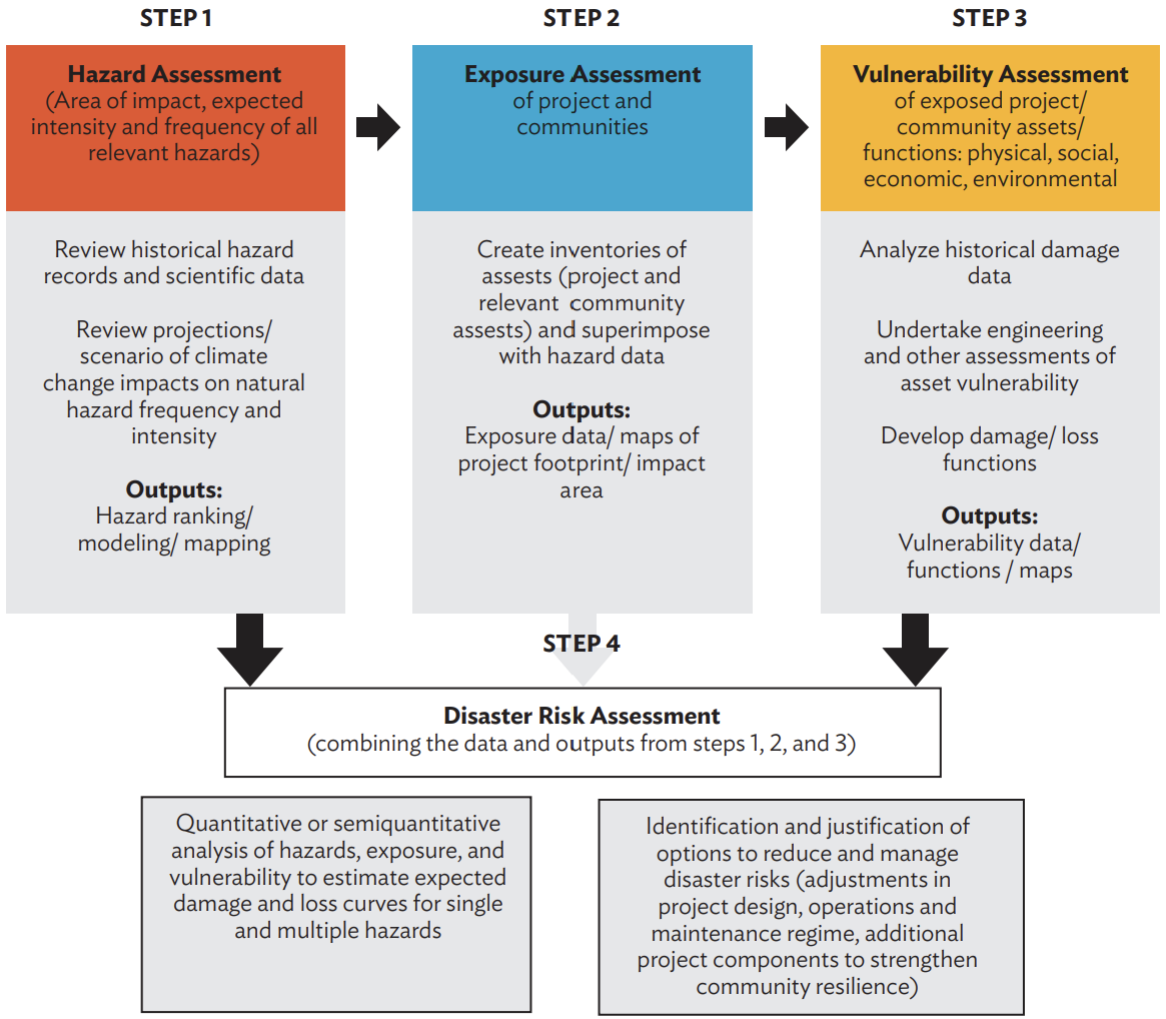


Disaster map of India

Steps in undertaking a disaster risk assessment

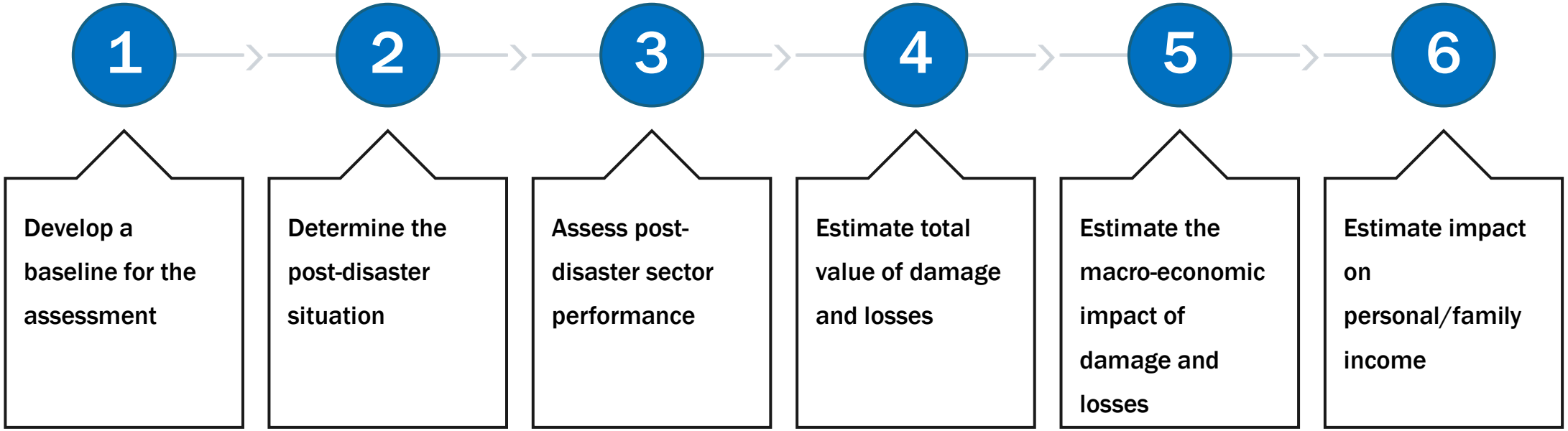


Recall risk assessment from Module 1 (Slides 17-21)



Source: ADB.

Key steps in the assessment process



1. Develop a baseline for the assessment

- Provides a picture of the prevailing conditions prior to the disaster
- Foundation for the estimation of damage and losses
- Critically essential to be able to discern:
  - Level of damage to physical assets resulting from the disaster
  - How the provision of basic services have been affected
  - The changes in production and sales

Source:https://www.boredpanda.com/italy-earthquake-before-after/

Damage (Direct)

Baseline of physical assets refers to:

- Existing facilities in the affected area (before the disaster occurred)
- Nearby facilities that may provide services to the affected area on a temporary basis
- Examples of baseline data:
  - Number and type of health facilities
  - Length and type of roads
  - Number and type of housing units

Losses (Indirect)

Baseline data is also essential for determining losses

- Refers to the performance of all economic activities in the affected area:
- As projected for the current and subsequent 2 years
- Measured as the volume and value of production sales of goods and services, etc.
- Examples of Baseline Data describing losses:
  - Calendar of agriculture production activities (annual crops and plantations)
  - Statistical information on volume of production, yields, prices
  - Production and sales forecasts for ongoing and subsequent years in each sector
  - Volume and value (rates) of essential services (electricity, water and sanitation, transportation, and communications)

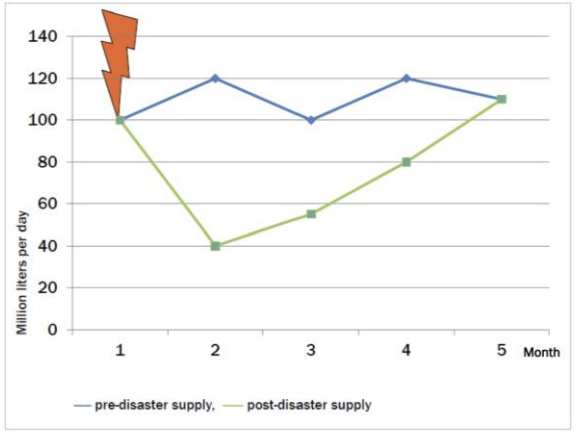
Step 2: Determine the post-disaster situation

This step results in:

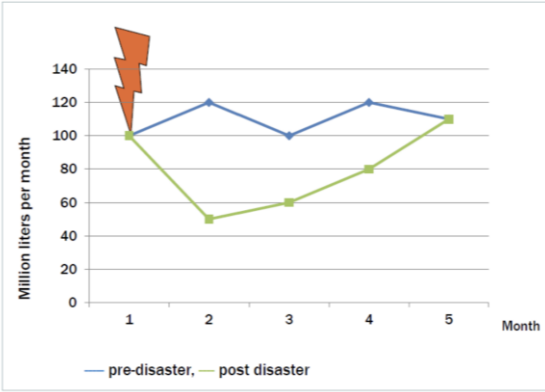
- Preliminary calendar or schedule for the reconstruction of physical assets
- Corresponding post-disaster, preliminary performance forecast of socio-economic activities in each affected sector

To develop the preliminary calendar for reconstruction, the following information is collected:

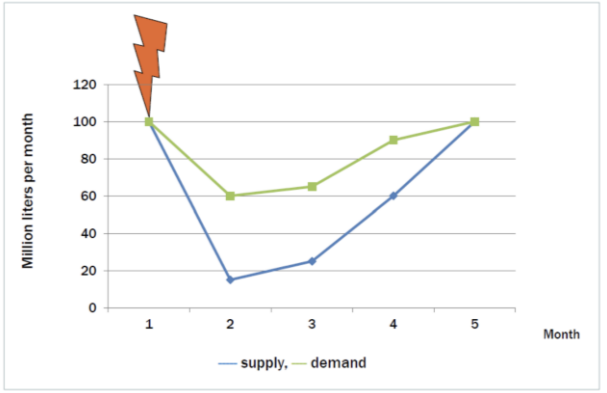
- A typology of physical assets (size, capacity, construction materials, etc.)
- Unit repair costs and reconstruction estimates for those assets, are not affected by scarcity or speculation
- A preliminary calendar of repair and replacement of physical assets



Example - Water Supply based on Damages to Water Supply Plant



Example - Water Demand Based on Damage to Housing Sector



Example - Water Shortage in the Affected Area

Step 3: Assess post-disaster sector performance

This step of the assessment process:

- Examines the disaster impacts on each sector
- Comparison of sector performance indicators from before and after the disaster

The assessment Team should include:

- Expertise in each sector (e.g., engineers, sociologists, economists, etc.)
- Members who are well-acquainted with the assessment methodology and with the affected area's socio-economic conditions
- Government officials representing the line ministries covering all sectors of economic activity

Agriculture Sector

Mining and Quarrying Sector

Manufacturing Sector

Trade or Commerce Sector

Tourism Sector

Housing Sector

Education Sector

Health Sector

Culture Sector

Transport Sector

Communications Sector

The Electrical Sector

Water Supply and Sanitation Sector

Environment

Step 5: Estimate macro-economic impact of damage and losses

Calculates the disaster impact on:

- Gross domestic product (GDP)
- Balance of trade and payments (BOP)
- Fiscal budget
- Other macro-economic aggregates

Baseline information regarding the most recent estimates or

projections of macro-economic variables is required

- e.g., GDP, BOP, and fiscal budget for current and forthcoming years for non/pre-disaster conditions

Impact on GDP examines:

- Temporary negative repercussion of disaster losses on economic performance
- Any positive effects on the various sectors that may have resulted due to recovery and reconstruction process (i.e., improvements to infrastructure)

Data for GDP should include a breakdown by sectors.

Impact on BOP involves estimating:

- Increase in imports and decline of exports arising from the disaster
- Possible reinsurance payments from abroad and relief donations from the international community

Disaster impacts on the public sector budget are estimated in terms of:

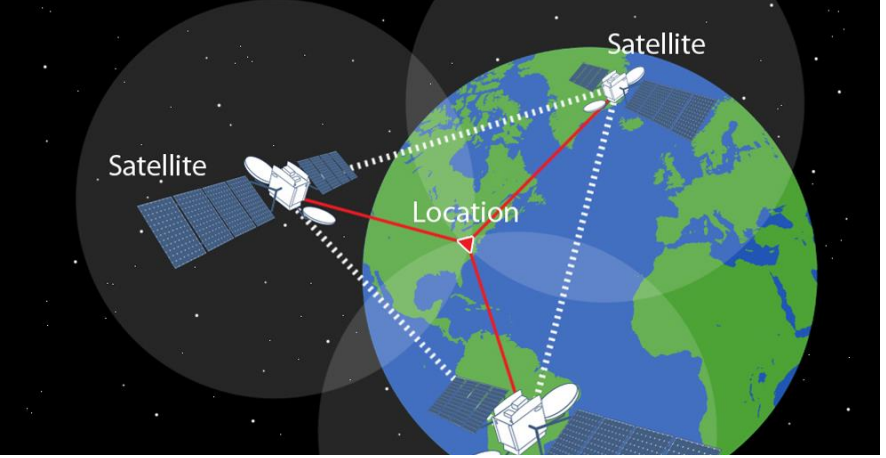
- Increased operational costs
- Lower revenues

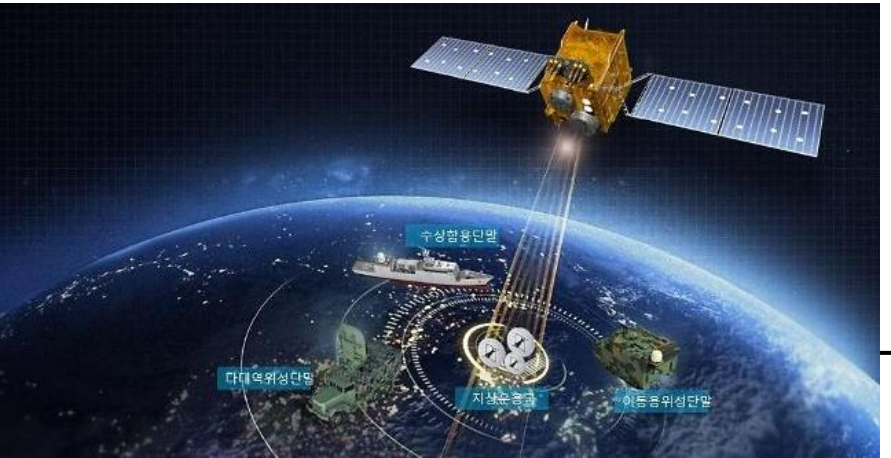
Data for GDP and fiscal budget should be obtained in current values of local currency

Data for BOP should be expressed in current U.S. dollars

Step 6: Estimate impact on personal/family income

- Examines the relationship between production and the labor force
- Includes an estimation of the decline in employment income due to losses sustained in the productive and services sector
- Includes an estimation of employment opportunities brought about as a result of the emergency itself (e.g., reconstruction activities)
- Loss of personal income can be estimated in relation to normal monthly income





Introduction to space technology

There are several types of space technology applications, including

1. Remote sensing,
2. Satellite navigation systems such as the Global Positioning System (GPS),
3. Satellite communication systems

Remote sensing

Remote sensing is a technique to observe the earth's surface or the atmosphere with cameras or sensors installed in satellites. Its advantages include

(i) the ability to record data for inaccessible or dangerous areas;

(ii) a comparatively low cost per unit of area;

(iii) wide, objective, frequent, and periodic data collection; and

(iv) the availability of historical data.

Case study

Pakistan Floods (2010) Damage and Needs Assessment

Space Technology (ST) Application: Satellite-based flood damage assessment

ST Data: Satellite imagery and radar data

ST Service Providers: Satellite image analysis and GIS process; Space and Upper Atmosphere Research Commission of Pakistan (SUPARCO), Satellite data; Japan Aerospace Exploration Agency (JAXA)

Context

Pakistan experienced extraordinary rainfall from mid-July to September 2010. According to the National Disaster Management Authority, the rains and floods have affected over 20 million people. In the wake of this extraordinary situation, the Government of Pakistan asked ADB and the World Bank to lead the Damage Needs Assessment jointly.

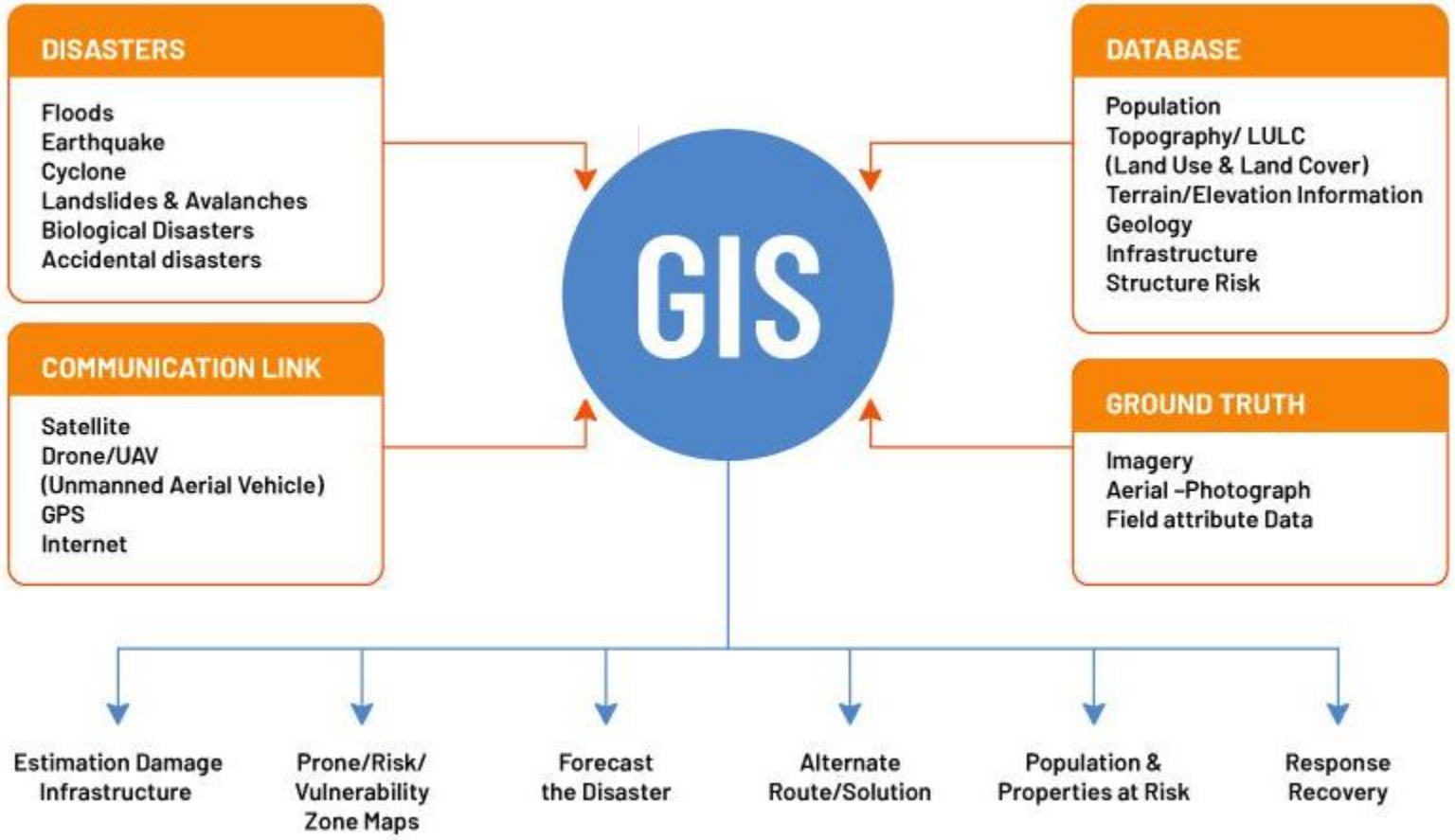
Source: https://www.adb.org/sites/default/files/publication/148901/space-technology-and-gis-applications-adb-projects.pdf

Example of space technology for disaster

Classify	Case example
Earthquake	Discrimination collapsed houses.
Flood	Flood prediction based on satellite rainfall data. Discrimination flood area.
Tsunami	Discrimination Tsunami damage area.
Forest fire	Direction of fire. Discrimination Forest fire area.
Volcano	Hazard Map (pyroclastic flow, lava flow, volcanic mudflow) Monitoring ground deformation before an eruption. Discrimination a fall of ash area.
Land slide	Monitoring land slide hazard area. Discrimination land slide area.
Typhoon (Hurricane)	Monitoring a typhoon. Discrimination flood, damage area.
Snow damage	Discrimination snow covered area. Estimation amount of snowfall.
Glacial lakes	Discrimination damage area by rupture of glacial lakes.

GIS in disaster management

Geographical Information System (GIS) is a system that creates, manages, analyzes, and maps all types of data. GIS connects data to a map, integrating location data (where things are) with all descriptive information (what things are like there).



GIS in DM cycle

Mitigation

Hazard and Vulnerability maps (mitigation can be determined and prioritized)

Preparedness

GIS can display "real-time" monitoring for emergency early warning.

GIS can provide answers to questions such as How many paramedic logistics units are required, and where should they be located?

Response

Helping decision-makers understand the scope of the damage and identify locations where people may be trapped or injured or require medical support and rescue.

Critical infrastructure analysis, including health services, food services, and government operations, is crucial for restoring vital services and operations.

Geospatial technology aids in emergency supply chain management, enabling decision-makers to allocate response resources to prioritize life safety and facility repair.

Recovery

GIS and GPS can collaborate to identify damaged facilities, determine damage type and extent, and establish action priorities through triage. Long-term plans and progress can be displayed and tracked utilizing a GIS.

Source: https://www.sgligis.com/gis-in-disaster-management/
https://www.unescap.org/sites/default/files/Day2-8Indonesia_0.pdf

GIS

There are three main components of GIS, namely: computer system, software and spatial data, and data management and analysis procedures. Spatial data is also called geographical data and is characterized by information about position, connections with other features, and details of non-spatial characters.

For example, spatial data about a particular area may include:

1. Latitude and longitude as a geographical reference.
2. Connection details, such as service roads, railheads, etc., allow outsiders to access that area.
3. Non-spatial (or attribute) data, such as details of the amount of snow or rainfall, wind speed, and direction. GIS uses geographical position or location as a common thread to integrate and analyze information from various sources. GIS can also assess risks to life and property stemming from natural hazards, such as earthquakes, cyclones, tsunamis, and floods.

Satellite Navigation - Global Positioning System (GPS)

The Global Positioning System (GPS) is a navigation system using satellites, receivers, and algorithms to coordinate location, velocity, and time data for air, sea, and land travel. It consists of 24 satellites orbiting 13,000 miles above Earth at 8,700 mph. A fourth satellite validates the information and calculates the device's altitude.

The three segments of GPS are:

Space (Satellites) — The satellites circling the Earth, transmitting signals to users on geographical position and time of day.

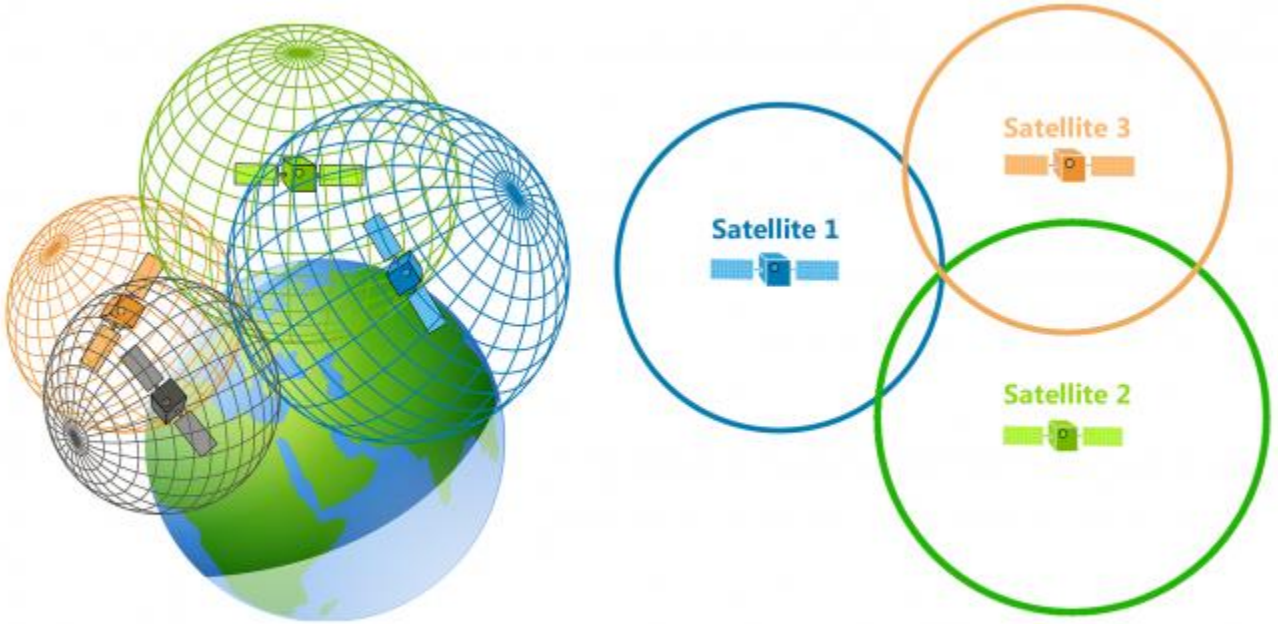
Ground control — The Control Segment comprises Earth-based monitor stations, master control stations, and ground antenna. Control activities include tracking and operating the satellites in space and monitoring transmissions.

There are monitoring stations on almost every continent worldwide, including North and South America, Africa, Europe, Asia, and Australia.

User equipment — GPS receivers and transmitters, including watches, smartphones, and telematic devices.

Uses of GPS

1. Location — Determining a position.
2. Navigation — Getting from one location to another.
3. Tracking — Monitoring objects or personal movement.
4. Mapping — Creating maps of the world.
5. Timing — Making it possible to take precise time measurements.



Source: https://gisgeography.com/trilateration-triangulation-gps/

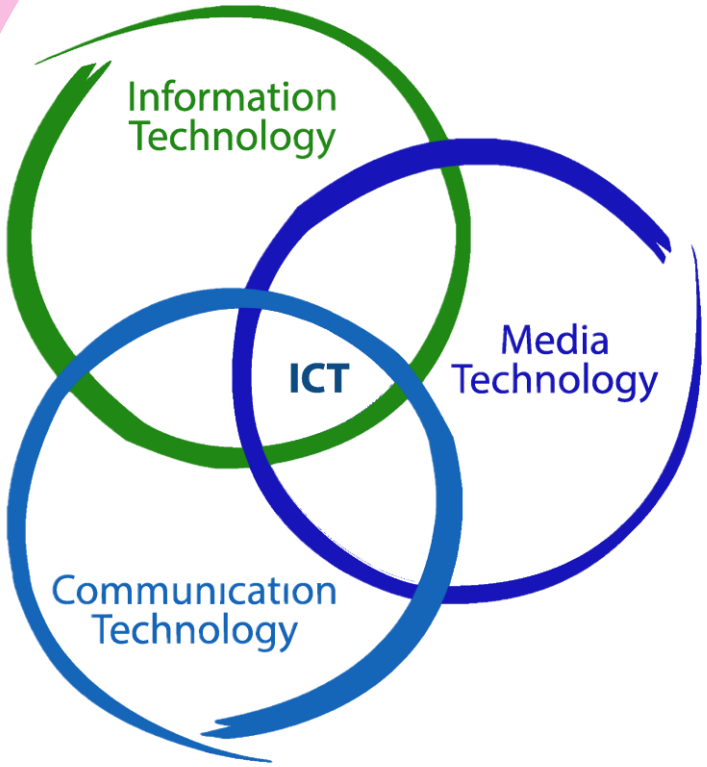
Information and Communication Technology (ICT)

ICT is a term that encompasses all forms of technology used to create, store, exchange, and use information in its various forms (business data, voice conversations, still images, motion pictures, multimedia presentations, and other forms, including those yet to be conceived).

ICT uses an array of modern electronic gadgets like satellites, radars, computers, sensors, cameras, etc., to collect, process, and disseminate information. It is a reliable, cost-effective, and fast medium of handling information.

There are a number of components of Information Technology like Remote Sensing, Satellite Imagery, Internet, Geographical Information Systems, mobile and satellite telephones, etc., which either work individually or in combination towards handling the available information.

Information and Communication Technology (ICT)

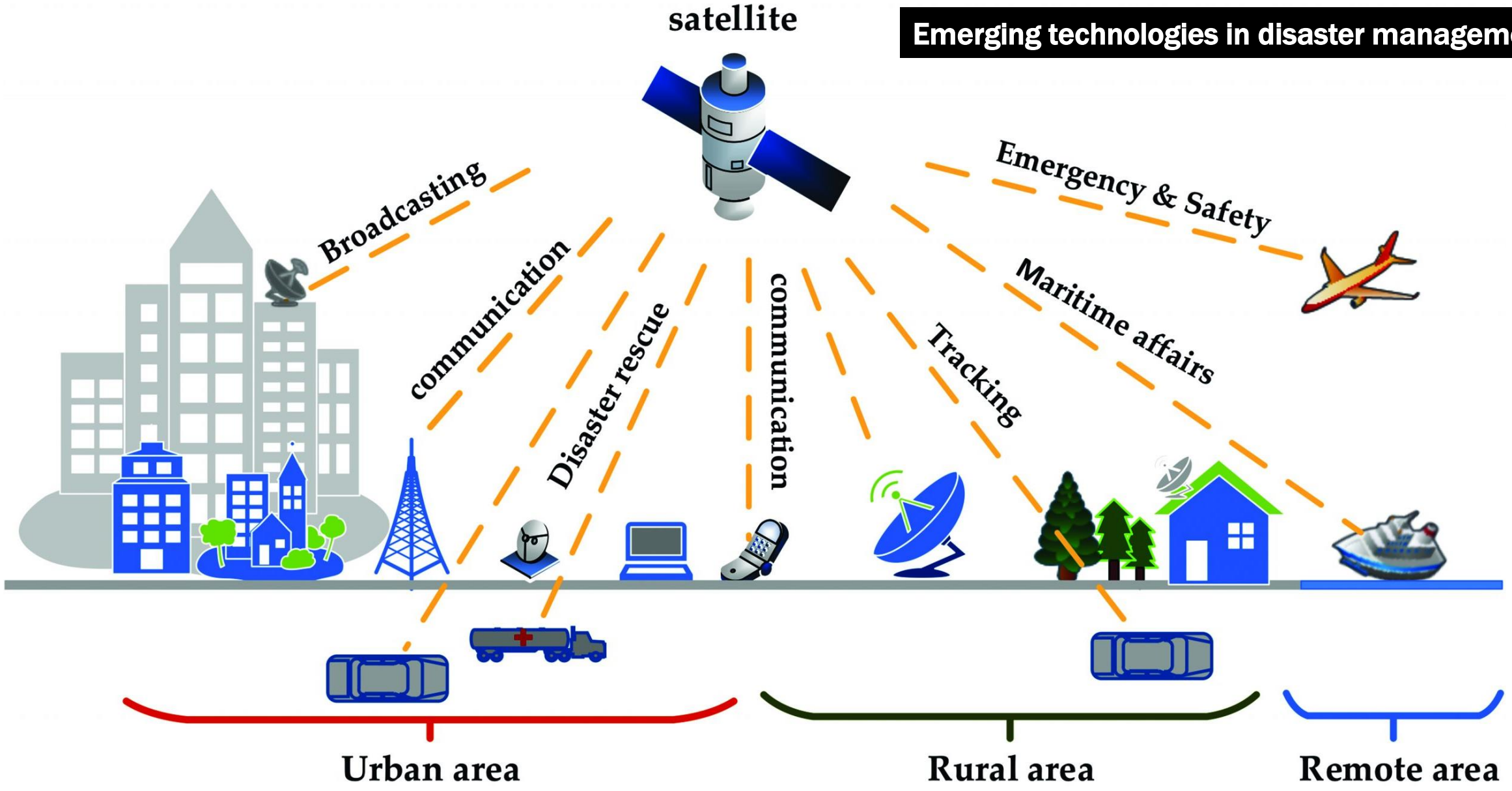


Information technology (IT) is the use of computer systems or devices to access information.

Media technology refers to the use of technological innovations in the circulation, storage, and production of media content.

Communications technology, also known as information technology, refers to all equipment and programs that are used to process and communicate information.

Emerging technologies in disaster management



Source: https://www.defstrat.com/magazine_articles/emerging-technologies-in-disaster-management/

Terrestrial radio and television

- Radio and television remain the traditional media used in disaster management because they are cheap and provide a reliable one-to-many communication medium and most importantly do not require literacy.
- They can be used to spread a warning quickly to a broad population
- Effectiveness depends on its usability

Mobile technology

- Mobile technology is probably the most rapidly expanding technology in terms of the speed of expansion and reach to the unconnected.
- Based on voice and short message service (SMS).

Cell broadcasting

- CB has several advantages over SMS, particularly for EWS
- While SMS is one-to-one and one-to-a-few service, CB is one-to-many geographically focused messaging service. Messages can be tailored to multiple phone subscribers located within a given part of its network coverage area at the time the message is broadcast.

Broadcast radio

Broadcast radio has been used to disseminate early warning messages, as well as for awareness raising and community education.

Satellite Radio

- Satellite radio receives its signal from a communication satellite and therefore has a wider geographical range than terrestrial radio. It is very useful when transmission towers are damaged.
- Satellite usage is very costly for both service setup and the purchase of a satellite-enabled radio. Service can also be interrupted by trees, buildings and some weather conditions.

Amateur and community radio

- In terms of crisis, amateur and community radio is often used as a means of emergency communication when other conventional means of communication become damaged or destroyed.
- This is because amateur radio is not as dependent on terrestrial systems that can fail. Amateur Radio operates are trained volunteers known worldwide not only for their skills in providing emergency communication facilities but also for their dedication to help save lives.
- Amateur radio broadcasters are authorized to communicate on high frequency (HF), very high frequency (VHF), ultra-high frequency (UHF) or all three bands of the radio spectrum.

ICT for Early warning

Early warning is 'providing timely and effective information, through identified institutions, that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response' (UNISDR, 2004).

EWS defines a technological infrastructure that can assist in carrying out these tasks. USES GIS!

EWS has four interlocking elements

1. **Risk knowledge** — to understand the risks (hazards and vulnerabilities) and priorities at a given level;
2. **Monitoring** — to stay up to date on how the risks and vulnerabilities change through time;
3. **Response capability** — so that each level (pre-season mitigation activities, evacuation, or duck-and-cover reflexes) is able to reduce risk once trends are spotted and announced;
4. **Warning communication** — to prepare monitoring information into actionable messages understood by those needing it.

Source: https://drmkc.jrc.ec.europa.eu/portals/0/Knowledge/ScienceforDRM/ch04/ch04_subch0403.pdf

Early warning is an effective tool to reduce vulnerabilities, save lives, and help protect livelihoods as well as to improve preparedness and response to natural hazards.

In addition to the four elements, there are a number of cross-cutting issues that are critical to the development and sustainability of effective EWS; these include

1. Effective governance and institutional arrangements;
2. A multihazard approach to early warning;
3. Involvement of local communities;
4. Consideration of gender perspective, vulnerable populations, and cultural diversity

The most common view of EWS comprises a '**warning chain**' a linear set of connections from observations through warning generation and transmitted to users.

Effective early warning systems and warning communication

An effective EWS needs an effective communication system. Early warning communication systems are made up of the following two main components.

1. The communication infrastructure
   - Hardware that must be reliable and robust, especially during natural disasters (power supply and backup).
2. The warning messages
   - Critical element influencing the perception of risk and public behavior is how the warning information is structured and what it contains.

A message delivered during a critical situation should contain:

- Hazard — a short description of the physical characteristics of the hazard (nature and magnitude);
- Location — if possible, a certain position of the area affected by the hazard;
- Time (slow onset — occurring time, time estimated to reach the area; rapid onset — occurring time, rapid development);
- Guidance — the appropriate course of action necessary to prevent death or injury, providing protective action recommendations, including options for those unable to comply with recommended measures (e.g., evacuation orders);
- Pertinent details that should be included in messages, i.e., where to find shelter and the location of recovery supplies or aid stations that may not be obvious to the warning recipients.

Social media and communities in disaster: connecting the ‘last mile’

As the capacity of the community to take action in response to a received warning and that supports the development of the capacities of local institutions

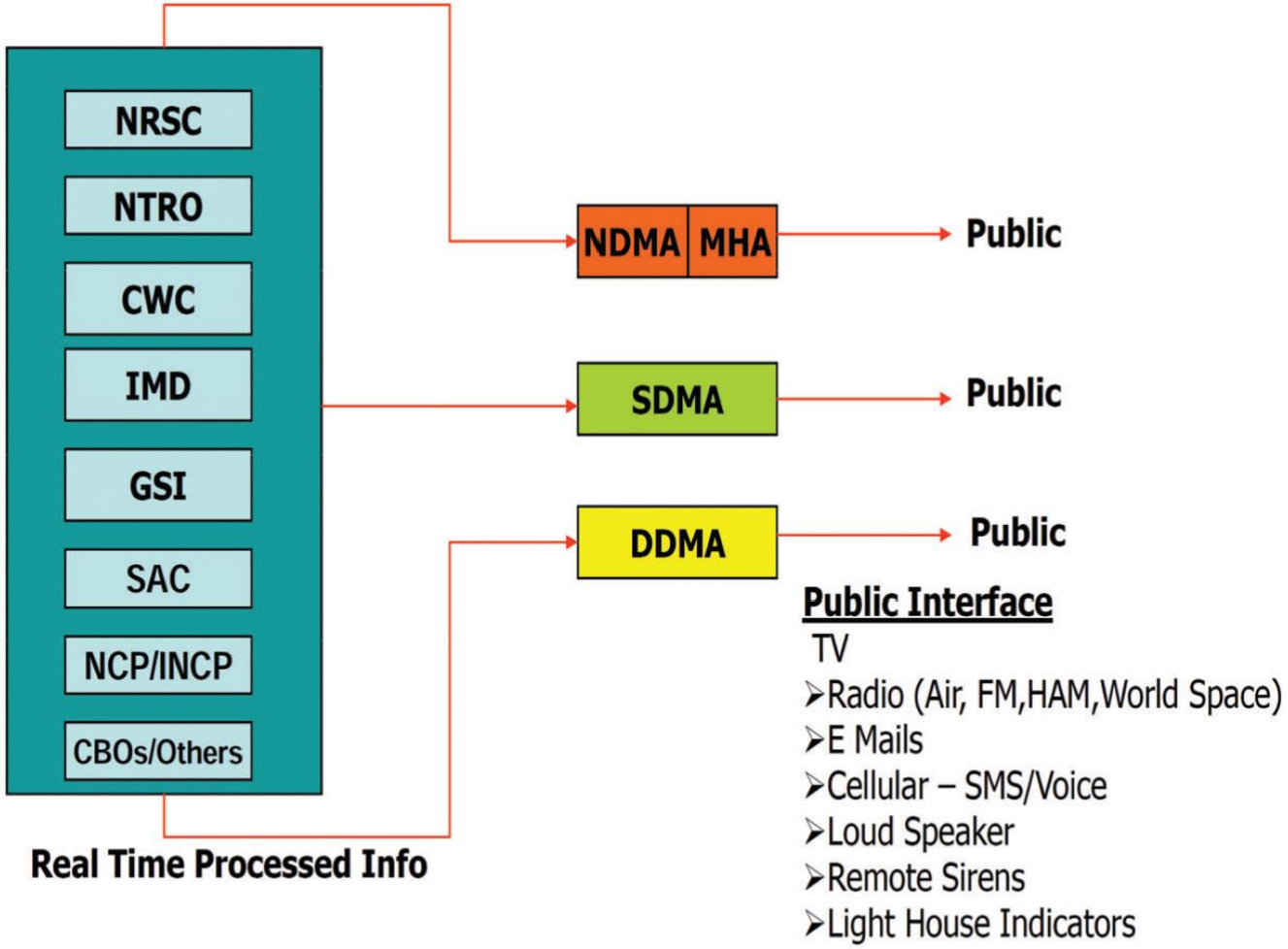


Fig. 3 List of Early Warning & Forecasting Agencies Requiring Due Connectivity.

(Source: NDMA 2012)

National Disaster Management Authority (NDMA)

State Disaster Management Authority (SDMA),

District Disaster Management Authority (DDMA)

National Remote Sensing Centre (NRSC)

National Technical Research Organisation (NTRO)

Central Water Commission (CWC)

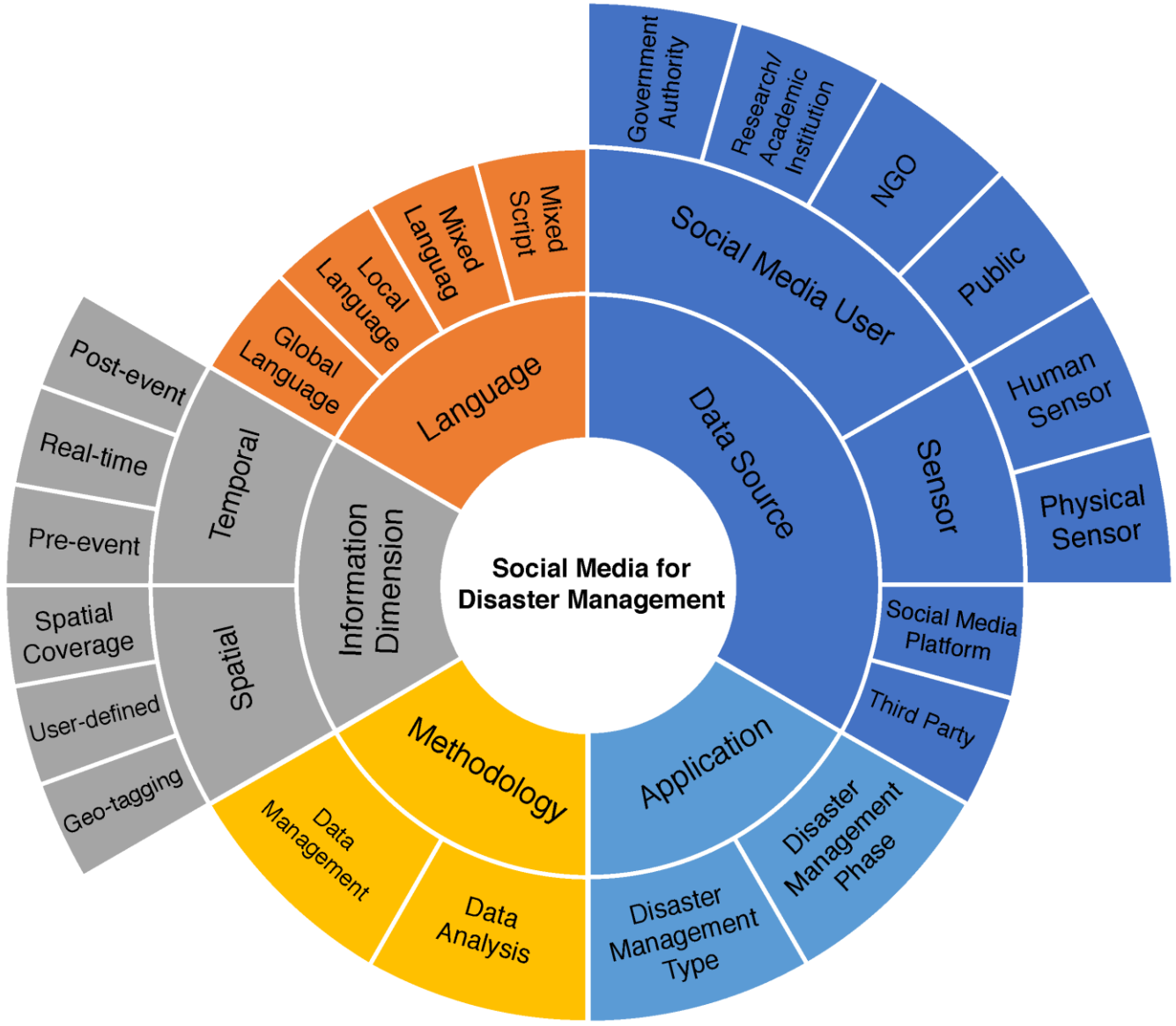
India Meteorological Department (IMD)

Geological Survey of India (GSI)

Space Applications Centre (SAC)

Interim National Command Post (INCP)

Community based organization (CBO)


Social Media for Disaster Management
Information Dimension
Temporal
Post-event
Real-time
Pre-event
Spatial
Spatial Coverage
User-defined
Geo-tagging
Language
Global Language
Local Language
Mixed Languag
Mixed Script
Methodology
Data Management
Data Analysis
Data Source
Social Media User
Government Authority
Research/ Academic Institution
NGO
Public
Sensor
Human Sensor
Physical Sensor
Social Media Platform
Third Party
Application
Disaster Management Phase
Disaster Management Type

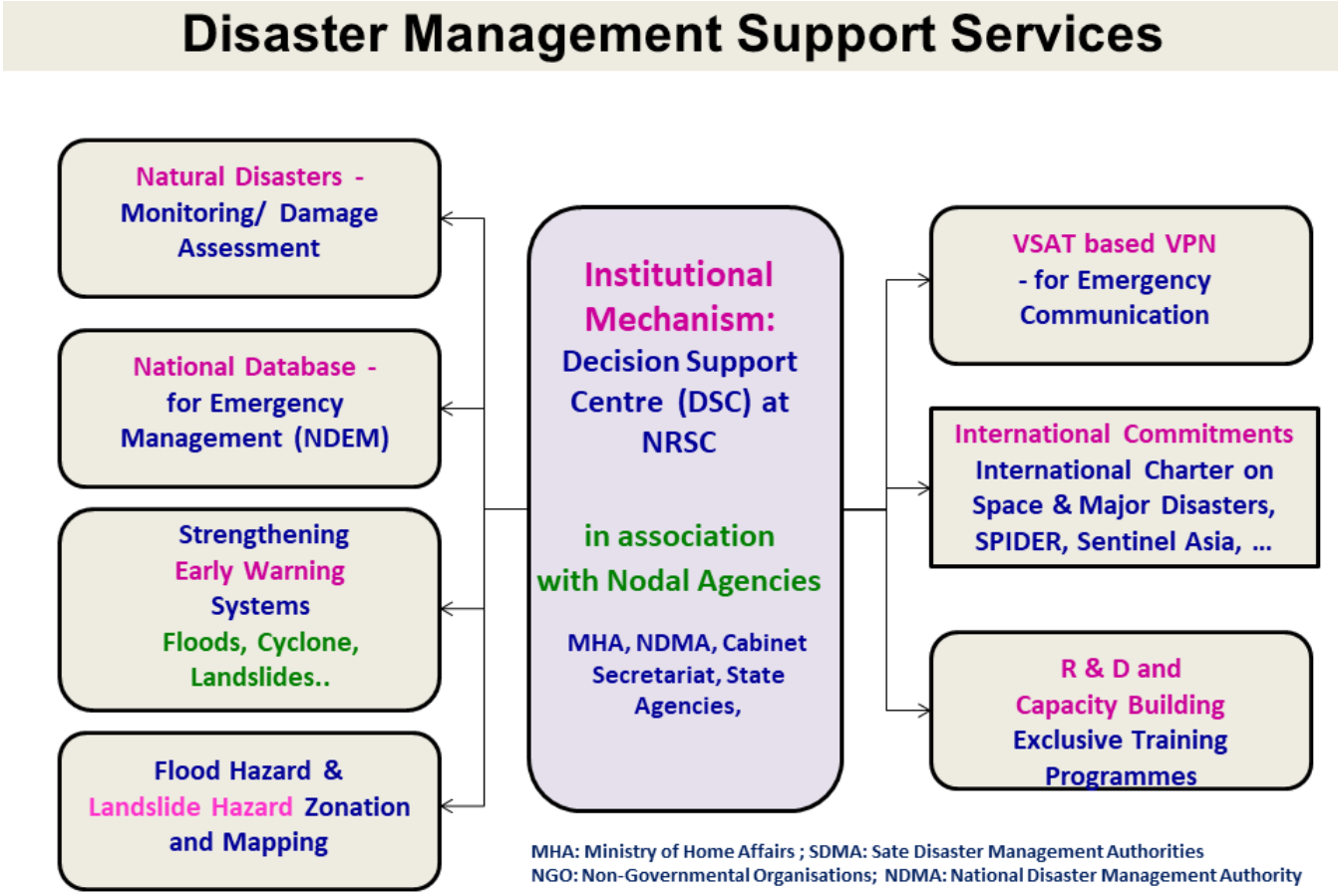
Disaster monitoring and support centre

As part of the Disaster Management Support Programme (DMSP), the Decision Support Centre was established at the National Remote Sensing Centre (NRSC) for monitoring natural disasters, viz. floods, cyclones, agricultural droughts, landslides, earthquakes, and forest fires in near real-time using space and aerial remote sensing based inputs.

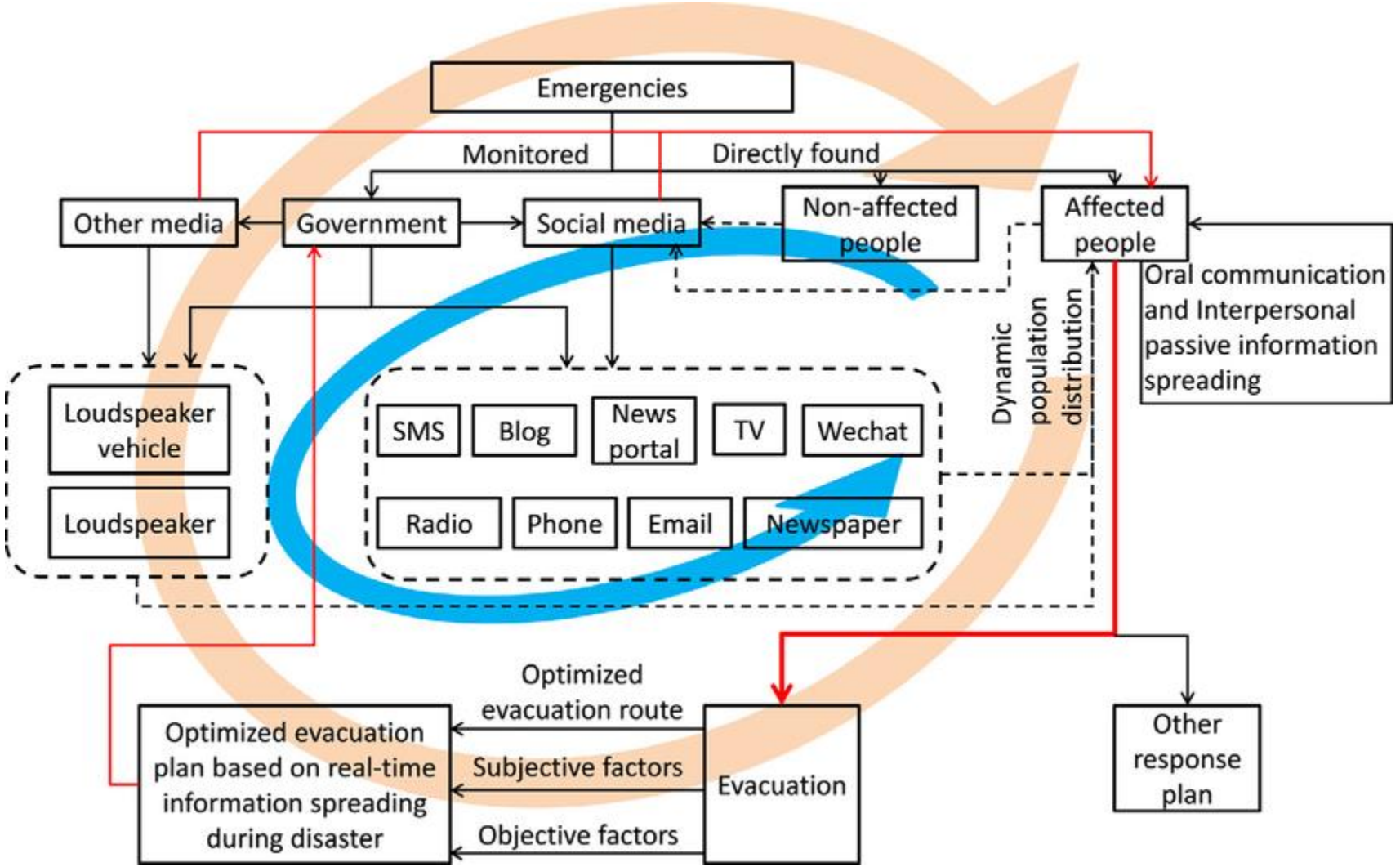
The National Database for Emergency Management (NDEM) serves as a national repository of GIS-based databases for the entire country, coupled with a set of Decision Support System tools to assist the State / Central Disaster Management Authorities in decision-making during emergencies.

Current activities to support disaster management support

Near Real-Time Flood and cyclone monitoring and mapping in the country, Flood Hazard/Risk Zonation for Flood prone states, Spatial Flood Early Warning, forest fire alerts, landslide zonation and inventory, agricultural drought studies, and Capacity Building and institutionalization are being done to the stakeholders.



Source: https://www.nrsc.gov.in/EO_Objective


Emergencies
Monitored
Directly found
Other media
Government
Social media
Non-affected people
Affected people
Oral communication and Interpersonal passive information spreading
Dynamic population distribution
Loudspeaker vehicle
Loudspeaker
SMS
Blog
News portal
TV
Wechat
Radio
Phone
Email
Newspaper
Optimized evacuation route
Optimized evacuation plan based on real-time information spreading during disaster
Subjective factors
Objective factors
Evacuation
Other response plan

References

Reference materials for each slide are quoted at the right end of the PowerPoint.