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IUNDRR-NIDM

CONCEPT OF DISASTER AND VULNERABILITY

Volume - 1

Handbook for Academicians on Disaster Risk Reduction

Foundation Course (Undergraduate Level)

"Reduce Risk, Save Lives, Secure Future"

CONCEPT OF DISASTER AND VULNERABILITY

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Concept of Disaster and Vulnerability: (Foundation Course – Undergraduate Level), 2026

Volume 1

Handbook for Academicians on Disaster Risk Reduction

"REDUCE RISK, SAVE LIFES, SECURE FUTURE"

National Institute of Disaster Management

(Ministry of Home Affairs, Government of India)

Handbook Vol. I: Concept of Disaster and Vulnerability. Handbook for Academicians on Disaster Risk Reduction (Foundation Course – Undergraduate Level), 2026

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FOREWORD

Disasters, both natural and human-induced, pose an ever-growing challenge to sustainable development and human security. As climate change accelerates, urbanization expands, and vulnerabilities deepen, the need for proactive disaster risk reduction (DRR) has never been more urgent. In this context, embedding DRR principles within higher education is not merely an academic pursuit but a societal necessity. The responsibility of equipping future generations with the knowledge and skills to anticipate, mitigate, and respond to disasters lies with our educators and institutions of learning.

This handbook is a pioneering effort in integrating disaster management into diverse academic disciplines. The objective is to provide a guidebook and content to the academicians for proper and effective implementation of the Disaster Management (DM) subject at the undergraduate level. This comprehensive resource provides a structured approach to incorporating DRR into higher education curricula.

A distinctive feature of this handbook is its pragmatic approach. Beyond theoretical knowledge, it provides ready-to-use PowerPoint presentations, real-world case

studies, and critical thinking exercises that encourage interactive learning. The inclusion of diverse disciplinary perspectives ensures that DRR is not confined to specialized domains but becomes a cross-cutting theme relevant to all fields of study. This approach aligns with the global commitment to mainstreaming disaster risk reduction in education, as emphasized in the Sendai Framework for Disaster Risk Reduction and the Sustainable Development Goals (SDGs).

The collaborative effort behind this handbook is commendable. The involvement of academicians from across the country and the guidance of a high-level committee have ensured that this resource is both comprehensive and adaptable. It embodies the collective wisdom of experts in the field, making it an invaluable tool for educators striving to prepare students for a world where disaster risks are an undeniable reality.

I am confident that this handbook will serve as a catalyst for transformative learning and inspire institutions to integrate disaster resilience into their academic frameworks. By equipping students with the knowledge and skills to address disaster risks, we take a crucial step toward a safer and more resilient future. I urge academicians to embrace this resource, customize it for their disciplines, and contribute to a culture of preparedness and sustainability.

Let us together build a generation that is not only academically proficient but also resilient in the face of uncertainties.

(Madhup Vyas)

PREFACE

In alignment with Agenda 6 of the Hon'ble Prime Minister's Ten-Point Agenda on Disaster Risk Reduction (DRR), which emphasizes the role of higher education in strengthening disaster management in India, the National Institute of Disaster Management (NIDM) has taken a proactive initiative under the *India Universities & Institutions Network for Disaster Risk Reduction (IUINDRR-NIDM)*. As part of this effort, NIDM has developed three comprehensive course curricula on Disaster Risk Reduction and Disaster Risk Resilience Management (DRR/DRRM), in consultation with academic experts from across the country.

Further reinforcing this national priority, the University Grants Commission (UGC) issued a notification (D.O. No. 2-9/2022 [CPP-II], dated 24th February 2022) urging all universities and colleges to integrate DRR into their academic curricula. This significant step underscores the urgent need for strategic action within the higher education sector to build a culture of resilience through knowledge, awareness, and skill development.

To support this vision, this handbook has been designed as a foundational resource for academicians across disciplines. It addresses the pressing need for a comprehensive understanding of disaster risks and the development of proactive, context-specific strategies to mitigate their impact. Recognizing that disaster risk reduction is a shared responsibility—transcending disciplines and sectors—this resource aims to empower educators to embed DRR principles into the heart of academic instruction.

This volume (Volume I) presents six key chapters focusing on the fundamentals of disaster management. It covers the phases of disasters, types and their impacts, India's vulnerabilities, and the role of science and technology in DRR. To support effective teaching and engagement, the handbook includes well-structured PowerPoint presentations that can be seamlessly integrated into lectures, real-world case studies demonstrating practical applications of DRR, and thought-provoking questions designed to encourage critical thinking and discussion among students. The present handbook provides a basic understanding of DRR and makes the subject easy to understand at the undergraduate level.

Importantly, the handbook does not adopt a one-size-fits-all approach. Instead, it offers a flexible and adaptable framework that academicians can tailor to suit their specific fields—whether in engineering, health

sciences, social sciences, humanities, or any other area. Each discipline brings unique insights and tools to the table, and this resource encourages educators to leverage those strengths in building a resilient future.

The development of this handbook involved the active participation of academicians from across the country, selected for their expertise in relevant domains. A high-level committee was constituted to guide the formulation of the chapter templates, ensuring academic rigor and relevance.

Our overarching goal is to foster a new generation of professionals who are not only proficient in their respective disciplines but also well-versed in anticipating, managing, and mitigating disaster risks. By embedding DRR within higher education, we aim to contribute meaningfully to a safer, more resilient society.

We invite you to explore the contents of this handbook, adapt the materials to your teaching needs, and most importantly, inspire your students to think critically about the global challenges ahead and their role in building a sustainable, disaster-resilient future.

P. Soni

(Preeti Soni)

ACKNOWLEDGEMENT

The development of this handbook marks an important step in advancing the integration of Disaster Risk Reduction (DRR) into higher education in India. Aligned with Agenda 6 of the Hon'ble Prime Minister's Ten-Point Agenda on DRR and supported by the University Grants Commission's call to action, this effort reflects a shared commitment to building a culture of preparedness and resilience through academic engagement.

This handbook would not have been possible without the valuable contributions, guidance, and encouragement of several distinguished individuals and institutions. I extend my sincere gratitude to the members of the Core Group Committee, whose vision and expertise were instrumental in shaping the structure and direction of this resource. My heartfelt thanks to Shri Taj Hassan, IPS (Retd.), former Director General of Fire Services, Civil Defence and Home Guards; Prof. H. Venkateshwarlu, former Vice Chancellor, Central University of Kerala; Prof. Vinita Sahay, Director, IIM Bodhgaya; Prof. Muthukalingan Krishnan, Vice Chancellor, Central University of Tamil Nadu; Prof. Ravi Sinha, Professor, IIT Bombay; Prof. S.N Labh, Patron, Asian Biological Research Foundation (ABRF); Prof. Masood Siddiqui, Professor, Jamia Milia Islamia and Ms. Vamsika C., Education Officer, University Grant Commission, New Delhi.

Their thoughtful support in the formulation of the chapter templates, and their strategic guidance toward the effective implementation of the model curricula on DRR have laid a strong foundation for this academic initiative.

I also extend my deep appreciation to the authors of this handbook for their outstanding contributions. Each chapter has been carefully crafted in accordance with the approved framework and delivers essential knowledge on various aspects of disaster management, including hazard types, their impacts, strategies for resilience, and the integration of modern tools such as Geographic Information Systems (GIS) and Remote Sensing in DRR. The content is designed to be accessible to undergraduate students, striking a thoughtful balance between academic depth and ease of understanding.

This collaborative achievement stands as a testament to the power of collective wisdom and the meaningful involvement of academia, experts, and institutions. By offering a flexible and interdisciplinary resource, this handbook aims to empower educators in embedding DRR concepts within their specific fields of study, ultimately contributing to resilience-building at the grassroots level.

A special note of gratitude is extended to **Shri Paras Nath Rai, IPS (Retd.)**, and **Dr. Nidhi Yadav**, Associate Professor, IIHMR, Delhi, for their valuable feedback and expert recommendations as the reviewer of this handbook.

I would like to express my sincere thanks to **Shri Rajendra Ratnoo, IAS (Retd.)** and **Shri Safi Ahsan Rizvi, IPS (Retd.),** former Executive Directors, NIDM, for their steadfast support and encouragement throughout the development of this handbook for academicians on DRR. Finally, the support and constructive guidance of **Shri. Madhup Vyas, IAS**, Executive Director, NIDM, marked by clarity and encouragement, are gratefully acknowledged. I also extend sincere thanks to the Library and Publication Division of NIDM for their support, particularly Mr. S. K. Tiwari, Dr. Ravinder Singh, Dr. Kundan Deval and Ms. Supreetha MK.

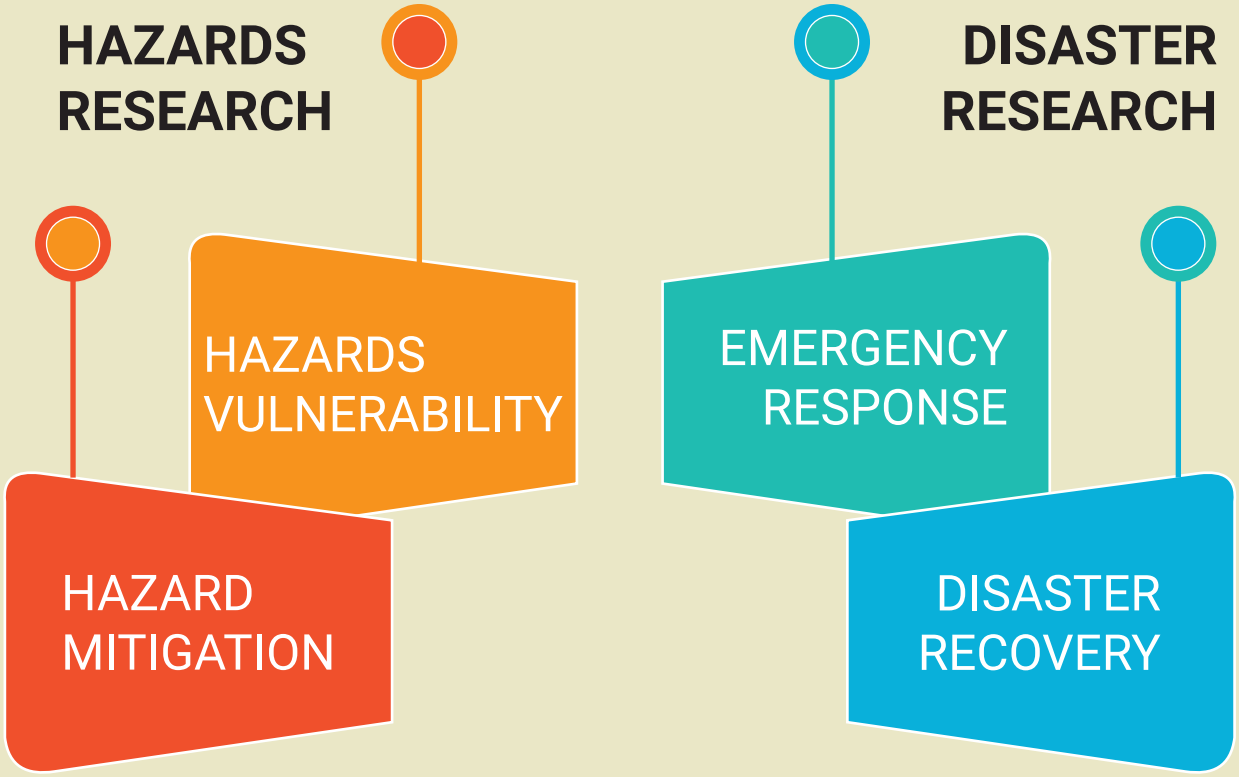
To everyone who contributed to this initiative, I offer my heartfelt thanks. Your efforts will go a long way in nurturing a generation of informed, proactive, and resilient professionals, ready to lead the way toward a safer and more sustainable future.

P. Soni

(Preeti Soni)

BASIC CONCEPTS OF HAZARD AND DISASTER

DISASTER PREPAREDNESS



CHAPTER- 1
HAZARD AND DISASTER – CONCEPTS

Dr. E. Parameswari

Total No. of Hours – 3

I. Background of the Topic

This chapter describes definitions of hazards, disasters, different terminologies, classifications, and types of potential hazards (including natural and non-natural disasters), understanding of types of disasters.

II. Learning Outcomes

1. To understand the basic concept of hazards and disasters
2. To understand the definitions and terminologies associated with hazards and disasters
3. To know about the classification and types of hazards and disasters

III. Pedagogy of the Session

- The session's teaching approach will be based on the National Institute of Disaster Management (NIDM) handbook.
- This approach will blend traditional methods, such as using black and white boards to visually explain key concepts, with modern tools like PowerPoint presentations to enhance understanding and engagement.
- Active participation will be encouraged through interactive group discussions, fostering a collaborative learning environment.

Integrating these diverse teaching strategies will bring the chapter to life, engaging students and facilitating a comprehensive exploration of hazards and disaster management.

IV. Content on the topic

1.1 Hazards

A hazard, as defined by the United Nations International Strategy for Disaster Reduction (UNISDR), is a dangerous phenomenon, substance, human activity or condition 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. Hazards include both natural and human factors. Disasters originate from hazards and can significantly impact human growth and the planet's continued existence. Throughout human history, people have been exposed to and have gradually understood various risks.

1.1.1 Classification of Hazards by Occurrences

Hazards can be classified based on their setting (disaster-formative environment) and causes (natural or human-induced). This classification focuses on the origin of risks and the environment in which they occur. The United Nations shifted the goal of global disaster reduction from preventing natural disasters to minimizing catastrophic event risks. The International Council for Science's (ICSU) Integrated Research on Disaster Risk (IRDR) programme categorises hazards into six families, twenty primary occurrences, and forty-seven perils. The six primary categories of hazards are:

a. **Geophysical Hazard:** Originates from the solid earth (e.g., earthquakes).

b. **Hydrological Hazard:** Caused by surface and subsurface water movement and distribution (e.g., floods).

c. **Meteorological Hazard:** Resulting from extreme weather conditions (e.g., storms).

d. **Climatological Hazard:** Due to long-term atmospheric phenomena (e.g., droughts).

e. **Biological Hazard:** Arising from exposure to living organisms or diseases (e.g., pandemics).

f. **Extra-terrestrial Hazard:** Caused by celestial bodies affecting the Earth (e.g., meteorite impacts).

1.2. Disasters

Disasters are the direct or indirect consequences of hazards. The term "disaster" comes from the French word "désastre", meaning "terrible star". Disasters can lead to loss of life, property destruction, environmental damage, social disruption, and threats to essential

services. The classification of disasters is closely linked to the hazards that cause them and their impact on affected bodies [2].

A disaster is characterized by significant human, economic, and property losses. Natural disasters disrupt normal life, causing misfortune, helplessness, and suffering, hence often requiring external assistance. The consequences of a disaster include:

- Interference with daily activities
- Negative impact on emergency response systems
- Worsened normal requirements and processes (e.g., food, housing, health)

Studies suggest that all disasters can be viewed as human-caused, as effective disaster management could prevent hazards from becoming disasters. Myths about disasters, such as the notion that nothing can be done, exacerbate the problem. Key characteristics of disasters include unfamiliarity, unpredictability, urgency, speed, threat, and uncertainty.

1.2.1. Different Types of Disasters

Disasters are typically categorized as natural or human-induced, with complex disasters often having multiple underlying causes. Primary disasters can lead to secondary disasters, worsening their effects. For instance, an earthquake causing a tsunami can result in coastal flooding, affecting agriculture and water quality.

Natural Disasters

Natural disasters occur without direct human involvement, but can be worsened by human behaviour. They include:

- **Land Movement Disasters:** Volcanic eruptions, avalanches, lahars, earthquakes
- **Water Disasters:** Tsunamis, floods, limnic eruptions
- **Weather Disasters:** Blizzards, cyclonic storms, droughts, hailstorms, heat waves, tornadoes
- **Health and Diseases:** Epidemics, famines
- **Space Disasters:** Gamma ray bursts, impact events, solar flares, supernovae, and hypernovae.

Human-induced Disasters

Human-induced disasters result from human activity, negligence, or error, and can involve technological or sociological factors. Examples include:

- **Major Human-induced Disasters:** Fires, epidemics, deforestation, pollution, wars
- **Minor Human-induced Disasters:** Road and train accidents, riots, food poisoning, industrial crises, theft, hijacking, terrorism, environmental pollution

1.2.2 Disasters Affecting India

India experiences various types of disasters, including:

- Landslides
- Cyclones
- Earthquakes
- Floods
- Droughts
- Volcanic eruptions
- Tsunamis
- Bushfires
- Major accidents (explosions, fires, hazardous material incidents)

1.2.3. General Effects of Disasters

Disasters cause widespread damage and disruption, including:

- Property destruction and damage
- Loss of life
- Damage to production
- Systemic disruption in government
- Interruption of essential services
- Injuries
- Disruption of lifestyle

- Damage to infrastructure
- Economic loss
- Sociological and psychological after-effects

As human society progresses, both the variety and geographical scope of disaster-affected bodies have increased, along with humans' ability to protect themselves from natural disasters. Disasters occur when hazards coincide with vulnerable situations, such as communities or cities. A disaster's severity depends on various factors, including causes, frequency, impact duration, onset speed, scope, destructive potential, and human vulnerability [1].

Understanding these elements helps in disaster analysis and highlights the importance of human resilience and adaptation to hazards. A disaster, therefore, is the result of the convergence of hazards and vulnerability.

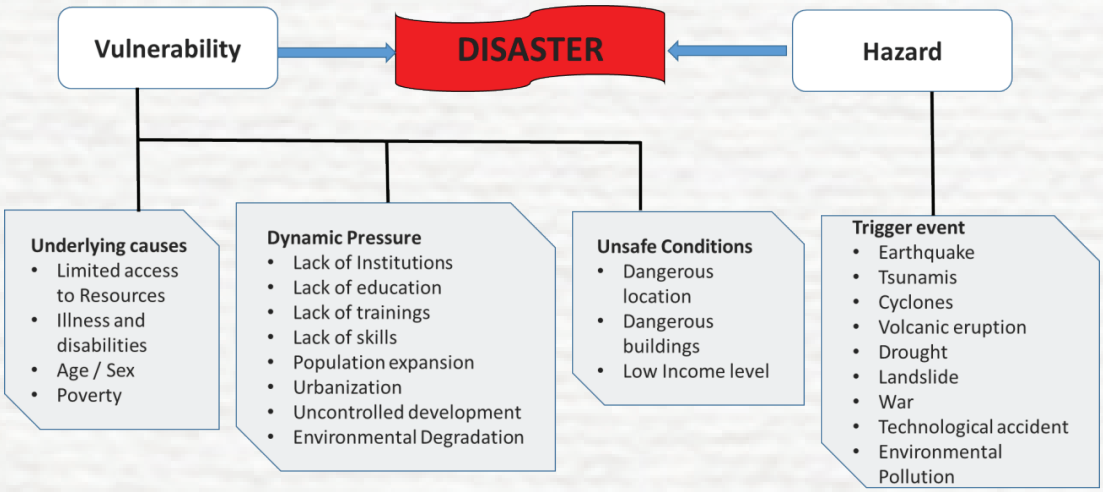


Fig. 1: Causes and impact of disasters

1.3. Vulnerability

Vulnerability is defined as the degree to which a community, structure, service, or geographical area is likely to be affected by a certain hazard due to its nature, construction, and proximity to hazardous terrain or disaster-prone areas. For example, a house made of cane and thatch is more vulnerable to wind damage during a tropical cyclone than a brick house. Conversely, a poorly constructed brick building is more likely to collapse during an earthquake than a cane or thatch hut. Therefore, structures should be built strong enough to withstand potential hazards.

Social and economic conditions also influence vulnerability. In developing countries, such

as India, natural disasters often result in higher losses of life compared to material losses, which is more common in developed countries.

1.4. Risk

Risk measures the anticipated losses (deaths, injuries, property damage, and economic activity) from a hazard of a defined magnitude in a given location over a certain time period. Risk involves four key elements:

- **Hazards:** Physical consequences from natural processes and their location relative to the community at risk.
- **Exposure:** The value and importance of buildings and systems (e.g., clean water supply, communication infrastructure, transportation) serving the population.
- **Vulnerability:** The susceptibility of exposed systems and structures to the anticipated risks during their useful life.
- **Location:** The proximity of a given location to a hazard may determine the extent of loss.

Fig. 2: Interrelationship of Risk with other factors

1.5. UNDRR Disaster Scale Indicator system

With regards to the Sendai Framework for Disaster Risk Reduction 2015–2030, there are seven disaster reduction indicators, four of which are related to the measuring of disasters, namely deaths due to direct impact of disasters, direct disaster economic losses as a percentage of global gross domestic product (GDP), destruction of important infrastructure, and interruption of essential services (particularly in the areas of health and education) (UNDRR 2015). Natural or human-induced disasters that occur under defined spatial and time constraints are included in disaster events.

Table 1: UNDRR catastrophe indicators' categories of disability (UNDRR 2015)

S. No	Disaster class	Sub-disaster class	Hazard factor
I	Natural hazard factors	Geophysics	Earthquake
			Tectonic plate movement
			Volcanic activity
		Hydrological	Flood
			Landslide
			Wave movement
		Meteorology	Convective storm
			Outside the tropical storm
			Extreme temperature
			Fog
		Climate	Tropical wind
			Drought
			Ice lake floods
			Wildfire
		Alien planet class	Collision
			Space weather
II	Environmental hazard factors	Environmental degradation	Erosion
			Deforestation
			Salinization
			Desertification
			Asian dust cloud
			Wetland degradation
			Cryosphere Depletion
III	Biological hazard factors	Biology	Infectious disease
			Epidemic
			Pandemic
			Injurious insect
			Pest
			Animal Attack
			Pollution

S. No	Disaster class	Sub-disaster class	Hazard factor
IV	Human-induced hazard factor (humanistic hazard factor)	Technical hazard factor	Industrial disaster
			Infrastructure collapse
			Power failure
			Fire
			Explosion
			Mine disaster
		Chemical radiation hazard factors	Chemical leakage
			Oil spill
			Radiation pollution
		Major traffic accident	Aviation accident
			Railway accident
			Road accident
			Sailing accident
			Space accident

1.6. Mortality and Affected People

Mortality refers to the number of people who died during an unsafe event. This includes those who died during or after the event, known as the death toll, and those who went missing during the event. Calculating mortality rates per 100,000 people helps standardize comparisons across different times and locations.

Affected People are those impacted by a disaster, either directly or indirectly. Directly affected individuals include those injured, sickened, evacuated, displaced, or who suffered damage to their livelihoods, infrastructure, environment, and properties. It also includes those whose homes were damaged or destroyed and those who received emergency food assistance. Indirectly affected people experience the cumulative effects of the disaster, such as economic disruption, loss of essential services, and social impacts. Statistics typically focus on directly affected individuals due to the difficulty in counting indirectly affected populations. It's also helpful to provide details about victims, such as age, gender, residence, and disabilities.

1.7. Economic Damage

Direct Economic Loss refers to the destruction caused by a natural disaster to specific materials or properties, including homes, businesses, and public infrastructure. Assessing

property loss promptly after a disaster helps estimate recovery costs and process insurance claims [2]. Calculating the percentage of the global or national GDP attributable to these losses provides further context. Direct economic loss can be divided into several categories:

a. **Agricultural Loss**: Includes the destruction of crops, livestock, poultry, fisheries, and forestry operations.

b. **Industrial Facilities**: Refers to the loss of manufacturing and industrial facilities.

c. **Commercial Facilities**: Includes damage to storage, warehouses, cargo terminals, and similar establishments.

d. **Homes**: Encompasses both minor cosmetic damage and homes destroyed beyond habitability.

e. **Critical Infrastructure**: Losses include educational and health facilities, as well as roads and other essential infrastructure.

1.7.1. Infrastructure Damage

Damage to Infrastructure covers both critical and other types of infrastructure:

1. **Educational Facilities**: The number of facilities such as schools and training centers damaged or destroyed.

2. **Health Facilities**: Includes health centers, clinics, hospitals, and outpatient centers.

3. **Roads**: The number of kilometers of road networks damaged or destroyed.

4. **Railways**: Distance of railway lines damaged or destroyed.

5. **Ports**: Number of ports damaged or destroyed.

6. **Airports**: Number of airports rendered inoperable.

1.7.2. Basic Services

Basic Services include publicly provided services disrupted by hazardous events. These services encompass medical and educational facilities, transportation systems, information and communications technology (ICT) systems, water supply, solid waste management, electrical supply systems, and emergency response services.

a. **ICT Systems**: Include communication networks and associated equipment like radio and TV stations, post offices, and public information offices.

b. Water Supply: Involves potable water supply and wastewater treatment systems, including water processing facilities, transport channels, and drainage systems.

c. Solid Waste Management: The process of collecting and treating solid wastes that are not generated by public sanitation systems.

d. Power and Energy: Includes power facilities, electrical substations, power control centers, and other power services.

e. Emergency Response: Comprises emergency control centers, police stations, fire departments, military bases, and disaster management offices.

1.8. GIS and Remote Sensing in Disaster Management

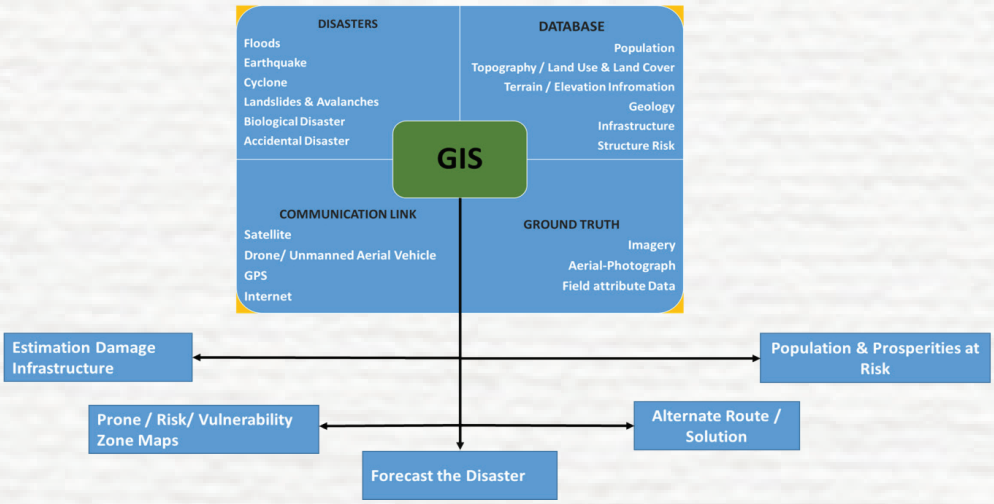


Fig. 3: Geographic Information Systems (GIS) for Disaster Management

The country of India is extremely susceptible to both natural and human-induced disasters. All disasters are spatial in nature. The use of GIS techniques can function as a decision-making aid. The examination of the many GIS layers available enables decision-making to take place. At the moment, data on socio-economic and geospatial conditions are useful not only for the management and planning of disasters but also for mitigating the effects of disasters. When it comes to disaster management, a number of different departments and agencies count themselves as stakeholders and utilize geospatial technologies. Applications for GIS, Remote Sensing (RS), and Global Positioning System (GPS) that involve disaster management and decision-making can benefit from their use. Both the academic study of natural disasters and their application in the real world are benefiting from the rapid development of computer technology and the increased availability of hardware.

The use of GIS for mapping hazard zones is helpful, and when there is an emergency, using these maps to assist in the evacuation of people is simple and straightforward. Both preparedness plans and mitigation strategies can significantly benefit from the use of GIS and RS. The allocation of response resources can be improved with the use of geographic data that is updated in real time. Technologies based on geographic information systems (GIS) are extremely helpful in the modelling of disaster risks and human responses to hazards (Fig. 3). In addition to that, they offer a decision-support system for use in emergency management [3].

1.9. Disaster Management is done by the following steps:

a. Planning and Analysis

b. Situational Awareness

c. Data Management

d. Field Operations

1.9.1. Important objectives of GIS database generation are:

a. Disaster managers from different states, cities, villages level use GIS database for disaster planning.

b. Preparedness and planning of disasters

c. Prediction and early notification of a catastrophic event

d. For managing relief efforts and rescue missions

A GIS database containing a range of topics is helpful to disaster managers in the decision-making process when catastrophic events occur.

1.9.2. GIS databases include the following information, which is beneficial in disaster management:

a. Use of different satellite imageries (Remote Sensing data) e.g. Quick bird, SPOT, IKONOS for GIS data creation.

b. Preparation of base map of different themes using satellite imageries.

c. Thematic maps such as a hydro geomorphological maps, slope maps, terrain maps, past

events density maps, and DEM generation in GIS. It is used for disaster planning.

d. Macro and micro-level maps are used for identifying vulnerability and threat condition.

e. Identification of safe locations and zones for rehabilitation.

f. Road and location maps are used for finding alternate routes, shelters, and locations.

g. Planning of evacuation and operation.

h. Management of Rehabilitation and post-disaster reconstruction.

i. Suitable locations are identified scientifically for construction of houses and shelters.

j. There are no designated construction zones, and existing residents can be rehabilitated.

k. Identification for injured persons at hospitals and medical facilities [4].

1.10. Vulnerability to Disasters

Because of its one-of-a-kind geoclimatic and socio-economic conditions, India has historically been exposed to a large number of natural as well as human-induced disasters, albeit to varying degrees of exposure in each case. It is extremely susceptible to natural disasters such as earthquakes, typhoons, floods, droughts, landslides, avalanches, and forest fires. There are 36 states and Union Territories in this country, and 27 of them have a high probability of being affected by natural disasters. Over 40 million hectares, or twelve percent of the coastal land, are vulnerable to floods and river erosion; of the 7,516 kilometres of coastline, close to 5,700 kilometres are vulnerable to cyclones and tsunamis; sixty-eight percent of the drought can affect cultivable land, and landslides and avalanches can happen in hilly locations.

India is consistently ranked among the top ten countries with the highest risk of natural disasters. The nation is vulnerable to natural and human-induced disasters for a variety of reasons, some of which include unfavourable topographic features, environmental deterioration, population growth, and geo-climatic conditions, urbanisation, industrialization, and other forms of development that do not adhere to scientific principles, among other things. The factors responsible for the acceleration of the severity and frequency of disasters are also responsible for the heavy toll on human lives and the disruption of the life support system in the country. In terms of susceptibility to natural disasters, each of the country's distinct regions, namely the Himalayan region, the alluvial plains, the hilly portion of the peninsula, and the coastal zone, faces its own unique set of challenges. On the one hand, the Himalayan region is susceptible to natural disasters such as earthquakes and landslides. On the other hand, the plain is almost always impacted by floods. The desert region of the

country is susceptible to droughts and famines, whereas the coastal zone is more likely to be struck by cyclones and storms.

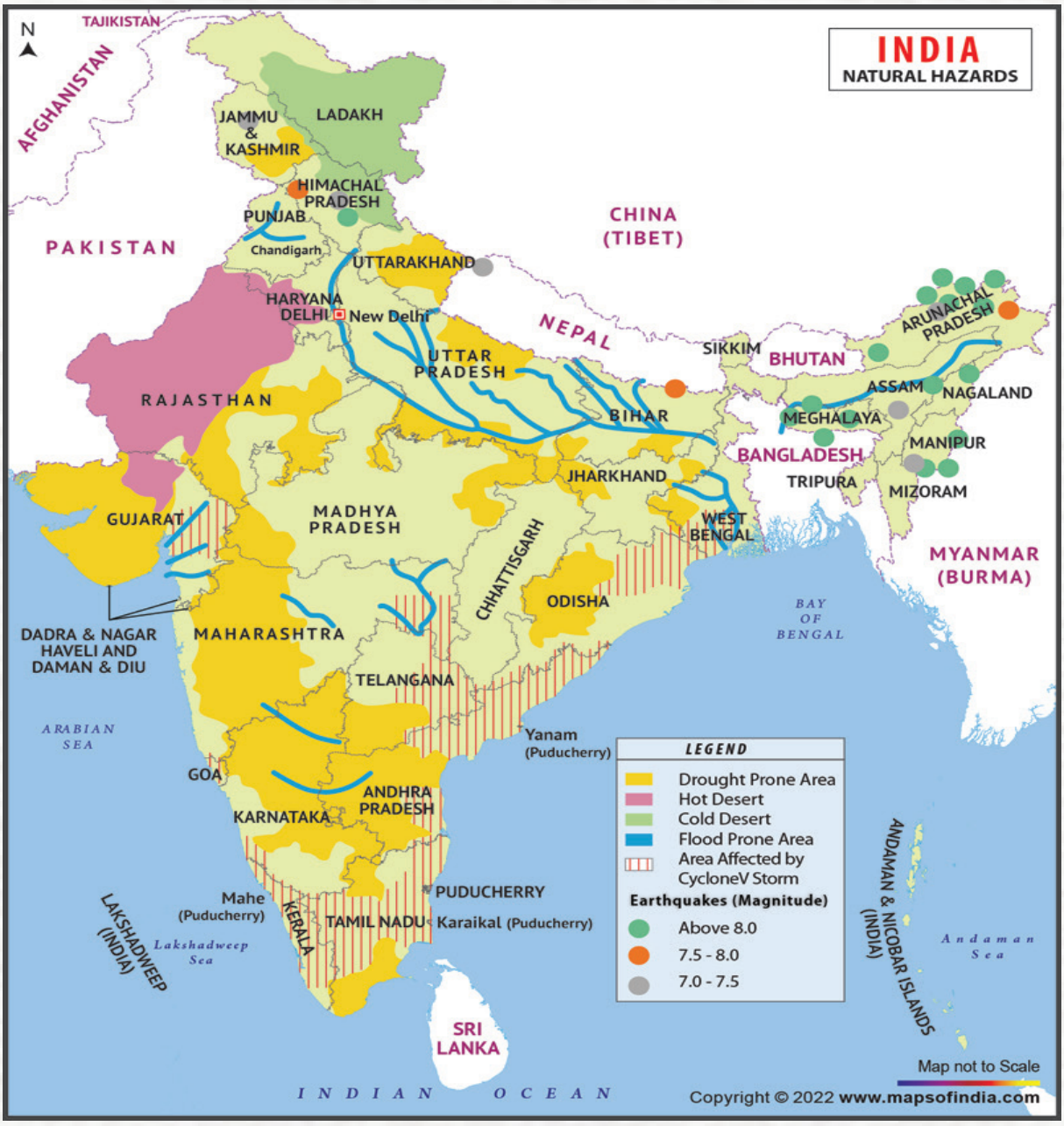


Fig. 4: Map of natural hazards in India

a) The country's unique geological environment is the main factor contributing to its greater susceptibility.

b) Cause and effect: The geo-tectonic characteristics of the Alluvial plains and the Himalayan region that are adjacent to it make the region prone to natural catastrophes like earthquakes, landslides, and water erosion, among other things. Even Peninsular India, although thought to be the steadiest portion of the country, is still subject to occasional

earthquakes, which demonstrates that geo-tectonic movements are still occurring within its depth.

c) The tectonic features and characteristics of the Himalaya can also be found in the Indus River's alluvial lowlands, Ganga, and Brahmaputra Rivers because the rocks that lie beneath the alluvial plains are simply an extension of the Himalayan ranges. As a result, this area is subject to a significant amount of seismic activity. The region is afflicted with river channel siltation as a consequence of the numerous major river systems that originate in the Himalayas and the enormous quantity of sediment that these river systems bring with them. This causes frequent flooding, particularly in the plains of Uttar Pradesh and Bihar.

d) The western region of the country, which includes Rajasthan, Gujarat, and some areas of Maharashtra, is frequently subject to drought conditions. In the event that the monsoon gets worse, the situation will spread to other areas of the country as well. Cyclones form in coastal areas as a direct result of disturbances in the pressure conditions that exist over the oceans. The geo-tectonic movements that are taking place on the ocean floor make the coastal region more susceptible to the devastation caused by tsunamis.

e) Other natural characteristics that contribute to the nation's susceptibility to a wide variety of natural disasters include harsh weather conditions, a large quantity of ice and snow that is stored in glaciers, and so on.

f) In addition to the natural factors that were covered in the previous section, various human-induced activities, such as increasing demographic pressure, worsening environmental conditions, deforestation, unscientific development, inadequate farming methods and grazing, unplanned urbanisation, and the building of big dams on river channels are also to blame for the country's increased frequency and hastened impact of natural disasters.

1.10.1. Disasters that frequently occur in India

The disasters were categorised as 31 types by the high-power Committee on Disaster Management. Tsunami was added in 2005 to this list. Table 2 below depicts the classification of various types of disasters.

Table 2: Classification of various types of disasters

Major disasters	Types of the Disaster
(i) Water and Climate related disasters	◆ Flooding and drainage control ◆ Cyclones ◆ Tornadoes and Hurricanes ◆ Hailstorms ◆ Cloud burst ◆ Cold and Heat Cold ◆ Snow avalanches ◆ Droughts ◆ Sea erosion ◆ Thunder and lightning ◆ Tsunami
(ii) Geological related disasters	◆ Landslides and mudflows ◆ Earthquakes ◆ Dam failure and/or Dam bursts ◆ Mine disaster
(iii) Chemical, industrial and nuclear related disasters	◆ Forest fires ◆ Urban fires ◆ Mine flooding ◆ Oil spills ◆ Major building collapse ◆ Serial Bomb blasts ◆ Festival-related disasters ◆ Electrical disasters and fires ◆ Road, Rail, and Air accidents ◆ Boat capsizing ◆ Village Fire
(iv) Biological disasters	◆ Biological disasters and epidemics ◆ Pest attacks ◆ Cattle epidemics ◆ Food poisoning

In conclusion, risks are factors that are harmful to people, and by comparing current observed data with historical data, it is possible to study the temporal and spatial patterns of hazards. Disasters may be quantified in terms of losses and damages since they are the effects of hazards on people. Future calamities brought on by hazards in a certain area are risks. In its simplest form, disaster risk science is the study of the mechanics, processes, and dynamics of interactions between hazards, catastrophes, and risks, as well as the prevention

and mitigation of disaster risk. Below are some links between risks, hazards, and disasters (Fig. 5) [5].

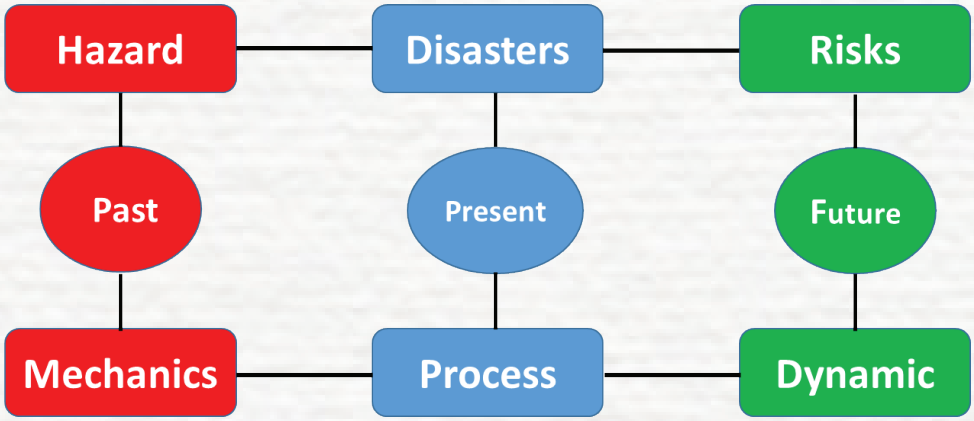


Fig. 5: Relationships among hazards, disasters, and risks

Suggestive Activities:

Points for Group discussion

- **GIS Mapping Projects**: Create and analyze hazard maps to identify vulnerable areas and critical infrastructure.
- **Community Awareness Programs**: Conduct workshops to educate local residents about disaster preparedness and response.
- **Role-Playing Exercises**: Simulate disaster response scenarios with assigned roles like emergency responders and community leaders.
- **Emergency Kits Preparation**: Guide students in assembling and planning emergency kits for their homes.
- **Expert Sessions**: Invite disaster management professionals to share experiences and insights through guest lectures.

References:

1. Bankoff, G. (2012). Historical concepts of disaster and risk. In *Handbook of Hazards and Disaster Risk Reduction* (pp. ٤٧-٣٧). Routledge.

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4. Schneiderbauer, S., & Ehrlich, D. (2004). Risk, hazard and people's vulnerability to natural hazards. *A review of definitions, concepts and data. European Commission Joint Research Centre. EUR*, *21410*, 40.

5. Shi, P. (2019). Hazards, Disasters, and Risks. In: Disaster Risk Science. IHDP/Future Earth-Integrated Risk Governance Project Series. Springer, Singapore.

Glossary

United Nations International Strategies for Disaster Reduction: Some Key Definitions (UNISDR, 2009)

Disaster: A disaster is a major interruption of a community or society's ability to function that causes widespread losses and effects in terms of people, property, money, or the environment. It also exceeds the capacity of the afflicted community or society to recover using its own resources.

Disaster risk: The potential disaster losses to a community or society during a given time period in terms of lives lost, health status, livelihoods lost, assets lost, and services lost. People, things, systems, or other components could suffer losses if they are in hazard zones.

Geological hazard: A geological process or phenomenon that may result in environmental harm, social and economic disruption, property damage, injury or other health effects, loss of livelihoods or services, or loss of life.

Hazard: The term "hazard" refers to any potentially harmful event, human action, substance, or circumstance that has the potential to result in loss of livelihoods, property damage and services, social, economic upheaval, or environmental harm.

Hydrometeorological hazard: A hydrometeorological hazard is an atmospheric, hydrological, or oceanic process or phenomenon that could result in loss of livelihoods, property damage services, disruption of the social and economic system, or environmental harm in addition to potential health effects.

Natural hazard: Natural hazards include any process or phenomenon that occurs naturally and may result in property damage, loss of livelihoods and services, disruption of the social and economic system, or environmental harm.

Socio-natural hazard: The phenomenon of increased occurrence of specific hydrometeorological and geophysical hazard events, such as floods, landslides, land subsidence, and drought that result from the interaction of natural hazards with overused or degraded land and environmental resources is known as a socio-natural hazard. Natural hazards include any process or phenomenon that occurs naturally and may result in loss of livelihoods, property damage and services, disruption of the social and economic system, or environmental harm.

Technological hazard: Risk posed by technological or industrial conditions, such as accidents, perilous procedures, infrastructure failures, or specific human activities, which may result in loss of life, injury, illness, or other adverse effects on health, loss of livelihoods, property damage and social and economic disruption, services, or environmental damage.

Vulnerability: A community, system, or asset's traits and circumstances that leave it open to a hazard's destructive impacts.

Suggestive questions:

MCQ questions carry one mark each (MCQ/ Fill the blanks)

1. From which language is the word ‘disaster’ derived?

a) French, b) Latin, c) Greek, d) English

2. Which one is a geophysical disaster?

a) Drought, b) Earthquake, c) Pollution, d) Fire

3. What is an example of a human-induced disaster?

a) Earthquake, b) Cyclone, c) Oil-spill, d) Tsunami

4. What is an example of a natural disaster?

a) War, b) Pollution, c) Deforestation, d) Tsunami

5. UNISDR Stands for United Nations International Strategy for Disaster Reduction.

True/ False

6. A hazard originating from the solid earth is known as Geophysical hazard

True/ False

All short questions carry three marks each (short notes)

7. What are the definitions of disaster, hazard, risk, and vulnerability?

8. What are the different types of natural and human-induced disasters?

9. How does remote sensing play a role in disaster management?

10. What are the common disasters that have occurred in India?

All long questions carry three marks each (essay type, logical analysis, inferring practical situation)

11. What are the different types of disasters and their impacts?

12. What is the role of remote sensing and GIS in disaster management?

Suggestive powerpoint slides for reference

Hazards and Disasters – Concepts

Hazards

According to United Nations International Strategy for Disaster Reduction (UNISDR) hazard is defined as follows

A hazard is a natural process or phenomenon that, according to the, has the potential to have a negative impact on the economy, society, and ecology

Classification of Hazards by Occurrences

There are six broad hazard categories within the family group:

Geophysical hazard: a hazard originating from solid earth. This term can be used interchangeably with the term geological hazard.

Hydrological hazard: a hazard caused by the occurrence, movement, and distribution of the surface and subsurface freshwater and saltwater.

Meteorological hazard: a hazard caused by short-lived, micro- to mesoscale extreme weather and atmospheric conditions that last from minutes to days.

Climatological hazard: a hazard caused by long-lived, meso- to macro-scale atmospheric processes ranging from intra-seasonal to multi-decadal climate variability.

Biological hazard: a hazard caused by the exposure to living organisms and/or the toxic substances or vector-borne diseases that they may carry.

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 magnetosphere, ionosphere, and thermosphere.

Disasters

The word Disaster is from a French word Disaster meaning bad or evil star. Disasters are direct or indirect results of hazards. Disasters The English term "disaster" originates from the French word "desastre," which means "terrible star."

A disaster is a natural or manmade event that results in widespread human loss, loss of livelihood, property and life, often resulting in permanent changes to human societies, ecosystems and the environment

Generally, disaster has the following effects in the concerned areas,

1. It completely disrupts the normal day to day life
2. It negatively influences the emergency systems
3. Normal needs and processes like food, shelter, health, etc. are affected and deteriorate depending on the intensity and severity of the disaster.

Types of Disaster

Natural disasters and Human induced disaster

Natural disasters : Arise without direct human involvement, Thus a natural disaster is the effect of a natural hazard (e.g., flood, tornado, hurricane, volcanic eruption, earthquake, or landslide). It leads to financial, environmental or human losses.

Land movement disasters : Avalanches, Earthquakes, Lahars, Volcanic eruptions

Water disasters : Floods, Limnic eruptions, Tsunami

Weather disasters : Blizzards, Cyclonic storms, Droughts, Hailstorms, Heat waves, Tornadoes, Fire

Health and diseases : Epidemic, Famine

Space : Gamma ray bursts, Impact events, Solar flares, Supernovae and hypernovae

Human induced disaster

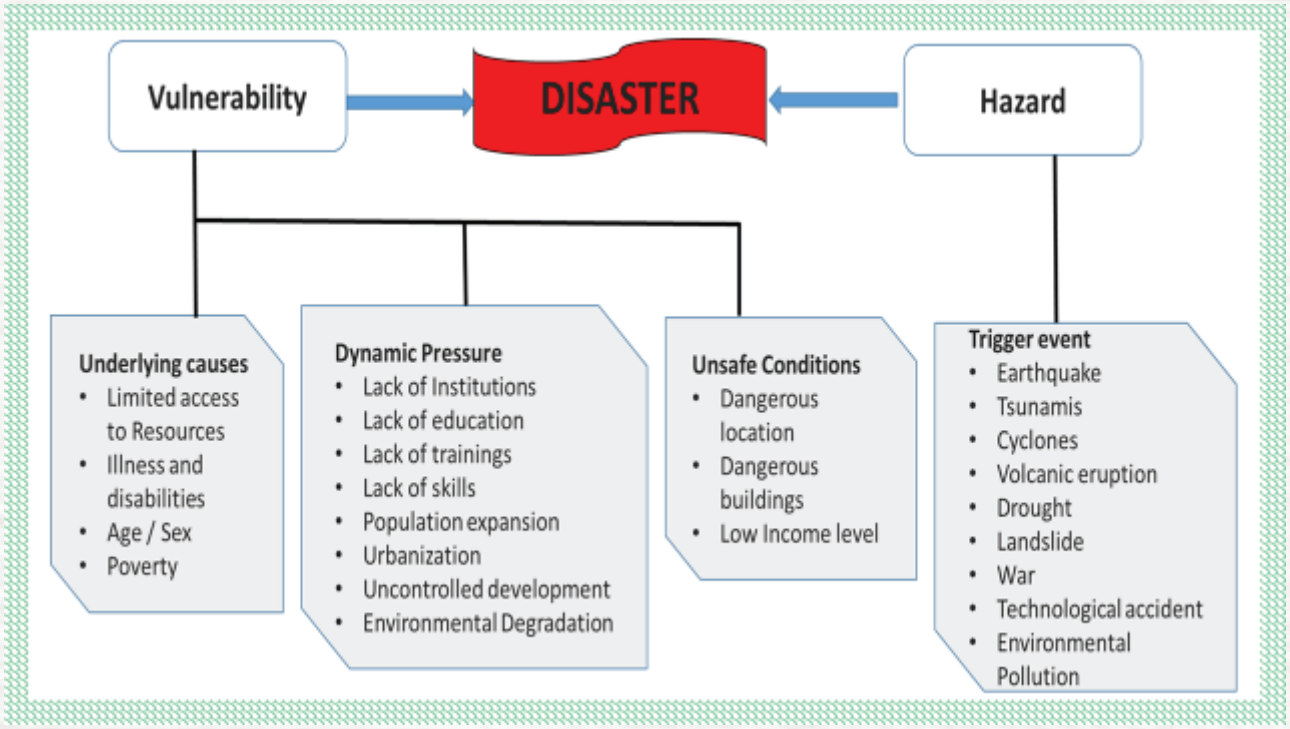
Disasters that are the result of human activity, negligence, or error, or that involve the breakdown of a system, are referred to as man-made disasters

Major manmade disaster
- Setting of fires
- Epidemics
- Deforestation
- Pollution due to prawn cultivation
- Chemical pollution
- Biological Pollution
- Wars

Minor manmade disaster
- Road / train accidents, riots
- Food poisoning
- Industrial disaster/ crisis
- Theft and Destruction of Tourism Infrastructure
- Hijacking and Terrorism
- Social and Cultural Disaster
- Environmental pollution

Disasters affecting India
- Earthquake
- Volcanic eruption
- Tsunami
- Cyclone
- Flood
- Landslide
- Bushfire
- Drought
- Major accident (fire, explosion, hazmat)

General Effects of Disaster
- Loss of life
- Injury
- Damage to and destruction of property
- Damage to and destruction of production
- Disruption of lifestyle
- Loss of livelihood
- Disruption to essential services
- Damage to national infrastructure
- Disruption to governmental systems
- National economic loss
- Sociological and psychological after effect



RISK

Risk is a measure of the expected losses (deaths, injuries, property, economic activity etc) due to a hazard of a particular magnitude occurring in a given area over a specific time period

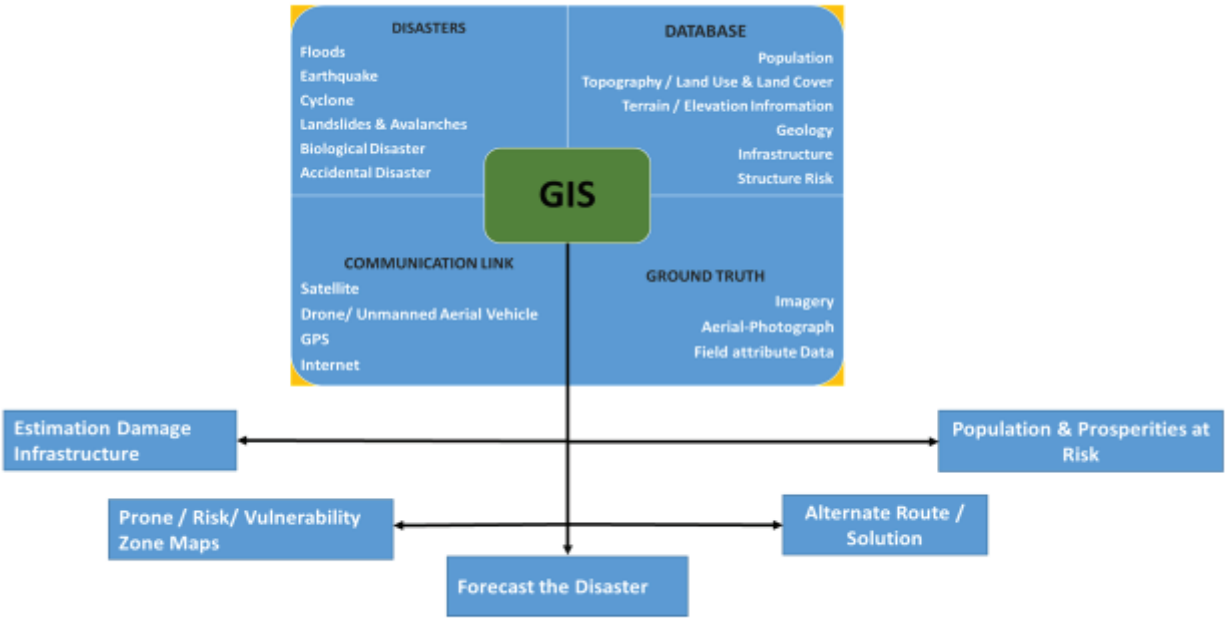
GIS and Remote sensing in Disaster Management

Disaster Management is done by following steps

1. Planning and Analysis
2. Situational Awareness
3. Data Management
4. Field Operations

Important objectives of GIS database generation are,

1. Disaster managers from different state, city, village level using GIS database for disaster planning.
2. Preparedness and planning of disasters
3. Forecasting and early warning of a disastrous event
4. For relief management, rescue operations
5. GIS database with various themes is helpful to disaster managers in decision making process when catastrophic event occur.



GIS database include following information which is beneficial in disaster management

- Use of different satellite imageries (Remote Sensing data) ex. Quickbird, SPOT, IKONOS for GIS data creation.
- Preparation of base map of different themes using satellite imageries.
- Thematic maps such as a hydro geomorphologic map, slope map, terrain map, and DEM generation in GIS. It is used for disaster planning.
- Macro and micro-level maps used for identifying vulnerability and threat condition
- Identification of safe locations and zones for rehabilitation
- Road and location maps used for finding alternate routes, shelters, and locations
- Planning of evacuation and operation
- Management of Rehabilitation and post-disaster reconstruction.
- Suitable locations identifying scientifically for construction of houses and shelters
- No construction areas identified and rehabilitation of existing people can be done.
- Hospitals and medical facilities identification for injured people

Vulnerability to Disasters in India

- It is extremely susceptible to natural disasters such as earthquakes, typhoons, floods, droughts, landslides, avalanches, and forest fires.

- There are 36 states and union territories in this country, and 27 of them have a high probability of being affected by natural disasters.

- Over 40 million hectares, or twelve percent of the land, are vulnerable to floods and river erosion; of the 7,516 kilometres of coastline, close to 5,700 kilometres are vulnerable to cyclones and tsunamis; sixty-eight percent of the cultivable area is susceptible to drought; and hilly areas are at risk from landslides and avalanches.

CHAPTER - 2

Hazards and Disaster- Vulnerability and Risks

C. Prakasam & Aravinth R

Total No. of Hours – 4

I. Background of the Topic

Hazard, vulnerability, and risk concepts are central to understanding and managing disasters. A hazard refers to a natural or human-induced event that has the potential to cause harm or damage to people, property, and the environment. Vulnerability refers to the susceptibility of a community or an individual to the impacts of a hazard, considering factors such as location, socio-economic status, and infrastructure. Risk, in turn, is the likelihood of a hazardous event occurring and its potential consequences. Understanding these concepts is essential for effective disaster risk reduction and management in the context of disasters. It involves:

- Identifying hazards and their likelihood.
- Assessing the vulnerability of communities.
- Evaluating the potential consequences of a disaster event.

Based on this information, strategies and measures can be implemented to reduce the risk of harm and minimize the impact of disasters on people and communities. It includes improving early warning systems, strengthening building codes, and preparing emergency response plans.

II. Learning Outcomes

- Understanding natural and human-induced disasters, their causes, and their environmental and societal impacts.

- The effectiveness of strategies and techniques for disaster risk reduction and mitigation, such as early warning systems, hazard mapping, and structural engineering, is a testament to their potential impact.
- Reconstruction and recovery processes, including the role of insurance, aid organizations, and government agencies. International cooperation and coordination in disaster risk management, including the role of the UN and other organizations.
- Social and environmental dimensions of disasters, including the impact on vulnerable populations and the protection of cultural heritage. Effective communication and stakeholder engagement in disaster risk management.

III. Session Methodology

- Begin with an engaging introduction emphasizing the significance of vulnerability and risk in the context of hazards and disasters.
- Use real-life examples and case studies to illustrate the impacts of vulnerabilities and risks on communities.
- Organize group activities to facilitate active learning and student collaboration.
- Incorporate interactive discussions and debates.
- Integrate multimedia resources to enrich the learning experience.

IV. Content on the topic

2.1 Introduction

We reside in an environment of potential dangers and risks, such as coastal areas susceptible to cyclones, tsunamis, or earthquake-prone mountainous regions. About 60% of India's land is exposed to earthquakes of different magnitudes, flood-susceptible lands of 40 million acres, cyclone-vulnerable areas (8%), and 68% prone to drought, as per BMTPC (2006). The annual average number of disaster-affected people during 1990-2000 was around 30 million, and the number of deaths was 4344, according to the "World Disasters Report (2004)". As per the Vulnerability Atlas of India (BMTPC Report 2019), the Indian Subcontinent is among the world's most disaster-prone areas.

- 57% of land is vulnerable to earthquakes
- 18% of land is vulnerable to High Wind Velocity (55 & 50 m/s)
- 12% of land area is vulnerable to Floods
- 12.6% of land is vulnerable to landslides in hilly regions of India.

The World Disasters Report 2022 highlights the unprecedented scale of the COVID-19 pandemic, which has claimed over 6.5 million lives globally, exceeding the devastation caused by any recorded natural disaster. While natural disasters, including earthquakes, floods, droughts, and cyclones, remain a significant threat, their impact is further amplified by anthropogenic factors like fires and epidemics. The frequency and severity of these events have been increasing globally, particularly in India, where unplanned development, high population density, and vulnerability to natural hazards contribute to escalating losses during disasters.

The concept of risk, involving the probability of an event occurring and the potential consequences, underscores the importance of understanding and mitigating these hazards. Despite efforts to reduce the human toll of disasters, the number of fatalities and the financial losses associated with them continue to rise, demanding comprehensive strategies for preparedness, mitigation, and response.

2.2 Vulnerability

Vulnerability refers to the potential for damage or disruption to a human-made structure, community, or entire geographical area due to a specific hazard. In other words, it is the expected damage caused by a hazard.

Assessing how a hazard interacts with various aspects of vulnerability is crucial when dealing with a specific threat. A vulnerability study evaluates the potential impact on individuals or communities, and while there is no certainty that a disaster will occur, it can impact different populations differently. Vulnerability denotes the link between the physical threats posed by a disaster event to a community and the capacity of such a community to respond to those threats. Threats can arise from a combination of social and physical processes and human vulnerability. The effects of a disaster event on a population are determined not only by physical vulnerability but also by the social and economic conditions in the affected society. Studies have shown that groups such as single-parent families, women, people with disabilities, children, older people, and people with low incomes are particularly vulnerable in the aftermath of disaster. For example, coastal communities may be more susceptible to the effects of cyclones, but some families within those communities may be better equipped to withstand the impact or recover more quickly due to their financial resources, support systems, and adaptation strategies. However, the poorest communities, which often reside in the most exposed areas and have limited assets, are likely to be the most vulnerable in the face of a natural disaster. The level of vulnerability is primarily a result of people's limited ability to protect themselves and recover without outside help.

Types of Vulnerability

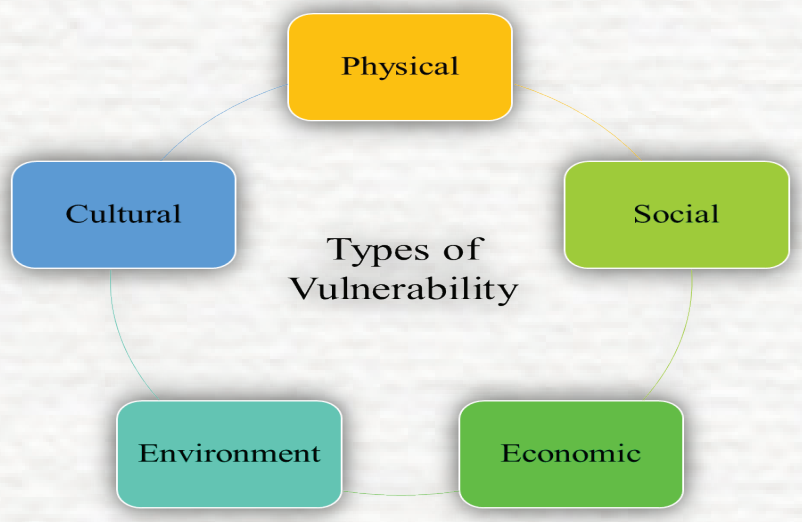


Fig. 1: Vulnerability type

Physical Vulnerability

Physical vulnerability refers to the potential for damage or disruption to a human-made structure, community, or entire geographical area due to a specific hazard. In other words, it is the expected damage caused by a hazard.

For example, a building located in an area prone to earthquakes is physically vulnerable as it is at a higher risk of collapsing or experiencing structural damage during an earthquake. Similarly, a coastal community located close to the sea is physically vulnerable to damage from cyclones, tsunamis, and storm surges. The lack of protective infrastructure, such as seawalls and storm shelters, increases their physical vulnerability (Fig. 2).

Fig. 2: Impact of various disaster

In conclusion, physical vulnerability is a crucial factor in determining a hazard's impact on a community, and its assessment is essential for disaster risk reduction and management.

Economic vulnerability

It refers to the extent to which a population or community risks economic loss or disruption due to a disaster or hazard. Several factors can contribute to this, including poverty, dependence on a single industry, lack of access to resources and services, and insufficient infrastructure.

For example, in a coastal community dependent on fishing as the main source of income, a hurricane that damages boats and fishing gear can result in economic vulnerability, as the community may have fewer means of earning a livelihood. Similarly, a community with limited access to financial resources and insurance may be able to recover from a disaster with outside assistance, making them economically vulnerable. The loss of jobs, damage to businesses and infrastructure, and decreased economic activity can also contribute to financial vulnerability for a larger region or country post-disaster.

Social Vulnerability

Social vulnerability refers to a community's or population's inherent social characteristics that increase their susceptibility to the negative impacts of a disaster. It encompasses poverty, lack of access to resources, social exclusion, and marginalization. The intersection of various social, economic, and political factors determines social vulnerability.

Examples of social vulnerability include:

- ✓ Poor communities, where residents lack the financial resources to mitigate the disaster.
- ✓ Aging populations may have limited mobility and be unable to evacuate quickly during a disaster.
- ✓ Communities with limited access to healthcare are more susceptible to disease and illness during and after a disaster.

Environmental Vulnerability

It refers to the environment's and its components' susceptibility to the adverse impacts of natural or human-induced disasters. It considers the natural and built environment, including ecosystem services, critical infrastructure, and settlement patterns.

Examples of environmental vulnerability in disaster situations include:

- ✓ Coastal areas are prone to hurricanes, typhoons, or tsunamis due to their proximity to the ocean and low-lying elevation.

- ✓ Areas with fragile ecosystems, such as wetlands, provide important services such as water regulation and flood control, but are susceptible to damage during disasters.
- ✓ Areas with high concentrations of hazardous material storage facilities that are vulnerable to releasing toxic chemicals during a disaster.

Cultural Vulnerability

In a disaster, it refers to the susceptibility of a particular culture or community to the adverse effects of a disaster due to their cultural norms, values, beliefs, and practices. It refers to the cultural barriers, lack of access to information and resources, and social exclusion that can make a community more vulnerable to the impacts of disasters. Cultural vulnerability can exacerbate the impact of a disaster and impede recovery and rehabilitation efforts.

Examples of cultural vulnerability in the disaster include:

- ✓ Indigenous communities with limited access to mainstream resources and information may be vulnerable to the impacts of natural disasters.
- ✓ Women and children who face gender-based discrimination may have limited access to evacuation and emergency services during a disaster.
- ✓ Rural communities that depend on agriculture and traditional livelihoods may be especially vulnerable to drought or flood impacts.

2.3 Vulnerability profile of India

India is among the top ten countries in the world that are vulnerable to disasters. This is due to various reasons, such as unfavourable geological and climatic conditions, topographical characteristics, degradation of the environment, and growth in population, urbanization, industrialization, and development practices that need more scientific grounding. These factors are contributing to an increase in the intensity and frequency of disasters, causing heavy losses in terms of human lives and disrupting the country's life support systems. Regarding disaster vulnerability, the five distinct regions of India, i.e., the Himalayan region, the desert region, the alluvial plains, the hilly part of the peninsula, and the coastal zone, each have their specific challenges. For example, while the Himalayan region is susceptible to earthquakes and landslides, the alluvial plains experience floods annually. The desert region faces droughts and famines, and the coastal zone is at risk of cyclones and storms.

Some major vulnerability profiles of India

Landslide Vulnerability

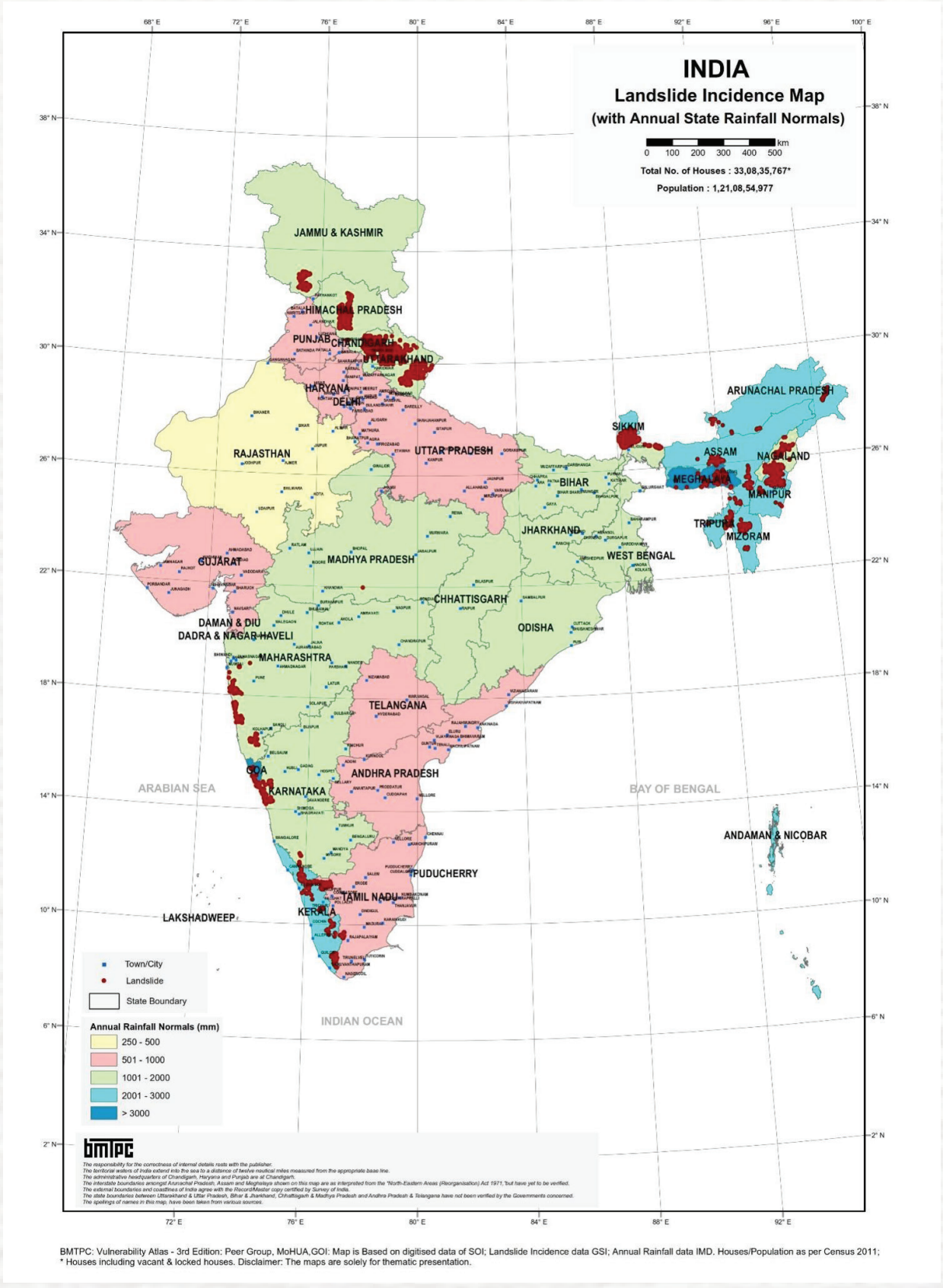
India is prone to landslides due to its diverse topographic and climatic conditions. The hilly and mountainous regions, particularly the Himalayas, are especially vulnerable to landslides

(Fig. 2). The combination of steep slopes, loose soil, rock, and intense rainfall makes them susceptible to landslides. Landslides cause significant damage to life and property and disrupt transportation and communication networks. They also result in soil erosion and degradation, which can lead to long-term environmental impacts. The vulnerable populations in landslide-prone areas are often rural and marginalized communities that rely on agriculture and natural resources for their livelihoods. In addition to natural factors, human activities such as deforestation, construction of roads and other infrastructure, and unscientific land use practices also contribute to the vulnerability of these regions to landslides. Climate change, causing more frequent and intense rainfall patterns, also increases India's landslide risk. India has implemented several measures to mitigate the risk of landslides, including developing early warning systems, risk assessment and management, and landslide-resistant construction techniques. However, more must be done to ensure the safety and resilience of communities in landslide-prone areas, including better land-use planning and education and awareness programs.

Over the years, several major landslides have occurred in India, causing significant social and economic impacts.

Some of the major landslides with a high social and economic impact in India include:

- ***Kedarnath disaster of 2013:*** This landslide occurred in Uttarakhand, causing widespread destruction and loss of life. The disaster resulted from heavy rainfall, which triggered several landslides and flash floods, leading to devastating impacts The economic impact of the disaster was estimated to be in the billions of dollars, and the social impact was massive, with thousands of people losing their homes, livelihoods, and loved ones.
- ***Kotropi landslide of 2017*:** The Kotropi landslide in Himachal Pradesh, India, occurred on August 13, 2017. The landslide occurred in the Mandi district and was triggered by heavy rainfall in the region. It resulted in the loss of at least 31 lives, and several others went missing.
- ***Munnar landslide of 2018*:** This landslide occurred in Kerala, causing widespread destruction and loss of life. The disaster resulted from heavy rainfall, which triggered several landslides, buried several villages, and destroyed property.
- ***Ratnagiri landslide of 2019*:** This landslide occurred in Maharashtra, causing widespread destruction and loss of life. The disaster resulted from heavy rainfall, which triggered several landslides, buried several villages, and destroyed property. The economic impact of the disaster was estimated to be in the millions of dollars, and the social impact was massive, with thousands of people losing their homes and livelihoods.



BMTPC: Vulnerability Atlas - 3rd Edition: Peer Group, MoHUA,GOI: Map is Based on digitised data of SOI; Landslide Incidence data GSI; Annual Rainfall data IMD. Houses/Population as per Census 2011;
* Houses including vacant & locked houses. Disclaimer: The maps are solely for thematic presentation.

Fig. 3: Landslide Incidence Map

Source: Vulnerability Atlas 3rd edition (BMTPC 2019)

Flood Vulnerability

India is highly vulnerable to floods due to its diverse geography and meteorology. The country experiences monsoon floods, flash floods, and riverine floods, each having different underlying causes and consequences. Monsoon floods result from heavy rainfall during the monsoon season and affect the low-lying areas along the coast and the floodplains of major rivers (Fig. 4). Flash floods are caused by intense rainfall over a short duration, leading to rapid runoff, and they can occur anywhere, but are common in hilly areas where the water cannot drain away quickly. Riverine floods occur when rivers overflow their banks and are often caused by heavy rainfall, melting snow, and high tides. Several factors, such as deforestation, urbanization, and climate change, exacerbate India's flood vulnerability. Deforestation reduces the capacity of the land to retain water, increasing runoff and the risk of flash floods. Urbanization has led to the concrete jungles replacing the green cover, leading to more runoff and decreased absorption of rainfall. Climate change is causing more frequent and intense extreme weather events, increasing the risk of floods. In terms of social and economic impact, floods can have devastating consequences. They can cause loss of life, property, and infrastructure damage, and people displacement. Floods also disrupt essential services such as electricity and communication, leading to economic losses. They also hurt agriculture, as crops are destroyed and livestock is lost. The impact of floods is particularly severe for the poor and marginalized communities, who often lack the resources to cope with the consequences.

Here are some of the devastating flood events that have occurred in India in the last two decades:

- ✓ ***Mumbai Floods, 2005:*** In 2005, Mumbai, the financial capital of India, was hit by heavy monsoon rains that resulted in severe floods causing over 1,000 deaths, and disrupting the city's infrastructure.
- ✓ ***Kerala Floods, 2018:*** Heavy monsoon rains caused widespread floods and landslides in the southern state of Kerala, causing over 400 deaths and affecting over a million people.
- ✓ ***Assam Floods, 2019:*** The state of Assam was affected by severe floods, causing widespread damage to property and crops and affecting over 5 million people.
- ✓ ***Chennai Floods, 2015:*** Chennai, the capital of the southern state of Tamil Nadu, was affected by heavy monsoon rains and subsequent floods, causing widespread damage and displacement of people.

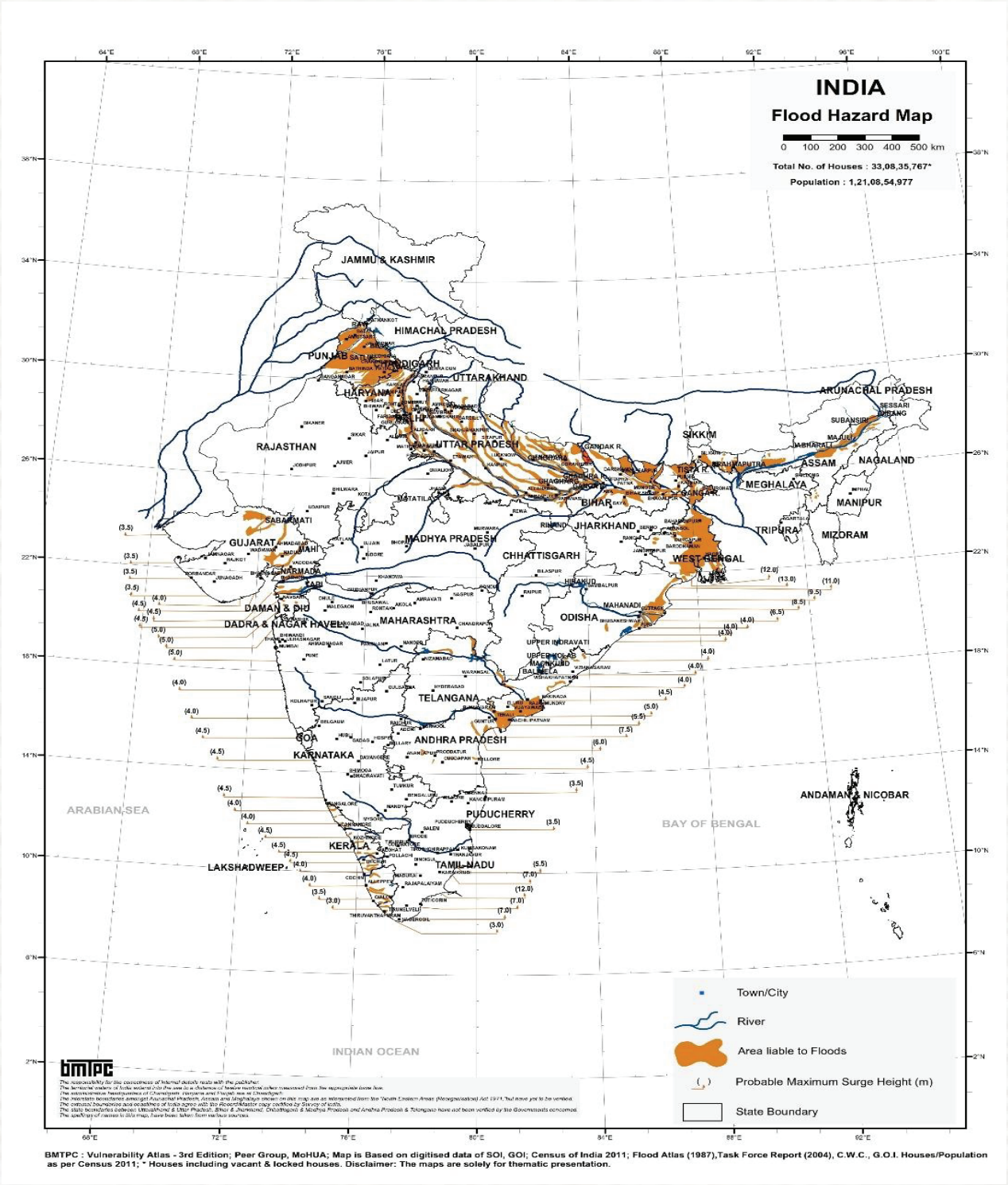


Fig. 4: Flood Hazard Map

Source: Vulnerability Atlas 3rd edition (BMTPC 2019)

Earthquake Vulnerability

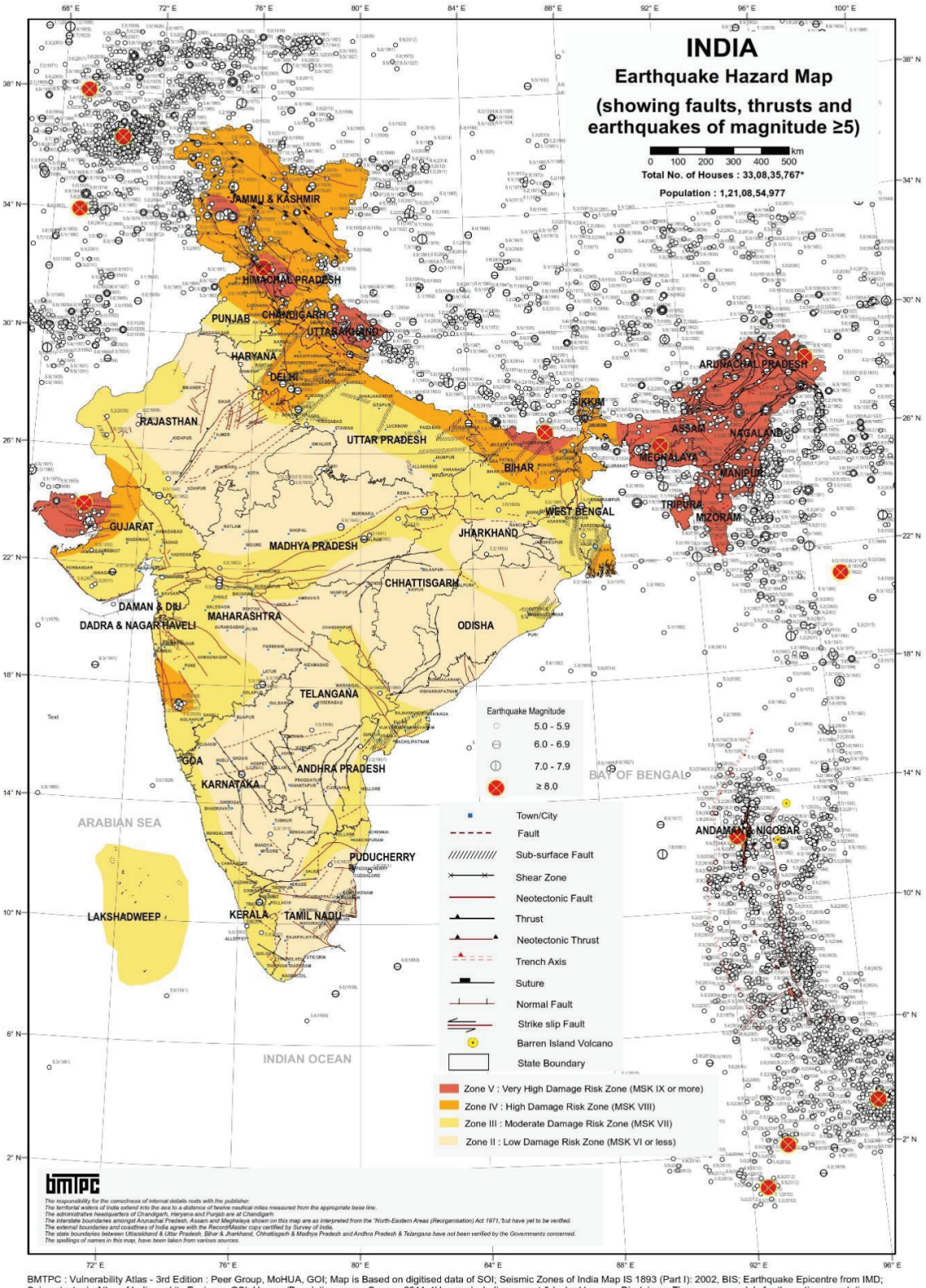
India lies in a seismically active region, making it a highly vulnerable country to earthquakes. The northern and north-eastern parts of the country are particularly prone to earthquakes

due to major fault lines in these regions. Over the past two decades, India has witnessed several devastating earthquakes, causing significant loss of life, property, and infrastructure. The 2001 Bhuj earthquake in Gujarat, the 2005 Kashmir earthquake, and the 2015 Nepal earthquake are some of the major earthquakes that significantly impacted India. The vulnerability of India to earthquakes can be attributed to several factors, including its geological and tectonic setting, lack of preparedness, and inadequate infrastructure, and rapid population growth and urbanization. The country has a high population density in urban areas, increasing the risk of damage and casualties in an earthquake.

Additionally, widespread poverty and lack of access to basic facilities such as healthcare, housing, and sanitation in many parts of the country make people highly vulnerable to earthquake impacts. To mitigate the country's earthquake vulnerability, the government must implement appropriate disaster management policies, strengthen building codes and standards, and invest in earthquake-resistant infrastructure. Additionally, awareness campaigns and training programs for communities and individuals must equip people with the knowledge and skills required to prepare and respond to earthquakes.

Table 1: Some of the major earthquake events that have occurred in India in the past few decades

Year	Earthquake	Location	Magnitude
2000	Arunachal Pradesh earthquake	Arunachal Pradesh	6.7
2001	Bhuj earthquake	Gujarat	7.7
2005	Kashmir earthquake	Jammu and Kashmir	7.6
2015	Nepal earthquake	Nepal-India border	7.8
2016	Imphal earthquake	Manipur	6.7



BMTPC : Vulnerability Atlas - 3rd Edition : Peer Group, MoHUA, GOI; Map is Based on digitised data of SOI; Seismic Zones of India Map IS 1893 (Part I): 2002, BIS; Earthquake Epicentre from IMD; Seismotectonic Atlas of India and its Environs, GSI; Houses/Population as per Census 2011; *Houses including vacant & locked houses. Disclaimer: The maps are solely for thematic presentation.

Fig. 5: Earthquake Hazard Map

Source: Vulnerability Atlas 3rd edition (BMTPC 2019)

Educational vulnerability refers to the susceptibility of individuals, households, and communities to the negative impacts of natural or anthropogenic disasters due to their level of education. Let's explore this concept further:

1. **Understanding Vulnerability:**
   - Exposure refers to the population and economic resources being in potentially dangerous settings, while vulnerability encompasses the susceptibility, sensitivity, and capacities of exposed elements to cope with and adapt to hazard events.
   - Vulnerability is influenced by various factors, including education. Educated individuals and societies tend to be better prepared, respond more effectively, and recover faster from disasters.
2. **Role of Education in Reducing Vulnerability:**
   - **Risk Perception and Knowledge:** Education directly influences risk perception, skills, and knowledge. Educated individuals are more aware of potential hazards and can take informed actions to mitigate risks.
   - **Indirect Effects:** Education also indirectly reduces vulnerability by improving health, reducing poverty, and promoting access to information and resources.
   - **Empowerment and Adaptive Capacity:** Educated people are assumed to be more empowered and adaptive in their response to, preparation for, and recovery from disasters.
   - **Positive Impact:** Research consistently shows that formal education has a positive impact on vulnerability reduction. Highly educated individuals and societies exhibit better disaster preparedness and response, suffer fewer negative impacts, and recover more quickly.
3. **Natural and Anthropogenic Disasters:**
   - **Natural Disasters:** These include events like earthquakes, floods, hurricanes, and droughts. Education plays a crucial role in minimizing vulnerability by enhancing preparedness and adaptive capacity.
   - **Anthropogenic Disasters:** These result from human activities, such as industrial accidents, pollution, and conflicts. Education helps communities understand and address these risks, leading to better resilience.
4. **Challenges and Solutions:**
   - **Challenges:** Disruptions to education during disasters can exacerbate vulnerability. For example, schools may be damaged, and children's education may be interrupted.

- **Solutions:** Ensuring continuity of education during and after disasters is essential. This involves disaster-resistant school infrastructure, emergency education programs, and community awareness.

2.4. Risk

While risks are integral to human existence, their acceptance and perception can vary among individuals and across regions, societies, and cultures. Risk has no universal definition, as it combines vulnerability and hazards that can result in expected damage or loss. People are at risk when they cannot manage a hazard, and a disaster occurs when a considerable number of vulnerable people encounter the hazard and experience severe damage or disruption to their means of livelihood, necessitating external aid for recovery. The likelihood of a disaster is referred to as disaster risk, and it is determined by the degree of the hazard, vulnerability, and capacity. The potential losses, including fatalities, injuries, property destruction, economic upheaval, and environmental degradation, represent the risk.

Disaster Risk = Hazard X Vulnerability / Capacity

The correlation between these four components emphasizes the equal significance of the three variables defining risk: hazard, capacity, and vulnerability. Either reducing the hazard or vulnerability or increasing the capacity of community can decrease the community's risk towards a disaster. Changing the hazard component is difficult in practice, so only the vulnerability and risk can be adjusted.

Risk Assessment: The correlation between these four components emphasizes the equal significance of the three variables defining risk: hazard, capacity, and vulnerability. Either reducing the hazard or vulnerability or increasing the capacity of the community can decrease the community's risk towards a disaster.

Risk Identification: This comprises activities such as collecting and mapping hazard data to ascertain any hazard event's frequency, magnitude, and location, evaluating the vulnerability of populations and exposed assets, and assessing the risk to determine the probability of anticipated losses.

Risk reduction and mitigation are strategies to reduce the impact of potential risks and hazards. They are an important part of risk management and are often used in business, finance, and other fields to minimize losses and protect assets. Risk reduction involves reducing the likelihood of a risk, such as implementing safety procedures or upgrading equipment. This can be achieved through measures such as implementing safety protocols, improving security measures, diversifying investments, conducting regular maintenance, providing training and education, or strengthening infrastructure.

Both risk reduction and mitigation are important components of a comprehensive risk management strategy. By taking a proactive approach to risk, organizations can minimize the impact of potential risks and protect their assets. Disaster risk reduction and mitigation efforts in India are implemented through a combination of policies, legislation, and programs at the national and local levels.

- **National Disaster Management Authority (NDMA):** The NDMA is the main body responsible for disaster management in India. It is responsible for developing policies, plans, and guidelines for disaster management and coordinating the efforts of various government agencies and non-government organizations in disaster risk reduction and mitigation.
- **Disaster Management Act of 2005:** This Act provides the legal framework for disaster management in India, including provisions for the creation of disaster management plans, the setting up of early warning systems, and the coordination of relief and rescue operations.
- **State Disaster Management Authorities (SDMA):** SDMAs are responsible for disaster management at the state level, including risk assessment, evacuation, and relief and rescue operations.
- **Community-based Disaster Risk Management (CBDRM):** CBDRM is a decentralized approach to disaster risk reduction that involves the active participation of communities in risk identification and management. The government and NGOs work together with communities to implement disaster risk reduction measures, such as the construction of cyclone shelters and the development of early warning systems.

Suggested Activities:

1. **Case Study Analysis:**
   - Assign different groups of students to analyze major natural disasters in India, such as the 2004 Indian Ocean Tsunami, the 2013 Uttarakhand floods, or the 2020 Cyclone Amphan.
   - Students will assess the vulnerabilities and risks faced by affected communities, the response measures taken, and lessons learned.
2. **Risk Assessment Project:**
   - Conduct a risk assessment for a specific region in India prone to natural hazards (e.g., Gujarat for earthquakes, Odisha for cyclones, Bihar for floods).
   - Identify key vulnerabilities such as infrastructure weaknesses, population density, socio-economic factors, and environmental issues.

- Propose risk reduction strategies tailored to the selected region.

3. **Community Interviews:**
   - Organize interviews with local community members, especially those from vulnerable areas (urban slums, coastal regions, hilly terrains).
   - Students will gather firsthand accounts of how communities perceive and manage risks and vulnerabilities.
4. **Mapping Vulnerability:**
   - Use GIS tools to create vulnerability maps of different regions in India.
   - Students can map out high-risk areas, critical infrastructure, and demographic data to visualize the spatial distribution of vulnerabilities.
5. **Debate on Policy Measures:**
   - Organize a debate on the effectiveness of current disaster management policies in India.
   - Topics could include the National Disaster Management Act, the role of NDMA (National Disaster Management Authority), or the efficacy of early warning systems.
6. **Research and Presentation:**
   - Research and present on specific risk reduction projects in India, such as the Mumbai Flood Mitigation Project or the Assam Flood Early Warning System.
   - Highlight the successes, challenges, and impact of these projects on reducing vulnerabilities.
7. **Create Awareness Campaigns:**
   - Develop and present public awareness campaigns focusing on reducing vulnerabilities and risks related to specific hazards in India (e.g., earthquake preparedness in Himalayan regions, flood safety in Assam).
   - Use multimedia tools like videos, pamphlets, and social media to design the campaigns.
8. **Field Trip:**
   - If feasible, organize a field trip to a disaster management agency or an NGO working on disaster risk reduction in India.
   - Students can learn about practical approaches to managing vulnerabilities and risks firsthand.

9. Expert Interaction:

- Arrange guest lectures or virtual interactions with experts in disaster management, environmental science, and public policy.
- Students can ask questions and discuss current challenges and innovations in reducing vulnerabilities and risks in India.

10. Deliverables:

- Reports summarizing the findings from case studies and risk assessments.
- **Presentations** on community interviews, mapping projects, and research on risk reduction projects.
- **Simulation Reports** detailing the outcomes and lessons learnt from the disaster simulation exercise.
- **Awareness Campaign Materials** including videos, pamphlets, and social media content.

References:

1. Asian Disaster Preparedness Centre (2000). Training module on Community-Based Disaster Preparedness, Bangkok, Thailand.
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8. Vulnerability Atlas of India (2006). Building Materials & Technology Promotion Council, Ministry of Housing & Poverty Alleviation, Government of India, New Delhi
9. Walia, A. (2009). Community based Disaster Preparedness: Need for a standardized training module, The Australian Journal of Emergency Management, Vol. 23, No. 2.

10. West Bengal Voluntary Health Association (2003). Guide Book: Disaster Preparedness and Response, Kolkata.

Glossary

Disaster Types:

- Cyclones
- Tsunamis
- Earthquakes
- Floods
- Droughts
- Landslides
- Epidemics
- Fires

Vulnerability Concepts:

- Vulnerability
- Physical vulnerability
- Economic vulnerability
- Social vulnerability
- Environmental vulnerability
- Cultural vulnerability
- Risk
- Risk assessment
- Risk reduction
- Mitigation

Vulnerability Factors in India:

- Geological conditions
- Climatic conditions
- Topographical characteristics

- Environmental degradation
- Population growth
- Urbanization
- Industrialization
- Development practices
- Poverty
- Marginalized communities

Specific Vulnerability Examples (India):

- Himalayan region (earthquakes, landslides)
- Alluvial plains (floods)
- Desert region (droughts)
- Coastal zone (cyclones)

Disaster Management in India:

- National Disaster Management Authority (NDMA)
- State Disaster Management Authorities (SDMAs)
- Disaster Management Act of 2005
- Community-Based Disaster Risk Management (CBDRM)

Additional Important Terms:

- Hazard
- Capacity
- Preparedness
- Response
- Recovery
- Resilience

Suggestive Questions:

MCQ questions carry one mark each

1. Which of the following is NOT a significant factor contributing to India's vulnerability to disasters?

a) Unfavourable geological and climatic conditions

b) High literacy rate and educational infrastructure

c) Degradation of the environment

d) Growth in population and unplanned urbanization

2. Which type of vulnerability is BEST illustrated by the following scenario: "A coastal community heavily reliant on fishing experiences a hurricane that destroys most of their boats and fishing equipment?"

a) Physical vulnerability

b) Economic vulnerability

c) Social vulnerability

d) Environmental vulnerability

3. What does the term "cultural vulnerability" refer to in the context of disasters?

a) The susceptibility of historical artefacts and monuments to damage.

b) The risk of losing traditional knowledge and practices after a disaster.

c) The challenges faced by diverse cultural groups in accessing aid.

d) The influence of cultural norms and beliefs on disaster preparedness and response.

4. Which of the following is NOT a primary component of the disaster risk equation?

a) Hazard

b) Vulnerability

c) Capacity

d) Geographic location

5. Which of these actions focuses on mitigating the risk of earthquakes in India?

a) Constructing cyclone shelters in coastal regions.

b) Implementing early warning systems for floods.

c) Enforcing stricter building codes and standards for earthquake resistance.

d) Promoting drought-resistant crops in arid and semi-arid areas.

All short questions carry three marks each

6. What is a disaster?

7. What is a hazard?
8. What is vulnerability?
9. What is a risk?
10. How does hazard lead to disaster?
11. What factors contribute to vulnerability?
12. How is risk assessed?
13. What is the relationship between hazard, vulnerability, and risk?
14. What measures can be taken to reduce risk?
15. What is disaster preparedness?
16. What is the role of the government in disaster management?
17. What is the importance of community involvement in disaster management?
18. What are the different types of disasters?
19. How can the impact of disasters be reduced?

All long questions carry ten marks each

20. How does the impact of a disaster vary with different communities, and what factors determine the vulnerability of a community to a hazard?
21. What are the primary sources of risk and vulnerability in communities affected by natural disasters, and how can these be reduced?
22. What is the relationship between hazard, vulnerability, and risk, and how do these concepts influence disaster management and response efforts?
23. How can the sustainable development goals be incorporated into disaster risk reduction and management efforts, and what role do they play in reducing vulnerability and enhancing resilience?
24. What are the challenges and limitations of current disaster risk reduction and management approaches, and how can these be overcome to enhance the effectiveness of response efforts?
25. What are the best practices for engaging communities in disaster risk reduction and management, and how can community-based approaches be integrated into wider disaster response efforts?

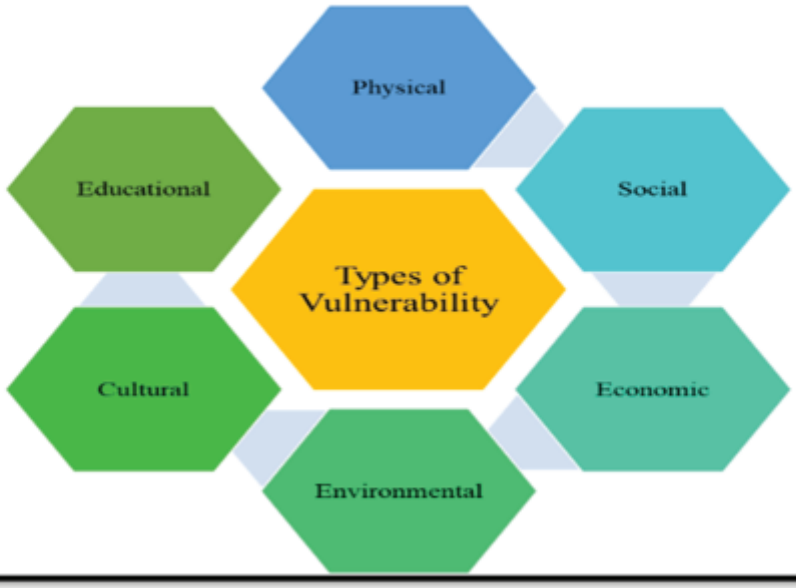
Suggestive PowerPoint slides for reference

Hazards and Disasters: Vulnerability and Risks

Learning outcomes

i. Understanding of natural and human-made disasters, their causes, and impacts on the environment and society.
ii. Approaches for disaster risk assessment, analysis, and evaluation.
iii. Strategies and techniques for disaster risk reduction and mitigation, such as early warning systems, hazard mapping, and structural engineering.
iv. Emergency response planning, including evacuation procedures and the provision of essential services.
v. Reconstruction and recovery processes, including the role of insurance, aid organizations, and government agencies.
vi. International cooperation and coordination in disaster risk management, including the role of the UN and other organizations.
vii. Social and environmental dimensions of disasters, including the impact on vulnerable populations and the protection of cultural heritage.
viii. Effective communication and stakeholder engagement in disaster risk management.

Types of Vulnerability



Understanding the vulnerability and hazard
Preparedness
Improved Response
Risk Reduction
Economic Resilience

Vulnerability
Disaster
Hazard
Risk

Disaster Risk

- ✓ The likelihood of a disaster is referred to as disaster risk, and it is determined by the degree of the hazard, vulnerability, and capacity.

Disaster Risk = Hazard X Vulnerability / Capacity

- ✓ When the hazard and vulnerability are high, it results in a disaster, but having the capacity can mitigate the impact. Hence, to reduce disaster risk, it is essential to concentrate on reducing vulnerability and increasing capacity.

Risk Assessment

Risk assessment represents the initial crucial stage in any concerted endeavor to minimize the probability of disasters and is essential for formulating and executing disaster risk reduction strategies.

Risk Identification

This comprises activities such as the collection and mapping of hazard data to ascertain the frequency, magnitude, and location of any hazard event; evaluating the vulnerability of populations and exposed assets; and assessing the risk to determine the probability of anticipated losses.

Disaster risk reduction and mitigation efforts in India are implemented through a combination of policy, legislation, and programs at the national and local levels.

- ✓ National Disaster Management Authority (NDMA)
- ✓ National Institute of Disaster Management
- ✓ Disaster Management Act of 2005
- ✓ National Cyclone Risk Mitigation Project (NCRMP)
- ✓ State Disaster Management Authorities (SDMA)
- ✓ Community-based Disaster Risk Management (CBDRM)
- ✓ Insurance Schemes

TYPES OF HAZARD AND DISASTERS

CHAPTER - 3

Hazard and disaster type- Human-Induced Hazards and Disasters

Dr. Arunava Ray

Total No. of Hrs - 3

I. Background of the Topic

This chapter discusses the transition from natural disasters (floods, earthquakes) to human-induced disasters. Disasters are defined as events requiring external aid, while hazards are phenomena that may lead to disasters. Human-induced hazards are additional disaster types beyond natural ones. The impact of these disasters varies depending on factors like type, population density, environment, and preparedness.

II. Learning Outcomes

In this chapter you will learn how to:

i. Identify a human-induced disaster and what makes it different from a natural disaster;

ii. Tackle the various challenges associated with human-induced disasters;

iii. Classify human-induced disasters into various classes or types;

iv. Assess the impact of the human-induced disaster and the importance of pre-disaster risk reduction measures

III. Session Methodology:

i. Mode of dealing with the session

- The session should be in an interactive manner with lots of photographs and case studies.

- A multimedia presentation incorporating audio and visual elements can be additionally exhibited.

ii. Pedagogy

- Starting with what is a human-induced disaster, how it is different from a natural disaster.
- Types and classification of human-induced disasters and their management.
- Case studies related to different types of human-induced disasters.
- Lesson learnt

iii. Handouts if any:

- Emphasis on the latest case studies and visual material for demonstration
- Some websites for the latest disaster update: https://ndma.gov.in/; https://www.fema.gov/; https://www.ready.gov/
- Extracurricular activities like assignments on a particular human-induced disaster, its effect, and its management or site visits for hazard and vulnerability identification.

IV. Content on the topic

3.1 Introduction

Human-induced disasters, caused by intentional or accidental human activities, pose threats to public health and welfare (Rahman, 2019). These accidents, excluding war or terrorism, can result in death, property damage, and injury (Harding, 2007). Their unpredictable nature necessitates proper preparation and response (Fig. 1). Human-induced disasters can also significantly impact a country's economy and production capacity (Rose, 2007). This chapter explores the causes and effects of various types of human-induced disasters.

Fig. 1: Various types of human-induced disasters (Source: Edupedia Publications, July 2021)

3.2 Distinction from Natural Disasters

Human-induced disasters result from human error, intent, or neglect, causing system malfunctions, unlike natural disasters, which have natural triggering factors (Pidgeon and O'Leary, 2000). While natural disasters may have easy-to-identify hazards, human-induced disasters tend to have a variety of root causes (Rahman, 2019). Excluding accidents, human-induced disasters like terrorism can emerge slowly over time within a society or system and all be categorized as disasters. The consequences of human-induced disasters are often more severe than natural disasters. For example, nuclear accidents can leave thousands of human casualties, and land degradation, as well as have socio-political consequences (Halkos et al., 2015). Sometimes people and communities are more vulnerable to human-induced disasters than to natural disasters.

3.3 Causes of Human-induced Disasters

The World Health Organization quoted the term "complex humanitarian disaster" after the collapse of the Soviet Union to describe a specific type of human-induced disaster and its consequential events, such as illness or property damage (Brennan and Nandy, 2001). Human-induced disasters occur due to various causes. This can be done intentionally, accidentally, or through improper management of human-made systems (negligence). Accidents and unintentional activities like substandard work or poor maintenance can also contribute to human-induced disasters (Shaluf and Said, 2003). Deliberate acts like riots, sabotage, and mob violence can lead to such disasters as well. Hazards like gas leaks, nuclear

radiation, fires, and explosions often result from failures in industrial and technical processes or systems. A combination of natural and human-induced disasters is also possible, such as the occurrence of an earthquake that can destroy a nuclear power plant (Zibulewsky, 2001).

3.4 Nature of Human-induced Disasters - Basic Facts

Notwithstanding what was said in the previous sections, human-induced disasters have the following characteristics that distinguish them from natural disasters (Bolin, 1985):

- **Predictability is zero in most cases**: Predictions and warnings are often not possible for human-induced disasters. Even though we know the risk, we cannot predict when and where a hazard will become a human-induced disaster.
- **No system is truly fail-safe**: Safety plans are usually inadequate, and practice drills are rare in industrial sites. Timely equipment maintenance improves safety, but attentiveness often declines without accidents.
- **Area of impact**: "Zero Point" and its surroundings will be damaged, as well as other nearby areas due to the adverse effects/transmission caused by wind, water, or travellers.
- **Involvement of human factor**: (a) technical failures and/or (b) system failures or mere accidents all due to human error/negligence.
- In developing countries, **human-induced disasters** increase with unplanned development and vulnerability has increased due to population growth in large cities.
- During disasters, the public is not prepared, and the information and outside help often come too late. There is a **lack of awareness** of serious human-induced hazards in communities.

3.5 Concerns in Human-Induced Disaster Management

Disasters are not unknown, they happen frequently. Authorities responsible for dealing with these disasters have a critical role to play. Every time a disaster strikes; their role receives a mixed response from the affected community. The main concerns related to human-induced disaster management are described below.

i. **Weak Coordination:** Effective management requires coordination among multiple authorities, as no single organization can handle high-impact disasters alone, and poor coordination can hinder rescue and relief efforts.

ii. **Inadequate and/or Irregular Flow of Resources**: Effective disaster response requires sufficient resources like supplies, funds, and trained personnel, which must be strategically

allocated to bridge the gap between demand and availability.

iii. **Frequent Movement of Trained Personnel**: Disaster management success relies on trained personnel, but shortages occur during ground disasters, leading to underutilization of resources and leaving a skilled workforce unused.

iv. **Lack of staff motivation**: Staff in disaster management need motivation to work efficiently, and avoiding disaster-prone areas undermines preparedness for human-induced disasters, highlighting low motivation among officials responsible for civil protection tasks.

v. **Lack of Accountability**: Civil protection personnel, those who are not accountable to disaster victims or the public, face challenges in situations like traffic accidents. Responsibilities such as initial reporting and victim care, handled by various personnel, often lead to delays and accountability issues.

vi. **Golden Hour Concept**: The time between the occurrence of an emergency and its response is referred to as the "Golden Hour". This concept is more suitable for human-induced disasters. If the duration can be shortened, the loss of life and property damage can be minimized.

vii. **Lack of rewards and penalties**: Rescue and relief organizations often lack systems to motivate employees through rewards, potentially contributing to a lack of motivation. Implementing a reward system that acknowledges good performance and penalizes those who fail to perform their duties effectively is recommended.

3.6 Types of Human-induced Disasters

There are several types of human-induced disasters which could be grouped into the following classes (Shaluf, 2007):

i. **Sociological Disasters** include crime, arson, civil unrest, terrorism, and warfare.

Arson is the criminal act of causing harm by starting a fire (Burton et al., 2012). It is also a leading cause of fires, which can be accidental, often due to mechanical failures like kitchen appliance malfunctions.

To describe various forms of interference by law enforcement agencies, use the term civil unrest (Xu et al., 2014). Obstructions, riots, and other crimes are examples. While riots can lead to chaos, fuelled by factors like socioeconomic issues and racism, civil unrest may not always become a disaster.

Terrorism is a term that refers to violence aimed at instilling fear for religious, political, or ideological purposes or violence targeting civilians (Cox, 2008). Warfare involves large-scale conflict using weapons, causing widespread destruction to economies, cultures, and countries.

ii. **Technical Disasters** include industrial hazards, mining hazards, structural collapse, power outages and fire.

Mining and industrial hazards, like bridge collapses, can significantly impact the environment due to human negligence or technical errors. Short-term power outages are manageable, while prolonged power outages disrupt emergency services and cause business losses. Large areas are devastated by fires and wildfires.

iii. **Toxic Disasters** include chemical, biological and nuclear hazards.

Radioactive fallout can irradiate large areas when a nuclear weapon explodes or a containment system fails, making them unsafe for generations (Ohtsuru et al., 2015). Such events are considered weapons of mass destruction (Secombe et al., 2004). Similarly, warfare can cause widespread and long-lasting impacts due to the use of deadly chemicals or biological agents.

iv. **Accidents** that include air, rail, road, and waterways. Accidents affect travellers using any mode of transportation which includes trains, buses, aeroplanes, and ships. Most accidents are the result of human error or the low/neglected maintenance of mechanical systems and subsystems.

3.7 War and Terrorism

The prolonged conflicts between political groups, conducted according to socially accepted practices and customs are referred to as war (Blainey, 1988). It can be termed as interventions, expeditions, revolts, or uprisings based on the context and parties involved. If resistance is strong or lasts long, such conflicts become “Wars”. (Angstrom and Widen, 2014).

An example of war is between Armenia and Azerbaijan over the control of Nagorno-Karabakh. Nagorno-Karabakh Autonomous Oblast, established in 1923 by the Soviet Union, was officially part of the Azerbaijan Soviet Socialist Republic (Krüger, 2010). In 1988, Nagorno-Karabakh’s local council declared its intention to join Armenia, despite being officially in Azerbaijan. The region experienced armed conflict between the two republics, which was controlled under Soviet rule. Nagorno-Karabakh declared independence in 1991, following the dissolution of the Soviet Union. The Azerbaijan-Armenia conflict 1991-1994 resulted in 30,000 casualties and hundreds of thousands of refugees (Fig. 2) (Askerov, 2020). By 1993, Armenia had

seized Nagorno-Karabakh, capturing 20% of Azerbaijan. A ceasefire agreement, the Bishkek Protocol, brokered by Russia in 1994, granted Armenia control over Nagorno-Karabakh and seven surrounding districts. However, Azerbaijan recaptured much of Nagorno-Karabakh, resulting in thousands of deaths and forced migration.

Fig. 2: Shows the extent of damages to physical infrastructure and human suffering in the Nagorno-Karabakh war (Source: International Committee of the Red Cross, Oct 2020).

There has been a long history of Indians dealing with the issues of terrorism since independence. Terrorism involves violence and creates fear, not just among the victims, but among the wider audience as well. The Mumbai terror attacks of 2008 are a famous example of violence and fear in India, involving ten gunmen affiliated with Pakistan-based terrorist organization Lashkar-e-Taiba (Khetan et al., 2009). The attacks targeted various locations in Mumbai, including the Leopold Café, Chhatrapati Shivaji railway station, a theatre, and two hospitals (Fig.3). Most attacks ended within a few hours, but the terror continued at three sites: the Taj Mahal Palace & Tower, the Jewish outreach centre Nariman House, and the Oberoi Trident Hotel. Two gunmen and six hostages were killed at the Nariman House, while hundreds of guests and hotel staff were captured or held hostage at the two hotels. The siege of the Oberoi Trident and Taj Mahal Palace hotels ended on November 28, resulting in over 300 injuries, nine terrorists killed, and one arrested. At least 166 people were killed, including 20 security force personnel and 26 foreigners (Bhandarwar et al., 2012).

Fig. 3: The terrorist attack on Mumbai and the following military operations (Source: Muslim Mirror, Nov 2018)

3.8 Industrial Disasters

Industrial accidents are unavoidable in industrial cities (Heinrich, 1941). They often occur due to malfunctions or technical failures, requiring strong legal regulations. At any stage of production, including extraction, manufacturing, storing, and transporting hazards can arise. Hazardous leaks, such as chemicals or radioactive materials, can cause explosions, fires, and spills. Emissions result from technical errors or natural events and can be sudden or gradual (Hale and Hale, 1972).

On May 7, 2020, LG Polymers in Vishakhapatnam experienced a major styrene vapour release, known as the Vizag Gas Leak. This incident, a result of several incidents, was a result of the long-term storage of styrene in the M6 tank during the COVID lockdown and the plant's startup without proper safety guidelines (Tammineni and Dakuri, 2020). The uncontrolled release of styrene gas, which spread over a three-kilometre radius, was the primary cause of the catastrophe (Fig. 4). Styrene monomer should be kept at temperatures below 20 °C to prevent self-polymerization. Substandard maintenance of the M6 tank and poor refrigeration contributed to the increase in temperature and further release of styrene into the atmosphere. The accident resulted in the deaths of 11 people and 585 hospitalizations, causing loss of livestock and vegetation (Nair et al., 2021).

Fig. 4: Images showing the effects of the Styrene gas leak, Vishakhapatnam. (Source: K V Rao, May 2020)

In another industrial disaster, a massive fire in the port of Beirut on the Mediterranean coast north of Beirut preceded the Beirut chemical explosion that occurred on 4th August 2020 (AlHajj et al. 2021). The explosion occurred due to welding works causing white smoke to come from warehouse number 12. The explosion was triggered by a stockpile of ammonium nitrate in the port warehouse, causing mushroom clouds and a supersonic blast that killed over 200 people and severely damaged nearby infrastructure. The blast destroyed 77,000 homes, injured 7,000 people, and displaced over 300,000 people, including at least 80,000 children (Fig. 5). The explosion caused havoc in Lebanon's capital city, with hospitals struggling to cope with the influx of injured and dying people (Abouzeid et al. 2020).

Fig. 5: The destruction of the Port city of Beirut, Lebanon (Source: The New York Times, Aug 2020)

3.9 Fires

In flammable areas like high-rise buildings, slums, and poorly protected factories, fires are common (Navitas, 2014). In rural areas, wildfires are prevalent during hot summers, often caused by human activity, illegal logging, or carelessness during dry seasons (Toledo et al., 2018). Various types of fires exist, including those in urban settlements, vehicles, industries, coal mines, and forests (Mackie, 1965).

Fires are not only a physicochemical phenomenon but also possess social factors such as fire frequency, damage patterns and assistive technology. A major tragedy occurred in June 1997 when a fire broke out at the Uphaar cinema hall (Bhattacharya and Ahuja, 2003). The Uphaar Cinema Building in New Delhi's Green Park Extension Shopping Centre had a 750-seat cinema hall and a 250-seat balcony. On June 13, 1997, a transformer caught fire, causing holes in the radiator fan and poor contact during operation. The transformer was repaired and power restored, but the transformer continued to spark, causing oil leaks, and a massive stampede and suffocation that killed 59 people (Fig. 6). The building had a chimney area through which gas flows were closed off. During a Blockbuster movie screening, a fire broke out in the basement, causing people to feel suffocated due to smoke and carbon monoxide (Taneja, 2005). The Delhi Fire Brigade attempted a rescue operation, which took about 45 minutes to save the rest of the people. There was no theatre administrative staff to help out, and the incident highlights the need for proper safety measures in cinemas.

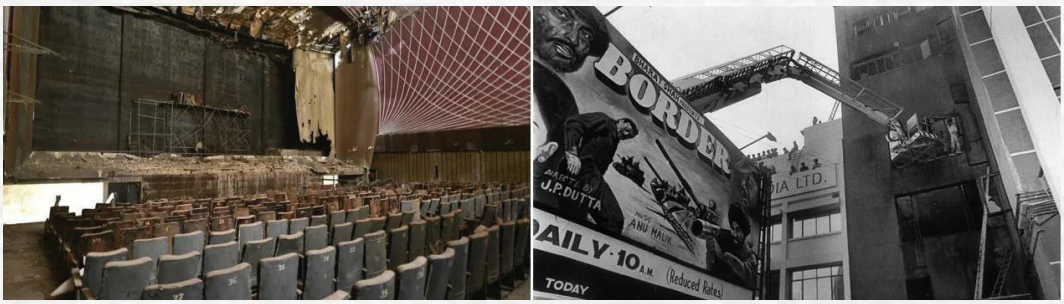


Fig. 6: Uphaar Cinema Hall after the fire incident (Source: The Hindu, Business Line, March 2018)

Another example of a fire accident was at AMRI Hospital, Kolkata. A fire broke out in an outbuilding of the hospital in the early morning hours of December 9, 2011 (Pal and Ghosh, 2014). Around 3:30 am, local residents were the first to notice the fire. Kolkata's Fire Control Room was notified of the incident at 4:10 AM. The fire brigade quickly responded to the scene within 20 minutes. The fire mostly started in the basement of the hospital and was brought under control, but toxic fumes were inhaled through air conditioning ducts through rooms and corridors of this seven-story centrally controlled hospital. Many patients died

from burns, but most died from asphyxiation due to carbon monoxide build-up throughout the building. A thick cloud of smoke filled the entire hospital building. Ninety people were suffocated, many sleeping or unable to escape (Fig. 7). Several people from other countries and states are also on the list of victims, including Bangladeshis, Biharis, Tripuris and two nurses from Kerala (Mukherjee, 2012).

Fig. 7: Fire incident at AMRI Hospital, Kolkata, India (Source: Wirally, Kalyan Bharath, Oct 2022)

3.10 Drowning

Drowning incidents in India are influenced by several factors. Many Indians live near rivers, ponds, and wells, often without adequate safety measures or supervision, especially for children. Monsoon rains exacerbate the situation by causing flooding, which is worsened by poor drainage systems, making communities more vulnerable to drowning. Cultural perceptions in some communities view drowning as inevitable, which hinders the implementation of safety measures and awareness campaigns. Economic constraints also play a significant role, as poverty limits access to safety equipment, swimming lessons, and emergency services, particularly affecting low-income families in high-risk areas. Additionally, inadequate safety regulations contribute to the problem. There is a lack of stringent safety regulations governing the use of public water bodies, and the enforcement of safety measures, such as lifeguards at beaches and swimming pools, is often lacking. This combination of factors leads to higher drowning rates and highlights the need for comprehensive safety measures and awareness campaigns to prevent such tragedies.

World Drowning Prevention Day, observed annually on July 25th, aims to raise awareness and promote action on global drowning prevention[1]. Drowning, defined by WHO as respiratory impairment from submersion or immersion in liquid, has caused over 2.5 million deaths in the past decade, predominantly in low- and middle-income countries. The 2024 theme, "Anyone can drown, no one should," and the slogan, "Seconds can save a life," emphasize the importance of water safety.

Drowning is a significant public safety concern in India, with around 38,000 deaths annually. According to the National Crime Records Bureau (NCRB) report for 2022 (Time period: 1st Jan to 31st Dec 2022), drowning accounted for 9.1% of all accidental deaths, totalling 38,503 fatalities. For the year 2022, Madhya Pradesh reported the highest number of drowning deaths at 5,427, followed by Maharashtra with 4,728 and Uttar Pradesh with 3,007, highlighting the widespread nature of the issue across multiple states. Children aged 1-14 are particularly vulnerable, making drowning a leading cause of death in this age group.

3.11 Accidents

For managing human-induced disasters, effectively addressing accident hazards is important (Singh, 2017). Hindering a fully functional accident-proof system, ineffective early warnings, inadequate rescue equipment, and poor coordination are some of the challenges faced. Rapid responses can be enhanced by streamlining emergency services procedures and utilizing advanced technologies. Improving coordination among multiple relief agencies is crucial. Addressing the shortage of trained personnel and coordinating efforts among various departments is essential, alongside tackling the lack of motivation among staff working under stressful conditions. Some of the disasters occurring in different modes of transportation are discussed here.

i) Road accidents

India faces a significant increase in traffic accidents, accounting for 6% of all global accidents, despite owning only 1% of vehicles. The country's roads are experiencing an 8% increase, with 57% of all accidents in 25 years occurring in 23 large cities (Ruikar, 2013; Pai, 2016). The rise in vehicles blocking roads is leading to a rise in pedestrian and cyclist traffic fatalities. Leading causes include driving negligence, public traffic ignorance, and unfit vehicles.

ii) Rail accidents

Railways in India are crucial for transporting people and goods, but safety is increasingly

[1] https://www.downtoearth.org.in/natural-disasters/drowning-in-disappointment-delhi-coaching-institute-deaths-symbolic-of-all-thats-wrong-with-disaster-preparedness-in-india, Accessed on 11 September, 2024.

important due to factors like heavy rain, cyclones, human error, equipment failures, bridge collapses, landslides, unmanned level crossings, sabotage, and track manipulation (Sheikh et. al., 2008). The weather department alerts agencies and conducts regular foot patrols to monitor vulnerable areas (Nayak et al., 2018). The government and railway police handle bomb threats and dispatch accident relief trains. Accidents often occur at unmanned level crossings due to non-compliance with safety regulations outlined in the Motor Vehicles Act of 1988.

iii) Air accidents

Aircraft accidents often occur during take-off and landing near airports, with safety guidelines issued by the Director General of Civil Aviation (Ashford et. al, 2013). These accidents can occur on the ground, in flight, or during landing, and can include collisions, engine stalls, take-off incidents, and nose-down landings. The Directorate General of Civil Aviation investigates accidents in Indian Territory and waters, while those outside are investigated by the aircraft's registered country or the accident location.

iv) Sea accidents

With the increase in sea traffic along with an increase in the frequency of occurrence of climatological natural hazards like cyclones and floods, the risk of capsizing/sinking has also increased. Vessels near shorelines, ports, high seas, and deep waters are the high-risk areas. The Indian Navy under "Supporting Civil Forces" and "Safety of Life at Sea" manages the search and rescue operations (Gray, 2001). The Civil Aviation Department, the Merchant Marine Department, the Port Authority, the Coastal Guard, the Indian Air Force, the Navy Command, the Police, and Customs are involved in such operations. Significant hazards are posed at ports by oil spill risks from tanker collisions, equipment failures, and transfers.

3.12 Response to Human-Induced Disasters

Human-induced disasters can be greatly minimized by taking the following measures:

- Proper training of personnel working in hazardous industries.
- Appropriate maintenance of security measures.
- Eliminate human intervention in hazardous industries.
- Raise public awareness of first aid measures in the event of an accident.
- Covering your mouth and nose with a damp cloth in the event of a gas leak can minimize health hazards.

- Stay indoors after a radioactive accident.
- Provide adequate medical care to people, possibly throughout their lives.
- Provide appropriate compensation to affected individuals in the form of money and employment.

Due to a lack of prediction or warning, human-induced disasters like fires, ship and traffic accidents, railroad accidents, and plane crashes are unpredictable and hard to plan. Each type of disaster has unique characteristics and they fall into the category of failures to provide warning for disaster preparedness, making it essential to configure responses to each specific situation.

Human-induced disaster response should involve specific mitigation and preparedness measures for specific hazards at the site, as well as a general response. These precautions should be (a) source-specific, such as gas leaks or radioactive releases, and (b) target-specific, such as vulnerable locations or properties. Therefore, both onsite and offsite preparedness plans should be developed, published, and practised to ensure the safety of people and property during such disasters. Most human-induced disasters lack any warning or prediction, and disaster management plans are based on post-disaster scenarios.

3.13 Conclusion

Disasters not only setback progress, but sometimes interrupt the entire flow of life, causing death, injury, and property damage. There is the heterogeneity of human-induced causes, meaning that human-induced disasters can be of many different types, posing a complex problem in response. Such disasters, although localized, are frequent and often very severe. Promoting measures to ensure safety from these threats is a technical and management challenge. The purpose of this introductory unit has been to enumerate human-induced disasters, describe their effects and explain typical recovery requirements after a disaster. A general concern was also raised about how to deal with human-induced disasters.

Points for Group discussion with students

Identify a recent human-induced disaster and try to discuss the following points:

-Where and when did it occur?

-How did it occur or what are the underlying causes of its occurrence?

-Vulnerability of the community at the time of disaster.

-What impact does it have?

-How do the people react and immediately respond?

-Lesson learnt

Suggested Activities (In a group of 3-4 people):

a. Select the busiest traffic junction in your locality and conduct a detailed survey of the traffic junction. Try to find out the causes of road accidents and suggest some remedial measures.

b. Survey your locality and try to find out various vulnerabilities concerning different human-induced hazards and suggest some solutions.

Recent Case Studies:

Already included in the text

Suggested Reading

- Human Factors in Safety Critical Systems by Felix Redmill, Jane Rajan

- Safety and Risk Management by Singh, Shailendra K. & Kundu, Subhash C. & Singh, Shoba

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Glossary

Accident: An undesirable or unfortunate happening that occurs unintentionally and usually results in harm, injury, damage, or loss; casualty; mishap.

Disaster: Disasters are serious disruptions to the functioning of a community that exceed its capacity to cope using its own resources.

Evacuation: The act of moving people from a dangerous place to somewhere safe.

Emergency: An unforeseen combination of circumstances or the resulting state that calls for immediate action.

Golden hour: The first hour after a serious medical event or injury during which treatment is likely to be the most effective.

Hazard: A hazard is any source of potential damage, harm or adverse health effects on something or someone.

Rehabilitation: A set of interventions designed to optimize functioning and reduce disability in individuals with health conditions in interaction with their environment.

Reconstruction: The process of building or creating something again that has been damaged or destroyed.

Stampede: An occasion when many large animals or many people suddenly all move quickly and in an uncontrolled way, usually in the same direction at the same time, especially because of fear.

Suffocation: The act of killing by preventing air from getting to the blood through the lungs or gills.

Vulnerability: Vulnerability is the inability to resist a hazard or to respond when a disaster has occurred.

Wildfire: An unplanned, uncontrolled, and unpredictable fire in an area of combustible vegetation.

Suggestive Questions:

MCQ questions carry one mark each

I. Which of the following is a human-induced disaster?

a. Earthquake b. Industrial Disaster

c. Flood d. Cyclone

II. Toxic disasters include which of the following?

a. Chemical disaster b. Biological disaster

c. Nuclear disaster d. All of the above

III. World Drowning Prevention Day is observed on:

a. 25th July b. 26th February

c. 27th October d. 24th May

IV. The Vizag (Vishakhapatnam) gas tragedy is an example of which kind of disaster?

a. Geotectonic disaster b. Hydrological disaster

c. Chemical disaster d. Biological disaster

V. Sea accidents are not associated with which of the following phenomena?

a. Oil spill b. Underwater earthquake

c. Tsunami d. Heat wave

All short questions carry three marks each (3 marks each)

1. What are the typical characteristics of a human-induced disaster?
2. What makes human-induced disasters different from natural disasters?

3. Explain how fire hazards can be initiated by natural as well as human-induced incidents.
4. What are the major causes of starting a war?
5. Explain the different types of accidents related to different modes of transportation.
6. Explain the 'Golden Hour' rule in case of accidents.
7. Explain the impact of a human-induced disaster by taking an example of any event.
8. Explain with an example how a human-induced disaster can lead to a natural disaster.

All long questions carry ten marks each (10 marks each)

1. What are the main challenges of disaster management concerning human-induced disasters?
2. Explain in detail how various human-induced disasters are classified.
3. Take one case of a human-induced disaster and explain in detail its initiation, effect, and disaster response.
4. Explain in detail how to minimise the technical/industrial disaster by assuming any hazardous conditions.
5. "Road accidents can be effectively managed." Discuss.

Suggestive PowerPoint slides for reference

Hazards and Disasters: Human Induced Hazards

Man Made Disaster

Caused by:

Occur when humans cause them, either accidentally or intentionally.

Affect:

Threaten public health and welfare directly or indirectly. It can also negatively impact the economy and production capacity of a country for a long time

Nature:

Man-made disasters are particularly serious threats because of their unpredictable nature.

Nature of Man-made Disasters - Basic Facts

- **Predictability is zero in most cases:** Predictions and warnings are not possible in most cases of man-made disasters.
- **No system is truly fail-safe.** Monitoring and maintaining equipment in a timely and careful manner can improve safety however it can not be considered fail safe.
- **Area of impact** can range from immediate zero point to far away point.
- **Involvement of human factor:** All man made disaster have some kind of human indulgence is involved.
- **The number and scale of man-made disasters** are increasing due to rapid unplanned developmental activities.
- **Minimum awareness** among people.

Problems Associated with Man-Made Disasters Management

- **Weak Coordination** among various stakeholders.
- **Inadequate and/or Irregular Flow of Resources:** Adequate resources such as supplies, funds and trained personnel may not be available all the time.
- **Frequent Movement of Trained Personnel:** Disaster time demands the availability of trained person for various works like relief and rescue operations. However, with increase in the frequency of disasters, the mobilisation of trained personnel has became a big issue.
- **Lack of staff motivation:** Sometimes officials avoid disaster-prone or disaster-affected areas owing to their safety concerns.
- **Lack of Accountability:** Civil protection personnel are generally not accountable to disaster victims and the general public.
- **Golden Hour Concept:** It is not effectively handled during a disaster resulting in more casualties.
- **Lack of rewards and penalties:** Organizations involved in rescue and relief operations lack systems to motivate employees through rewards.

Types Of Man-made Disasters

- **Sociological Disaster** that includes crime, arson, civil unrest, terrorism and warfare.
- **Technical Disasters** that include industrial hazards, mining hazards, structural collapse, power outages and fire.
- **Toxic Disasters** that include chemical, biological and nuclear hazards.
- **Accidents** that include air, rail, road and waterways.

Sociological Disaster

Arson
The remains of Kyoto Animation Studio 1 after being set ablaze by an arsonist.
(Source: SoraNews24,Casey Baseel, July 2022)

Terrorism
The World Trade Center during the September 11 attacks of 2001 in New York City.
(Source: NepalNews, Ani, Sept 2023)

Civil Unrest
Mass demonstration in Iran, during the Iranian Revolution.
(Source: The three paradoxes of the Islamic revolution in Iran, Abbas Milani, Jan 2009)

The Kyoto Animation Studio Arson attack

Date and Time: July 18, 2019, around 10:30 AM JST.

Location: Kyoto Animation (KyoAni) Studio 1, Fushimi ward, Kyoto, Japan.

Perpetrator: A 41-year-old man named Shinji Aoba.

Method: Aoba entered the building, carrying about 40 liters of gasoline in two containers. He spread the gasoline around the studio's ground floor and ignited it.

Casualties:

Deaths: 36 people, including many talented animators, directors, and staff members.

Injuries: 33 people, some with severe burns and life-threatening injuries.

Survivors: Around 70 people were in the building at the time of the attack, and many managed to escape, although some sustained injuries.

Safety Reforms: The incident prompted discussions about fire safety regulations and emergency preparedness in workplaces across Japan.

Mental Health Awareness: The attack highlighted the importance of mental health awareness and the need to address grievances before they escalate into violence.

Technical Disaster

Fire

The December 9 2011 fire at AMRI Hospital Dhakuria, Kolkata.
(Source: Hindustan Times, Dec 2011)

Industrial Disaster

The Bhopal Gas Tragedy on 2-3rd December 1984.
(Source: DishaNews.com,June 2021)

Structural Collapse

Flyover collapsed in north Kolkata's Girish Park area on 31 March 2016.
(Source: The New York Times, Harikumar and Nida Najar, March 2016)

Flyover Collapsed in North Kolkata's Girish Park

Date and Time: March 31, 2016, around 12:32 PM IST.

Location: Girish Park area, North Kolkata, West Bengal, India.

Event: A portion of the under-construction Vivekananda Road flyover collapsed, crushing pedestrians and vehicles underneath it.

Structure: The flyover had been under construction for several years, and the portion that collapsed spanned a busy road in a densely populated area.

Casualties:

- **Deaths:** At least 27 people lost their lives.
- **Injuries:** Over 80 people were injured, with many requiring hospitalization.
- **Survivors:** Several individuals were trapped under the debris and were rescued by emergency responders and local volunteers.

Property Damage: The collapse caused extensive damage to vehicles and surrounding infrastructure.

Regulatory Changes: The incident led to calls for stricter regulations and oversight in construction projects across India.

Toxic Disasters

Biological Disaster
Gruinard Island, off the coast of Scotland, in the Northwest reaches of the United Kingdom is contaminated with bioweapons.
(Source: The Battlefords Now, July 2018)

Nuclear Disaster
The Chernobyl nuclear power disaster in 1986 Soviet Union.
(Source: Times Travel, Priya Shrivatsav, July 2019)

Chemical Disaster
March 17, 2019 Chemical Fire at Intercontinental Terminals Company (ITC) petrochemical plant in Houston, USA.
(Source: Insurance Journal, Racheal Adams Heard, June 2019)

The Chernobyl Nuclear Power Plant Disaster in 1986, Soviet Union

Date and Time: April 26, 1986, at 1:23 AM local time.

Location: Chernobyl Nuclear Power Plant, near the city of Pripyat in the northern part of the Ukrainian SSR (now Ukraine).

Event: A sudden and unexpected power surge during a reactor systems test led to a series of explosions and a catastrophic meltdown of the reactor core.

Explosion: The explosions blew off the reactor's 1,000-tonne sealing cap and exposed the graphite moderator to air, causing it to ignite and releasing a massive amount of radioactive particles into the atmosphere.

Deaths: Two plant workers died on the night of the explosion; 28 emergency workers and plant operators died from acute radiation syndrome within a few weeks.

Injuries: Dozens of workers and emergency responders suffered from severe radiation sickness.

Radiation Exposure: An estimated 600,000 people were exposed to high levels of radiation, including plant workers, emergency responders, and nearby residents.

Emergency Preparedness and Response

- Comprehensive emergency preparedness plans and rapid response protocols are essential for nuclear facilities.
- Training for plant operators and emergency responders in handling nuclear incidents is vital.

Accident

Rail Accident
Bikaner–Guwahati Express derailed near New Domohani railway station on the 13 January 2022.
(Source: The Economic Times, Aug 2017)

Waterway Accident
The famous RMS Titanic sank in the early morning hours of 15 April 1912 in the North Atlantic Ocean.
(Source: Scientific American, Giles Milton, April 2016)

Air Accident
Malaysia Airlines Flight 370 (MH370/MAS370) disappeared on 8 March 2014 over South China sea.
(Source: Arab News, Siva Govindasamy and Alwyn Scott, March 2014)

Bikaner–Guwahati Rail Accident, 2022

Date and Time: January 13, 2022, around 5:00 PM IST.

Location: Near Domohani in the Jalpaiguri district of West Bengal, India.

Train: Bikaner–Guwahati Express (Train No. 15633), traveling from Bikaner in Rajasthan to Guwahati in Assam.

Derailment: Twelve coaches of the train derailed near Domohani, causing significant damage and casualties.

Immediate Cause: The specific cause of the derailment is still under investigation, but initial reports suggest it may have been due to a sudden track defect or mechanical failure.

Casualties:

Deaths: At least 9 people lost their lives in the accident.

Injuries: More than 45 people were injured, with some in critical condition.

Survivors: Many passengers were rescued from the derailed coaches, and immediate medical assistance was provided.

Property Damage: Several coaches were heavily damaged, and the railway track was significantly affected, disrupting rail services in the area.

Track Maintenance and Safety:

- Regular and thorough inspections of railway tracks are crucial to identify and rectify defects.
- Enhanced maintenance protocols and timely repairs can prevent accidents caused by track defects.

CHAPTER - 4

Hazard and disaster type – Natural Disasters and Water Related

Dr. Sumant Kumar

Total No. of Hours – 2

I. Background of the Topic

Introduction

Every year, disasters take thousands of lives worldwide. Organizations like the United Nations Office for Disaster Risk Reduction (UNDRR), the United Nations Development Programme (UNDP), and the World Meteorological Organization (WMO) are working together to track hazards and the damage they cause more effectively. The UNDRR's job is to get governments, partners, and communities to work together to lessen disaster risks and build a safer, more sustainable planet.

II. Learning Outcomes

a. **Understanding Hazards:** Students will learn to recognize and describe different natural disasters and water-related causes, including natural events and human actions.

b. **Evaluating Effects:** Students will understand how to determine the impact of natural disasters and water-related disasters on nature, society, and the economy, using real situations as examples.

c. **Prevention and Readiness:** Students will discover ways to reduce the damage from water hazards through techniques like building improvements, alert systems, and community safety plans.

III. Session Methodology

a. Mode of dealing with the session

This session is to explain hazards and disasters, it will mix regular lectures with hands-on and group activities for better understanding and to keep students involved. The session may include group talks, debates, role-play, guest speakers, and community projects.

b. Pedagogy

i. **Lectures and Presentations:** Use of multimedia to introduce hazards and disasters, including videos and images for context.

ii. **Case Studies:** Analyse recent disaster-related incidents to understand causes, impacts, and responses. Encourage students to evaluate mitigation and response strategies.

iii. **Group Discussions:** Facilitate small group discussions on managing natural and human-induced hazards and exploring engineering vs. nature-based solutions.

iv. **Simulations:** Perform exercises where students tackle disaster-related issues to apply knowledge practically.

v. **Guest Lectures:** Bring in field experts to offer unique perspectives and enhance student learning.

IV. Content on the topic

4.1 Meaning of Hazards and Disasters

A. Definition

Environmental resources and hazards are closely linked; controlled water acts as a valuable resource, whereas uncontrolled water may cause flooding. Disaster management is a step to investigate the process of how a hazard can be turned into a disaster and also to identify the reason and rectify the same through the mitigation process. The United Nations Office for Disaster Risk Reduction describes a hazard as something that has the potential to cause harm or damage, such as the loss of lives, injury, property damage, or environmental harm. Hazards can be categorized as natural or induced by human processes. However, some of the hazards induced by the human process could be environmental degradation and technological hazards. Similarly, disaster is defined as "A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability, and capacity, leading to one or more of the following: human,

material, economic and environmental losses, and impacts" (Eslamian, 2021). Selected notable disasters throughout history and the number of people killed are shown in Table 1.

B. Natural Disasters and Human-Induced Disasters

Disaster is classified as natural disasters and human-induced disasters. Natural disasters happen due to natural causes such as earthquakes, landslides, volcanic eruptions, blizzards, and wildfires. However, human-induced disasters happen due to human intent, negligence, error, etc. such as civil disorder, human stampedes, shipwrecks, oil spills, terrorism, war, conflict, fire, flood, accidents, and climate change. Although both natural and human-induced disasters affect life and property, their distinction can be identified by classifying them into major groups.

Table 1. Below shows notable disasters and casualties throughout history

Table 1. Selected Notable Disasters Throughout History

Disaster	Year	Number Killed
Mediterranean earthquake (Egypt and Syria)	1201	1,100,000
Shaanxi earthquake (China)	1556	8,30,000
Calcutta typhoon (India)	1737	300,000
Caribbean hurricane (Martinique, St. Eustatius, Barbados)	1780	22,000
Tamboro volcano (Indonesia)	1815	80,000
Influenza epidemic (World)	1917	20,000,000
Yangtze River flood (China)	1931	3,000,000
Famine (Russia)	1932	5,000,000
Bangladesh cyclone (Bangladesh)	1970	300,000
Tangshan earthquake (China)	1976	655,000

Source: St. Louis University 1997: NBC News, 2004

Fig. 1: Categorisation of natural and human-induced disasters

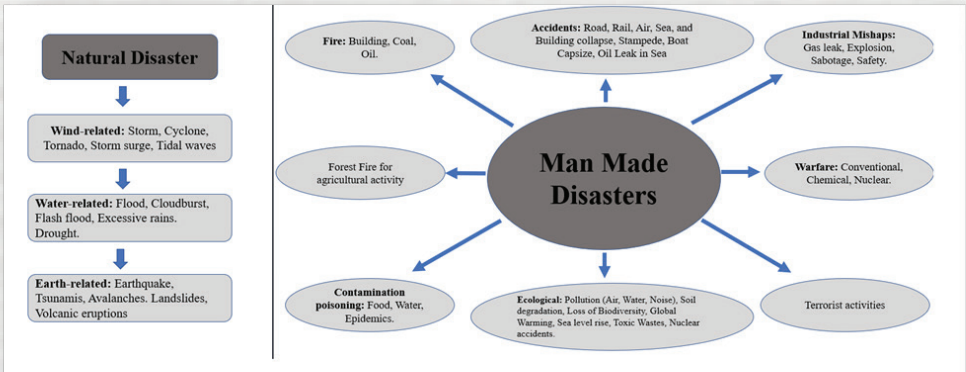

Diagram 1: Natural and Man-Made Disasters

4.2 Types of Natural Disasters

i. Earthquake

Earthquakes occur suddenly and without any prior notice, as noted by the World Health Organization (WHO). It's unexpected trembling of the earth due to the shifting of huge plates beneath the surface along cracks known as faults. The aftermath of an earthquake can result in ground shaking, landslides, and fires. WHO estimates that around 750,000 people died from earthquakes between 1998 and 2017, with over 125 million people impacted. The magnitude of an earthquake can be measured on a scale, with Richter magnitudes being the most common. Seismic moments are a new indicator of earthquake size.

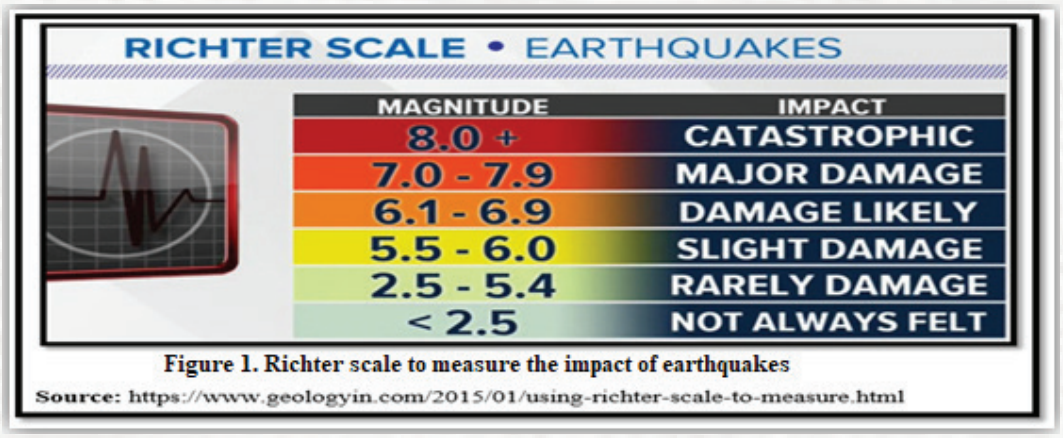

Fig. 2: Richter scale to measure the impact of earthquakes

ii. Volcanic Eruption

The World Health Organization (WHO) defines a volcano as an opening in the Earth's surface that can cause eruptions. Around the world, there are about 1500 volcanoes that could potentially erupt. Volcanic eruptions can spew forth hot and harmful gases, along with ash, lava, and rock. These can seriously harm people and damage property, especially where lots of people live. The Tilt meter device helps to track minute changes in volcanoes' ground slope and shape. The WHO estimated that between 1998 and 2017, volcanic eruptions affected around 6.2 million people and resulted in the deaths of approximately 2400 individuals. In addition to direct impacts, volcanic eruptions can also cause significant damage to property and soil. It can generate clouds of toxic gases and aerosols, potentially leading to the occurrence of wildfires. Moreover, large eruptions can trigger rock avalanches, and if these reach the ocean, they may cause tsunamis. The occurrence of volcanic hazards varies, and their effects can encompass people, property, infrastructure, and economic activity to differing degrees.

Fig 3: Volcanic Eruption.

- Do you know if there are any volcanoes in India and if it is active or not?

Information: The Pacific Rim, known as the 'Ring of Fire', is where most volcanoes erupt. The Ring of Fire is a path along the Pacific Ocean known for active volcanoes and frequent earthquakes. Three out of four volcanoes are along the Ring of Fire.

iii. Heat Wave

Heat waves are the result of extremely hot weather, which generally happens in the summer or may be caused due to humidity or an oceanic climate. A heat wave is when the air temperature rises to a point that can be dangerous for people. It's measured by how hot it gets in a certain area, either by looking at how much hotter than normal it is, or by using the heat index, which considers both heat and humidity. A heat wave is officially announced if temperatures reach at least 40 ℃ in flat areas or 30 ℃ in mountainous areas. The India Meteorological Department (IMD) considers only maximum temperatures (Tmax) for defining heat waves. They define a heat wave as "if the maximum temperature of a station reaches at least 40°C or more for plains, 37°C or more for coastal stations and at least 30°C or more for a hilly region"[1].

iv. Large Fires/Forest Fires

A wildfire is also called a forest, bush, or vegetation fire. Wildfires can happen due to natural reasons and human actions like clearing land for agricultural and mining purposes. It can be described as the "non-prescribed combustion or burning of trees in a natural setting such as a forest, grassland, brush land or tundra, which consumes the natural fuels and spreads based on environmental conditions" (e.g., wind, topography). Wildfire can be incited by human

[1] https://mausam.imd.gov.in/responsive/pdf_viewer_css/met2/Chapter%20-2/Chapter%20-2.pdf, Accessed on September 17, 2024.

actions, such as “land clearing, extreme drought or in rare cases by lightning.” Wildfires can lead to significant destruction as they spread to areas where people live and places of economic importance. There are three types of situations in which wildfire burns: fuel, oxygen, and heat wave sources.

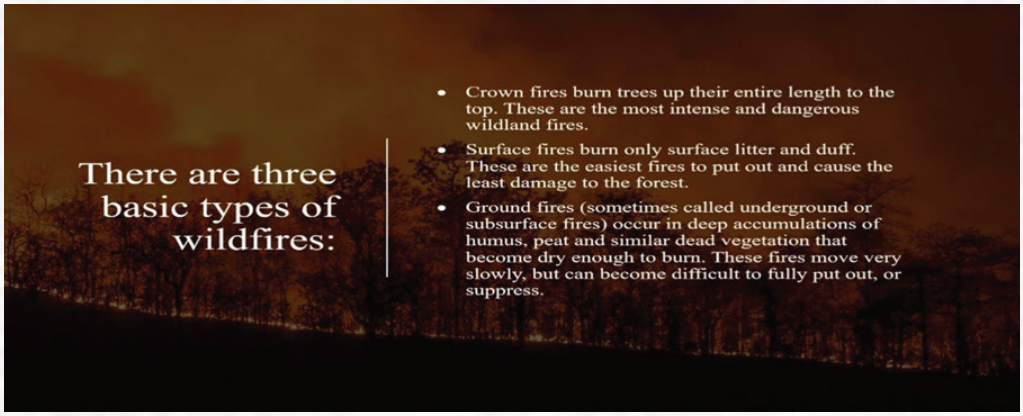

Fig 4: Three basic types of wildfires.

Task for the students

In the last 10 years, forest fires have damaged the forests of the Amazon and California. List down the flora and fauna native to these two regions.

4.3 Types of Water-Related Disasters

Currently, we are facing challenges from water-related disasters such as floods, heavy rains, hurricanes, tsunamis, and droughts that wreak havoc on people’s lives as well as on the economy and the environment. We must understand these water hazards – what causes them, what damage they do– so we can prepare for them better.

i. Flood

Floods are among the most common and destructive natural disasters, amplified by climate change and global warming. Despite advancements in prediction technology and early warnings, widespread relocation during floods is impeded by overpopulation and infrastructure limitations. Efforts such as dam construction help mitigate but not eliminate flood risks. Human factors like rapid urbanization and environmental degradation exacerbate these disasters. Floods can be categorized into three different parts; (i) River Floods (ii) Flash floods (caused due to immediate heavy rain) and (iii) Coastal floods (due to tsunamis, and tidal wave storm surges).

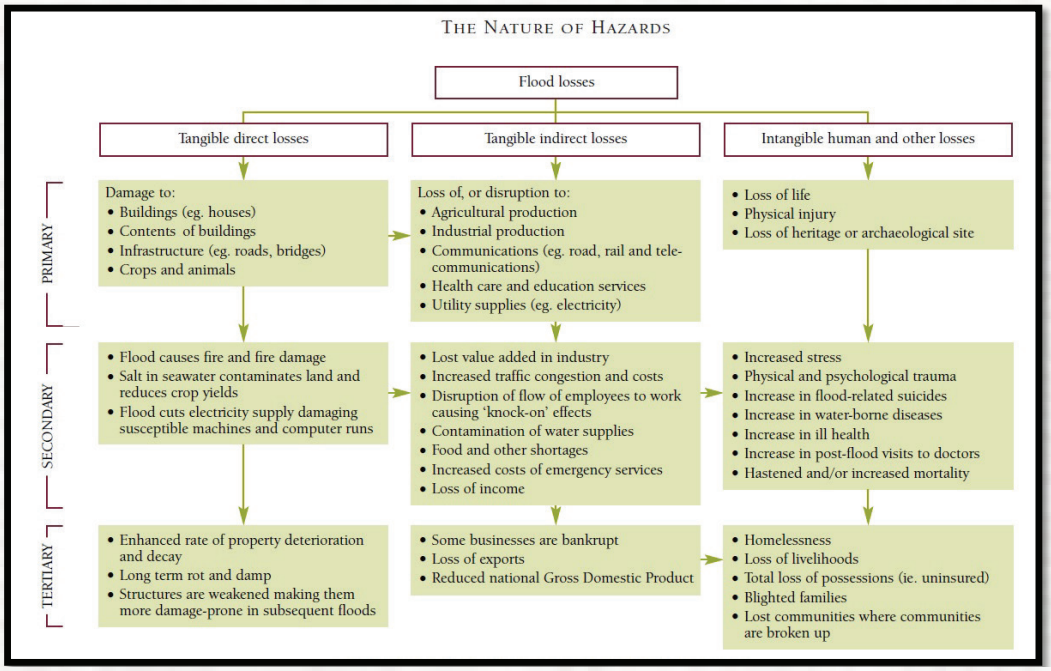

Fig. 5: Adverse impacts of Flood as a Disaster

ii. Tsunami/Hurricanes/Cyclone

Tsunamis, triggered by events like earthquakes and volcanic eruptions, create devastating ocean waves that can quickly overwhelm coastal areas, leading to loss of life and significant damage to habitats and infrastructure. These natural disasters, along with hurricanes in the Atlantic and Pacific Oceans, cyclones over the South Pacific and Indian Oceans, and typhoons in the Northwest Pacific Ocean cause extensive property damage annually. Despite efforts such as quick evacuations, early warning systems, and protective coastal barriers, tsunamis still result in deaths and economic setbacks each year. Education and preparedness training stand out as key strategies in saving lives from these events (Hebenstreit, 2013).

Table 2 shows the scale, pressure, wind speed, and surge of the hurricane.

Scale Number (Category)	Central Pressure (inches)	Winds (mph)	Surge (feet)	Damage
1	>28.04	74-95	04-May	Minimal
2	28.50-28.91	96-110	06-Aug	Moderate
3	27.91-28.47	111-130	09-Dec	Extensive
4	27.17-27.88	131-155	15-18	Extreme
5	<27.17	>155	>18	Catastrophic

Source: Ingleton, Jon (1999). Natural Disaster Management: A Presentation to Commemorate the International Decade for Natural Disaster Reduction (IDNDR) 199-2000. United Kingdom: Tudor Rose

iii. Landslides

Landslides are movements of earth, debris, or rocks that slide down slopes. Various triggers like heavy rains, earthquakes, volcanic activity, and more can destabilize these slopes and lead to landslides. These phenomena are sometimes categorized by geologists - the experts on Earth's physical structures - as a form of mass wasting. Seen as both an environmental and geomorphic phenomenon, landslides happen due to natural changes in the landscape but can also be caused by human activities such as cutting down trees, mining operations, or unlawful construction. For example, when slopes are stripped of vegetation by fire or drought, they become much more susceptible to landslides since the roots of trees, shrubs, and plants that usually hold the soil together are no longer present to provide stability. Erosion from water interaction is another primary geological factor that can cause the ground to weaken and potentially lead to a landslide.

iv. Drought

The World Health Organization defines drought as "a period when an area or region experiences below-normal precipitation. The lack of adequate precipitation, either rain or snow, can cause reduced soil moisture or groundwater, diminished stream flow, crop damage, and a general water shortage." Weather patterns, like differences in rainfall, the average amount of precipitation, and how much water the air lacks, usually determine if there's a drought—basically when rain isn't enough to compensate for water lost to evaporation.

4.4 Glacial Lake Outburst Floods (GLOFs)

Glacial Lake Outburst Floods are sudden releases of water from a glacial lake due to the failure of a dam formed by ice or moraine (accumulated earth and stones deposited by a glacier). These floods can cause significant downstream flooding, posing threats to human life, infrastructure, and the environment. Glacial lakes form when meltwater from glaciers accumulates behind natural barriers made of ice or moraine. These lakes are common in high mountain regions where glaciers are retreating due to climate change. The natural dams holding these lakes are often unstable and susceptible to failure.

Students can find what happened in the 1985 Dig Tsho GLOF in Nepal and 2023 South Lhonak GLOF of Sikkim.

4.5 Climate Change

Climate change describes the gradual shift in weather and temperature patterns over time. These shifts can occur from natural events, like changes in insolation. However, human

activities, especially burning fossil fuels like coal, oil, and gas since the 1800s, have become the dominant factor driving climate change. When we burn these fuels, we emit greenhouse gases into the atmosphere, creating a layer that holds in the sun's heat, which results in rising global temperatures. Climate change has severe effects on the environment such as rising temperatures could increase sea levels, melting glaciers, catastrophic storms, forest fires, declining biodiversity, drought, and floods. By 2050, 216 million people might be affected globally because of climate change, uprooting major populations as early as 2030. In the worst-case scenario, the scarcity of water, food, and land resources brought on by climate change might spark intergroup or inter-communal conflict and even lead to civil war. When mitigating methods increase marginalization and inequality, tensions and social unrest may escalate.

Task for Students

✓ Check how rising sea levels are affecting the populations of Thailand and Maldives.

4.6 Pandemic/Endemic

An epidemic is a disease that spreads quickly through a community, or population or is limited to a geographic area. However, pandemic disease outbreaks and spread quickly through human-to-human infection in several nations or continents. Endemic is specific to a nation or people. Pandemics have several detrimental factors that can cause social, economic, and political disruptions on a large scale. These are typically more prevalent in pandemics caused by new pathogens, with significant rates of hospitalization and/or mortality. For instance, the novel coronavirus pandemic is a perfect example to understand what happened during the COVID-19 pandemic and how it affects life at the global level. The pandemic not only affected all countries but also challenged global health issues. Even after recovering from COVID-19, it affects the human immune system which leads to other diseases. The Centers for Disease Control and Prevention (CDC) describe an epidemic as a sudden increase in disease cases within a certain area. This can include various diseases such as measles, polio, yellow fever, and smallpox, and not all of these need to be contagious. For example, non-communicable diseases like the rising rates of obesity and West Nile fever are also considered epidemics. On the other hand, the World Health Organization (WHO) characterizes a pandemic as a disease that spreads very quickly across countries, with new cases popping up daily. The term 'pandemic' focuses on the wide geographic spread of a virus and not on the type of virus, how immune the population is, or how serious the illness is.

Table 3 shows past pandemics and their effects.

Pandemic	Effects
The Black Death (1346-1353)	The Black Death caused an estimated death of 25 million deaths across the world in the 14th century. According to scientists, the outbreak was caused by a bacterium called *Yersinia pestis*. The Bubonic Plague lasted for about four years.
American Plagues (16th Century)	The American Plagues were caused by a group of Eurasian diseases brought to the Americas by European explorers. Smallpox was one of the main illnesses. The American Plagues contributed to the fall of the Inca and Aztec civilizations, with some estimates suggesting a 90% loss among the indigenous population in the Western Hemisphere.
The Flu Pandemic (1889-1890)	The Industrial Age's new transport networks facilitated influenza's swift U.S. and global spread. First appearing in Russia, the virus quickly engulfed St. Petersburg, pervaded Europe, and circled the globe within months—predating air travel—claiming a million lives.
Spanish Flu (1918-1920)	Another massive disease outbreak was the influenza pandemic, popularly called the Spanish Flu. This viral pandemic began in 1918, mutating during World War I. Over 50 million deaths were recorded during this outbreak, with the disease lasting only two years.
The Asian Flu (1957-1958)	The Asian Flu pandemic, which was a blend of avian flu viruses, began in China and spread worldwide, infecting millions of people. The CDC notes that the rapid pandemic came in two waves, with the first appearing in February 1957, Hong Kong in April 1957, and the coastal cities of the U.S. in the summer of 1957. The total death toll was more than 1.5 million, including 60,000 deaths nationally.
Acquired immunodeficiency syndrome (AIDS) Pandemic	When it was first identified, AIDS had claimed an estimated 36 million lives. Scientists believe that HIV, the virus that causes AIDS, is likely to have evolved from a virus found in chimpanzees that was transferred to humans in West Africa in the 1920s. By the late 20th century, AIDS had made its way around the world. For decades, the disease had no known cure, but medication was developed in the 1990s.

4.7 Hazards and Disasters in India

India is home to both natural and human-induced disasters. On the one hand, the population growth ratio in India is leading the world. India presently has the largest population in the world. Due to poverty, population growth is one of the major challenges for India, as increasing population exerts additional strain on agricultural land, resources, and water. India is facing floods almost every year, in almost all the states. For instance, Bihar, Assam, Madhya Pradesh, Kerala, Gujarat, Maharashtra, Tamil Nadu, Odisha, Andhra Pradesh, Punjab, etc. are facing floods each year. Due to flooding millions of people are not only forced to leave their places

but also face severe problems, such as homelessness, loss of all agriculture, poverty, loss of food, water, sanitation, etc. Apart from floods, drought is another major disaster in India. Down to Earth, a magazine on research on environments in India, in 2019 stated that around 42 percent of India's land area is under drought, which has affected 500 million people. Drought has increased the food crisis and the farmers' suicide rate in India. National Crime Records Bureau (NCRB) data shows that 42,480 farmers and daily wagers committed suicide in 2019. Due to climate change and global warming, heat waves, forest fires, desertification, floods, and drought issues have become frequent in India. Due to climate change, India's coastal states are facing cyclones every year. The Internal Displacement Monitoring Centre (IDMC) report stated that in the year 2020-21, around 2.5 million people were displaced due to the three worst-hit cyclones, Yaas, Tauktae, and Gulab. Several disasters happened in India for which those people themselves are responsible, such as the 1984 Bhopal Gas Disaster, the Vishakhapatnam gas leak (2020), Poverty, Desertification, and Flood due to unorganized development in cities (Chennai, Mumbai, Delhi, Bangalore). Iqair.com in their year 2023 report based on the air quality mentioned that India's 9 cities occupied out of the world's top 10 most polluted cities. In the year 2021, Down to Earth magazine published that around 351 rivers are polluted in India. In terms of air, water, soil, thermal, and sea, pollution is creating long-term hazards and affecting millions of people.

Points for Group discussion with students

- Identify five natural and water-related disasters in any country and find out which one most affected the people (natural or water-related) the people and why.
- Also, suggest five solutions from each on Disaster Risk Reduction

Group Exercise

Identify the reason for the Tsunami in 2004. How many countries were affected, and people died? Explain what you learned from this disaster and identify what Disaster Risk Reduction Steps were not taken in the 2004 Tsunami.

4.8 Case Study: Floods in Kerala

Kerala, a state in southern India, experiences heavy rainfall during the monsoon season which results in devastating floods every year. More than 400 people have died, and lakhs have been relocated to relief camps due to the Kerala flood in 2017. Similar incidents happened in 2018, and floods have become a common issue in every monsoon. In August 2018, Kerala experienced rainfall that was 96 percent more than its average, leading to floods that claimed

the lives of 433 people. The floods also caused economic damages worth Rs. 31,000 crores. If we can see the effect of floods in Kerala happening every year, that can be considered as a hazard and disaster type. The heavy downpours led to overflowing rivers, landslides, and widespread damage to infrastructure and livelihoods. Flood is one type of hazard (natural disaster caused by natural phenomena) that impacts flash floods, overflowing rivers, and landslides, resulting in loss of life, property damage, and disruption of essential services. Almost every year several lives have been affected including agricultural damage and economic loss. Students are advised to opt for any one year between 2017-2022 to take 'Kerala Flood' as a case study and have to find out:

- The reason for the excessive rainfall and subsequent flooding caused by the monsoon season.
- The factors contributing to the hazard: topography, deforestation, and climate change leading to intensified rainfall.
- How it is impacting society and infrastructure, such as the loss of life, displacement of people, damage to houses, infrastructure, and disruption of transportation systems?
- Is there any unplanned development, deforestation, or encroachment in ecologically sensitive areas?
- The state of Kerala how to deal with flooding of low-lying areas, inundation of buildings, and damage to critical infrastructure like roads, bridges, and power supply networks?
- Vulnerability factors such as population density and settlements in flood-prone areas, inadequate awareness, and preparedness.

Suggestive Activities:

Task for Students

- How many people were affected and displaced due to the flood this year?
- What are the major factors behind the drought in India?

Video Link for reference

https://www.youtube.com/@naturaldisastersdocumentar9868

J. Reference

1. Bobrowsky, Peter T. (2013), Encyclopaedia of Natural Hazards, New York: Springer Dordrecht

2. Eslamian, Saeid and Eslamian, Faezeh (2021). Handbook of Disaster Risk Reduction for Resilience: New Frameworks for Building Resilience to Disasters. Germany: Springer International Publishing.

3. Hebenstreit, Gerald T. (2013). Tsunami Research at the End of a Critical Decade Netherlands: Springer Netherlands.

4. Ingleton, Jon (1999). Natural Disaster Management: A Presentation to Commemorate the International Decade for Natural Disaster Reduction (IDNDR), 1990-2000. United Kingdom: Tudor Rose.

5. Sulphey, M. M. (2016). Disaster Management. India: Prentice Hall India Pvt., Limited.

Glossary

- **Cyclone:** A system of winds rotating inwards to an area of low barometric pressure, with an anticlockwise (northern hemisphere) or clockwise (southern hemisphere) circulation; a depression.
- **Earthquake:** A sudden, violent shaking of the ground, typically causing great destruction, as a result of movements within the earth's crust or volcanic action.
- **Flood:** An overflow of a large amount of water beyond its normal limits, especially over what is normally dry land.
- **Storm:** A storm with a violent wind, in particular a tropical cyclone in the Caribbean.
- **Tsunami:** A Long, high sea wave caused by an earthquake or other disturbance
- **Volcanic eruption:** A volcanic eruption is when gas and/or lava are released from a volcano—sometimes explosively.

ABBREVIATIONS

CDC- Centres for Disease Control

GLOFs- Glacial Lake Outburst Floods

IDMC- The Internal Displacement Monitoring Centre

NCRB- National Crime Records Bureau

UN- United Nations

UNDP- United Nations Development Programme

UNDRR- United Nations Office for Disaster Risk Reduction

WHO- World Health Organization

WMO- World Meteorological Organization

Suggestive Questions

MCQ questions carry one mark each

I. Explain which one is not associated with a Geological Disaster?

a. Landslides and Mudflows

b. Earthquakes

c. Dam Failures/Dam Bursts

d. Thunder/Lightning

II. Match the following disasters with their Nodal Ministry?

Disaster	**Concerned Ministry**
a. Air Accidents	1. Ministry of Health
b. Civil Strife	2. Ministry of Environment
c. Chemical Disasters	3. Ministry of Home Affairs
d. Biological Disaster	4. Ministry of Civil Aviation

III. The National Institute of Disaster Management (NIDM) was established on _____ ?

a. January 1, 2005

b. September 11, 2001

c. October 16, 2003

d. November 15, 2004

IV. Which organization declared COVID-19 a global pandemic in March 2020?

a. Centres for Disease Control and Prevention (CDC)

b. World Health Organization (WHO)

c. United Nations (UN)

d. International Red Cross

V. What are the devices used to track minute changes in volcanoes› ground slope and shape?

a. Strain meters

b. Tiltmeter

c. Both a and b

d. None of these

All short questions carry three marks each (short notes)

1. Define Disaster & Hazards and their types.
2. Define types of Water-related Disasters
3. The difference between a Hurricane and a Cyclone

All long questions carry three marks each (essay type, logical analysis, inferring practical situation)

1. What is the difference between Natural and Human-induced Disasters? Elucidate with examples.
2. What are the primary causes of climate change, and how has it become a catalyst for disasters? Additionally, how is climate change impacting society on a broad scale?
3. What are the major steps taken for Disaster Risk Reduction? Explain concerning Flood and Cyclones.

Suggestive PowerPoint slides for reference

Hazards and Disasters Type: Disaster arising out of natural origin and water related

Introduction

Every year hazards and disasters kill thousands of people all over the world. The United Nations Office for Disaster Risk Reduction (UNDRR), United Nations Development Programme (UNDP), and World Meteorological Organization (WMO) collaboratively develop new tracking systems for hazardous events and disaster losses and damages.

The role of UNDRR is to bring all the governments, partners and world communities together to reduce the risk and losses from disasters and to ensure a safe and sustainable world

Learning Outcomes

Understanding Hazards:	• Students will learn to recognize and describe different natural disaster and water related and their causes, including natural events and human actions.
Evaluating Effects:	• Students will understand how to determine the impact of natural disaster and water related disaster on nature, society, and the economy, using real situations as examples.
Prevention and Readiness:	• Students will discover ways to reduce the damage from water hazards through techniques like building improvements, alert systems, and community safety plans.

The United Nations Office for Disaster Risk Reduction (UNDRR) defines

- **Hazard** is something that has the potential to cause harm or damage, such as the loss of lives, injury, property damage, or environmental harm. Hazards can be categorized as natural or induced by the human process. Natural hazards could be geological, hydro-meteorological, and biological. However, some of the hazards induced by the human process could be environmental degradation and technological hazards.
- **Disaster** is defined as "A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability, and capacity, leading to one or more of the following: human, material, economic and environmental losses, and impacts"

UNDRR
UN Office for Disaster Risk Reduction

Natural Disasters and Man-Made Disasters

Disaster is classified as natural disaster and man-made disaster:

- Natural disasters happen with natural causes such as earthquakes, landslides, volcanic eruptions, blizzards, and wildfires.
- However, man-made disasters happen due to human intent, negligence, error, etc. such as civil disorder, human stampedes, shipwrecks, oil spills, terrorism, war, conflict, fire, flood, accidents, and climate change. Although both natural and man-made disasters affect life and property, their distinction can be identified by classifying them into major groups.

Diagram 1: Natural and Man-Made Disasters

Types of Natural Disasters

Earthquake

- World Health Organization (WHO) explains "earthquakes can strike suddenly and without warning. An earthquake is a violent and abrupt shaking of the ground, caused by movement between tectonic plates along a fault line in the earth's crust. Earthquakes can result in ground shaking, soil liquefaction, landslides, fissures, avalanches, fires and tsunamis".

Volcanic Eruption

- a volcano is a vent in the Earth's crust from which eruptions occur. There are about 1500 potentially active volcanoes worldwide. When volcanoes erupt, they can spew hot, dangerous gases, ash, lava and rock that can cause disastrous loss of life and property, especially if it happens in heavily populated areas

Types of Natural Disasters

- **Heat Wave**
  - Heat waves are the result of extremely hot weather, which generally happens in the summer season or may be caused due to humidity or an oceanic climate. Johansen an academic expert on climate changes defined that "a heat wave is a condition of air temperature which becomes fatal to the human body when exposed, based on temperature thresholds over a region in terms of actual temperature or deviation from normal" (Johansen, 2017).
- **Large Fires/Forest Fires**
  - Wildfire is also called a forest, bush, or vegetation fire. Wildfires can happen due to natural reasons and by human actions for clearing land for agricultural and mining purposes. It can be described as the "non-prescribed combustion or burning of trees in a natural setting such as a forest, grassland, brushland or tundra, which consumes the natural fuels and spreads based on environmental conditions (e.g., wind, topography). Wildfire can be incited by human actions, such as land clearing, extreme drought or in rare cases by lightning".

Types of Water-Related Disasters

Flood

- Flood Disasters are one of the world's continuous and most terrible forms of disaster. Due to climate change and global warming, incidents of flooding have become more widespread and destructive over time. Despite several efforts, floods have become a common form of disaster in most countries.
- Floods can be categorized into three different parts;
  - (i) River Floods
  - (ii) Flash floods (caused due to immediate heavy rain) and
  - (iii) Coastal floods (due to tsunamis, tidal wave storm surges)

Tsunami/ Hurricanes/ Cyclone

Tsunamis are

- a series of ocean waves generated by abrupt, large disturbances of the ocean surface such as earthquakes, volcanic eruptions, landslides, slumps, and meteor impacts. These waves can engulf a coastal community within minutes of their birth and cause loss of life, catastrophic destruction to structures and infrastructure, and severe erosion of the shoreline by hours of repeated attack of waves many minutes apart.

Hurricanes defined

- "tropical storms that form over the North Atlantic Ocean and Northeast Pacific.

Cyclones

- are formed over the South Pacific and the Indian Ocean. Typhoons have formed over the Northwest Pacific Ocean

Types of Water-Related Disasters

Landslides-Mudslides

- Landslides are the earth, debris, or rock movement down in a sloped section. There are many factors which cause landslides such as earthquake, volcanic eruptions, excessive rain etc. which make earth slope unstable which can cause landslides. Geologists, experts, and scientists who study the formation of Earth, occasionally referred to landslides as one type of mass wasting. Landslides are also considered an environmental or geomorphic result of dynamic processes associated with landscape evolution. The landslide could also result from natural as well as man-made damages such as deforestation, mining, illegal development, etc.

Drought

- The World Health Organization defines "drought as a period of time when an area or region experiences below-normal precipitation. The lack of adequate precipitation, either rain or snow, can cause reduced soil moisture or groundwater, diminished stream flow, crop damage, and a general water shortage". Meteorological indicators, such as the rainfall anomaly, standardized precipitation index, and accumulated atmospheric water deficits, are principally responsible for defining the drought hazard (precipitation minus evapotranspiration).

Climate Change & Pandemic/Endemic

Climate Change

- Due to global warming, temperature and the patterns of weather changing worldwide, which is referred to as climate change. Climate change can be happened with natural causes as well as manmade causes. Natural processes include oscillation in the solar cycle. Man-made causes include combustion of fossil fuels such as coal, wood, oil and gas etc. Fossil fuel combustion produces greenhouse gas emissions that blanket the planet, trapping heat from the sun and increasing temperatures. Climate change has severe effects on the environment such as rising temperatures could increase sea levels, melting glaciers, catastrophic storms, forest fires, declining biodiversity, drought, and floods.

Pandemic/Endemic

- An epidemic is a disease that spreads quickly through a community, or population or is limited to a geographic area. However, pandemic diseases outbreaks and spread quickly through human-to-human infection in several nations or continents. Endemic is something that is specific to a nation or people. Pandemics have several detrimental factors that can cause social, economic, and political disruptions on a large scale. These are typically more prevalent in pandemics caused by new pathogens, with significant rates of hospitalization and/or mortality.

CHAPTER - 5

Hazard and Disaster Types – Pandemic Management during Pandemic

Dr.A.Lovelin Jerald & Dr. S.Malarvizhi

Total No. of Hours: 3

I. Background of the topic:

Global health is a fundamental concern haunting people all over the world today. Disease outbreaks, epidemics and pandemics are common in communities. The frequent prevalence of a disease depends on various epidemiological factors like the host, agent, environment and geographical location. Most diseases follow a normal pattern in a population.

The emergence of the Coronavirus pandemic marks an unprecedented challenge in modern history, underscoring the critical importance of addressing and managing global health crises. Originating in Wuhan, China, COVID-19 swiftly disseminated worldwide, presenting a formidable challenge to nations striving to contain the rapidly mutating SARS-CoV-2 virus. Variants like Delta and Omicron have heightened concerns due to their heigh transmissibility. [3] The indiscriminate nature of the virus has amplified fear, stress and societal disruption pushing people to an era of remote work, unemployment, and altered social dynamics.[1] This has resulted in a dearth of physical contact with family members, friends and colleagues ushering in a series of challenges associated with adapting to the "new normal" of our current reality. These kinds of unprecedented circumstances necessitate a holistic approach to take care of both our physical and mental well-being while dealing with a crisis like a pandemic. The current pandemic has taught us that it is crucial to rethink the existing approaches and strategies to combat and control the disaster effectively.

The crisis also highlights the need to prevent disasters before they happen by investing in better healthcare systems instead of just reacting after they occur. This change means focusing on improving healthcare services and infrastructure worldwide, with the help and support from organizations like the World Health Organization (WHO). International cooperation and governance are key in making this shift happen smoothly.Top of Form

II. Learning Outcomes:

The students will be able to

i. Define hazards, disaster and pandemic and understand their impact on society.

ii. Comprehend the complexities during a health emergency that demand rapid and inclusive solutions.

iii. Acquaint themselves with disaster risk management principles and learn effective ways to handle and reduce risks during emergencies.

iv. Implement measures to reduce the spread of infectious diseases.

III. Session Methodology:

i. Mode of dealing with the session:

- Chalk and Talk method
- Online teaching
- Blended mode
- Chart Preparation
- Case Study Analysis

ii. Pedagogy

- PowerPoint presentation
- Interactive boards
- Video lectures
- Group Discussions
- Role play
- Training and Drills

IV. Content on the topic

5.1 Introduction

The emergence and spread of the worst epidemics have devastated humans by claiming millions of lives. History shows that diseases have doomed certain civilizations and crippled the once-mighty nations. The bubonic plague, cholera, smallpox, Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV), and Middle East Respiratory Syndrome Coronavirus (MERS-CoV) stand out as among the most ruthless killers in human memory. These formidable diseases continue to pose a threat to humanity.[2] Infectious diseases can spread rapidly, driven by various factors including the infectiousness of the pathogen, human-to-human transmission, and the efficiency of modern transportation methods such as air travel.[4]

Pandemic originates from the Greek word, Pan meaning 'all' and demos meaning 'the people.' The Association for Professionals in Infection Control and Epidemiology (APIC) clearly states the difference between a pandemic, an epidemic and an outbreak. The terms pandemic, epidemic and outbreak indicate how common a condition is at a point in time relative to how common it was at an earlier time '. As per APIC:

An **outbreak** is a sudden rise in the number of disease cases. An attack may occur in a community or geographical area or affect several countries. It may last for a few days or weeks or even several years. Some outbreaks are expected each year, such as influenza.

An **epidemic** occurs when an infectious disease spreads rapidly to too many people. In 2003, the Severe Acute Respiratory Syndrome (SARS) epidemic took the lives of nearly 800 people worldwide.

An **endemic** refers to diseases that persistently occur within a defined geographic area or population group without significant fluctuations in incidence rates over time.

A **pandemic** is a disease outbreak that spreads across countries or continents. It affects more people and takes more lives than an epidemic.

The following are some key features that can be applied to identify pandemic diseases.

a. **Wide Geographic Extension:** Describes diseases that spread over large geographic areas like Human Immunodeficiency Virus, HIV/AIDS, influenza, and the 14th century plague.

b. **Disease Movement**: This term refers to the transmission and spread of diseases among individuals, populations, or geographic regions. It involves the transfer of pathogens from infected individuals to susceptible hosts through various means such as direct

contact, airborne particles, contaminated food or water or vectors like insects or animals. Understanding patterns of disease movement is crucial for controlling outbreaks and implementing effective public health measures.

c. **Novelty**: In pandemic context, this term refers to the emergence of a new and previously unseen infectious agents such as a virus or bacteria that spreads rapidly among populations. This novel pathogen often presents unique challenges as it may not be well understood and there may be limited existing immunity or effective treatments available. For example, the emergence of HIV/AIDS in the early 1980s.

d. **Severity**: This condition refers to the extent of physiological deterioration, organ dysfunction or the overall seriousness and harmfulness of a disease that can be life-threatening. It also considers the disease's impact on individuals, communities, and healthcare systems. Examples include the Black Death and HIV/AIDS, with severity often influencing the probability of death.

e. **High attack rates and explosiveness**: Pandemics due to rapidly escalating rates of attack and explosiveness are defined by their high attack rates and rapid spread as shown by outbreaks like Ebola. However, diseases with widespread but slower transmission are not classified as pandemics.

f. **Minimal population immunity:** Pandemics often feature a lack of population immunity, leading to rapid and widespread infection. For instance, the infection rates surged globally with the emergence of the H7N9 influenza, a new variant for which the population had no prior immunity.

g. **Infectiousness and contagiousness:** Diseases that are transmitted from one person to another person are termed infectious and contagious diseases. These diseases, transmitted between individuals, can occur through direct means (such as the person-to-person spread of the SARS virus) or indirectly (like the H7N9 virus, which spreads through contact with live poultry).

5.2 Role of WHO during the Pandemic:

The WHO introduced pandemic phases in 1999, updating them in 2005 to aid countries in pandemic preparedness and response planning. Phases 1-3 focus on preparedness, encompassing capacity building and response planning, while phases 4-6 underscore the need for response and mitigation actions.

The following are the six pandemic phases developed by WHO:

Phase 1: No infection in humans due to the virus in animals.

Phase 2: Infection in humans due to the animal influenza virus in animals.

Phase 3: Sporadic infection in small clusters of people by animal or human-animal influenza. But this has not caused human-to-human transmission.

Phase 4: Community-level outbreaks due to human-to-human transmission of an animal or human-to-animal influenza virus.

Phase 5: Spread of virus from human to human in at least two countries in one of the WHO regions.

Phase 6: Community-level outbreaks in at least one other country in a different WHO region and is called the pandemic phase.

5.3. CORONAVIRUS (COVID -19)

In December 2019, an unidentified virus emerged from Wuhan, China, sparking an outbreak that swiftly spread to numerous other cities within China before intensifying into a global pandemic. Dubbed Coronavirus disease 2019 (COVID-19) by the World Health Organization (WHO) in February 2020, the virus known as SARS-CoV-2 induces a severe and potentially life-threatening condition.[2]

As this virus spread was declared as a Public Health Emergency of International Concern on January 30, 2020, and later classified as a global pandemic on March 11, 2020, by the WHO, COVID-19 rapidly became a significant global health crisis.

India reported its first COVID-19 case in the Kerala district on January 27, 2020. The disease is believed to be zoonotic, capable of transmission from animals to humans, with person-to-person spread occurring through respiratory droplets produced during coughing and sneezing even in asymptomatic individuals. These droplets can travel short distances and settle on surfaces where the virus can remain viable for days under favourable conditions but is easily inactivated by standard disinfectants like sodium hypochlorite and hydrogen peroxide.

Common symptoms of COVID-19 as outlined by the Centres for Disease Control and Prevention (CDC) include fever, dry cough and fatigue. Though some infected individuals may also experience symptoms such as sore throat, diarrhoea, body aches, loss of taste or smell or skin rashes. In severe cases, the disease can progress to pneumonia, respiratory failure and even death. Fig. 1 shows the microscopic view of the dangerous coronavirus.[3]

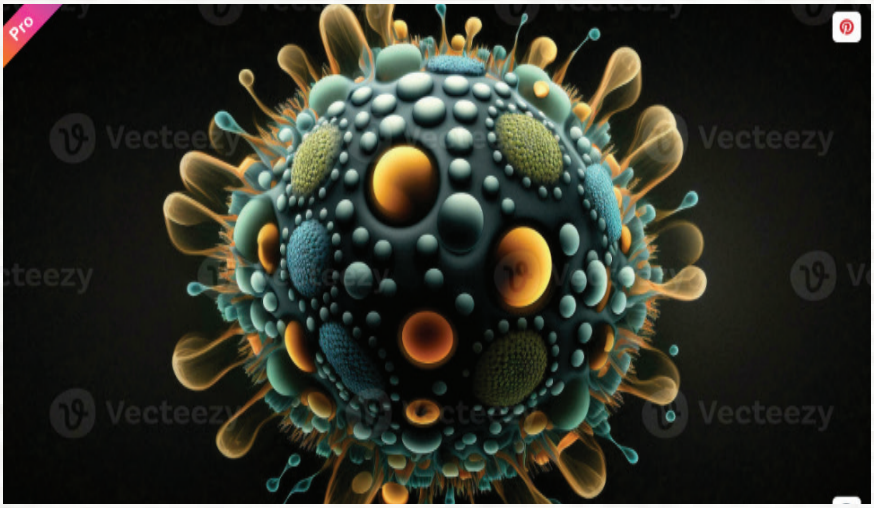

Fig. 1: Microscopic View of the Dangerous Coronavirus
(Source-https://www.vecteezy.com/)

5.4 Impacts of COVID-19

The COVID-19 pandemic has caused a global health crisis, where countless people have lost their lives. In addition to directly impacting COVID-19 patients, the lives of non-infected people and healthcare workers have also been affected dramatically, posing an unprecedented challenge for healthcare systems worldwide and healthcare staff who are the most vulnerable. High healthcare costs, shortage of protective equipment, and insufficient ICU beds and ventilators are weaknesses of patient care.[1,2]The pandemic has affected the entire world, as trade restrictions, confinement measures and border closures have prevented farmers from accessing markets, buying imports and selling their produce that resulted in major crisis in food system. Agricultural workers could not harvest crops which disrupted the domestic and international food supply chains and reduced access to healthy, safe and diverse diets.

The restrictions due to lockdowns have caused a severe reduction in the production of goods in factories, decreased demand, consumption and utilization of products and services. These disruptions in the supply chain have adversely affected the financial markets and the global economy. The outbreak of COVID-19 has threatened the economic stability of nations worldwide. Measures like imposing quarantine, isolation of infected persons, preparation of health facilities and shortage of labour due to illness and mortality have resulted in a decline in tax revenue and increased expenditure. The pandemic has triggered a massive migration of labourers, with many relocating from cities back to rural areas, which has severely affected their economic status.[1] The lockdown during the pandemic had a huge impact on the academic system, from primary to university education. Though efforts were

made to continue education programs online through TV channels and other e-platforms, many students did not benefit as they needed access to digital media. Prolonged screen time causes stress, physical inactivity, eye and neurological problems. [4]

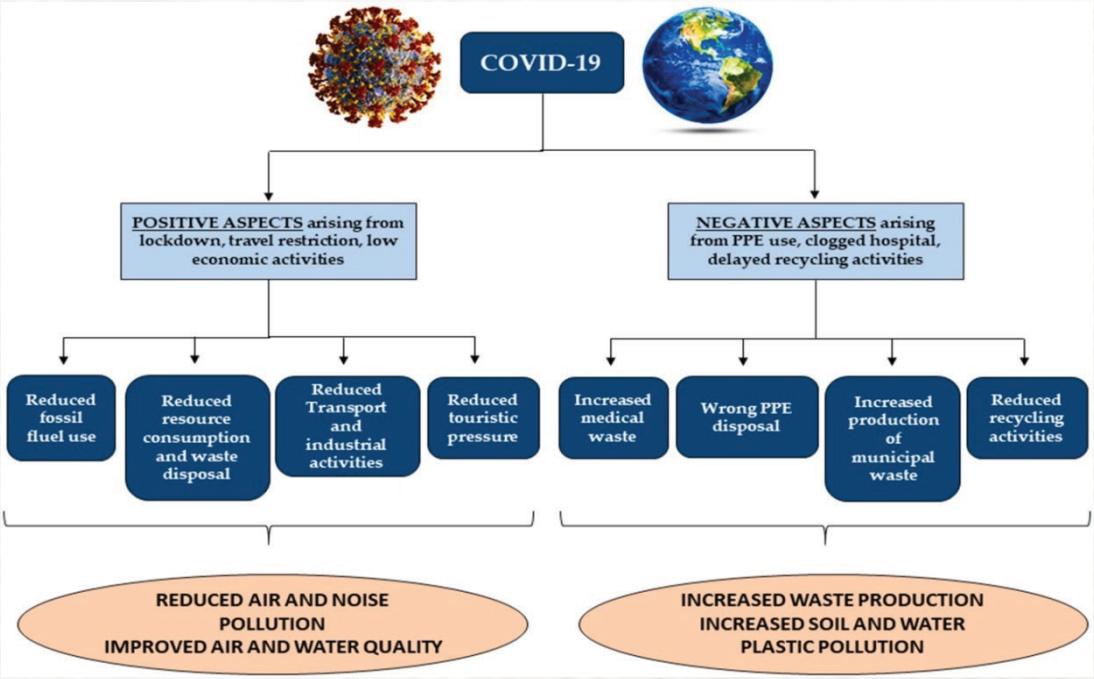

Fig. 2: Environmental Impact of Coronavirus

(Source: Facciola et al., 2021. Link: https://www.sciencedirect.com/science/article/pii/S0013935121009427)

Fig. 2 indicates the impact of the coronavirus on the environment. The absence of social interactions, inadequate housing, stress, limited freedom to move around, and other issues have contributed to increased aggression and behavioural changes among children and teenagers.[2]

5.5 Measures to be taken for Disaster Risk Reduction:

To tackle unforeseen or poorly understood risks, it is essential to blend traditional disaster risk management principles with modern approaches to risk management. Effective risk management focuses on immediate response actions. The real-time needs are crucial as it is equally important to plan for the long-term recovery and rehabilitation of affected communities. This involves not only responding to the immediate health crisis but also considering the broader socio-economic impacts and implementing measures to support individuals in returning to normalcy. Fig. 3 explains the various measures to be taken to combat the risk during a disaster

Rehabilitation efforts include a wide range of activities aimed at restoring essential services, infrastructure, and livelihoods disrupted by the pandemic. This may transform the society by rebuilding healthcare systems, restoring access to education, ensuring food security and providing support for economic recovery. Moreover, efforts should be taken towards addressing the psychosocial impacts of the crisis by providing mental health support and community-based interventions to handle stress, anxiety and trauma among all age groups. (2)

Additionally, reconstruction involves long-term investments in building resilience and preparedness for future crises. This may involve improving healthcare infrastructure, strengthening social safety nets and enhancing disaster response capabilities. By integrating these efforts into disaster risk management plans, communities can withstand and recover from the impacts of pandemics and other disasters.

Overall, a comprehensive approach to risk management in pandemics involves not only addressing immediate needs but also investing in long-term recovery and resilience-building measures to enable affected individuals and communities to return to their everyday lives. Effective management against the pandemic depends on the combined efforts of various stakeholders, including government authorities at both central and state levels, healthcare professionals such as doctors and nurses, as well as individuals from private and public health sectors, civil society and beyond.

Fig. 3: Measures Taken for Disaster Risk Reduction

(Kratochvilova and Rehak, 2015. Link: https://www.researchgate.net/figure/Disaster-risk-reduction-measures-at-the-regional-level-331-Disaster-Risk-Reduction_fig2_297208810)

The global economic meltdown triggered by the COVID-19 pandemic necessitates targeted short and long-term economic strategies from governments to mitigate its adverse effects.

Implementing appropriate monetary, health, and fiscal policies is essential to address the financial challenges stemming from the pandemic. [4]

Initially, disaster management was prioritized on post-disaster recovery and rehabilitation but now the focus is shifted towards disaster risk reduction and mitigation. This shift emphasizes the importance of building resilience, thereby reducing a community's vulnerability to disasters. Achieving resilience involves leveraging research findings from around the world to implement best practices in diagnostic and treatment norms, as well as optimizing resource allocation. Safeguarding against a pandemic such as COVID-19 necessitates drawing lessons from past experiences. Conducting thorough research on the origin and primary drivers of the disaster, its global transmission patterns and the strain it placed on healthcare infrastructure is crucial. Hence this knowledge is instrumental in preparing proactive measures to prevent future disasters, mitigate their devastating effects and enhance the resilience of existing systems.[1,5]

Possible short-term solutions include:

- Monitoring of emerging infectious diseases in both livestock and wild animals.
- Regulating the animal husbandry industry and wet markets.
- Strengthening the core public health services and increasing pandemic preparedness
- Taking measures to ramp up the availability of health interventions.

Long-term solutions lie in the concept of 'One Health', an understanding that human health is linked to all organisms, animals, plants, and the entire biosphere. It is necessary to mobilize a variety of sectors, disciplines and collaborate with communities at various societal levels.

It is essential to manage and establish the risks arising from the pandemic and develop a nationwide digital repository containing comprehensive patient and treatment data, including symptoms, treatment protocols, demographics, test results, and treatment outcomes. Strengthening the nation's IT and digital infrastructure is very significant to support this initiative. The digitization process can be facilitated by engaging community workers, organizations and local healthcare professionals. This will spark the development of fresh, improved ideas that will help deal with the underlying problems and produce long-term viable solutions.

5.6 Group discussion can be focused on the following points

Topic: Closure of educational institutions worldwide as a preventive measure to curb the spread of the COVID-19 virus.

a. Impact of the COVID-19 pandemic on the education system.

   i. During the pandemic, many families faced income loss which led to increased dropout rates in schools.

   ii. Students from low-income families who did not have access to computers, smartphones, internet, etc., faced more difficulties.

   iii. The sudden transition to online learning led to feelings of isolation and disconnection among students and teachers.

b. What is your opinion on online education?

   i. Teachers and students globally started adopting virtual learning methods or technology in education.

   ii. The pandemic helped in accelerating e-learning.

   iii. With increased screen time, there is a loss of social connection and the development of the child is affected.

c. Explore alternate strategies to minimize school closures.

   i. Implementing robust remote learning programs, providing support for vulnerable students.

   ii. Prioritizing the safe reopening of schools with appropriate health and safety measures in place

   iii. Striking a balance between protecting public health and ensuring continued access to quality education is vital in navigating this complex issue.

d. What are the suggestions for the future?

   i. Students should be educated about the preventive and precautionary measures to manage the crisis.

   ii. The existing digital divide and lack of infrastructure should be addressed by the government and educational institutions.

   iii. Teachers and students should be given training to adapt to new teaching methodologies and technologies.

5.7 Case Studies:

5.7.1 Nipah Virus Outbreak in Kerala

On May 2, 2018, a patient admitted to a public health centre in Perambra, Kozhikode district, was later transferred to Kozhikode Government Medical College Hospital due to worsening symptoms and eventually passed away. Subsequently, his brother exhibiting similar symptoms was also confirmed to be affected by the Nipah Virus through testing by the National Institute of Virology, Pune. Tragically, a nurse who treated the initial patient also contracted the virus and succumbed to the illness. Furthermore, ten individuals at Kozhikode Medical College were also infected. This marked the onset of the first Nipah virus outbreak in South India, the third in India's history, following occurrences in 2001 and 2007 in West Bengal. Investigations traced the virus's origin was from the infected fruit bats in Kerala. Nipah virus led to a severe fatal disease characterized by acute encephalitis and respiratory distress syndrome in humans. Human transmission primarily occurred through direct contact with the respiratory secretions or body fluids of infected animals like bats and pigs or through consuming contaminated fruits.

By June 2018, the outbreak had resulted in 17 deaths and 18 confirmed cases. Timely diagnosis and Kerala's robust healthcare infrastructure played pivotal roles in containing further spread. The health minister, secretary, local officials, and volunteers swiftly mobilized and devised a comprehensive containment strategy. They identified and monitored nearly 2000 potential contacts, including family members, neighbours and healthcare professionals. Isolation wards were established and medical staff adhered to strict protective measures. Extensive awareness campaigns via social media, television, village announcements and door-to-door campaigns were undertaken. These rigorous efforts effectively controlled the outbreak by early June 2018. Despite the resurgence of the Nipah virus in 2019 and 2021, Kerala's proactive approach, strengthened by the experience gained from the initial outbreak, facilitated successful containment with only one fatality reported in 2021.[4]

5.7.2 Avian Influenza Outbreak in South East Asia:

H5N1, a strain of the Avian Influenza Virus, posed a significant pandemic risk. It first emerged in birds and humans in Hong Kong in 1997, resurfacing in 2003 and spreading across Asia from Vietnam to Turkey resulting in nearly 100 fatalities. The virus subsequently appeared in bird populations in Africa and Europe. Throughout 2013 and 2014, numerous Asian and European countries reported H5N1 cases often spread by migratory birds. With a human fatality rate of approximately 50%, H5N1 presents a grave threat, which is capable of causing severe illness and death.

Efforts to combat the avian influenza virus vary widely among affected nations. Control

measures include quarantining infected areas, vaccinating or culling exposed poultry and wild birds, restricting poultry trade, testing and monitoring exposed individuals, raising public awareness and providing antiviral medication.

Many countries collaborated closely with neighbouring nations and international health organisations. Thailand and Vietnam initially faced challenges in controlling the outbreak, but through governmental commitment and international support, they managed to contain it. Countries like Japan, Taiwan, and Singapore stockpiled antiviral medications for treatment, while Japan and South Korea successfully controlled outbreaks in bird populations.

5.8 Suggested Activity: Role Play

The participants/students can be assigned roles to simulate the responsibilities of the community to handle a pandemic situation.

- Assign roles such as doctors, public health officials, health care workers, volunteers, community or public, local authorities and non-government organization members.
- Inform to depict the community affected by the pandemic and the preventive measures to tackle the situation.
- Engage in creating awareness through role-play exercises, simulating community meetings, health education sessions, door-to-door outreach, and other interventions, thereby promoting behaviour change among the community.
- Experience sharing on the lessons learnt and ways to improve community health interventions.

5.9 Conclusion:

The devastating impact that emerging pathogens can have on people's lives and livelihoods is exemplified by the coronavirus pandemic. The global response to the pandemic has revealed the underlying weaknesses and disparities in pandemic preparedness and response. To avoid such mistakes in the future, preventive measures should be taken to advance pandemic preparedness. With this objective in mind, governments around the world have suggested a number of programmes to improve pandemic preparedness globally, supported by the World Health Organization.

Preparedness and response to future pandemics should aim at providing equitable access to health care and pandemic preventive tools such as medicines, vaccines, personal protection equipment, etc. for all people. This can be achieved by strengthening the manufacture of

medical health products. To enhance prompt access to life-saving tools the global health community must invest in and accelerate research to develop new therapeutics. The health workforce must be expanded and trained to tackle any global health emergency. Effective surveillance for the detection of pathogens and response systems should be strengthened. The international community should work together to be better prepared and resilient to future pandemics.

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Glossary

Animal husbandry - Science concerned with animals that are reared, bred, and raised for meat, fiber, milk, eggs and other products.

Biosphere – Zone of life on the surface of the earth.

Biodiversity - The Existence of different kinds of life like animals, plants, and microorganisms which together make a good and healthy environment.

Bubonic plague - The Most common form of plague caused by the bacteria *Yersinia pestis.*

Epidemiology – Study of disease in populations and of the factors that determine the presence or absence of diseases.

Health intervention- An item or service undertaken to improve human health by preventing or treating diseases.

Morbidity - Having a disease or a symptom of a disease.

Mortality - Being susceptible to death.

Pathogen - An organism that causes disease to its host

Raw sewage - Waste water produced from residences and commercial, institutional and public facilities.

Shanty town - A settlement where poor people live in temporary houses made of materials like plywood, corrugated metal, plastic sheets, cardboard, etc.

Urbanisation- A Shift of population in large numbers living in relatively smaller areas, forming cities.

Vectors - Living organisms that cause disease to their hosts.

Wet markets – Markets selling fresh produce, fish and meat.

Zoonotic disease - An infectious disease that is transmitted from non-human to humans.

Suggestive Questions:

MCQ questions carry one marks each.

I. Which of the following defines a virus pandemic?

a. A sharp and rapid epidemic involving more than one country.

b. A recurring outbreak

c. A rapid global outbreak starting from a single focus

d. A characteristic of the common cold virus.

II. Which of the following is the most important factor for the spread of the virus and Infection?

a. Travel b. Age

c. Genetic factors d. Sex

III. If a disease spreads from a non-human to a human, it is called

a. an infectious disease b. a zoonotic disease

c. a congenital disease d. a latrogenic disease

IV. Disaster recovery efforts include:

a. Conducting a hazard vulnerability analysis

b. Reconnecting displaced populations with essential health and social services.

c. Training responders to strengthen capabilities

d. Strategies for reducing the impact of disasters

V. Which of the following defines individual resilience?

a. Maintaining the safety of infrastructure.

b. Sustained action taken to eliminate the long-term risk

c. The ability to adapt to changing conditions

d. The capability to equitably meet the vital human needs

All short questions carry three marks each (short notes)

i. What is meant by the term pandemic?

ii. Differentiate between an epidemic and an endemic.

iii. What is meant by disease movement?

iv. List down the six pandemic phases developed by WHO.

v. Write notes on Nipah Virus.

All long questions carry three marks each (essay type, logical analysis, inferring practical situation)

i. Explain the origin and impact of the Coronavirus in India?

ii. Elaborate on the impact of COVID-19 on the community.

iii. Discuss a few key features that can be applied to identify pandemic diseases.

iv. Illustrate the preliminary measures taken to reduce the risk of disaster.

v. Summarize the factors responsible for the Avian Influenza outbreak in South East Asia and the steps taken to eradicate the disease.

Suggestive PowerPoint slides for reference

Hazards and Disaster Type: Pandemic /Management during pandemic

What is Pandemic ?

Pandemic originates from the Greek word, Pan meaning 'all' and demos meaning 'the people.' The Association for Professionals in Infection Control and Epidemiology (APIC) clearly states the difference between a pandemic, an epidemic, endemic and an outbreak.

- An **outbreak** is a sudden rise in the number of disease cases. An attack may occur in a community or geographical area or affect several countries which last for a few days, weeks or even several years. Some outbreaks are expected each year, such as influenza.
- An **epidemic** occurs when an infectious disease spreads rapidly to many people. In 2003, the severe acute respiratory syndrome (SARS) epidemic took the lives of nearly 800 people worldwide.
- An **endemic** refers to diseases which persistently occur within a defined geographic area or population group without significant fluctuations in incidence rates over time.
- A **pandemic** is a disease outbreak that spreads across countries or continents. It affects more people and takes more lives than an epidemic.

Key Features to Identify Pandemic Diseases:

- **Wide Geographic Extension**
- **Disease Movement:**
- **Novelty**
- **Severity**
- **High Attack Rates and Explosiveness**
- **Minimal population immunity**
- **Infectiousness and contagiousness**

Phases of Pandemics by World Health Organisation:

Phase 1: No infection in humans due to the virus in animals.

Phase 2: Infection in humans due to animal influenza virus in animals.

Phase 3: Sporadic infection in small clusters of people by animal or human-animal influenza. But this has not caused human-to-human transmission.

Phase 4: Community-level disease outbreaks due to human-to-human transmission of an animal or human-animal influenza virus

Phase 5: Spread of virus from human to human in at least two countries in one WHO region.

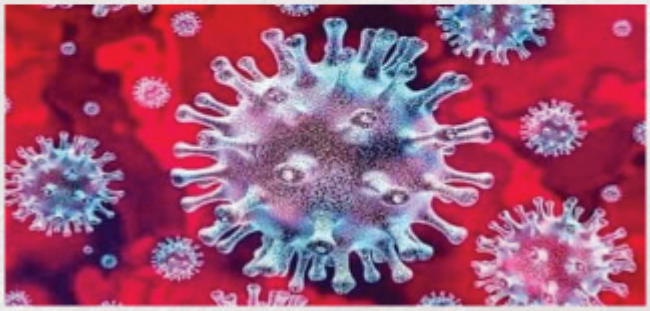
Phase 6: Community-level outbreaks in at least one other country in a different WHO region and is called the pandemic phase.

ORIGIN Of CORONA VIRUS (COVID -19):

The Corona Virus orginated December 2019, a previously unknown virus emerged from Wuhan, China, resulting in an outbreak in many other cities in China, which then expanded globally and reached pandemic proportions. The outbreak was declared a Public Health Emergency of International concern on January 30, 2020, and a global pandemic on March 11, 2020, by WHO.

Variants of COVID-19

- Alpha (α) for B.1.1.7 (U.K. variant)
- Beta (β) for B.1.351 (South Africa)
- Gamma (γ) for P.1 (Brazil)
- Delta (γ) for B.1.617.2 (India)
- Lambda (C.37)
- Omicron XBB variant



Microscopic View of Corona Virus

Measures to be taken for Disaster Risk Reduction:

- **Effective management against the pandemic-** Collective efforts of everybody, including Central and State governments, doctors, nurses and other private and public health workers, civil society etc.,
- **Economic meltdown across the world** - The negative impact of economy on the pandemic can be managed by specific short- and long-term economic plans from the government.
- **Post-disaster recovery and rehabilitation-** which has now shifted to disaster risk reduction and risk mitigation.
- **Protection against a pandemic-** Preparing ourselves to prevent disasters, limit their catastrophic impact and help promote the current system as a better system.
- **Nationwide Digitalization-** Creation and preservation of databases on patient and treatments related information like symptoms, treatment protocols, demography, reports on tests, and responses to treatment.

Short-Term Solutions to Combat Pandemic:

- Monitor emerging infectious diseases in both livestock and wild animals.
- Regulate the animal husbandry industry and wet markets.
- Strengthen the core public health services.
- Increase pandemic preparedness.
- Take measures to ramp up the availability of health interventions.

Long -term solutions to combat Pandemic:

Long-term solutions lie in the concept of 'One Health', an understanding that human health is linked to that of all organisms, animals, plants and the entire biosphere.

- Strengthen the investment in healthcare systems and enhance the capacity for pandemic or any other disaster preparedness and response
- Surveillance network and data systems can be improved to facilitate early detection, monitoring and assessment of pandemic threats
- Promote inclusiveness, interdisciplinary collaborations and cross training to build resilience and adaptability in healthcare systems.
- Encourage public–private partnership in vaccine manufacturing, drug development and healthcare delivery to ensure unbiased access to pandemic counter measure
- International cooperation and governance mechanisms can be enhanced with the assistance of the World Health organisation (WHO) and other global organisations

Conclusion

- The global response to the pandemic has revealed the underlying weaknesses and disparities in pandemic preparedness and response.
- Preventive measures should be taken to advance pandemic preparedness.
- Preparedness and response to future pandemics should aim at providing equitable access to health care and pandemic preventive tools such as medicines, vaccines, personal protection equipment etc,. for everyone.
- Effective surveillance and prompt access to life saving tools for the detection of pathogens and response systems should be strengthened.
- The international community should work together to be better prepared and resilient to future pandemics.

CHAPTER – 6

Hazard and Disaster type- Climate related

Prof. [Dr.] Sanjay Thakur

Total No. of Hours – 3

I. Background of the Topic

Natural disasters and hazards are as old as our civilization is. While thinking of disasters and hazards impressions of volcanic eruptions, earthquake-destroyed houses, tsunami tsunami-devastated coastal villages come to mind. Their occurrence and frequency have caused a significant loss to human life and nature. Their dramatic increase and damage caused by them in recent years have become a matter of concern for every nation to save its ecosystem. Several initiatives have been taken by international agencies like: United Nations (UN), the Kyoto Protocol Summit to reduce carbon emissions and to maintain the balance with nature.

II. Learning Outcomes

By the completion of this chapter, you will be able to understand the:

- Differences between Hazard and Disaster
- Classification of natural hazards/ disasters
- Consequences caused by natural Hazards & Disasters
- Human-induced hazards and disasters

III. Session Methodology

Mode of Dealing with the Session: Field Survey, PowerPoint.

Pedagogy of the Session

i. Students will be divided into groups and assigned specific climate-related hazards, such as hurricanes, droughts, or heat waves.

ii. Each group will analyse their assigned hazard, exploring its causes, characteristics and impacts. Findings & consequences will be discussed with classmates.

iii. Case studies of notable climate-related disasters will be explored to provide real-world examples. Students will examine the environmental & socio- economic consequences of the hazards with measures being undertaken in affected areas.

iv. Interactive discussions and debates will be integrated, encouraging students to critically analyse the causes and consequences of climate-related hazards.

IV. Content on the topic

6.1 Introduction

Hazards are dangerous situations or events that pose a threat to human life. Hazards include events like floods, heat waves, droughts, pandemics, etc. While disasters are abrupt events that completely disrupt human life. They generally cause large-scale damage, widespread deaths, damage to property and disturbance to the ecosystem. Like: Earthquakes, Tsunami, Tornadoes, and Volcanoes. Natural disasters can occur every day at any place in the world. The term disaster is taken from the French word "Disaster," meaning *evil star*. These are undesirable events resulting from forces beyond human control. Disasters can occur as a result of natural consequences or due to human activities: the Bhopal Gas tragedy, Chernobyl nuclear disaster, Russia–Russia-Ukraine War, the COVID-19 pandemic, etc. Disasters may remain confined to a smaller area, occurring within a few seconds like hailstorms, tornadoes and dust storms, or can have global dimensions such as depletion of the ozone layer and global warming. Each disaster is unique in terms of the local environmental and social factors that control it and the consequences it generates. Over the last few years, the frequency, magnitude and intensity caused by natural disasters have increased significantly. There is a growing concern among scientists, people worldwide to deal with the menace created by disasters so that the loss of human life and property can be minimized.

6.2 Natural Hazards

Natural Hazards are the circumstances in the environment that have the potential to harm people and property. These may occur in several forms, viz. currents in oceans, landslides

in the Himalayas. The most common natural disasters in India are cyclones, flash floods, droughts, avalanches, and landslides caused by torrential rainfall. Hazards are generally classified as:

i. **Geotectonic hazards:** Natural processes having their origin in Earth's crust and mantle resulting in convective movements. These movements cause lithospheric plates to come permanently in motion; this motion further builds up mountain ranges and develops oceanic ridges. The hazards like earthquakes, tsunamis, volcanic eruptions and uplifting or subsidence of land come in this category.

ii. **Hydrometeorological hazards:** Hazards having their origin in the Earth's atmosphere. They are responsible for climate variations that create flash floods, storms, droughts and extreme weather.

6.3 Natural disasters and hazards in India

India is a vast and diverse country in terms of its physical and socio-cultural attributes. It is due to its massive geographical area, environmental diversity and cultural pluralities, which encompass a wide range of climates, landscapes, languages, religions, and traditions. There are several consequences of natural disasters or events that threaten life. These disasters are broadly categorized as -

Table 2.1: Worldwide Natural Disasters Since 1948

Year	Location	Type	Deaths
1948	Russia	Earthquakes	110,000
1949	China	Floods	57,000
1954	China	Floods	30,000
1965	East Pakistan (now Bangladesh)	Tropical Cyclones	36,000
1968	Iran	Earthquakes	30,000
1970	Peru	Earthquakes	66,794
1970	East Pakistan (now Bangladesh)	Tropical Cyclones	500,000
1971	India	Tropical Cyclones	30,000
1976	China	Earthquakes	700,000
1990	Iran	Earthquakes	50,000
2004	Indonesia, Sri Lanka, India, etc.	Tsunamis	500,000*
2005	Pakistan, India	Earthquakes	70,000*
2011	Japan	Tsunami	15,842*
2019	Australia	Forest fire	445 (Source: BBC)

Source: United Nations Environmental Programme (UNEP), 1991

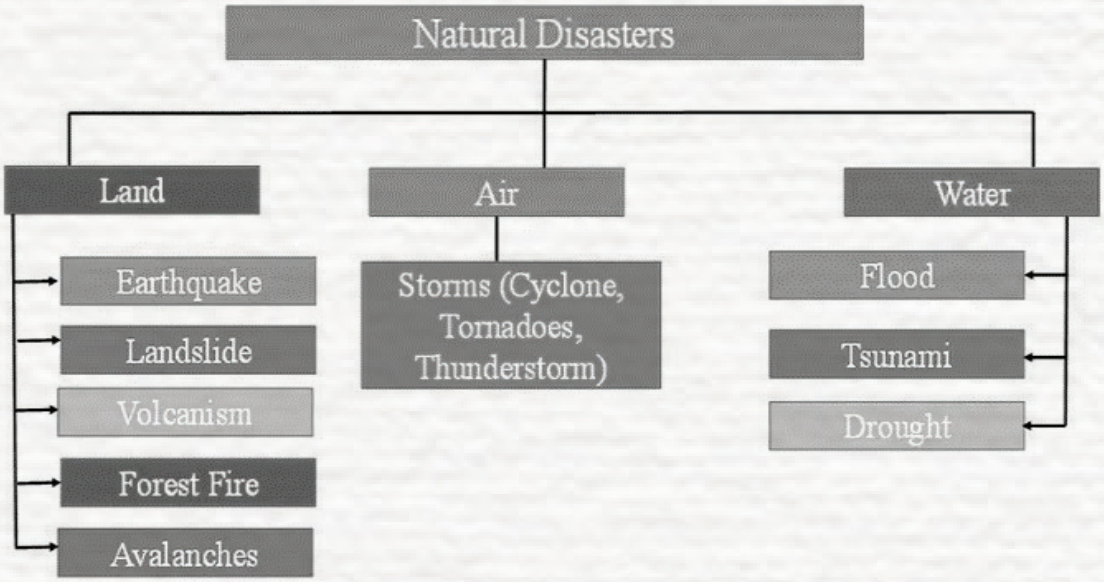


Fig. 1: Natural disasters and their classification

(News Report from National Institute for Disaster Management, GoI, New Delhi)

Disasters can occur on land, air and water. Natural disasters that occur on land are earthquakes, landslides, volcanic eruptions, forest fires and avalanches.

6.3.1 Earthquake

An earthquake is a series of underground shock waves and movements (tectonic activities) on the earth's surface caused by natural processes writhing the earth's crust. Earthquakes are by far the most unpredictable and destructive of all the natural disasters. The probability of an earthquake is high in India, with nearly 60% of the territory being classified as a moderate to severe seismic risk zone. The agencies like: Geological Survey of India, Department of Meteorology, National Geophysical Laboratory and Bureau of Indian Standards (BIS) have grouped India into four seismic zones on the basis of their severity. These zones are described in Table 2.2. below.

Table 2.2: Seismic zone classification

Seismic Zone II:	Area with minor earthquakes corresponding to intensity of V to VI on the MM scale (i.e., MM-Modified Mercalli Intensity scale).
Seismic Zone III:	Moderate damage areas corresponding to intensity VII on the MM scale.
Seismic Zone IV:	Major damage areas corresponding to intensity of VII and higher on the MM scale
Seismic Zone V:	Earthquake zone V is the most susceptible to earthquakes, where some of the country's most powerful shocks have ever occurred. Earthquakes with magnitudes above 7.0 have occurred in these areas. E.g. *China earthquake in Sichuan in 2008.*

Socio-environmental consequences of earthquakes:

The earthquakes are believed to shatter human life. They become a calamity when they strike in areas of high density of population density. Earthquakes not only destroy the settlement, transport, infrastructure, communication networks, industries and other progressive activities but also rob the population. People become homeless and deprived of their property.

6.3.2 Landslides

Landslides generally occur in the hilly regions of India such as the Himalaya, North-East India, the Nilgiris, Eastern Ghats and Western Ghats. In Nilgiris, in 1978 alone, unprecedented rains in the region triggered about one hundred landslides, which caused severe damage to communication lines, tea gardens and other cultivated crops. Landslides have been a major and widely spread natural disaster that affects life and property. It is estimated that economic loss due to landslides may reach between 1-2% of GNP in many countries.

In India, about 0.42 million $km^{2,}$ i.e., 12.6% of land area, excluding snow-covered area, is prone to landslide hazard. Out of this, 0.18 million sq. km falls in North East Himalaya, including Darjeeling and Sikkim; 0.14 million sq. km falls in North West Himalaya (Uttarakhand, Himachal Pradesh and Jammu & Kashmir); 0.09 million sq. km in Western Ghats and Konkan hills (Tamil Nadu, Kerala, Karnataka, Goa and Maharashtra) and 0.01 million km^2 in Eastern Ghats of Andhra Pradesh. The landslide-prone Himalayan terrain falls in the highest earthquake-prone zones (Zone IV and V; BIS 2002) and thus is also prone to earthquake-triggered landslides. The most recent example is the aftermath of the September 18, 2011, Sikkim Earthquake.

The Geological Survey of India, as a Nodal Agency is responsible for: Coordinating and undertaking geological studies for landslide hazard mitigation. The need for an evolving Early Warning System for landslides has long been felt by the agency.

6.3.3 Volcano

A volcano is an opening in the Earth's surface that allows lava, volcanic ash, rocks and gas to escape. Volcanoes occur due to a change in pressure and density of the magma chamber, which can force lower-density lava and rocks to rise, sometimes explosively. More than 75% of the active volcanoes are within the Pacific 'Ring of Fire'. The Ring of Fire stretches along the western coast of America, the eastern coast of Russia, China, and the entirety of Japan, the Philippines and other islands in the Pacific Ocean. *Mount Vesuvius* volcano in Italy had destroyed its cities completely.

Volcanoes are generally classified as being active, dormant or extinct based on their level of activity. Lava and rocks emitted from the volcano pose a serious threat to the surrounding area. Sulphur dioxide a toxic gas poses respiratory hazards to ecosystems in nearby areas. Ash from volcanoes often extends to several kilometres causing air pollution.

6.3.4 Forest Fires

It is a commonly observed phenomenon in pine forests during the summer season. Increasing human intervention is a major cause of the incidents in the forest. As per the Forest Survey of India (FSI), human activities trigger nearly 95 per cent of the forest fires in India. Global warming, solar flares and human intervention are common causes of forest fires. Its impacts include loss of homes, property and critical infrastructure, damage to watersheds and destruction of commercially valuable timber. Besides damaging the forest, the fire adversely affects forest regeneration, microclimate, soil erosion, and the wildlife ecosystem. Recently, many self-help groups and NGOs have played a significant role by training rural people in making products of pine leaves to stop forest fires.

6.3.5 Avalanches

Avalanches occur when snow rapidly flows down a mountain. It is triggered when the ice on a slope breaks loose from its surroundings, and it quickly collects and carries additional ice down the slope.

The various kinds of avalanches include snow avalanches, rock avalanches, ice avalanches, and debris avalanches (which contain a variety of unconsolidated materials, like stones and soil). The occurrence of an avalanche depends on the interaction of mountainous terrain, weather conditions, snowpack conditions, and a trigger. The probability of avalanches may be increased or decreased by terrain features, such as slope shape, slope's exposure to sun and wind and elevation.

Protective Measures: Explosives are used to trigger avalanches on potentially unstable slopes, ski areas and highway corridors so that the avalanches do not occur when people are there. In other areas, particularly near villages and fixed structures, avalanche rakes are used on slopes to hold snow in place, and diversion structures such as dams or wedges are also used at the base of the slope to stop, split or deflect the snow in an avalanche.

6.3.6 Cyclones

The word Cyclone is derived from the Greek word '*Cyclos*' meaning the coils of a snake. It was coined by Henry Paddington because the tropical storms in the Bay of Bengal

and the Arabian Sea appear like coiled serpents of the sea. The initial development of a cyclonic storm depends upon conditions like: A warm sea (temperature exceeding 26^0C to a depth of 60 m) with abundant transfer of water vapour to the overlying atmosphere by evaporation. Atmospheric instability encourages the formation of massive vertical cumulus clouds due to convection with condensation of rising air above the ocean surface. Cyclones are usually accompanied by violent storms and bad weather. The air circulation is inward in an anticlockwise direction in the Northern hemisphere and clockwise in the Southern hemisphere.

Cyclones are given several names in different countries – they are called typhoons in the China Sea and Pacific Ocean; hurricanes in the Caribbean Sea and Atlantic Ocean; tornadoes in West Africa and Southern USA.; willy-willies in Australia and tropical cyclones in the Indian Ocean.

Types of Cyclones

I. **Temperate Cyclones**: Cyclones that develop in the regions between the Tropics of Capricorn and Cancer are temperate cyclones. They are large-scale weather systems developing over tropical or subtropical waters.

II. **Tropical Cyclones**: Tropical cyclones are the progeny of ocean and atmosphere, powered by the heat from the sea, and driven by easterly trades and temperate westerlies, high planetary winds. The World Meteorological Organisation uses the term 'Tropical Cyclone' to cover weather systems in which winds exceed 'Gale Force', i.e. minimum of 34 knots/63 kmph.

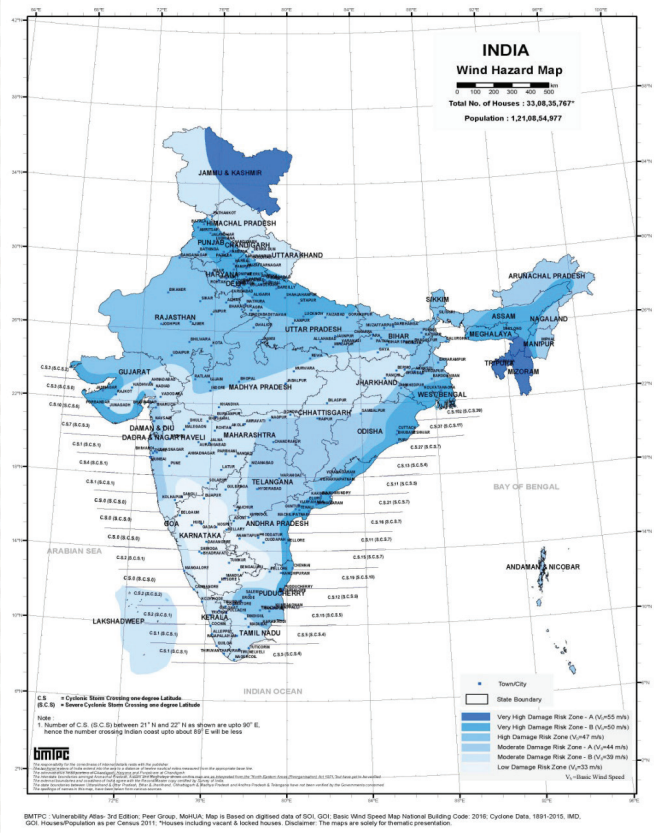


Fig. 2: India Wind Hazard Map

(BMTPC (Building Materials & Technology Promotion Council). (n.d.). *India Wind Hazard Map*. Vulnerability Atlas of India (3rd Ed.). Based on IS 875 (Part 3), NBC 2016, and IMD Cyclone Data (1891–2015).

Indian Context of Cyclones

The Indian subcontinent is one of the most affected regions by cyclones. The country with a long coastline

of 8,041 kilometers is highly exposed to tropical cyclones. More cyclones occur in the Bay of Bengal than in the Arabian Sea. An analysis of the frequency of cyclones on the East and West coasts of India between 1891 and 1990 shows that nearly 262 cyclones occurred (92 of these severe) in a 50 km wide strip above the East coast.

6.3.7 Thunderstorms

A thunderstorm is formed by the combination of moisture, rapidly rising warm air, sea breeze and a mountain. All thunderstorms contain lightning. Thunderstorms may occur singly, in clusters, or lines. Hence, it is possible for several thunderstorms to affect one location in a few hours, giving rise to severe weather conditions. They can bring heavy rains (which can cause flash flooding), strong winds, hail, lightning, and tornadoes. Thunderstorms are destructive and can cause extremely dangerous weather conditions.

6.4 Water Disasters

The following disasters are caused by water and water bodies. They are also called hydroponic disasters.

6.4.1 Flood

Floods are usually caused by storm surges and high-intensity rainfall for a longer time period, melting of ice at a higher rate and due to eroded materials in water. They are relatively slow in occurrence and generally occur in well-identified regions. Unlike other natural disasters, human beings play a significant role in its origin and spread. Deforestation, unscientific agricultural practices, disturbances along the natural drainage channels, and colonization of flooded river beds are some of the human-induced activities that play a significant role in increasing the intensity, magnitude and severity of the floods. The National Flood Commission has identified 40 million hectares of land as flood-prone in India. Assam, West Bengal, and Bihar are among the highly flood-prone states. Apart from these, most of the rivers in the northern states like Uttar Pradesh and Punjab are vulnerable to frequent floods. States like Rajasthan, Gujarat, and Haryana are also getting swamped in recent years due to flash floods. Some of the practices used to tackle the flood situations involve strengthening the ability of communities to handle floods by training self-help groups, national cadet corps (NCC), NSS volunteers, Yuva Aapda Mitras, and youth.

6.4.2 Tsunami

Tsunamis are a series of very large oceanic waves with extremely long wavelengths, in the deep ocean, the length from crest to crest may be 100 km or more. It is octenyl generated

by sudden displacements in the sea floor caused by earthquakes or volcanic activities. When the seafloor abruptly deforms, sudden vertical displacements over large areas disturb the ocean's surface, displace water and generate tsunami waves. These waves could travel away to very long distances from the triggering source with speeds exceeding 800 km/h. They are extremely dangerous and destructive when they reach the coast. In shallow waters, a large tsunami crest height may rapidly rise to several meters causing enormous destruction in a very short time. Tsunamis have the potential to cause significant casualties, widespread property damage, massive infrastructure loss and long-term negative economic impacts. People caught in the path of a tsunami often have little chance of survival. People die from drowning or debris crushing them. The tsunami resulting from the earthquake in the Indian Ocean on December 26, 2004 had devastating effects in the country. Many people died and millions were displaced. The hardest hit areas were on the Southern coast and the Andaman and Nicobar Islands.

6.4.3 Drought

Drought is a sharply felt water deficit caused by variations in the natural hydro-meteorological factors and agro-ecological conditions. Conceptually, drought is characterized by a protracted period of deficient precipitation resulting in water deficits, extensive crop damage, and further resulting in loss of yield. The Global Assessment Report 2015 noted that agricultural drought is probably the most "socially constructed" of all disaster risks and warns that global climate change may increase its frequency. Drought is considered a *'creeping disaster'* whose onset, end, and severity are difficult to determine. Unlike the suddenly occurring disasters, a drought may develop very slowly over several months affecting a very large geographical area without causing little or no structural damage. Droughts affect vast areas of the country. Parts of Rajasthan (chronically), Gujarat, Maharashtra, Madhya Pradesh (MP), Uttar Pradesh (UP), Chhattisgarh, Jharkhand and Andhra Pradesh are drought-prone states. Recurring drought results in adverse impacts on people's livelihoods and young children's malnutrition. Common types of droughts observed in India are meteorological drought, agricultural drought and hydrological drought.

Useful Practices to Mitigate Drought

- Ensure rainwater harvesting and storage in drought-prone areas.
- Promote water-efficient irrigation systems (sprinklers, drip, etc.)
- Ensure risk cover for dry-land / rain-fed farmers.

6.5 Human-Induced Hazards

6.5.1 Pandemics

A pandemic is an outbreak of a severe infectious disease that spreads across countries. It affects more people and takes more lives than an epidemic. The World Health Organization declared COVID-19 to be a pandemic when it became clear that the illness was severe and was spreading quickly over a wide geographical area. The pandemic has caused 66,56,60 deaths worldwide. An infectious disease caused by the SARS-CoV-2 virus.

Prevention: Slowing the Spread of Pandemic Disease

There's no sure way to prevent the spread of pandemic disease during its outbreak. It might take a long time to make the vaccine. The following steps may be taken to stop the outbreak.

- Washing hands often with soap and water. Use an alcohol-based sanitizer.
- Cover your mouth and nose with a cloth while coughing or sneezing.
- Avoid crowded places. Stay at home.
- Quarantine an infected person to prevent the spread of the virus.

Notable pandemics in history so far are: Plague, Spanish flu, Smallpox, HIV, etc.

Mass Gathering: Whether it is a festival occasion, a political rally or a temple like Vaishno Devi, Sri Sai mass gathering is a common phenomenon attracting crowds. Inadequate planning to handle such a crowd may lead to disaster, a stampede.

6.5.2 Chemical Disaster: Bhopal gas

The growth of industries has led to an increase in the risk of the occurrence of incidents associated with hazardous chemicals and hazardous materials. The states with a very large number of chemical industries are Gujarat, Maharashtra, Uttar Pradesh (UP), Tamil Nadu (TN), MP, and Punjab.

Common causes for chemical accidents are human errors, deficiencies in safety management systems, negligence in following international standards for chemical handling, etc. Such incidents lead to injuries, loss of lives, damage to property and the environment. Adoption of the International Organization for Standardization and Occupational Health and Safety Assessment Series standards for the production and storage of chemicals is one way to prevent chemical hazards. Some of the major incidents are: Bhopal Gas Tragedy, Chernobyl Disaster, Benxi Colliery disaster, Oil spills, etc.

6.6 Case Studies

6.6.1 Case Studies 1: Kerala Floods (2018 and 2019)

Kerala experienced devastating floods in consecutive years, first in 2018 and then again in 2019, due to heavy monsoon rains and overflowing rivers. The floods submerged vast areas, displaced millions of people, and caused extensive damage to homes, infrastructure, and agriculture. In response to the disasters, the Kerala government implemented various measures, including rescue operations, relief distribution, and rehabilitation efforts. However, the floods also underscored the need for improved water management practices, sustainable urban planning, and ecosystem conservation to reduce vulnerability to future flooding events.

Lessons learnt and recommendations from this flash flood include strengthening early warning systems, promoting community engagement, and integrating climate change adaptation.

6.6.2 Case Study 2: Nepal Earthquake (2015) and its Impact on India

In April 2015, a catastrophic earthquake with a magnitude of 7.8 struck Nepal, causing widespread devastation and loss of life. The earthquake also had significant repercussions in northern India, particularly in the states of Bihar, Uttar Pradesh, and West Bengal, where buildings collapsed, roads were damaged, and casualties were reported. The disaster emphasized the transboundary nature of seismic risk and the importance of regional cooperation in disaster preparedness, response, and recovery efforts. In response to the seismic threat, India has implemented various measures to enhance resilience and mitigate the impact of earthquakes. These include: strengthening building codes, establishing early warning systems, capacity building and public awareness.

Suggestive Activities:

i. Observe the early warning systems mounted to sensitize to the occurrence of natural hazards (earthquakes, forest fires, floods, etc.) in your locality. Prepare a report about its functioning.

ii. Promote tree plantation in the rainy season to mitigate the risks of heat waves and floods. Run a sensitivity campaign through social media to plant & protect trees.

iii. Persevere and support the ecosystem by saving honeybees, birds and plants.

iv. Observe the preparations being made in the school building to handle earthquake and fire-like situations.

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Glossary

Disaster: It is an undesirable event resulting from forces that are generally beyond human control.

Hazards: They are the dangerous situations or events that pose a threat to human life.

Climate: The average weather conditions in a considerable area of the Earth's surface over

a period of time.

Pandemic: Spread of a communicable disease in several countries over a period of time.

Suggestive Questions:

MCQ questions carry one mark each

I. Which of the following is a Geo-tectonic Hazard?

a. Flood
b. Drought
c. Earthquake
d. Extreme Precipitation

II. How many Zones exist in the seismic classification of Earthquakes?

a. 5
b. 6
c. 4
d. 3

III. Which of the following is not a hydroponic disaster?

a. Flood
b. Tsunami
c. Drought
d. Thunderstorm

IV. Which regions are the most active regions of the volcanic activities?

a. Sea floor
b. Mountains
c. River Basins
d. Plateau

V. What percentage of forest fires are triggered by human activities, as per the Forest Survey of India (FSI)?

a. 95
b. 98
c. 65
d. 87

All short questions carry three marks each (short notes).

I. How are hazards different from disasters?

II. What are the different types of natural hazards? Which one of them is most destructive in your opinion? Discuss.

III. Discuss the causes and consequences of the massive landslide in Himachal Pradesh University, Shimla in year 2023. Why are such incidents to be taken as a learning for society?

All long questions carry ten marks each (essay type, logical analysis, inferring practical situation)

I. Suppose the building of your school/college catches fire in the summer season. What steps could have been taken by the school administration and staff members to rescue each and every student of the school?

II. Discuss how and when developmental activities like: widening of roads, mega construction in urban areas, deforestation for building colonies, etc., can become the cause of disaster?

III. Discuss the factors responsible for forest fires in the summer season. How is forest life impacted by these incidents? Propose a policy with strong recommendations for a state like India to handle incidents of forest fires.

Suggestive PowerPoint slides for reference

Hazards and Disaster Type - Climate Related

Learning Outcomes

- Differences between Hazard and Disaster
- Classification of natural hazards/ disasters
- Disturbance and consequences caused by natural Hazards Disasters
- Pandemic its consequences and solutions
- Human induced hazards and disasters

Hazards and Disasters

- Hazards are dangerous situations or events that pose a threat to human life. like; floods, droughts, disease or infection etc.

- Disasters are sudden events that completely disrupt the human life. They generally cause large scale damage, widespread deaths, loss of life, property and disturbance to social systems. Like: Tsunami, tornados, volcanos. Natural disasters can occur every day at any place in the world

A glimpse of natural hazards/Disasters

Table 7.1: Some Natural Disasters Since 1948

Year	Location	Type	Deaths
1948	The Soviet Union (now Russia)	Earthquakes	110,000
1949	China	Floods	57,000
1954	China	Floods	30,000
1965	East Pakistan (now Bangladesh)	Tropical Cyclones	36,000
1968	Iran	Earthquakes	30,000
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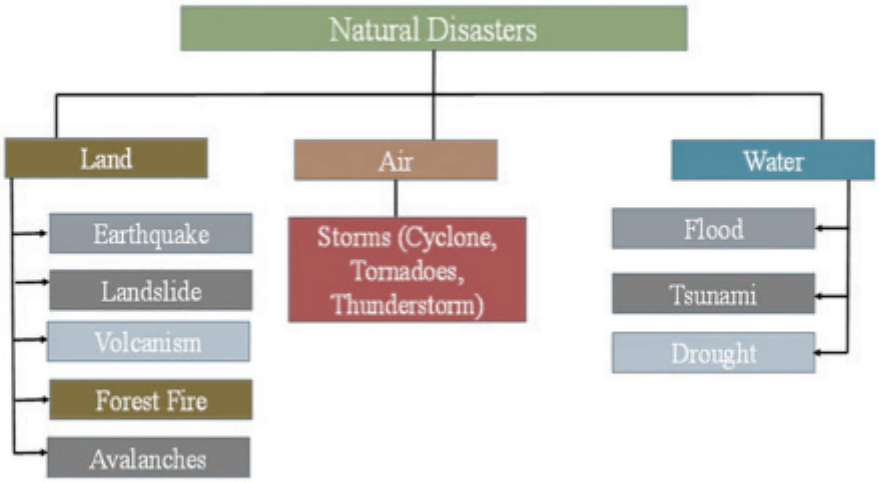
1990	Iran	Earthquakes	50,000
2004	Indonesia, Sri Lanka, India, etc.	Tsunamis	500,000*
2005	Pakistan, India	Earthquakes	70,000*
2011	Japan	Tsunami	15,842*
2019	Australia	Forest fire	

Source : United Nations Environmental Programme (UNEP)

Classification of Natural Hazards



Pandemics

- A pandemic is an outbreak of a severe infectious disease that spreads across countries or continents. It affects more people and takes more lives than an epidemic.

- COVID-19 to be a pandemic when it became clear that the illness was severe and that it was spreading quickly over a wide area. The pandemic has caused 66,56,601 deaths worldwide.

- Mass Gatherings (Crowd)
- Chemical Disasters
- Urban Flooding

Mass Gatherings (Crowd)

- Events viz. festivals, political rally, Navratras in temples that attract crowds.
- Inadequate planning may lead to crowd disaster, stampede.

Chemical Disasters

- The growth of industries has led to an increase in the risk of occurrence of incidents associated with hazardous chemicals (HAZCHEM) and hazardous materials (HAZMAT).
- Common causes for chemical accidents are human errors, deficiencies in safety management systems, negligence in following international standards for chemical handling etc.
- It leads to injuries, pain, suffering, loss of lives, damage to property and environment. e.g : Bhopal Gas Tragedy

Urban Flooding

- Occurs when rainfall exceeds drainage systems' capacity due to flooding of land or property in densely populated tows/cities.
- The most notable amongst them are Hyderabad in 2000, Ahmedabad in 2001, Delhi in 2002 and 2003, Chennai in 2004.

CAUSES AND IMPACTS OF DISASTERS

CHAPTER – 7

Causes and impacts of disasters- Impact on natural ecosystems; physical, psychological, and social impact.

Dr. S. Brinda Devi

Total No. of Hours – 3

I. Background of the Topic

Disaster:-

It is defined as any occurrence that causes damage, ecological disruption, loss of human life and property. The damage caused by disasters is immeasurable and varies with the geographical location and climate. When a disaster happens, you mightbe left stunned and struggling to understand. How could this happen? Was it an act of God or nature? However, the destructionis multiplied or diminished when combined with economic, environmental and social factors [1].

People in poverty and lack of awareness will always feel the impact most strongly. So it is our individual responsibility to help them survive. A natural disaster is an inevitable event that affects the environment. It not only results in mass loss of human life but also adversely affects the economy of the region. Natural disasters have a long history of occurrence that cannot be predicted, nor can they be avoided. Many recent disasters like the Tsunami of the Indian Ocean in 2004, the Earthquake in 2010, the Uttarakhand flood in 2013, Chennai flood in 2015 swept most of the people. Throughout the history of disaster behavioural health research, people have tended to think that women are more vulnerable to the adverse mental consequences of disaster. Any disaster,whether it is man-made or a natural disaster, will alter the environment and cause climatic changes.

II. LEARNING OUTCOMES: -

1. Discuss the causes and the impacts of disasters on the environment, psychological and social impacts to understand the sufferings ofthe victims.
2. Improve the understanding of disaster risk, hazards and vulnerabilities.
3. Identify how families and communities work together to recover from disasters.
4. Inculcate the importance of humanity and the psychological support to the victims.

III. PEDAGOGY OF THE SESSION

- **Critical pedagogy;**
  - Teachers can include critical pedagogy using a PowerPoint presentation.
  - Visual learners see information and look into the global issues, this pedagogy induces the learners to construct ideas and to find solutions for disasters.
- **Boost cognitive skills;**
  - Field visit to the victim's place, learning practically, this education focuses on the evaluation, analysis and finding a solution if any disaster occurs.
- **Collaborative method;**
  - Students can form a group and learn together, they can present their case study presentation and bring a solution for the problems.
  - Collaborative pedagogy can enhance the intellectual efforts of the students and also boost team spirit and build peer relationships.
- **Project-based learning;**
  - This type of learning inculcates the students to find solutions to problems. This creates the confidence of self-learning.
- **Psycho pedagogy;**
  - This psycho pedagogy helps the students to identify their own character, strengths, and positive thinking amongthemselves.
  - This helps the student's mind to overcome a bad situation during any disaster.

IV. CONTENT ON THE TOPIC

7.1 Causes and the impacts of disasters

A disaster is an undesirable occurrence resulting from forces that are largely outside human control, strikes quickly with little or no warning, and results in serious disruption of life and property, including death and injury to a large number of people.[3] Disaster can be caused by natural and human-induced factors. There are two types of disasters:

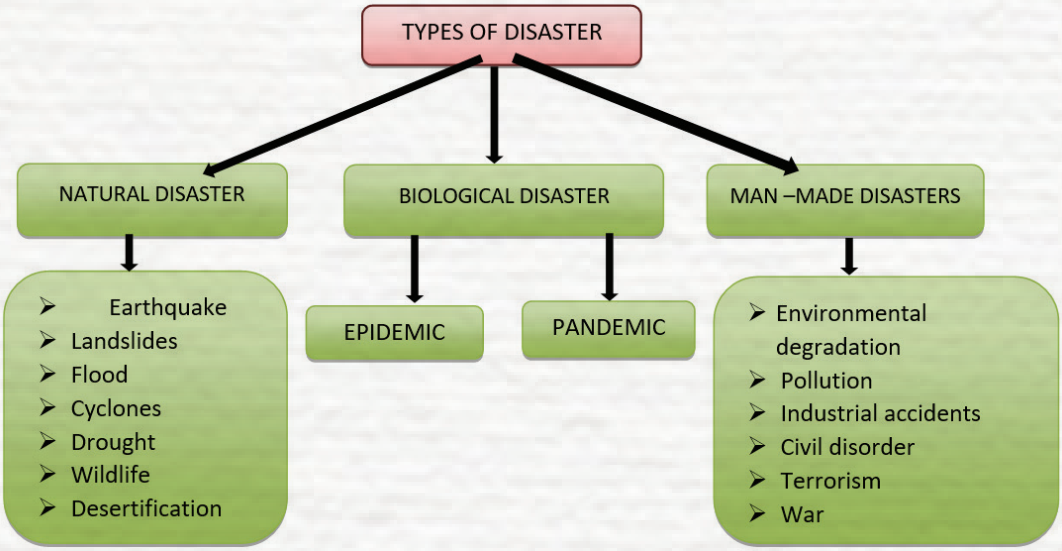


Fig. 1: Types of Disaster

7.1.1 Causes of Disaster:-

Disasters not only have dramatic effects on humans, but they also destroy the habitat of many animals and plants and the entire ecosystem. Human activities also make causes of natural disasters, such as climate change and deforestation. India is especially vulnerable to natural disasters because of its unique geo-climatic conditions, having recurrent floods, droughts, cyclones, earthquakes,and landslides. It may take years to rehabilitate and repair the damage caused by natural disasters. India ranks among the three countries that have borne the impact of natural disasters in recent years. Nearly 10 million people were affected, while 1300-1400 people have losttheir lives in these natural disasters in 2021.

7.1.2 Important causes of Disaster:-

- Exploitation of land use
- Rapid urbanization
- Climatic changes
- Deforestation
- Soil erosion

- Pollution
- Natural phenomenon
- Technological hazards
- Global warming
- Mining
- Tectonic movements
- Increased population
- Lack of awareness

7.1.3 Impacts of Disasters:-

Natural disasters can have long-term negative consequences beyond the immediate loss of life and demolition of infrastructure often an area impacted by a natural disaster will show scars of the event for years to come. Both natural and human-induced disasters can have life-altering impacts on the individuals and families fortunate enough to survive them. [6]

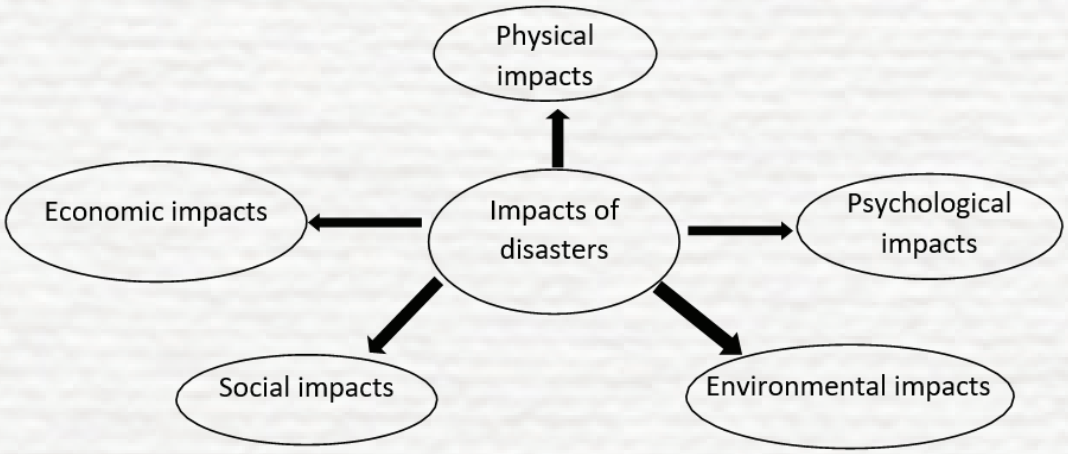


Fig. 2: Impacts of Disaster

Physical impacts

- Injuries, burns, casualties, sanitation problems, miscarriages, weakness etc.,

Economic impacts

- Loss of property, mass unemployment, loss of livelihood, loss of crops and public infrastructure.

Social impacts

- Change in an individual's role, isolation, loss of life, health, relations, orphans' poverty, alcohol misuse, domestic violence etc.,

Environmental impacts

- Pollution, climate change, loss of biodiversity, migration, depletion of natural resources, falling of trees, ecological imbalance food scarcity and water contamination.

Psychological impacts

- In secured, loneliness, distress, loss of trust and confidence, hopelessness, depression, insomnia, anxiety, emotional and mental instability, etc.

Impacts of natural disasters

Natural events can cause great loss of life or property damage. Natural disasters like earthquakes, floods, cyclones, volcanic eruptions, famine & landslides can lead to financial, environmental or human losses. [5]

7.2 Cyclone

Cyclones are the powerful, spinning storms that form over warm tropical waters and reach wind speeds of over 120km/hr. When it moves and crosses over land, it brings with it heavy rain and high-velocity winds, which cause severe damage to buildings and property. The Indian Ocean is one of the six major cyclone-prone regions of the world. About 5-6 percent of tropical cyclones are formed in the Bay of Bengal and the Arabian Sea every year. [4]

Effects of cyclone:

- Heavy rain can cause flooding
- Destroy crops
- Removes the roofs of the building
- Rise in sea level
- Loss of biodiversity
- Migration of people.

7.3 Earthquake

Earthquakes are caused by tectonic movements in the Earth's crust. The focus of an

earthquake is the point at which movement firstoccurs. The epicentre of an earthquake is the point on the surface of the Earth directly above the focus.

Effects of an Earthquake

- Loss of life and property
- Damage to infrastructure
- Liquefaction
- Causes tsunami
- Damage to the transport system
- Psychological trauma
- Economic damage
- Environmental damage
- Causes landslides

7.4 Flood

A flood happens because of heavy rain. The intensity of a flood is determined by the amount of rainfall and the amount of time that it rains. The worst flood happens when there is a heavy rainfall over a period of time. This is most common due to an overflowing river,a dam break, snow-melt, or heavy rainfall. Global warming, deforestation, melting of snow, dam failures, and soil erosion are the main reasonsfor the flood.

Effects of Flood

- Contamination of water
- Spread of diseases
- Loss of human life
- Property loss
- Electricity shutdown
- Affects the roads
- Communication breakdown
- Destruction of agricultural lands

7.5 Volcanic eruptions

It is defined that when lava and gases are released from a volcano, sometimes explosively. Volcanic eruptions are the most stunning phenomena in the natural world. During a volcanic eruption, lava and other debris can flow at speeds of up to 100mph, destroying everything in their path.

Effects of Volcanic eruptions

- Carbon dioxide emitted from volcanoes adds to the natural greenhouse effect.
- Houses, buildings, roads, and fields get covered with ash.
- Crop failure
- Causes suffocation
- Acute and chronic respiratory diseases
- Burns & injuries from falls
- Vehicle accidents
- Water contamination
- Wild fires
- Causes floods

7.6 Drought

Global climate change is expected to trigger droughts. Ethiopia has the most vulnerability to drought. In some parts of India, the failure of the monsoon results in water shortage, resulting in below–average crop yields. The major drought-prone regions such as southern and eastern Maharashtra, Karnataka, Haryana, Gujarat and Rajasthan.

Effects of drought

- Hunger and famine
- Diseases
- Wildfires
- Loss of biodiversity
- Migration

- Increase the crime rate for the survival of life
- Malnutrition

7.7 Landslides

Landslides are rock, earth, and/ or debris flowing or sliding down the slopes due to gravity. Landslides travel at least over than 260 feet per second.

Impacts of landslides

- Deaths
- Disability
- Increase in communicable disease
- Food shortage
- Shortage of food
- Socio–economic losses
- Loss of natural resources
- Block the roads
- Loss of life
- Psychological problems

7.8 Biological disaster

A biological disaster is a disaster caused by the rapid spread of disease among humans, animals and plants caused by micro-organismslike bacteria, virus or toxins, and bio- active substances that may cause loss of life, injury, illness or other health impacts, property damage, loss of livelihoods, social and economic disruption or environmental damage. A biological disaster may be in the form of:

i. Epidemic

An epidemic affecting a disproportionately large number of individuals within a population, community or region at the same time, examples include cholera, plague, Japanese Encephalitis, and Acute Encephalitis Syndrome.

ii. Pandemic

Pandemic is an epidemic that spreads across a large region, that is, a continent, or even worldwide of existing, emerging or re -emerging diseases and pestilences. Examples include Influenza, H1N1 (Swine Flu), and COVID-19.

7.9 Man–made disaster

Accidents are a common feature in most industries. Most of the industries are known for accidents. A man–made or human-induced disaster is a severe event caused by humans interacting with the Earth. It's very distressing to see that humans die due to human-induced activities. Man-made disasters may adversely affect other organisms and ecosystems. Example Bhopal gas tragedy, Mina-Mata disease, Chernobyl Nuclear disaster, Love Canal, etc.

Causes /Reasons of human-induced disasters:

- Illiteracy
- Carelessly handling danger
- Lack of awareness
- Poorly organised emergency services
- Lack of warning to the people
- Improper waste disposal
- Nuclear bombing and testing
- Terrorism
- Pollution

7.10 Impacts of disasters on natural ecosystems

The impacts of disasters create environmental degradation and ecological imbalance. Wildlife can be killed by the force of the disaster, which results in the endangered and threatened species in the ecosystem. Most of the earthquakes have severely damaged the structure and function of the grassland ecosystem, whichcauses biomass decrease and soil erosion.[7]

- Falling of trees
- Dried lakes and water sources

- Water crisis for wild animals
- Loss of habitat
- Migration of wild animals
- Loss of crops due to heavy rainfall
- Affects the soil quality
- Causes soil erosion
- Toxic gases released into the atmosphere affect the entire biodiversity
- An increase in temperature causes the melting of snow, which affects the endemic species
- Carbon dioxide emitted from volcanoes adds to the natural greenhouse effect
- Exposure to toxic gases /alters the food chain and food web in the ecosystem. which results in an imbalanced ecosystem

7.11 Impacts of disaster on physical environment

Damages to physical and material have a significant impact on our society, for example collapsed buildings, damaged houses, poor evacuation, injuries, burns, physical disability, sanitation problems, miscarriages, weakness, psychological problems.

7.12 Impacts on health

Most of the disasters have direct impacts on health, while some are indirect. Each year, approximately 300 natural disasters occur worldwide. Earthquakes and floods are capable of producing a large number of deaths. There are also members of each community whohave special health care needs. Communicable diseases and vector–borne diseases are most common during the post-disaster period. Communicable or infectious diseases are caused by microorganisms such as bacteria, viruses, parasites, and fungi that can be spread directly or indirectly from one person to another. Some are transmitted through bites from insects, and the common health impacts likecold, flu, sore throat, or throat infections, headaches and increased blood pressure.

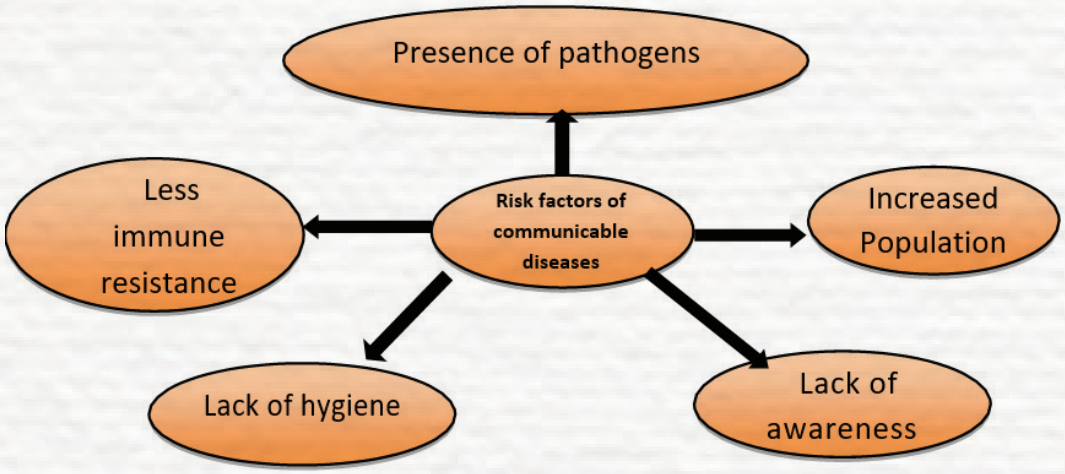


Fig. 3. Risk factors of communicable diseases (RFCD)

Communicable disease:

Environmental factors can increase the likelihood of communicable diseases outbreaks. Communicable diseases were defined as infectious diseases transmissible by direct contact with an affected individual or the individual's discharges or by indirect means (as by a vector). Examples of pathogens are viruses, bacteria, fungi, protozoa and worms. Natural and complex disasters dramatically increase the mortality and morbidity due to communicable diseases. The major causes of communicable diseases in disasters are due to contaminated food and water, respiratory infections, vector, insect-borne diseases, and infections due to wounds and injuries.

Common communicable diseases are

- Water-borne (cholera, typhoid, amebiasis, diarrhoea, gastroenteritis, etc.)
- Vector-borne (dengue, chikungunya, yellow fever, malaria, etc.)
- Airborne (anthrax, chicken pox, influenza, COVID-19, measles, mumps, whooping cough, tuberculosis)

Non-communicable diseases

According to WHO the non-communicable diseases as a chronic disorder that happens due to a combination of a variety of factors including environmental, physiological, genetic as well as behavioural factors. Most of the non-communicable diseases are caused due to air pollution, UV exposure or weather changes.

- Heart disease

- Stroke
- Cancer
- Diabetes
- Hyper tension
- Blindness
- Lung disease

Preventive methods

- Vulnerability analysis and risk assessment
- Good sanitation
- Safe water supply and proper maintenance of the sewage pipeline
- Personal hygiene awareness
- Vector control
- Avoid water stagnant
- Immunization
- Isolation and quarantine of the patient
- Bio–safety measures in the laboratories, dealing with bacteria, viruses or toxins
- Disposal of the dead bodies with safety measures
- Disaster education [11]

7.13. Impacts of disaster on psychological and social aspects:

The psychological effects of the disaster are more drastic among children, women and the dependent elderly population. Disasters are mostly unpredictable, which leaves the victims in a state of shock. The victims are more vulnerable to stress and anxiety. Home is a place that provides safety and security to people. But, when the unavoidable situations induced by disasters damage properties and other valuable assets, it leads to a feeling of insecurity in the victims. Death of a closed one also leaves the victim in a state of insecuritybecause the sense of love, attachment and belongingness is deprived.

Psychological distress is common in the victims, along with socio-economic distress. It is important that all family members should develop coping skills for dealing with problems. A serious illness or disability can disrupt a family's normal activities and lead to stress.

Psychological impacts of disaster:

Emotional instability, stress reactions, anxiety, trauma and other psychological symptoms are observed commonly after the disaster and other traumatic experiences. These psychological effects have a massive impact on the concerned individual and also on communities.

The psychological impacts of natural disasters are widespread, expanding across a spectrum of severity, extending along a range of duration, and are related to the nature of the disaster event. The psychological consequences of disasters are spawned by, and directly proportional to, the degree of exposure to hazards, loss, and change, the "forces of harm" that characterize natural disasters. High-risk populations in harm's way, those that are particularly vulnerable to the ravages of disaster and the combination of physical and psychological consequences, can only be partially defined before disaster strikes. Disaster impact, compounded by adversities in the aftermath, "reshuffles the deck" by creating new special populations of persons needing medical and psychological support, composed of those who have sustained extreme exposure to trauma and harm. [12]

Psychologically, some of the most affirmative guidance to emerge is that resilience, positive adaptation in the face of disaster's adversity, is the most common and expected outcome. Some survivors even emerge from the disaster experience stronger and more vital psychologically, a recently-recognized phenomenon known as post-traumatic growth. This sets the future agenda for the field, integrating disaster mental and behavioural health with the disciplines of public health, public safety, and emergency response to enhance preparedness for future catastrophic events.

PSYCHOSOCIAL CARE

Psychosocial programming consists of structured activities designed to advance children's psychological and social development and to strengthen protective factors that limit the effects of adverse influences.

NEED FOR PSYCHOSOCIAL CARE

Mitigate the effect of trauma, alleviate psychological distress, strengthen resiliency re-establish the normal development process

7.14 Disaster lifestyle changes

Worse changes in lifestyle might be associated with the bad habits of cigarette smoking, consuming alcohol, family violence, wife battering, child neglect, finally, all these mental stress will lead the victim to get suicidal ideas, etc.

In the immediate aftermath of a natural disaster, the first reaction is often a combination of shock and denial. Sometimes this can make it challenging to take the necessary steps to begin picking up the pieces—calling insurance, assessing what property waslost, even finding temporary housing. But shock tends to give way to much stronger feelings, which can hit days, weeks, or months after a disaster strikes.

7.15. Impact of disaster on children

- Loss of familiar environment
- Fear of darkness
- Struggle for food, shelter
- Injuries and crying
- Refuse to go to school
- Witnessing violence and destruction
- Scary nightmares
- Helplessness
- Regressive behaviour (thumb sucking, wanting to be carried, bed-wetting)
- Moodiness, irritation
- Sleeping alone
- Easily frightened
- Increased aggression, especially in boys

7.16 Impact of disaster on women

Studies show that natural disasters tend to lower life expectancy more in women than in men. This has to do with their lack of physical ability to get to safety, their sacrificing their safety for their children and elders, and their cumbersome clothing. Apart from this, in the aftermath of a disaster, women are much more vulnerable to trafficking, rape, and violence. During recovery, women and girls may have to work harder to carry out the functions of daily living for their families. This can include lining up for relief supplies, having

to travel farther to access water or cooking in challenging conditions. These activities often happen during disasters, which causes serious impacts on women's health. However, the women with poor socio-demographic backgrounds appeared to have a lower capacity for managing and coping with both pre-disaster and post-disaster situations. Women's health issues like stress, chronic illness, and low-quality marital status potentially make women vulnerable to health problems.

Women are more vulnerable in some circumstances such as pregnancy, delivery, and menstruation, thus greater attention should be paid to their mental health needs. In most of the families, we often place extra loads on women, which threatens women's mental health. In 2018 the world was affected by 315 natural disasters, which took 11,804 lives and affected 68.5 million people. Women experience major depression after disasters, mostly it affects pregnant women, which can lead to form more complications during the delivery period, significantly more likely of having pregnancy-induced–induced hypertension and gestational diabetes, followed by these health issues may affect the physical health of children. Women were highly affected by the Uttarakhand flood in 2013.

7.17 Social impact of disaster

Social impact means looking at how natural disasters affect individuals in the community, and it goes way beyond just dealing with casualties and property damage. It is about working directly with the people.

Social impacts, which include psychosocial, demographic, economic, and political impacts, can develop over a long period of time and can be difficult to assess when they occur. Despite the difficulty in measuring these social impacts, it is nonetheless important to monitor them, and even to predict them if possible, because they can cause significant problems for the long-term functioning of specific types of households and businesses in an affected community.

It increases the mental health issues, alcohol misuse, domestic violence, chronic disease and short-term unemployment that have resulted from extreme weather events such as COVID-19, landslides, severe storms, cyclones, floods and earthquakes.

Economic and social development throughout the world is frequently interrupted by extreme events. Although disaster events impact both developed and developing countries, in the latter, they can cause a sharp increase in poverty. Most economic assessments of the impacts of disasters have concentrated on direct losses—that is, the financial cost of physical

damage. Equally important are indirect and secondary impacts of disasters, including the destruction of communities and their negative impacts on families

7.18 Case study of Kerala flood

Kerala, which lies in the tropical region, is mainly subject to the humid tropical wet climate experienced by most of Earth's rainforests. On 16 August 2018, severe floods affected the south Indian state Kerala, due to unusually heavy rainfall during the monsoon season. It was the worst flood in Kerala. Over 483 people died, and 15 went missing. 140 are hospitalized, while The Economic Times reported that 33,000 people were rescued. The Kerala State Disaster Management Authority had placed the state on red alert as a resultof the intense flooding.

The Indian state of Kerala receives some of India's highest rainfall during the monsoon season. However, in 2018 the state experienced its highest level of monsoon rainfall in decades. According to the India Meteorological Department (IMD), there was 2346.3 mm of precipitation, instead of the average 1649.55 mm.

Kerala has 41 rivers flowing into the Arabian Sea, and 80 of its dams were opened after being overwhelmed. As a result, water treatment plants were submerged, and motors were damaged. Parts of Kerala's commercial capital, Cochin, were underwater, snarling up roads and leaving railways across the state impassable. In addition, the state's airport, which domestic and overseas tourists use, was closed, causing significant disruption.

Local plantations were inundated by water, endangering the local rubber, tea, coffee and spice industries. Schools in all 14 districts of Kerala were closed, and some districts have banned tourists because of safety concerns. More than 300 boats were involved in rescue attempts. Army, Navy and Air Force personnel were deployed to help those stranded in remote and hilly areas. Dozens of helicopters dropped tonnes of food, medicine and water over areas cut off by damaged roads and bridges. Helicopters were also involvedin airlifting people marooned by the flooding to safety.

Fig. 4: Kerala flood in 2018

Points for group discussion:

- Development of disaster education at each level of studies to create awareness among the students and people have to join hands to together in reducing the impacts of disaster.
- India started an Act called the NDMA (Natural Disaster Management Act) for helping the victimsduring any disaster. Awareness of diseases during any disease.
- Measures to be taken during COVID-19 for example, social distancing, temperature checking, wearing a mask, necessary hygiene and sanitation products. proper hand washing, etc.
- Risk factors of psychological impacts, proper counselling, care and love towards the victim, importance of humanity.

Suggested activity

- Prepare a puppet show, explaining the impacts of disaster.
- Chalk and talk; effective speaking skills by using chalk on a blackboard. The talk should be on the current issues not exceeding 15-20 minutes.
- A photo journalism competition for presenting their disaster case study.
- Role play drama/street play showing the psychological impacts.
- A mock drill can be conducted.

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Glossary

1) **Biosafety** is the prevention of large-scale loss of biological integrity, focusing both on ecology and human health.

2) **Poverty** is defined as the state or condition where people and communities cannot meet a minimum standard of living because they lack the proper resources.

3) **Calamity** is a disastrous event marked by great loss and lasting distress and suffering.

4) **Drought** is a prolonged dry period in the natural climate cycle that can occur anywhere in the world.

5) **Urbanization** is a process where the population shifts from rural to urban areas due to various factors.

6) **Tectonics** is the study of the Earth's structural features, especially the folding and faulting (cracking) of the Earth's crust.

7) **Sanitation** is the hygienic means of preventing human contact with the hazards of waste to promote health.

8) **Famine** is a lack of food over a long period of time in a large area that can cause the death of many people.

9) **Trauma** is a very severe shock or very upsetting experience, which may cause psychological damage.

10) **Epicentre** refers to the part of the Earth's surface directly above the focus of an earthquake.

11) **Biodiversity** is the existence of a wide variety of plant and animal species living in their natural environment.

12) A **pandemic** is an infectious disease epidemic that is spreading between people in multiple countries.

13) **Hypertension**, also known as high blood pressure, is a long-term medical condition in which the blood pressure in the arteries is persistently elevated.

14) A **Pathogen** is simply defined as an organism that has the potential to cause infectious diseases in its host.

Suggested Questions:

MCQ questions carry one mark each

1. Natural disasters generally involve which of the following?

   a) Events with a single clear –cut cause

   b) Events that involve overlapping natural causes

c) Events wholly caused by the activities of man

d) Events that are unaffected by the activities of man

India's total cyclone–prone area is -------

a)15% b)10% c)8% d)20%

2. According to the Indian Meteorological Department (IMD), which storm is classified as a "super cyclone" when the wind blows at whatever speed?

a) Above 200km b) Above 110km

c) Above 220km d) None of the above

3. Which one of the following is not a natural disaster?

a) Volcano eruption b) Flood

c) Blow-out d) Tsunami

4. Which one of the following is mainly considered a human-induced disaster?

a) Fire b) Landslides c) Drought d) Erosion

5. Which is a nuclear disaster?

a) Bhopal gas tragedy b) Chernobyl disaster

c) Love Canal d) Minamata disease

6. Which one of the following states of India experiences floods frequently?

a) Bihar b) West Bengal

c) Assam d) Uttar Pradesh

7. An earthquake releases -------

a) Vibrations b) Tremors

c) Vibrations and tremors d) Tremors and fire

8. The percentage of drought-prone area in India is --------

a) 8% b) 30% c) 15% d) None of the above

All short questions carry three marks each (short notes)

- What are the types of disasters?

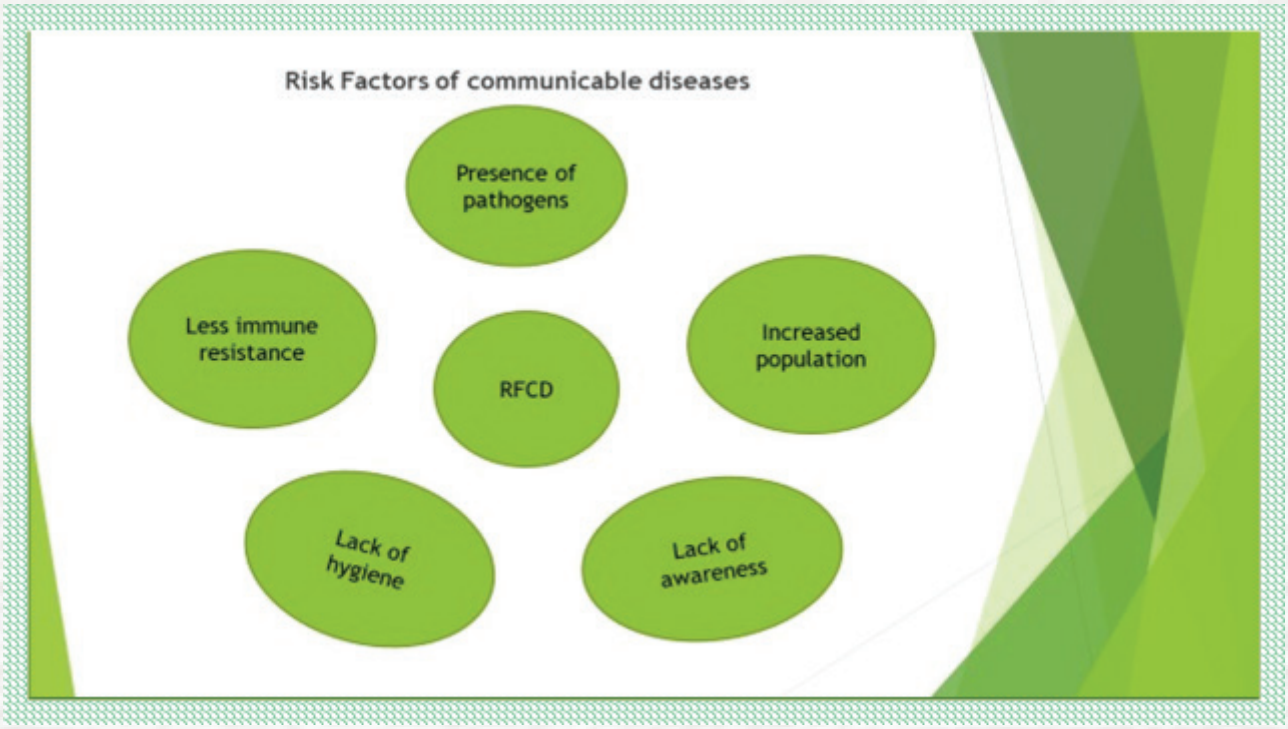
- Write examples of human-induced disasters.
- Name some communicable diseases.
- Mention a few physical impacts of a disaster
- List out the causes of the disaster

All long questions carry ten marks each (essay type, logical analysis, inferring practical situation)

- Explain in detail the impacts of disasters on the natural ecosystem.
- Write a detailed account of the psychological impacts faced by the people during the pandemic period.

Suggestive PowerPoint Slides for reference

Causes and impacts of disasters- Impact on natural ecosystem; Physical, psychological and social



CAUSES AND THE IMPACTS OF DISASTER

- Define Disaster
- It is defined as any occurrence that causes damage,ecological disruption,loss of human life and property.
- Natural Disaster have along history of occurrence, which cannot be predicted, nor can it be avoided. Most of Disaster was swiped the people's population.
- Any Disasters, whether it is man- made Or natural disaster, will definitely alter the Environment and causes the climatic changes.

Impacts of Disaster on Natural Ecosystem

- Falling of leaves
- Dried lakes and water sources
- Water crisis for wild animals
- Loss of habitat
- Migration of wild animals
- Loss of crops due to heavy rainfall
- Affects the soil quality
- Affects the Biodiversity
- Increases the global warming
- Affects the food chain & food web in the Ecosystem.

Non- Communicable diseases

- Non-communicable diseases (NCDs), also known as chronic diseases, tend to be of long duration and are the result of a combination of genetic, physiological, environmental and behavioural factors.

Examples are

- Heart disease
- Stroke, Cancer
- Diabetes
- Hypertension
- Blindness
- Lung disease

Impacts of Disaster on psychological and social impact

Any factor impacting or arising in the mind related to the mental and emotional state of a person.

Psychological distress is common in the victims, along with socio- economic distress. It is important that all family members should develop coping skills for dealing with problems.

A serious illness or disability can disrupts a family 's normal activities and lead to Stress.

Disaster life style Change

- Cigarette smoking
- Consuming alcohol
- Family violence
- Wife battering
- Child neglect
- Suicidal ideas

Impact of Disaster on women

- Women's are more vulnerable in some circumstances such as pregnancy, delivery,menstruation, thus greater attention should be paid to their mental health needs.
- Women health issues like stress, chronic illnesses, and low marital status potentially make women more vulnerable to health problems.
- Women's are affected during Uttarakhand flood in 2013.
- Women's are highly affected during this Covid 19 lockdown.
- In most of the families, often we place extra loads on women,this threatens women's mental health.

Social impact of Disaster

- *"Social impact means looking at how natural disasters affect individuals in the community, and it goes way beyond just dealing with casualties and property damage. It's about working directly with the people."*
- Economic and social development throughout the world is frequently interrupted by extreme events. This causes increase ratio of poverty, which makes the person to commit more crimes in the society.
- If you destroy the nature, the nature will destroy the human beings.

Psychological impacts of Disaster

- Emotional instability
- Stress reactions
- Anxiety
- Trauma
- Fear of darkness
- Easily frightened

DISASTER AND FINANCIAL RESILIENCE

CHAPTER – 8

Disaster Risk Finance - Disasters and Financial Resilience

Dr. R. Siva Kumar and Dr.Snehasish Ghosh

Total No. of Hour: 1 hour

I. Background of the topic:

The United Nations endorsed the Sustainable Development Goals (SDGs) to overcome the developmental backlog for all countries and set a common target for achievement by the end of the year 2030. SDGs 11 and 13 target to achieve safe, resilient, sustainable cities and human settlements. In the context of disaster risk reduction, SDGs state that the integrated policy and plan have to be adopted and implemented by focusing on mitigation and development strategy. The number of deaths and population affected by disaster has to be reduced, whereas direct economic loss has to be minimized (SDGs 2020). Financial resilience is an important aspect in this regard because all disasters are associated with financial loss, which affects economic growth.

II. Learning Outcomes:

1. To understand risk assessment and management skills
2. To understand about emergency planning and responses
3. To understand financial planning and resource allocation

To understand the community and social support system

III. Session Methodology:

i. **Mode of presentation:** PowerPoint presentation

ii. **Pedagogy:** Activity-based learning, Collaborative learning, Field-based active learning

iii. **Handouts:** Materials will be given to the students. Listed in the reading materials

IV. Content on the topic :

8.1 Introduction

Disaster resilience defines the early preparation of the community to protect itself from future incidents by learning a lesson from past incidents. It focuses on the pre- and post-disaster risk reduction strategy to minimize the effects of hazards (Hosseinzadeh & Galal 2021). The damage probability increases due to the lack of maintenance of infrastructure and increasing human utilization of land use without any limit. Several prevention strategies are essential to reduce the disaster-induced damages in this region. The adoption of retrofitting, recovery and reconstruction brings the system to the original function and can prevent earthquake-induced damages which leads to the stage of seismic sustainability (For Cellini 2017).

Every disaster is also associated with a major economic disaster. It affects on Gross Domestic Product (GDP). Developing country suffers more than developed countries. Damages to private assets affect economic activity and ultimately reduce government revenue. There are 3 elements in disaster resilience which include physical, financial and social resilience. The financial resilience refers to the pre-arrangement for post-disaster activity to protect the balance, sub-national government, household and business which are mainly managed by the Ministry of Finance. Asia is exposed to various natural hazards such as earthquakes, floods, landslides, cyclones, etc. which result in more financial losses.

The United Nations endorsed the Sustainable Development Goals (SDGs) to overcome the developmental backlog for all countries. It fixed a common target of achievements by the end of the year 2030. SDG 11 is targeted to achieve safe, resilient, sustainable cities and human settlements. As per the amendment, the number of deaths and affected population by disaster has to be reduced whereas direct economic loss has to be minimized (SDGs 2020). In the context of disaster risk reduction, the SDGs stated that the integrated policy and plan have to be adopted and implemented by focusing on mitigation and development strategy. The Sendai Framework for Disaster Risk Reduction (SFDRR) focused on community

safety and disaster resilience to minimize the effects of disasters by protecting human assets from damage (UNISDR 2005).

8.2 Financial protection strategy against disaster

Governments need the right information to make financial decisions. The risk information allows public and private decision makers to assess the cost of disasters for allocating resources. Timelines are very important where Relief, recovery and reconstruction are important. But everything is not required at the same time quick allocation of funds is required to support relief efforts and early recovery. More time is required for reconstructions. Financial resilience can be further strengthened through working together with other countries in collaboration (Fig. 1).

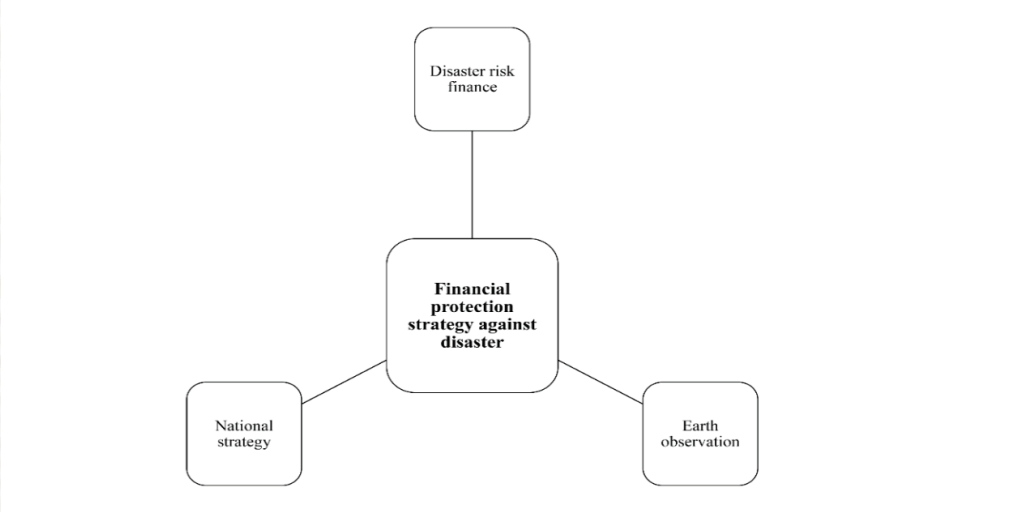


Fig. 1. Financial protection strategy against disaster

8.2.1 National strategy

The Finance Ministry plays having major role and the implementation of disaster risk policy in collaboration with line ministries and disaster risk management agencies. Countries can mitigate the long-term fiscal impact of disaster shocks by developing a strategy that supports policy objectives. The strategies can be made for national, subnational and individual levels. A Catastrophic risk pool sometimes helps to reduce the insurance premium by lowering capital and operating costs. Regional collaboration helps to improve national financial resilience strategies.

8.2.2 Disaster risk finance

It is necessary to start the fundamentals for new development. The development of new technology enhances the financial resilience against disaster risk. Before implementing the new technology need to take proper decision of the replacement of the old technology.

8.2.3 Earth observation

The advancement of remote sensing techniques and satellite observation helps to support more accurate and timely financial decisions. SEADRIF is a new technology that helps to support flood risk assessment and provide information to the government. It provides risk data from Radar and optical satellites, which helps with quick damage assessment and reduces the related fiscal risk. It helps to estimate the insurance.

8.3 Factors for DDR finance

There are various factors for DRR finance (Fig. 2).

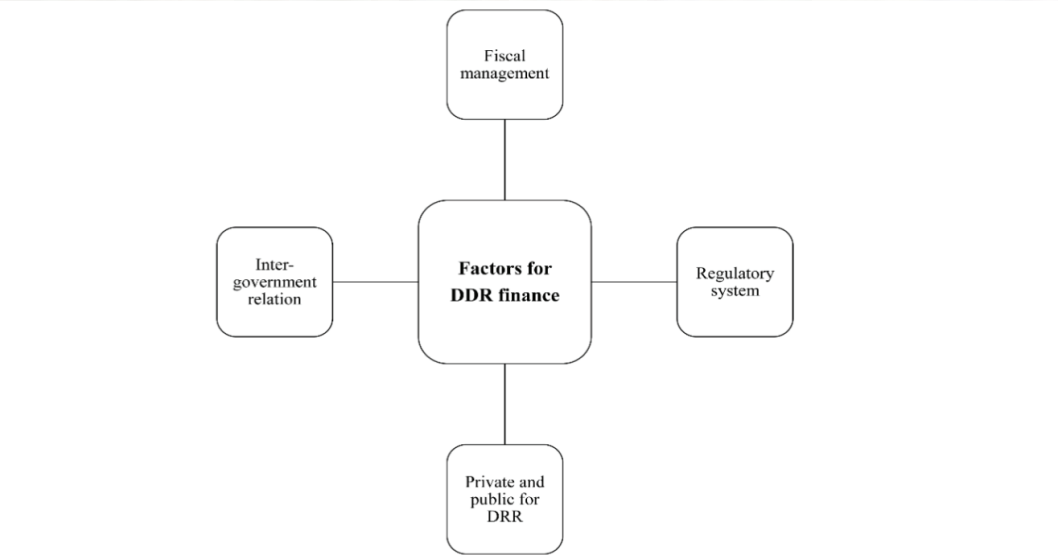


Fig. 2 Factors for DRR finance

8.3.1 Inter-government relations: It is complex because the management of disaster risk involves cross-disciplinarity. So it does not maintain the easy flow of funding for its measurement. The working nature of government with transparency is only able to track, manage and reduce disaster risk. In intergovernmental relations, it requires being focused on transparency and accountability, roles and responsibilities, arrangement of pre- and post-disaster action. It also requires incentives for cross-sector collaboration.

8.3.2 Fiscal management: Fiscal management is also necessary and recognizes the exposures of communities, funding for DRR which are the major aspects for management. Adequate resource allocation, effective fund flow, and preparation for risk reduction are also considered for fiscal management.

8.3.3 Regulatory system: A corresponding regulatory framework authorizing national entities is essential. The regularity framework effectively receives financial support from

different organizations and follows the regulations for the financial flow.

8.3.4 Private and public for DRR: It requires a certain action plan for execution through public and private collaborative action which includes mainly contextual enablers, instrument application with specific tools, resources, or strategies that are employed to implement the plan, business model and supply side. The adopted supportive regulatory framework facilitates the sustainable allocation of financial resources and ensures that investments in disaster risk reduction

8.4 Approaches to DRR finance

The approaches are made in three ways: particularly working in the public sector. The approaches are recognized at the national, subnational and government level (Fig. 3).

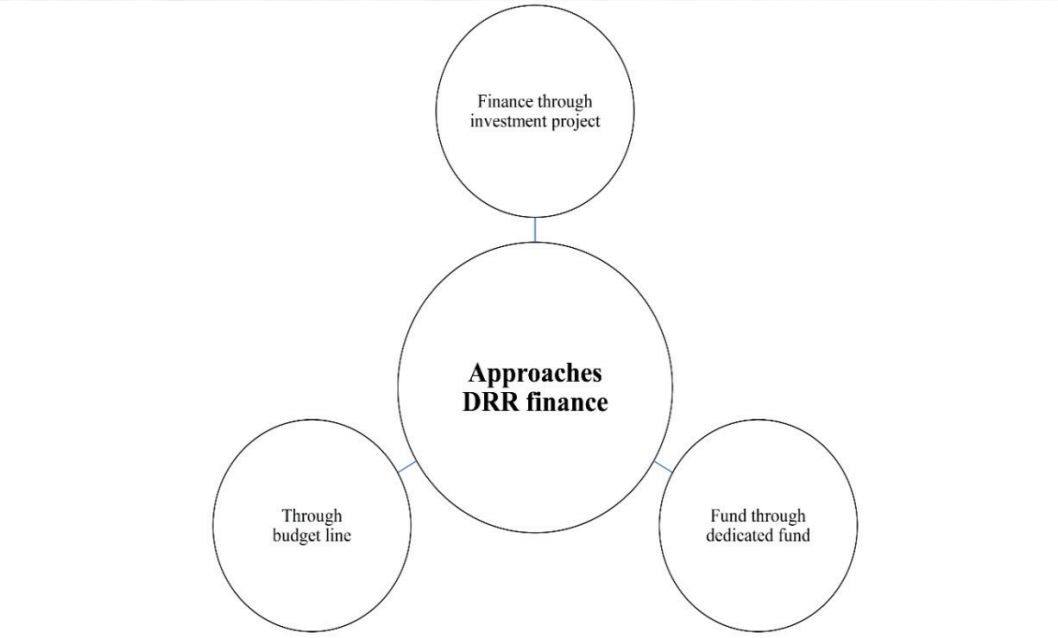


Fig. 3 Approaches of DRR finance

8.4.1 Finance through investment project: Funding is necessary for the planning and implementation of disaster risk reduction. The DRR project lies in a specialty that allows linking the funding to implement a definite time frame. The institutionalization of DRR is still limited. If the project is related to a spatial area measurement, the project may link to nonstructural measures and target reform to existing policies and implementing agencies. The individually financed DRR project can help to build further stakeholder support for long-term disaster risk reduction.

8.4.2 Funding through a dedicated fund: This fund will increase the country's resilience. In this case, DRR has a higher priority than the overall agenda. The dedicated fund for

Disaster Risk Reduction (DRR) ensures that specific resources are allocated to this cause, and the country can significantly improve its ability to mitigate and recover from disasters**.** The dedicated fund also comes from mandatory contributions from different organizational shares.

8.4.3 Through budget line. It is an approved budget from the financial sector to be utilized for DRR. The budget line may be allocated directly by the national government or mandatory contribution or allocation based on policy. In such cases, it focuses on specific requirements and follows different criteria for spending. It is a stand-alone financing and sectoral measurement as a surplus contribution.

8.5 Types of DRR finance

The allocated resource comes under two types of expenditures. It spends on physical and non-physical goods (Fig. 4).

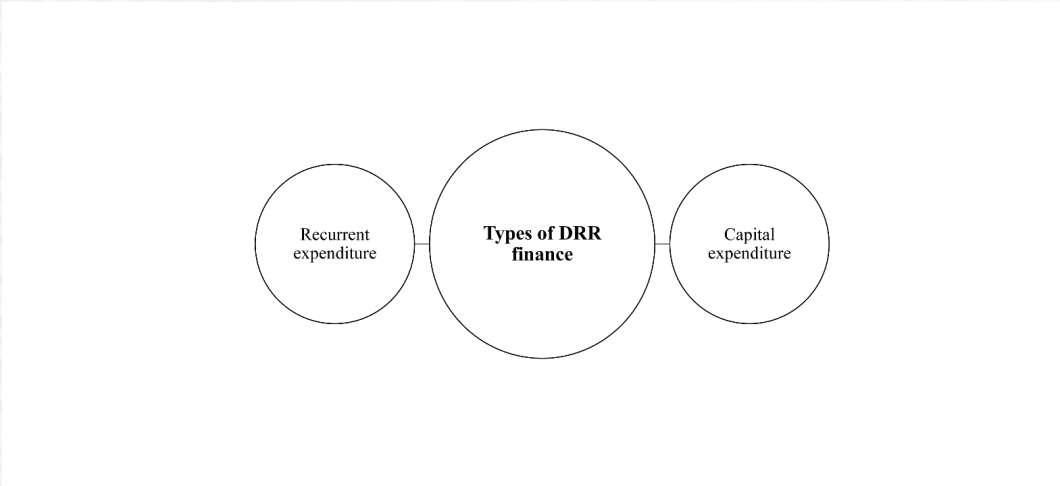


Fig. 4 Types of DRR Finance

8.5.1 Recurrent expenditure: Goods and raw materials are an important part of this expenditure. It is purchased as input for ensuring continuous functioning. On the other hand, operations and services are part of the daily operation and maintenance activity which is performed by the government. Such recurrent expenditures make investment into disaster risk reduction by ensuring the effective operation and performance to expected standards.

8.5.2 Capital expenditure: This is also inclusive of physical and non-physical elements. Always, physical capital investment is the real DRR asset. Such kinds of expenditures are observed for the construction of retaining walls in landslide-prone regions, seawall protection in low-lying coastal flooding regions, etc. On the other side, non-physical capital investment

is used for the model development in a non-real lab environment. It will be designed based on acquired data, which helps to make decisions for concerned people in a certain area.

8.6 Medium of financing DRR

Own-source revenue is a major resource. It is generated by tax and non-tax source tariffs, fees, fine and sales. Intergovernmental grants come from the upper-level government, unconditional grants and subsidies. Finance is borrowed from capital and primarily acquired from loans which may be obtained from commercial partners or bonds in the trade market. Equity-type finance includes shares, investments, fixed and regular interest payments.

8.7 Financial technology

Fintech and Insurtech have a greater role in the financial sector. The innovation in the digital payment system plays a significant role to the quick transformation of funds for relief operations. It helps to reduce disaster risk and speed up services. Similarly, the implementation of big data and machine learning technology helps with risk financing before, during and after events. The newly established technologies reduce the risk of finance and boost financial resilience for promoting effective risk managers (World Bank, 2018?).

8.8 Financial support

Financial support for disaster risk helps in response and reconstruction. It increases the financial capacity of the government to respond, reduces the impact of disaster on social and economic development, protects human development and economic gain, thus contributing to poverty reduction. The sharing of knowledge and joint mechanisms of the country increase the financial sustainability. The public and private assets are strengthening the financial resilience. The response of financial support is required at the household level. It is necessary to protect the finances for future disasters. It is necessary to keep insurance, income and savings for financial safety. The advancement of finance DRR support is depicted in Fig. 5.

In the initial stage, it is necessary to understand the risk through hazard frequency, intensity, exposure and vulnerability. It helps to reduce the risk by prevention, mitigation, and preparedness. In this case, structural and nonstructural measurements are necessary. Resilience infrastructure is given focus to avoid losses from disaster. The development is necessary through investment by households and businesses, with positive economic, social and environmental cost-benefit.

The main supporting elements are understanding and assessment, decision making and planning, acting and implementing. It is necessary to conduct efficient collection and management of data, regular risk management and recognition of resilience benefits.

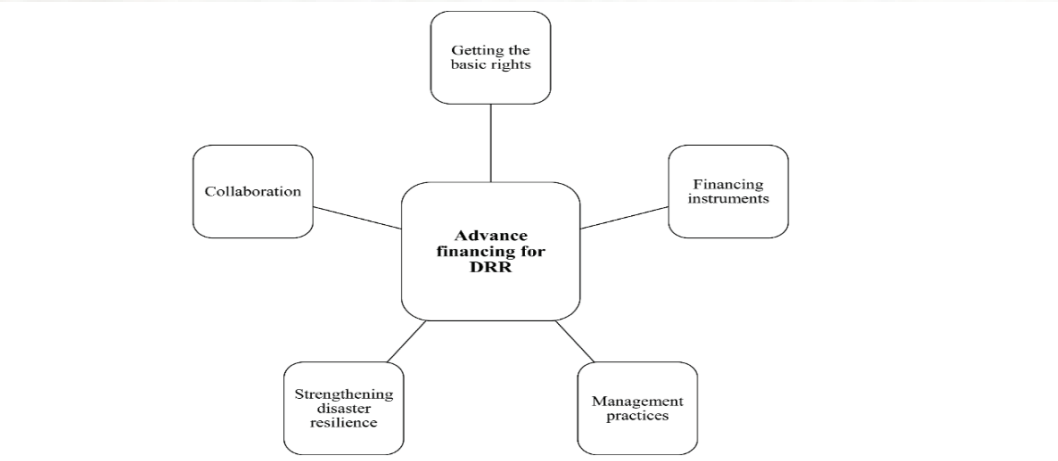


Fig. 5: Advance financing for DRR

8.9 Financial management of earthquake risk

It is a complex public policy for countries facing significant exposures. It promotes a risk assessment process that estimates exposures and identifies financial vulnerability. It manages the financial impact of disaster in all aspects. It is required for making decisions on emergency response, land use planning, building codes and risk reduction strategy.

8.9.1 Challenges in the accuracy of damage potential estimation

For earthquake risk, there are a number of provocations for accurate assessment. The occurrence of an earthquake is uncertain and its mechanisms are also complex phenomena. There is a lack of knowledge about the seismic potential study of all active faults. Also, the associated phenomena such as tsunamis, liquefaction and aftershock damage are more complex to estimate damage potential in financial aspects. Further human activity along the fault line is accelerating more stress on the fault leading to earthquakes which have not been considered earlier for a damage potential study.

Earthquakes are more costly natural phenomena where the damage is more severe. The impact of an earthquake is always notable on buildings, infrastructures and people which including a magnitude 6.7 earthquake in Imphal, resulting in many lives, injuries to hundreds and more. Similarly, a 6.4 magnitude earthquake in Taipei in 2016 killed dozens of people, injured many more and collapsed buildings which resulted in USD 750 million in economic losses (Swiss Re, 2017). Earthquake damages were more in Japan where USD 30 billion economic damages and losses were estimated (Aon Benfield, 2016a; SwissRe, 2017).

8.9.2 Improving the availability data reflecting the magnitude of earthquake loss

Size of expected losses*:* The losses from the earthquake (USD 9.85 billion) are more than climate-related disasters. The effect of the earthquake depends on the subsequent event also such as a Tsunami and fire which is induced after an earthquake. Sometimes damages are more due to the secondary incidents.

Risk diversification*.* Earthquake risk is higher for a large number of buildings nearby. For managing extreme events, significant uncertainty limits the exposers. A high level of risk creates challenges with limited geographical diversification.

Uncertainty in quantification of potential exposures*.* There is uncertainty regarding the occurrence of earthquakes, intensity and frequency. The premium rate of earthquake insurance needs to be modified as per the situation. Insurers will mitigate high-level uncertainty about the level of expected losses.

8.10 Conclusions

Financial loss affects economic growth whereas the death and affected population by disaster have to be minimized. Various strategies and approaches have been taken into consideration. Financial resilience can be further strengthened through working together with other countries in collaboration. The national strategy, disaster risk finance and earth observation are the main financial protection strategies. Various factors have also been discussed where it is observed that the regulatory system has maintained the financial flow. The improvement of financial strategy has also been done by computing the actual expected loss and providing a proper insurance policy.

Suggested activity :

- Project submission : Case study
- Emergency plan development : Chart preparation

Financial crisis : Role play

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Glossary

A
Accuracy
Advancement
Arrangement
Allocation
Application

B
Budget line

C
Capital
Challenges

F
Financial management
Financial protection
Financial protection strategy
Financial resilience
Financial support
Financial technology
Fiscal

G
Gross Domestic Products

I
Improving
Inter-government
Investment

P
Potential exposures
Private
Public

Q
Quantification

R
Recurrent
Regulatory
Risk

D
Damage potential estimation
Dedicated
Disaster
Disaster risk finance
Disaster Risk Reduction
Diversification

E
Earth observation
Earthquake
Earthquake loss

M
Medium
Mandatory

N
National strategy

S
SENDAI
SEADRIF
Sustainable Development Goals

U
Uncertainty
UNISDR
United Nation

Disaster Resilience: The preparedness of a community to mitigate future incidents by learning from past disasters. It involves pre- and post-disaster risk reduction strategies to minimize the impact of hazards.

Retrofitting: The process of modifying and strengthening existing infrastructure to make it more resistant to disasters, particularly earthquakes.

Seismic Sustainability: The state in which infrastructure and communities can withstand earthquake-induced damages, achieved through retrofitting, recovery, and reconstruction

Gross Domestic Product (GDP): The total value of goods and services produced in a country within a specific time frame. It is an important indicator of economic health.

Sustainable Development Goals (SDGs): A set of global goals endorsed by the United Nations to address various development challenges, including disaster resilience. SDGs aim to achieve specific targets by 2030.

Financial Resilience: The ability of individuals, households, businesses, and governments to withstand and recover from financial shocks caused by disasters.

Catastrophic Risk Pool: A mechanism that helps reduce insurance premiums by spreading the risk across a pool of participants, thus making insurance more affordable.

Earth Observation: The use of satellite and remote sensing technologies to gather data about the Earth's surface and atmosphere.

Inter-governmental Relations: Collaborative relationships between different levels of government to manage disaster risk and funding effectively.

Fiscal Management: The process of managing financial resources, including allocation,

utilization, and planning, to support disaster risk reduction.

Regulatory System: A framework of rules and regulations that govern financial flows, ensuring transparency and proper use of funds.

Intergovernmental Grants: Financial contributions from higher-level governments to lower-level governments for disaster risk management and reduction.

Fintech: Financial technology, which encompasses innovative technologies and solutions that enhance financial services.

Insurtech: Insurance technology that uses digital solutions to enhance insurance processes and services.

Own-Source Revenues: Financial resources generated by a government through taxes, fees, fines, and other sources.

Equity-Type Finance: Financial resources acquired through investments, shares, fixed and regular interest payments.

Risk Reduction: The process of minimizing the likelihood and impact of disasters through prevention, mitigation, and preparedness measures.

Resilient Infrastructure: Infrastructure designed and built to withstand and recover from the impacts of disasters, minimizing damage and disruptions.

Risk Assessment: The process of identifying potential hazards, vulnerabilities, and exposures to assess the financial impact of disasters.

Quantification: Measuring and estimating the financial impacts of disasters, including losses and damages.

Diversification: Spreading risk across different assets, locations, or sectors to minimize potential losses.

Sustainable Development: Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Emergency Response: Immediate actions taken to address the impacts of disasters and provide assistance to affected populations.

Risk Management: Strategies and measures to identify, assess, and mitigate risks, including financial risks associated with disasters

Suggestive questions:

MCQ questions carry one marks each

1. What does disaster resilience focus on?
   a) Predicting future incidents
   b) Learning from past disasters
   c) Ignoring past incidents
   d) Minimizing future hazards
2. Which type of expenditure includes operations and maintenance activities?
   a) Capital expenditure
   b) Recurrent expenditure
   c) Non-physical expenditure
   d) Financial expenditure
3. What is the main purpose of intergovernmental grants in disaster risk management?
   a) Generating revenue
   b) Allocating funds for relief efforts
   c) Strengthening financial resilience
   d) Collaborating between different levels of government
4. What is Fintech?
   a) Financial resilience strategy
   b) Earth observation technology
   c) Sustainable development goal
   d) Financial technology innovation
5. What does seismic sustainability aim to achieve?
   a) Rapid recovery after a disaster
   b) Elimination of all earthquake risks

c) Complete evacuation during earthquakes

d) Infrastructure resistant to earthquake damages

All short questions carry three marks each (short notes)

1. What are the approaches of DRR finance?
2. What are the advanced finance options for DRR?
3. What are those advanced techniques for financing DRR?
4. What is the financial technology for DRR? List the factors of DRR finance?
5. Explain the concept of disaster resilience and how it relates to pre- and post-disaster strategies.
6. Describe the role of financial resilience in disaster risk reduction and recovery.
7. What are the main components of a financial protection strategy against disasters? Provide examples.

All long questions carry ten marks each (essay type, logical analysis, inferring practical situation)

1. Financial management for DRR - special emphasis on earthquakes, landslides, and floods.
2. Discuss the challenges associated with accurately estimating earthquake damage potential. How can improved risk assessment contribute to better financial management of earthquake risks?
3. How does financial technology (Fintech) contribute to enhancing disaster risk reduction and financial resilience? Provide specific examples of how digital innovations are being used in disaster management.
4. Discuss the importance of sustainable development goals (SDGs) in the context of disaster risk reduction. How do these goals contribute to minimizing the economic impact of disasters?
5. Describe the factors that contribute to successful intergovernmental relations in disaster risk management. How can transparency, accountability, and cross-sector collaboration be promoted for effective disaster risk reduction?

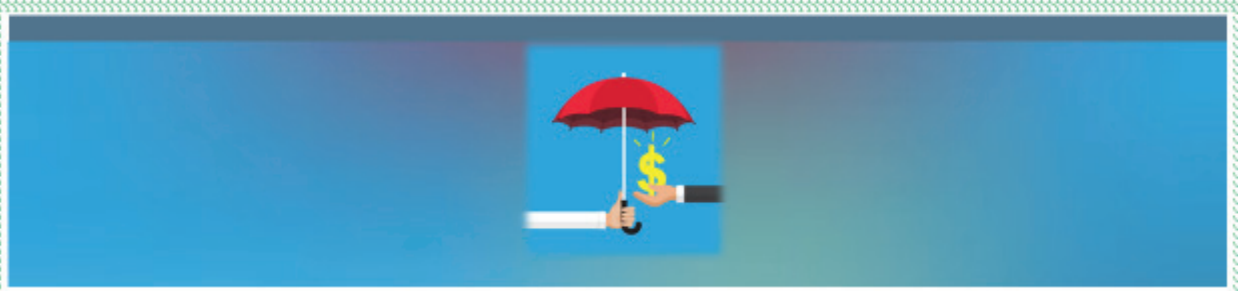
Suggestive PowerPoint slides for reference

Disasters and Financial Resilience

Achieving sustainable development goals for disaster risk reduction and resilient cities.

The Role of SDGs in Disaster Risk Reduction

The United Nations' Sustainable Development Goals (SDGs) have set a clear agenda for addressing the developmental backlog and building resilient communities worldwide. Specifically, SDGs 11 and 13 call for safe, resilient, and sustainable cities and human settlements, as well as integrated policies and plans for disaster risk reduction. These goals emphasize the importance of adopting a mitigation-focused development strategy and minimizing the loss of life, affected population, and direct economic impacts of disasters.

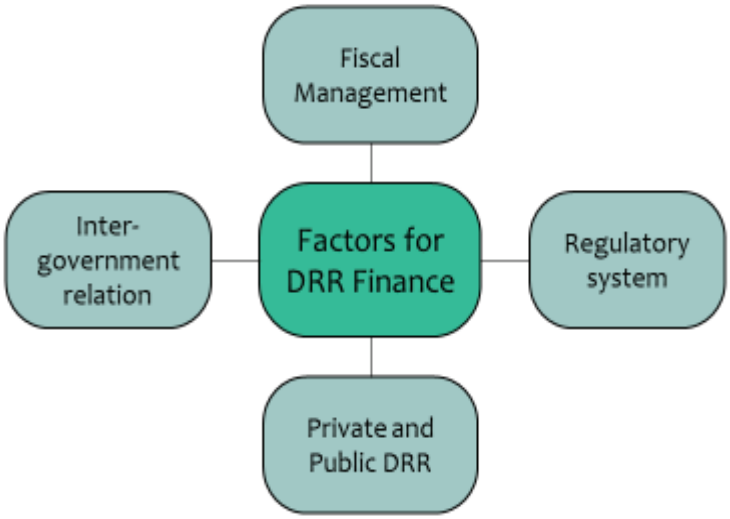


Financial Protection Strategy

Mitigation	Response	Recovery
Reducing disaster impact through prevention and preparedness.	Providing immediate financial aid and resources after a disaster.	Rebuilding and restoring communities after a disaster.

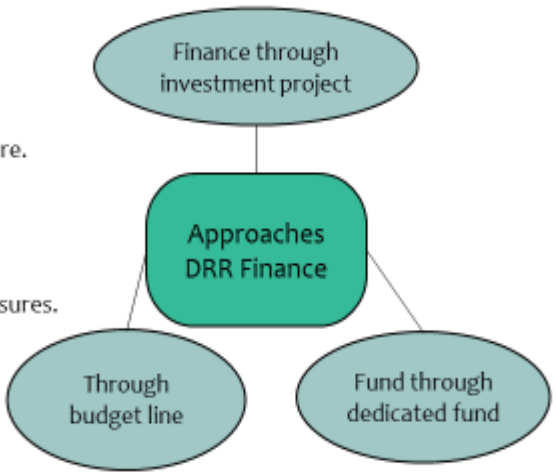
Factors for DRR Finance

- **Risk Assessment**
  Analyzing potential hazards and vulnerabilities.
- **Financing Mechanisms**
  Identifying appropriate funding sources and instruments.
- **Governance**
  Establishing policies and institutional frameworks.



Approaches to DRR Finance

1. **Risk Identification**
   Assessing hazards, vulnerabilities, and exposure.
2. **Risk Reduction**
   Implementing prevention and mitigation measures.
3. **Risk Transfer**
   Transferring risk through insurance and other mechanisms.



Types of DRR Finance

1. **Public Funding**
   Government budgets and international aid.
2. **Private Financing**
   Insurance, bonds, and other market-based instruments.
3. **Innovative Mechanisms**
   Catastrophe bonds, microinsurance, and risk pooling.

Financial Technology

Mobile Apps

Enabling access to financial services.

Blockchain

Improving transparency and efficiency.

Data Analytics

Enhancing risk assessment and decision-making.

Financial Support

1 **Preparedness**

Ensuring financial readiness for disasters.

2 **Response**

Providing immediate financial assistance.

3 **Recovery**

Enabling long-term financial resilience.

Financial Management of Earthquake Risk

Risk Assessment

Conduct detailed seismic hazard and risk assessments to understand the potential impact of earthquakes and inform financial planning.

Risk Transfer

Explore earthquake insurance, catastrophe bonds, and other risk transfer mechanisms to protect against the financial consequences of earthquakes.

Contingency Financing

Establish dedicated earthquake response funds and pre-arranged financing instruments to ensure the availability of immediate financial resources.

Fiscal Resilience

Strengthen public financial management and maintain fiscal reserves to enhance the government's ability to absorb and respond to earthquake-related financial shocks.

Conclusion

- Financial loss affects the economic growth whereas the death and affected population by disaster has to be minimized. Various strategy and approaches have been taken in concern. Financial resilience can be further strengthened through working together with other countries in collaboration.
- The national strategy, disaster risk finance and earth observation are the main financial protection strategy. Various factors have also discussed where it is observed regulatory system have maintain the financial flow.
- The improvement of financial strategy have also been done by computing actual expected loss and provides proper insurance policy.

SCIENCE AND TECHNOLOGY IN DISASTER MANAGEMENT

CHAPTER - 9
GIS in Disaster Management

Dr. D. Shanmugapriya

Total no of Hrs:- 5

I. Background of the topic:

Unanticipated or unprepared disasters can result in severe and enduring consequences, such as fatalities, property destruction, economic upheaval, health problems, and environmental harm. Advances in technology, especially Geographic Information Systems (GIS), have greatly enhanced disaster management capabilities. GIS supports disaster preparedness, response, and recovery by enabling spatial data visualization, analysis, and management. This includes mapping critical infrastructure, evacuation routes, and damage assessments. This chapter explores how GIS enhances the ability to effectively manage and respond to disasters, ultimately mitigating their impacts on communities and individuals.

II. Learning Outcomes:

1. Understand the role of GIS in Disaster Management.
2. Analyse how to use GIS to support disaster preparedness, response, and recovery efforts, including the creation of evacuation plans, risk assessments, and damage assessments.
3. Identify and differentiate various GIS tools and platforms for disaster Management.

III. Pedagogy:

i. Mode of Dealing with the Session:

1. Lecture and Demonstration

- Explain key GIS concepts and tools.

- Demonstrate tools: disaster mapping, evacuation planning, damage assessment, resource allocation, and risk assessment.
- Present real-life case studies.

2. **Interactive Session and Q&A**
   - Facilitate questions and discussions on GIS applications in disaster management.
   - Discuss challenges and solutions.
3. **Group Presentations**
   - Groups present their findings and strategies.
   - Discuss strengths and weaknesses.
4. **Activity-Based Learning**

ii. List of Materials Required:

1. Access to online GIS resources

iii. Handouts:

1. Case Studies

IV. Content on the topic

9.1 Geographic Information Systems

Geographic Information Systems (GIS) represent a technology that facilitates the collection, storage, manipulation, analysis, and visualization of spatial data. This technology has proven essential across numerous disciplines, including disaster management, and has experienced substantial growth over time.

Initially emerging in the 1960s for mapping and spatial analysis, GIS technology has since progressed with the development of advanced software and hardware. New types of data, such as satellite imagery and demographic information, were incorporated into GIS platforms. The 21st century has seen GIS evolve further with the emergence of cloud-based platforms, mobile applications, and the integration of real-time data streams from social media and sensors. These innovations enable disaster management professionals to access and deploy GIS tools in the field, supporting real-time decision-making.

GIS plays a crucial role in disaster risk reduction, with tools developed to evaluate and map hazards, vulnerabilities, and risks, thus aiding in devising and executing strategies for disaster

risk mitigation. The continuous evolution of GIS technology addresses the dynamic needs of disaster management professionals, allowing them to understand, respond to, and recover from disasters effectively. Given its expanding capabilities and applications, GIS is expected to play an increasingly significant role in disaster management in the future.

9.2 Disaster

A disaster is an unexpected and abrupt event that causes substantial harm or damage to individuals, communities, or the environment. Effective disaster management is crucial as it mitigates the adverse impacts on people, communities, and society and helps to minimize long-term consequences. Disasters can be classified into various categories, including Natural and Human-induced (Artificial or Anthropogenic) events. Fig. 1 below illustrates the different types of disasters.

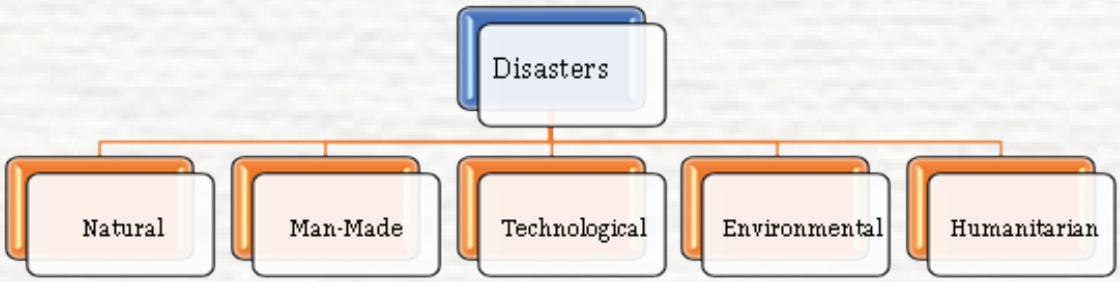


Fig. 1: Types of Disasters

Natural Disasters: Natural disasters are occurrences sparked by natural phenomena, encompassing earthquakes, hurricanes, tornadoes, floods, and wildfires.

Human-induced or Man-Made Disasters: These are incidents stemming from human activities, including chemical spills, nuclear mishaps, and deliberate acts of terrorism.

Technological Disasters: These disasters occur due to the breakdown of technological systems, such as power outages, computer system failures, and transportation mishaps.

Environmental Disasters: Environmental disasters are caused by environmental degradation and factors such as pollution, deforestation, and the overexploitation of natural resources.

Humanitarian Disasters: These disasters stem from humanitarian crises, including civil wars, famines, and epidemics, and can also be classified as health disasters.

Table 1 below outlines different types of disasters along with examples, impacts, and countermeasures:

Table 1: Types of disasters

Type of Disaster	Cause	Examples	Impact	Countermeasures
Natural Disasters	Natural phenomena	Earthquakes, hurricanes, tornadoes, floods, wildfires	Loss of life, property damage, and environmental destruction	Early warning systems, evacuation plans, and disaster-resistant infrastructure
Anthropogenic Disasters	Human activities	Chemical spills, oil spills, nuclear accidents, terrorism	Environmental pollution, health hazards, and economic loss	Regulation and monitoring, emergency response teams, and safety protocols
Technological Disasters	Failure of technological systems	Power outages, computer system failures, and transportation accidents	Disruption of services, economic loss, and potential loss of life	Redundant systems, regular maintenance, and emergency preparedness plans
Environmental Disasters	Environmental degradation	Pollution, deforestation, and overexploitation of natural resources	Long-term ecological damage, loss of biodiversity, and health issues	Sustainable practices, environmental regulations, and conservation efforts
Humanitarian Disasters	Humanitarian crises	Civil wars, famines, epidemics	Human suffering, displacement, and public health emergencies	Humanitarian aid, conflict resolution, and health interventions

9.3 Disaster Management

Disaster management is a critical endeavour, often exhibiting overlapping characteristics, and can stem from multiple causes. For instance, a hurricane can precipitate natural and environmental disasters by devastating ecosystems and infrastructure. Disasters profoundly and enduringly affect affected communities, resulting in loss of life, injuries, property and infrastructure damage, and disruptions to vital services such as water, electricity, and transportation. Moreover, disasters exert significant economic repercussions, including

income loss, business and industry damages, and increased need for emergency and recovery services. They also impose psychological and social burdens on affected communities, causing stress, anxiety, and trauma, all of which require effective management.

Technology is pivotal in disaster management, providing essential tools and systems to alleviate the impacts of disasters and facilitate swift recovery endeavours. Among these technologies, Geographic Information Systems stands out for its utility in disaster management (Tomaszewski, 2020). The ensuing section expounds on how GIS contributes to managing diverse disaster categories.

9.4 GIS for Natural Disaster Management

GIS is crucial in managing natural disasters. They enable the creation of maps and visualizations that depict a disaster's location, scale, and impact, along with available resources for response. GIS facilitates various disaster management tasks:

- **Planning and preparedness**: GIS aids in mapping potential disaster impacts like flooding or hurricanes, identifying vulnerable areas, and formulating emergency plans and resource allocation strategies.
- **Response and recovery**: During a disaster, GIS helps track resource movement, such as emergency teams, and pinpoints areas requiring immediate assistance. It also produces damage extent maps, guiding response prioritization efforts.
- **Long-term recovery**: Post-disaster, GIS assists in damage assessment, devising rebuilding plans, and monitoring recovery progress.

GIS for Human-induced Disaster Management

GIS serves as an invaluable tool for managing human-induced disasters, offering various functionalities:

- **Hazard identification and mapping**: GIS identifies and maps areas susceptible to human-induced disasters like chemical/oil spills or industrial accidents. This data informs emergency response plans and facilitates the evacuation of vulnerable populations.
- **Disaster tracking and forecasting**: GIS tracks disasters in real-time, forecasting potential impacts. This aids emergency responders in prioritizing efforts and allocating resources efficiently.
- **Coordination of response efforts**: GIS coordinates efforts among various agencies and organizations involved in responding to human-induced disasters. It also facilitates

communication with affected communities, providing essential information and resources.

- **Assessment and rebuilding post-disaster**: GIS assesses damage caused by human-induced disasters, aiding in planning, rebuilding and recovery efforts. It monitors progress and identifies additional needs as they arise.

GIS's real-time information, coordination of response efforts, and assistance in planning for recovery make it indispensable in managing human-induced disasters.

9.5 GIS for Technological Disaster Management

GIS proves highly beneficial in handling technological disasters, including cyberattacks, power interruptions, network breakdowns, and software malfunctions. GIS aids in pinpointing the disaster's location, scope, and potential impacts on individuals, infrastructure, and the environment.

For instance, GIS maps affected systems and networks during a cyber-attack, prioritizing critical assets for protection or restoration. During power failures, GIS detects the affected regions and locates backup generators or emergency energy resources.

A primary function of GIS in handling technological failures lies in its capability to visualize and analyse spatial statistics. This functionality empowers the responders to discover impacted regions and devise the most efficient responses rapidly. GIS additionally tracks disaster response and evaluates response effectiveness.

Moreover, past mapping affected regions, GIS identifies inclined populations like the aged or differently abled, devising evacuation routes and emergency shelters. It analyses the ability influences on critical infrastructures and essential services, helping in repair and recovery planning.

9.6 GIS for Health Disaster Management

For managing health Disasters, GIS is established as a potential device that integrates spatial and non-spatial data. The following are the unique applications of GIS in health disaster management:

Mapping distribution of disease: The spreading of disease and pinpointing the areas of its high occurrence are mapped with the assistance of GIS.

Hazard factors Identification: Identification of threat factors associated with unique illnesses, inclusive of environmental conditions or at-risk populations, is facilitated by GIS.

Planning and coordinating response efforts: GIS helps in planning and coordinating response team efforts, together with resource deployment and setting up quarantine zones, to ensure efficient handling of the disasters.

Response effectiveness monitoring: GIS assists in monitoring the effectiveness of response, which is vital to optimize the management of health disasters.

9.7 GIS for Environmental Disaster Management

GIS is important for the management of environmental hazards because it effectively integrates, analyses, and visualizes spatial information. This enables a comprehensive understanding of the impact of a disaster on a specific location and facilitates informed decision-making regarding response strategies. Some of the significant GIS applications towards Environmental disaster management are as follows:

Disaster magnitude and scale mapping: GIS enables the creation of complex maps of the affected area, showing the location, range, and associated damage.

Disaster Impact Assessment: GIS facilitates the assessment of disaster spatial patterns, the identification of severely damaged areas, and the guidance of prioritization efforts.

Potential hazard identification: GIS helps identify potential hazards in the affected area, such as areas prone to floods or landslides, so that mitigation strategies can be developed.

Response effort planning and coordination: GIS supports the planning and coordination of response efforts, including resource and personnel deployment, and enables real-time progress monitoring.

9.8 GIS for Humanitarian Disaster Management

GIS is an inestimable asset in humanitarian disaster management, providing decision-makers with real-time data analysis and visualization capabilities. This helps to understand the situation and develop a tailored plan for an appropriate response that meets the specific needs of the affected population.

GIS facilitates disaster area mapping and visualization and enables decision-makers to capture the location, severity, and impact on the environment and community. For example, GIS identifies areas most affected by disasters, with large numbers of people displaced or inadequate access to basic resources such as food, water, and shelter. This information guides prioritization and response planning efforts.

In addition, GIS tracks the movement of personnel, equipment, and supplies during disaster management and recovery. This assures the best use of resources and highlights operational limitations or difficulties that may occur in the process.

9.9. Enhancing Disaster Management Cycle with GIS

The disaster management cycle encompasses four primary phases: Preparedness, Response, Recovery, and Mitigation. Fig. 2 delineates the phases of the disaster management cycle.

Fig 2: Phases of Disaster Management Cycle

The subsequent section elucidates the application of GIS in overseeing the disaster management life cycle.

The use of GIS to manage the disaster management cycle includes four different phases.

Preparedness: This initial phase includes strategies aimed at preparing for potential disasters, including emergency planning, emergency responder training, and resource management. GIS plays an important role in identifying potential hazards, assessing various vulnerabilities, and developing mitigation strategies for hazard occurrence (Briggs, Forer, Järup, & Stern, 2002).

Response: Emergency measures in the post-disaster management phase include evacuation, emergency medical services, and rescue operations. GIS facilitates the identification of individuals in need, tracking emergency responders' movements, and optimizing resource allocation.

Recovery: This category focuses on efforts to restore such post-disaster conditions, including infrastructure rehabilitation, financial assistance to victims, and managing sustainable needs. GIS helps to map the extent of damage, identify areas of need, and coordinate the efforts of various stakeholders in the recovery process.

Mitigation: This phase includes measures to reduce potential or future risks. These actions include the use of building codes to increase the capacity of buildings, the adoption of regulations to better manage land use, and the improvement of basic infrastructure. GIS assists in identifying high-risk areas for future disasters and formulating strategies to mitigate such risks.

Fig. 3 illustrates how GIS is applied throughout the disaster management cycle.

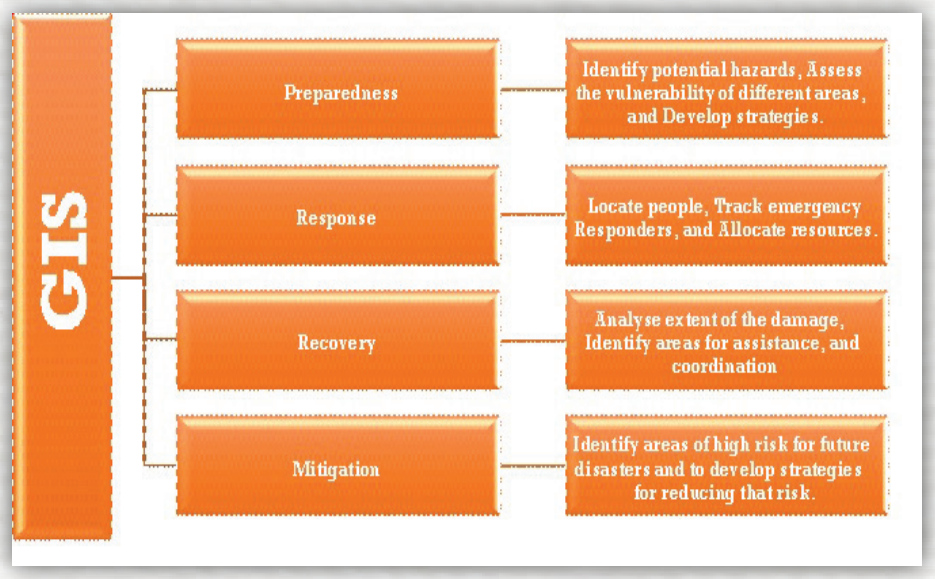


Fig. 3: Application of GIS throughout the disaster management cycle

9.10 GIS Tools for Managing the Disasters

- **Disaster mapping tools:** These tools enable the creation of maps illustrating the extent and location of a disaster, along with its impact on infrastructure and buildings. These maps facilitate the identification of areas requiring assistance and the monitoring of recovery progress.
- **Evacuation route planning tools:** These tools facilitate creating and disseminating evacuation routes and emergency plans to ensure safe evacuation from disaster-prone areas.
- **Damage assessment tools**: These tools assist in evaluating the extent and nature of damage following a disaster, aiding in prioritizing recovery efforts and resource allocation.
- **Resource allocation tools**: These tools facilitate the allocation of resources such as emergency personnel, supplies, and equipment to the most critical areas during a disaster.
- **Risk assessment tools**: These tools facilitate the evaluation of the probability and potential

consequences of different disasters within a defined geographical area. This information aids in identifying high-risk areas and developing strategies to mitigate future disaster risks.

These GIS tools collectively contribute to effective disaster management by providing essential data and facilitating informed decision-making processes.

9.11 Commercial and Open-Source GIS Tools and Platforms

Various disaster management tools and platforms are available, encompassing commercial and open-source options. These tools facilitate various tasks, including mapping, spatial analysis, and data management. Below are examples of such tools and platforms:

Table 2: Brief description of common GIS tools

1	**ArcGIS**: Developed by Esri, ArcGIS is a commercial GIS platform offering tools for map creation, analysis, and spatial data management. It includes features tailored for disaster mapping and spatial analysis (Maguire, 2008).	ArcGIS
2		**QGIS**: As an open-source GIS platform, QGIS provides various mapping and analysis tools suitable for disaster mapping tasks. It offers capabilities for creating and analyzing spatial data.
3	**OpenStreetMap (OSM)**: OSM is a collaborative, open-source world map. It serves as a valuable resource for disaster mapping and offers tools for spatial data creation and analysis.	
4		**Google Maps**: Google Maps is widely employed for diverse mapping needs and provides various tools for map generation, visualization, and analysis. It can effectively serve disaster mapping requirements and spatial data analysis tasks.

5	**Disaster AWARE**: This platform delivers real-time information about disasters and their ramifications, aiding entities responsible for emergency management in tracking and responding to disasters.	DISASTERAWARE
6		**Google Earth Pro**: Offering satellite imagery, maps, and 3D terrain visualization, Google Earth Pro enables users to assess disaster impacts, plan evacuation routes, and create disaster maps.
7	**Insafe**: Specifically designed for disaster risk assessment and emergency planning, Insafe assists in evaluating potential disaster impacts, formulating emergency plans, and resource allocation.	
8		**Geonode**: An open-source platform for disseminating geospatial data and maps, Geonode facilitates hazard mapping, vulnerability assessment, and disaster mitigation strategy development.
9	**Mapbox**: A cloud-based platform for custom map creation and sharing, Mapbox offers mapping, analysis, and data management tools suitable for disaster mapping and impact assessment.	

These GIS tools and platforms play critical roles across the disaster management lifecycle, from risk assessment and preparedness to response and recovery efforts. They enable effective spatial data management, analysis, and visualization, enhancing decision-making processes in disaster management contexts.

The table 2 summarizes various GIS tools, their descriptions, and applications in disaster management.

Table 3: Summary of Commercial and Open-Source GIS Tools and Their Applications

GIS Tools	Description	Applications
ArcGIS	Commercial GIS platform developed by Esri, offering map creation, analysis, and spatial data management tools.	- Disaster mapping - Spatial analysis - Data management
QGIS	Open-source GIS platform providing mapping and analysis tools suitable for disaster mapping tasks.	- Disaster mapping - Spatial data creation and analysis
Open Street Map (OSM)	Collaborative, open-source map of the world, serving as a resource for disaster mapping and spatial data analysis.	- Disaster mapping - Spatial data creation and analysis
Google Maps	Widely used online mapping platform offering tools for map creation, visualization, and analysis.	- Disaster mapping - Visualization of spatial data - Analysis of geographic information
Disaster AWARE	A platform that delivers real-time information about disasters and their ramifications, aiding in disaster tracking and response.	- Real-time disaster tracking - Impact assessment - Emergency response planning
Google Earth Pro	Software for satellite imagery, maps, and 3D terrain visualization, enabling assessment of disaster impacts and planning evacuation routes.	- Disaster impact assessment - Evacuation route planning - Disaster mapping
Insafe	GIS tool tailored for disaster risk assessment and emergency planning, facilitating impact evaluation, emergency planning, and resource allocation.	- Disaster risk assessment - Emergency planning - Resource allocation
GeoNode	Open-source platform for disseminating geospatial data and maps, supporting hazard mapping, vulnerability assessment, and disaster mitigation strategy development.	- Hazard mapping - Vulnerability assessment - Disaster mitigation strategy development
Map box	Cloud-based platform for creating and sharing custom maps, offering mapping, analysis, and data management tools suitable for disaster mapping and impact assessment.	- Custom map creation - Mapping analysis - Data management

9.12 Limitations of Using GIS in Disaster Management

While GIS provides substantial benefits for disaster management, several limitations should be taken into account:

1. **Data Availability**: The effective use of GIS depends on high-quality data, which can be challenging to obtain accurately and promptly during a disaster.

2. **Data Accuracy**: Available data may not always be reliable due to factors such as outdated maps or erroneous data inputs, compromising the reliability of GIS analyses.
3. **Data Integration:** GIS depends on amalgamating multiple data sources, which can be challenging to synchronize and harmonize effectively.
4. **Data Security**: Ensuring the security of sensitive data, including personal information, is a significant concern when deploying GIS in disaster management.

Despite these constraints, GIS remains a potent tool for disaster management. When applied appropriately, it offers invaluable insights and amplifies the efficacy of organizational responses to disasters.

9.13 Conclusion

GIS is indispensable in disaster management, offering a platform to organize, analyse, and portray geographic data. GIS empowers emergency responders and decision-makers to evaluate situations and make well-informed decisions swiftly. It helps identify risk areas, assess disaster impacts, plan and coordinate responses, and track the movement of people, resources, and equipment. Additionally, GIS aids in communicating information to the public and stakeholders. By analysing past disasters and predicting future impacts, GIS supports planning and preparedness efforts, ultimately reducing the effects of future disasters. Thus, GIS provides crucial tools and data for effective disaster response and mitigation.

9.14 Case Studies

Case Study 1: Use of GIS during the Kerala floods in 2018

This case study illustrates the utilization of Geographic Information Systems (GIS) in managing natural disasters, exemplified by the flood disaster in Kerala, India, in 2018. Following heavy monsoon rains in August 2018, Kerala faced extensive flooding, displacing over one million people and causing significant financial losses. The Kerala government utilized GIS to evaluate damage, coordinate response endeavours, and devise plans for recovery and reconstruction (Joy, Kanga, & Singh, 2020; Geospoc.com, n.d.). GIS facilitated the creation of precise maps pinpointing damaged roads, bridges, and infrastructure, prioritizing the distribution of emergency supplies to the worst-hit areas. Furthermore, GIS tracked the movement of emergency response teams and coordinated efforts among governmental agencies and NGOs, enhancing response efficiency and effectiveness. Post-response, GIS evaluated the disaster's long-term impact and assisted in prioritizing resources for rebuilding homes and infrastructure in the most affected regions. In conclusion, GIS played a pivotal

role in effectively managing the flood disaster in Kerala, contributing to life-saving measures, alleviating suffering, and facilitating recovery and reconstruction efforts.

Case study 2: Use of GIS to manage COVID-19 in India

This case study outlines the utilization of Geographic Information Systems (GIS) in managing the COVID-19 pandemic in India:

Tracking COVID-19 Spread: To monitor the nationwide spread of the virus, the Indian government extensively utilized GIS. The Ministry of Health and Family Welfare (MoHFW) developed an interactive map that is accessible through its website. This map provides real-time updates on the distribution of confirmed cases, active cases, recoveries, and deaths across the country.

Analysing Risk Factors: GIS facilitated the analysis of COVID-19 transmission risk factors in India. The Indian Institute of Technology (IIT) Delhi researchers utilized GIS to correlate population density with transmission rates, aiding in resource prioritization and intervention strategies in high-risk regions.

Planning and Coordination: GIS-supported response planning and coordination efforts. The Indian Council of Medical Research (ICMR) utilized GIS to pinpoint quarantine facilities, hospitals, and testing centres nationwide, facilitating medical personnel and supply deployment. Additionally, a dashboard was created to monitor hospital bed availability, ensuring patients' access to necessary care.

Public Communication: GIS tools were instrumental in conveying pandemic-related information to the public (Meer & Mishra, 2021). The MoHFW's dashboard displayed state and district-wise data on confirmed cases, recoveries, deaths, testing rates, and healthcare facility bed availability, enhancing transparency and public awareness. GIS tools were also used to analyse pre-lockdown, lockdown, and unlock phases (Gangwar & Ray, 2021).

GIS emerged as a pivotal tool in managing the COVID-19 pandemic in India, enabling effective tracking of virus spread, risk analysis, response planning and coordination, and public information dissemination.

Suggested Activities

Activity 1:

Explore the diverse roles of GIS in disaster management by conducting exhaustive research and utilizing the resources available from government agencies, academic publications, and

industry articles. Create an inventory of GIS applications in disaster management with the collected information.

Activity 2:

Select a specific disaster scenario (a natural calamity, technological mishap, or humanitarian crisis) and investigate the utilization of GIS in response and recovery efforts. Explore how GIS tools and techniques were applied to address challenges and aid in decision-making during the disaster event.

Activity 3:

Craft a comprehensive report elucidating the pivotal role of GIS in disaster management. Describe the diverse applications of GIS, providing examples of its implementation in the chosen disaster scenario. Highlight the significance of GIS in enhancing response and recovery endeavours, emphasizing its contribution to informed decision-making and overall effectiveness in disaster management efforts.

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Glossary

Disaster: An unpredictable event that results in destruction, devastation, or loss of life.

Disaster management: The process of the activities that are undertaken to prepare for and respond to disasters

GIS: The computer systems or devices that enable geographic information to be processed, analysed, and visualized.

Spatial data: Data associated with a specific location or area.

Risk assessment: The process of assessing the likelihood and impact of a risk.

Hazard Mapping: The creation of a map illustrating the locations and hazards of an area.

Vulnerability mapping: Creating a map of high-risk areas or populations.

Response planning: The process of developing and implementing a plan to respond to a disaster.

Recovery planning: The process of developing and implementing a plan to rebuild and recover after a disaster.

Suggestive questions:

MCQ questions carry one marks each

1. GIS stands for

   A) Generic Information System B) Geographic Information Systems

   C) Geological Information System D) Geographic Information Sharing

2. GIS deals with which kind of data

   A) Numeric data B) Binary data

   C) Spatial data D) Complex data

3. Which of the following is NOT a factor that GIS can be used to analyze when creating evacuation routes?

   A) Road networks B) Traffic patterns

   C) Population density D) Topography

4. Which one of the following is not a Natural Disaster?

   A) Volcano eruption B) Flood

   C) Nuclear Accidents D) Tsunami

5. Which of the following tools helps to prioritize recovery efforts and allocate resources to the areas that need them most?

   A) Disaster mapping tools B) Evacuation route planning tools

   C) Damage assessment tools D) Resource allocation tools

6. Choose the software program that allows users to view satellite imagery, maps, and 3D terrain of the Earth.

   A) ArcGIS B) QGIS

   C) Google Earth Pro D) Insafe

7. Which of the following is an open-source GIS platform that can be used for a variety of mapping tasks, including disaster mapping?

   A) ArcGIS B) QGIS

   C) Google Earth Pro D) Insafe

8. Which of the following is a cloud-based platform for creating and sharing custom maps?

   A) Map Box B) QGIS

   C) Google Earth Pro D) Insafe

9. Which of the following tools allows users to assess the likelihood of different disasters occurring in each area and the potential impact of those disasters?

   A) Disaster mapping tools B) Evacuation route planning tools

   C) Damage assessment tools D) Risk Assessment tools

10. In which phase of Disaster Management can GIS be used to locate people needing assistance, track emergency responders' movement, and allocate resources to where they are needed most?

    A) Preparedness B) Response

    C) Recovery D) Response

All short questions carry three marks each (short notes)

1. Discuss Geographic Information Systems for managing Natural disasters
2. Write a short note on managing the life cycle of disaster management with GIS

All long questions carry ten marks each (essay type, logical analysis, inferring practical situation)

1. Reflect on the limitations of GIS in disaster management. Are there any challenges or limitations to using GIS in this field? How can these challenges be addressed?
2. Elaborate on GIS Tools for Managing the Disasters.

Suggestive PowerPoint slides for reference

GIS IN DISASTER MANAGEMENT

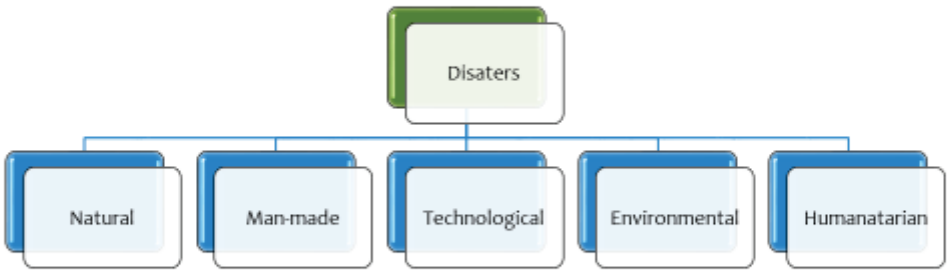
Learning Outcomes:

1. Understand the role of GIS in Disaster Management.
2. Analyse how to use GIS to support disaster preparedness, response, and recovery efforts, including the creation of evacuation plans, risk assessments, and damage assessments.
3. Identify and differentiate various GIS tools and platforms for disaster Management

Geographic Information Systems (GIS)

- Technology that facilitates the collection, storage, manipulation, analysis, and visualization of spatial data.
- One of the earliest forms of GIS was developed in the 1960s
  - In the following decades, the technology continued to evolve, with the development of more sophisticated software and hardware and the integration of new types of data, such as satellite imagery and demographic data
- Used increasingly in disaster risk reduction, with the development of tools that can be used to assess and map hazards, vulnerabilities, and risks, as well as to support the planning and implementation of disaster risk reduction measures.

Disaster Types



Type of Disaster	Cause	Examples	Impact	Countermeasures
Natural Disasters	**Natural phenomena**	**Earthquakes, hurricanes, tornadoes, floods, wildfires**	**Loss of life, property damage, environmental destruction**	**Early warning systems, evacuation plans, disaster-resistant infrastructure**
Anthropogenic Disasters	Human activities	Chemical spills, oil spills, nuclear accidents, terrorism	Environmental pollution, health hazards, economic loss	Regulation and monitoring, emergency response teams, safety protocols
Technological Disasters	Failure of technological systems	Power outages, computer system failures, transportation accidents	Disruption of services, economic loss, potential loss of life	Redundant systems, regular maintenance, emergency preparedness plans
Environmental Disasters	Environmental degradation	Pollution, deforestation, overexploitation of natural resources	Long-term ecological damage, loss of biodiversity, health issues	Sustainable practices, environmental regulations, conservation efforts
Humanitarian Disasters	Humanitarian crises	Civil wars, famines, epidemics	Human suffering, displacement, public health emergencies	Humanitarian aid, conflict resolution, health interventions

Phases of Disaster Management Cycle

Application of GIS throughout the disaster Management cycle

GIS Tools	Description	Applications
ArcGIS	**Commercial GIS platform developed by Esri, offering map creation, analysis, and spatial data management tools.**	**- Disaster mapping - Spatial analysis - Data management**
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Google Maps	Widely-used online mapping platform offering tools for map creation, visualization, and analysis.	- Disaster mapping - Visualization of spatial data - Analysis of geographic information
DisasterAWARE	A platform that delivers real-time information about disasters and their ramifications, aiding in disaster tracking and response.	- Real-time disaster tracking - Impact assessment - Emergency response planning

Limitations on using GIS in Disaster Management

- Data availability
- Data Accuracy
- Data integration
- Data security

GIS Tools	Description	Applications
Google Earth Pro	**Software for satellite imagery, maps, and 3D terrain visualization, enabling assessment of disaster impacts and planning evacuation routes.**	**- Disaster impact assessment - Evacuation route planning - Disaster mapping**
InaSAFE	GIS tool tailored for disaster risk assessment and emergency planning, facilitating impact evaluation, emergency planning, and resource allocation.	- Disaster risk assessment - Emergency planning - Resource allocation
GeoNode	Open-source platform for disseminating geospatial data and maps, supporting hazard mapping, vulnerability assessment, and disaster mitigation strategy development.	- Hazard mapping - Vulnerability assessment - Disaster mitigation strategy development
Mapbox	Cloud-based platform for creating and sharing custom maps, offering mapping, analysis, and data management tools suitable for disaster mapping and impact assessment.	- Custom map creation - Mapping analysis - Data management

CHAPTER – 10

Remote Sensing in Disaster Management

Dr. Nidhi Yadav & Ms. Ritika, and Mr. Nakul Yadav

Total No. of Hours: 4

Background of the Topic:

Disasters are a harsh reality of our planet. From floods and earthquakes to wildfires and hurricanes, they cause immense damage to life, property, and infrastructure. However, technology offers a powerful tool in mitigating these effects: remote sensing. By utilizing data collected from satellites and aerial platforms, we can gain valuable insights before, during, and after disasters, enabling better preparedness, response, and recovery efforts.

Learning Outcomes:

- Understanding the principles and applications of remote sensing technologies in disaster management.
- Identifying the types of disasters that can be monitored using remote sensing techniques, such as earthquakes, floods, fires, landslides, droughts, etc.
- Familiarizing oneself with different satellite sensors used for monitoring disasters, including optical (visible light), thermal, radar, and microwave sensors.
- Applying remote sensing data products and tools to make informed decisions about emergency response strategies, relief efforts, rescue operations, and recovery plans.

Session Methodology:

i. Mode of Dealing of the Session

- Interactive lecture with presentations and discussions
- Group activities and case studies
- Hands-on experience with analysing remote sensing data (if possible)

ii. Pedagogy

- Learner-centered approach, encouraging active participation
- Use of visuals and multimedia to enhance understanding
- Real-world examples and case studies to illustrate concepts

iii. Handouts

- A comprehensive handout summarizing key points, concepts, and resources
- Glossary of relevant terms in remote sensing and disaster management

IV. Content on the topic:

10.1 What is Remote Sensing?

Remote sensing, a term that once conjured images of science fiction, is now a cornerstone of modern data collection and environmental monitoring. It's a fascinating process that allows us to gather information about objects or phenomena from a distance, without making physical contact. This technology has revolutionized the way we understand and interact with our planet.

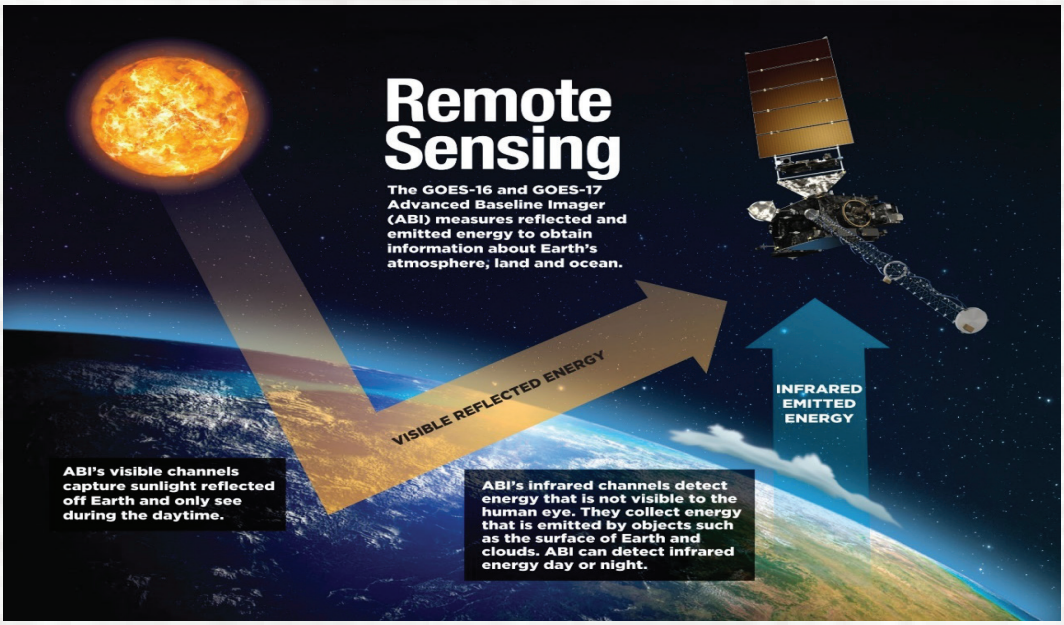

Fig. 1: The GOES-16 and GOES-17 Advanced Baseline Imager (ABI) measures reflected and emitted imagery to obtain information about Earth's land, atmosphere, and ocean.

(Source:https://www.goesr.gov/imagesContent/featureStories/transformingEnergy/RemoteSensing.jpg)

At its core, remote sensing involves capturing data about the Earth's surface using sensors mounted on various platforms such as airplanes, satellites, and drones. These sensors collect information by detecting the energy that is naturally emitted or reflected by objects. The data collected can be in the form of images, readings, or signals, which are then processed and analysed to extract valuable information about the Earth's surface and atmosphere.

- Airplanes equipped with sensors have been used for decades to collect high-resolution data over specific areas.
- Satellites, on the other hand, provide a broader perspective. They orbit the Earth, capturing data over vast areas, which is invaluable for global monitoring tasks such as climate change studies, deforestation tracking, and disaster management.
- Drones, or Unmanned Aerial Vehicles (UAVs), have emerged as a versatile platform for remote sensing. They can be deployed quickly and manoeuvred precisely, making them ideal for tasks that require high-resolution data over smaller, targeted areas. By combining aerial, satellite, and drone data, researchers can gain a comprehensive understanding of environmental patterns and changes. Remote sensing data is also instrumental in developing better Geographic Information Systems (GIS), which serve as powerful tools for decision-making and policy formulation.

10.2 Remote Sensing Techniques

Remote sensing has revolutionized the way we collect information and has applications in areas such as meteorology, geology, forestry, and urban planning.

10.2.1 Electromagnetic Spectrum in Remote Sensing

The electromagnetic spectrum is the range of all types of electromagnetic radiation. Radiation is energy that travels and spreads out as it goes – visible light that comes from a lamp in your house or radio waves that come from a radio station are two types of electromagnetic radiation. In remote sensing, sensors mounted on satellites or

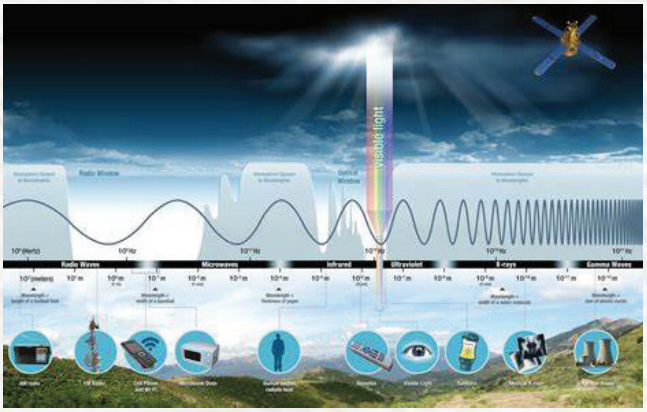

Fig. 2: Electromagnetic Spectrum

(Source: https://www.cdc.gov/radiation-health/about/electromagnetic-spectrum.html)

aircraft capture this energy, which is then used to analyse various characteristics of the Earth's surface.

Different wavelengths of the electromagnetic spectrum provide different information. For example, visible light can help identify vegetation cover, while infrared can be used to map heat variations in the environment.

10.2.2 Passive vs. Active Sensors

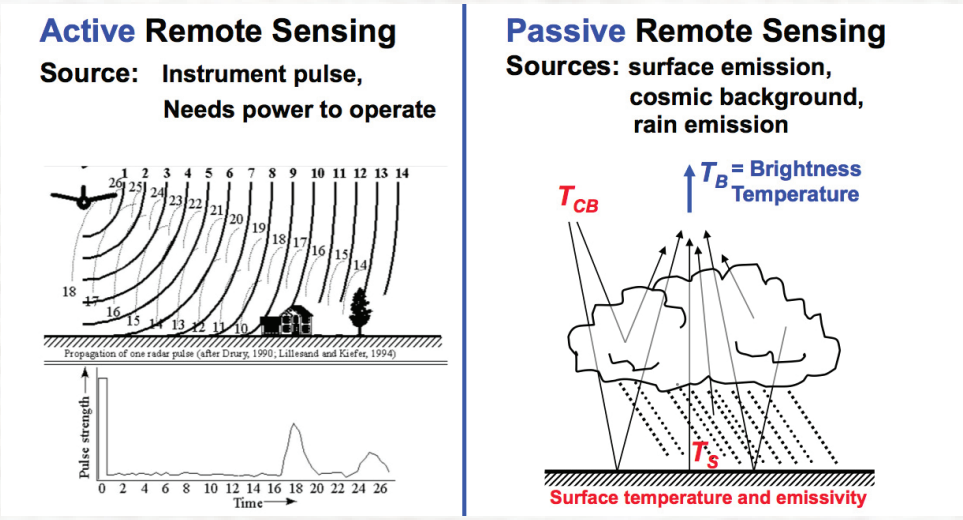

Fig. 3: Fundamentals of remote sensing

(Source:https://gpm.nasa.gov/sites/default/files/imageGallery/remote_sensing_diagram_0.jpg)

Passive sensors detect natural energy that is reflected or emitted from the Earth's surface. The most common source of radiation detected by passive sensors is sunlight. These sensors can only be used to collect data during the daytime when the sun is shining, or if the observed object emits its energy, as in the case of thermal energy.

Active sensors, on the other hand, provide their energy source for illumination. The sensor emits radiation, which is directed toward the target to be investigated. The radiation reflected from that target is detected and measured by the sensor. Technologies like LiDAR (Light Detection and Ranging) and Radar (Radio Detection and Ranging) are examples of active remote sensing where the time delay between emission and return is measured, establishing the location, speed, and direction of an object.

10.3 TYPES OF REMOTE SENSING

Remote sensing technology has revolutionized the way we observe and understand our planet. By capturing data from above, we can analyse the Earth's surface without being

physically present. This technology has applications in numerous fields, from environmental monitoring to urban planning. Let's dive into the main types of remote sensing data and their sources.

Optical Imagery

Optical imagery is perhaps the most well-known type of remote sensing data. It includes:

- **Multispectral Imagery**: This captures light across multiple spectral bands, including both visible and near-infrared wavelengths. It's widely used in agriculture to monitor crop health, in environmental science to study vegetation, and in oceanography to measure water quality.

- **Hyperspectral Imagery**: With the ability to capture hundreds of spectral bands, hyperspectral imaging provides a more detailed view. It's particularly useful for identifying minerals, detecting pollutants, and classifying vegetation types.

Radar Imagery

Radar remote sensing uses radio waves to capture images. This method is not dependent on sunlight, which means it can collect data day or night, regardless of weather conditions. It's especially useful for:

- Penetrating cloud cover, which is invaluable in regions with frequent cloudiness.

- Observing changes in Earth's surface, such as deforestation or urban expansion.

- Monitoring soil moisture levels, aiding in flood prediction and agriculture.

Satellites such as the Synthetic Aperture Radar (SAR) on board the Sentinel-1 mission are primary sources of radar imagery.

LiDAR (Light Detection and Ranging)

LiDAR is a powerful tool that uses laser pulses to measure distances. It creates highly accurate 3D models of the Earth's surface, which are essential for:

- Mapping topography and understanding geological features.

- Assessing forest biomass and structure, crucial for carbon storage studies.

- Urban modelling, including infrastructure planning and noise pollution mapping.

Airborne platforms, such as those used by the NASA Airborne Topographic Mapper, are common sources of LiDAR data.

Applications of Remote Sensing in Disaster Management: Pre-Disaster Risk Reduction with Remote Sensing. Disasters may seem sudden and unpredictable, but remote sensing offers a powerful tool to proactively reduce risks before they strike. Here's how:

10.4 Identifying Vulnerable Areas:

- **Flood Prone Areas:** By analysing elevation data (topography) from satellites, we can identify low-lying areas and historical floodplains susceptible to inundation during heavy rains.
- **Landslide Susceptibility:** Satellite imagery can reveal areas with steep slopes, unstable soil composition, and sparse vegetation cover – all factors increasing landslide risks. Additionally, radar data can detect subtle ground movements indicating potential landslide triggers.
- **Wildfire Risk Mapping:** Remote sensing helps assess vegetation health and dryness. By analysing long-term data on these factors, we can identify areas with a higher risk of wildfires. Land cover data also helps understand how fire might spread based on the presence of flammable materials.

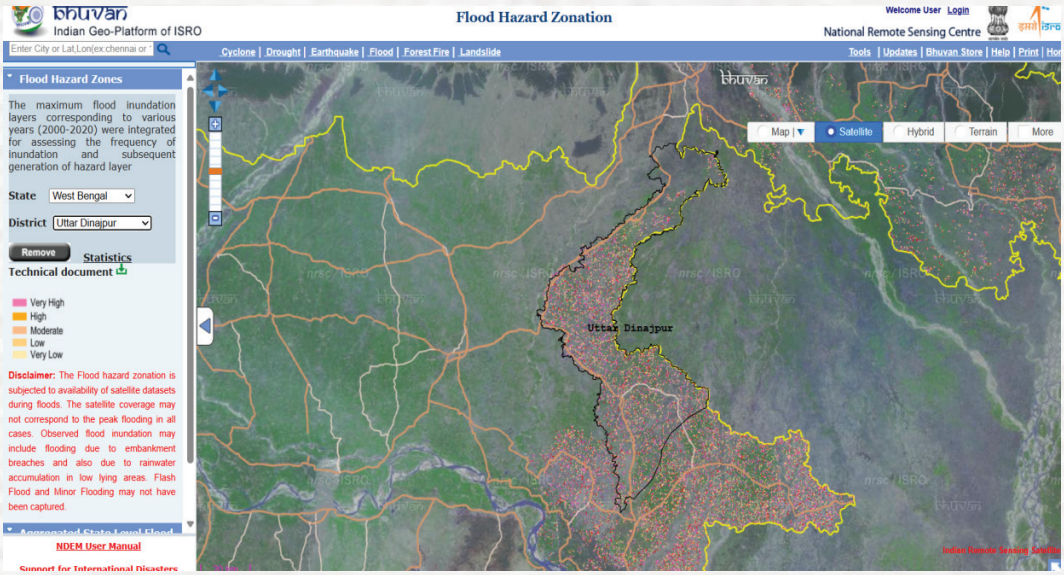

Fig. 4: Flood hazard zonation of Uttar Dinajpur district *(Source: Bhuvan. NRSC)*

Example: Mapping Flood Risk Zones

Using remote sensing data, we can create a flood risk map. This map would combine:

- High-resolution topographic data (like LiDAR) to show precise elevations across the city.
- Historical flood data to identify areas previously inundated during heavy rainfall.

- Land cover data to differentiate between built-up areas, vegetation, and water bodies.

By analysing this data, we can identify low-lying neighbourhoods and critical infrastructure most vulnerable to flooding. This information is crucial for:

- Urban planning and development, ensuring new construction avoids high-risk zones.
- Implementing flood mitigation strategies like building levees or drainage channels.
- Public awareness campaigns to educate residents about flood risks and preparedness measures.

10.5 Monitoring Land Use Changes and Deforestation for Disaster Risk Reduction

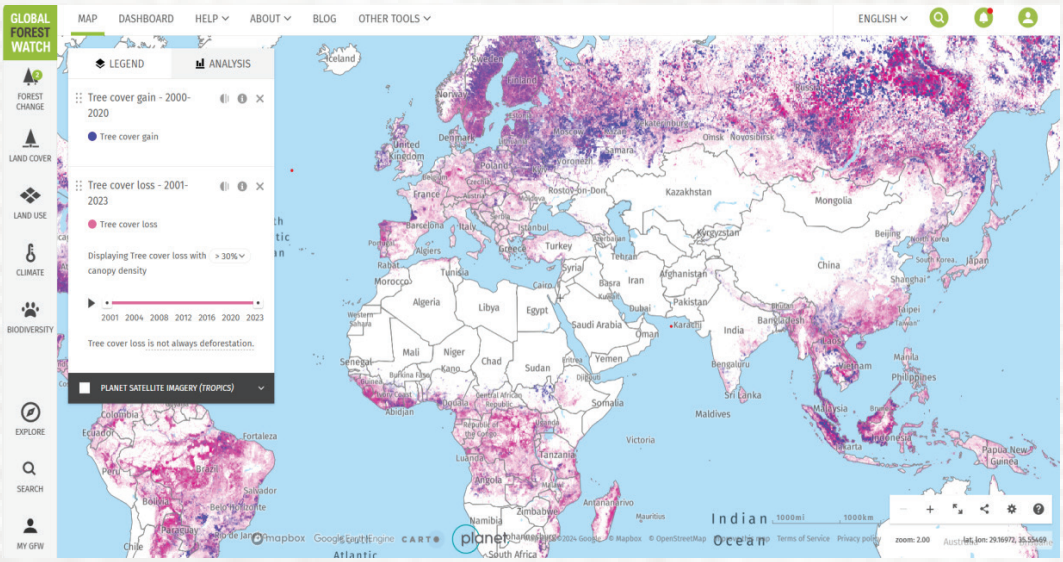

Fig. 5: Picture demonstrating trees gained (2000-2020) V/s trees cover loss (2001-2023)

(source: https://www.eomap.com/wp-content/uploads/2018/11/news_adria2018_S3-TUR-1200x675.jpg)

Detecting Deforestation:

- **Satellite Imagery Analysis:** Multispectral satellite imagery allows us to track changes in forest cover over time. By comparing historical and current images, we can identify areas with significant deforestation activity. Techniques like Normalized Difference Vegetation Index (NDVI) help quantify vegetation health and loss.
- **Early Warning Systems:** Automated analysis of satellite data can trigger alerts for deforestation hotspots, allowing authorities to take timely action.

Monitoring Land Use Changes:

- **Land Cover Classification:** Techniques like supervised classification can categorize land cover into different classes – forests, agricultural land, urban areas, etc. Analysing changes in these classes over time allows us to monitor how land use patterns are evolving.
- **Urban Sprawl Tracking:** Monitoring the expansion of urban areas helps us understand how human settlements are encroaching on natural ecosystems. This information is crucial for assessing potential flood risks in low-lying areas or increased landslide risks on unstable slopes due to deforestation for development.

10.6 Disaster Warning and Monitoring: Seeing the Unseen with Remote Sensing

Disasters often strike with a force of nature, but remote sensing empowers us to be proactive. Real-time satellite imagery acts as our eyes in the sky, enabling us to track the development and movement of cyclones, floods, and wildfires, providing crucial information for timely warnings and effective response.

Cyclones:

- **Early Warning Signs:** By analysing sea surface temperatures, wind patterns, and atmospheric pressure data collected by satellites, meteorologists can predict the formation and track the movement of cyclones. This allows for early warnings to be issued to coastal communities, giving them precious time to evacuate and prepare for the storm's impact.
- **Monitoring Intensity:** Satellite data helps assess a cyclone's intensity in real-time. Cloud formations, wind speeds, and precipitation levels can be monitored to determine the potential severity of the storm's impact.

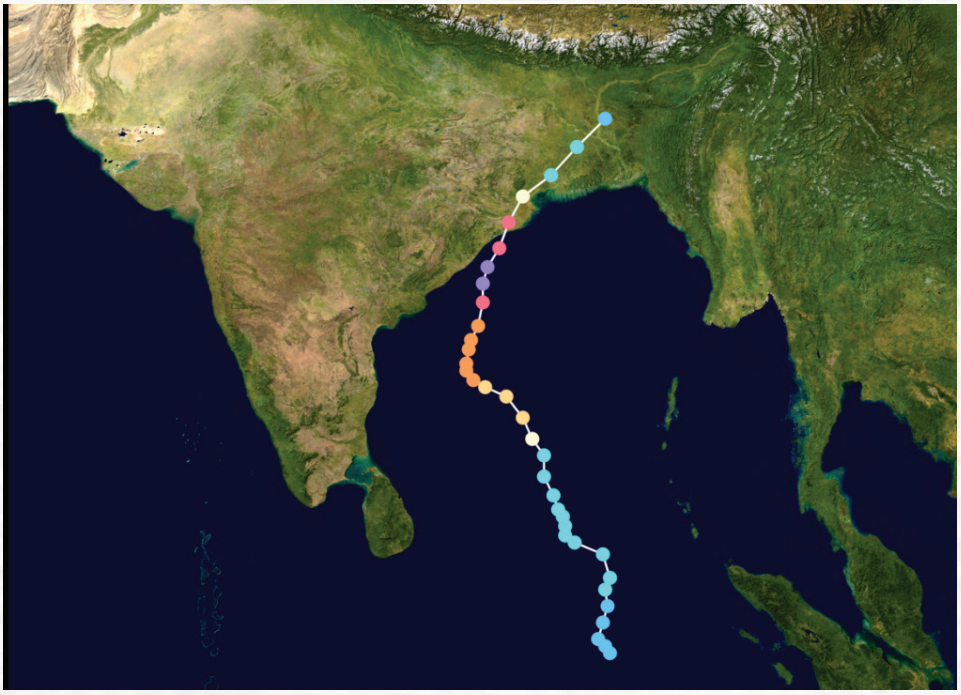

Fig. 6: Cyclone Fani – Track *(Source: Bhuvan. NRSC)*

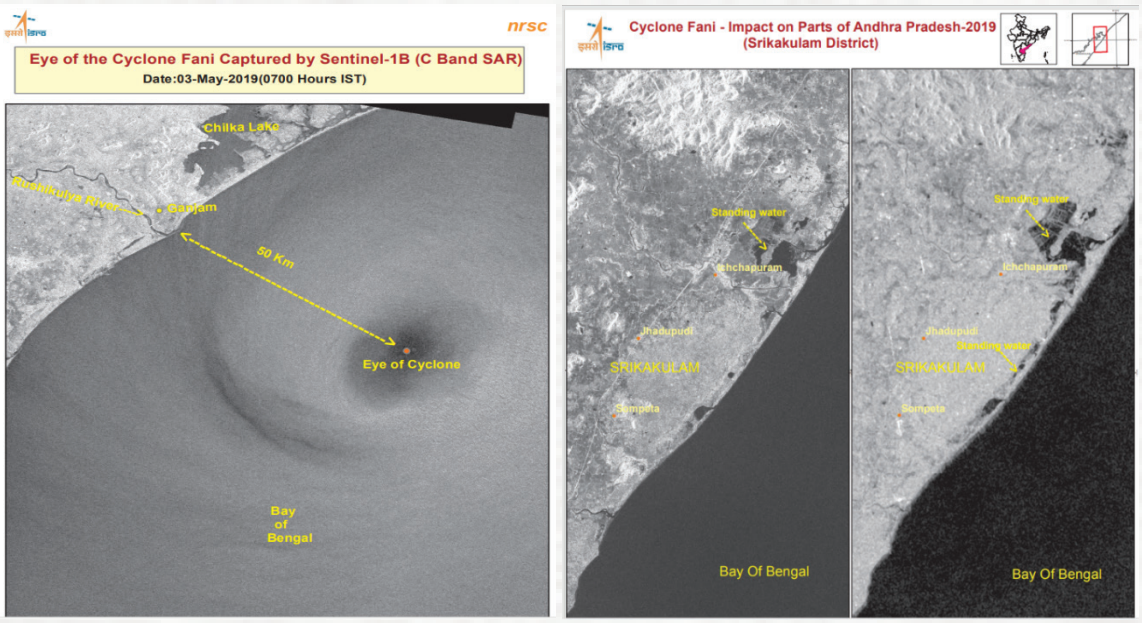

Fig. 7: Cyclone Fani satellite captured images *(Source: Bhuvan, NRSC)*

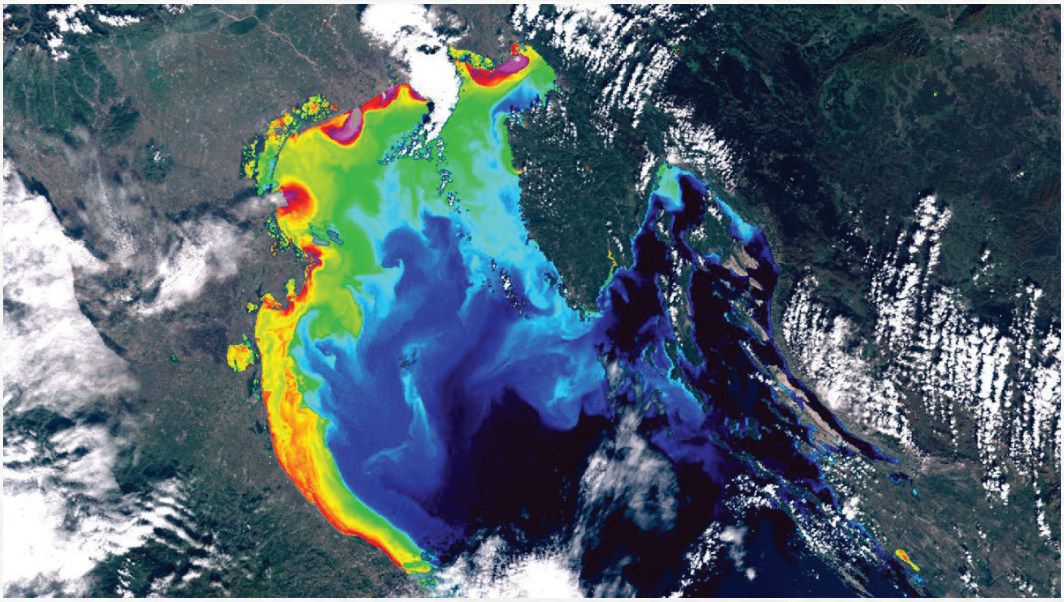

Fig. 8. Using satellite data for flood monitoring

(source : https://www.eomap.com/wp-content/uploads/2018/11/news_adria2018_S3-TUR-1200x675.jpg)

Floods:

- **Real-time Flood Monitoring:** Radar data from satellites can penetrate cloud cover, providing a clear view of flooded areas. This allows for real-time monitoring of flood extent and water levels. Early detection helps authorities issue evacuation warnings and deploy rescue teams to affected areas.
- **Predicting Flood Risk:** Historical flood data combined with real-time rainfall data from satellites can be used to predict flood risk in vulnerable areas. This information is crucial for preparing emergency response plans and deploying sandbags or other flood mitigation measures.

10.7 Post-Disaster Damage Assessment: Remote Sensing's Crucial Role

Rapid Damage Mapping:

- **Pre and Post-Disaster Imagery:** By comparing high-resolution satellite images taken before and after the disaster, we can quickly identify the areas affected and map the extent of the damage. This allows for a swift deployment of relief efforts to the most severely impacted regions.

- **Change Detection Techniques:** Automated image analysis techniques can identify changes in land cover, water extent, and vegetation health. This allows for rapid damage assessment over large areas, providing critical information for resource allocation.

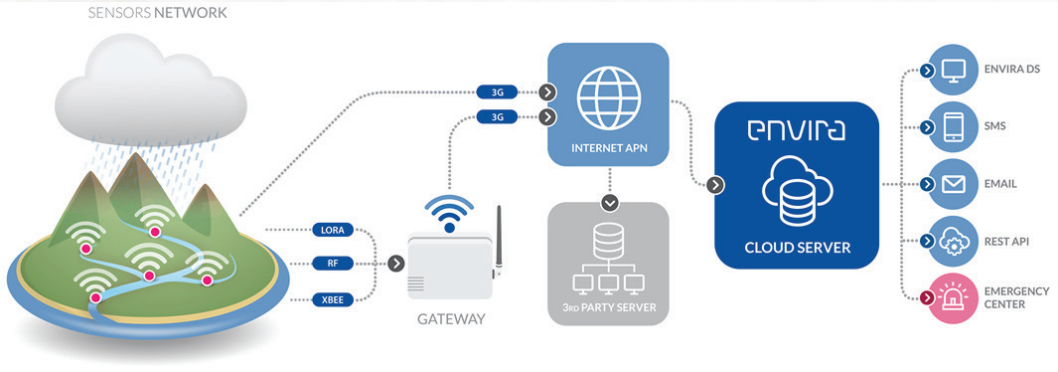

Fig. 9: Flood monitoring and Alarm system

(Source: https://envira.global/flood-monitoring-warning-system/)

Flood Mapping:

- **Flood Inundation Mapping:** Satellite data with high spectral resolution can differentiate between water and land, enabling the creation of detailed flood inundation maps. This information helps identify areas cut off by floodwaters, locate stranded populations, and prioritize rescue efforts.

Landslide Mapping:

- **Identifying Landslide Scars:** Optical and radar satellite imagery can detect changes in slope morphology, revealing areas with fresh landslide scars. This information helps assess the extent of landslide damage and identify areas at risk of further landslides due to post-disaster instability.

Deforestation Mapping:

- **Assessing Deforestation Impact:** While deforestation often occurs gradually, a major disaster like a wildfire can significantly accelerate this process. By comparing pre- and post-disaster satellite imagery, we can quantify the extent of deforestation caused by the disaster. This is crucial for assessing environmental damage and planning post-disaster reforestation efforts.

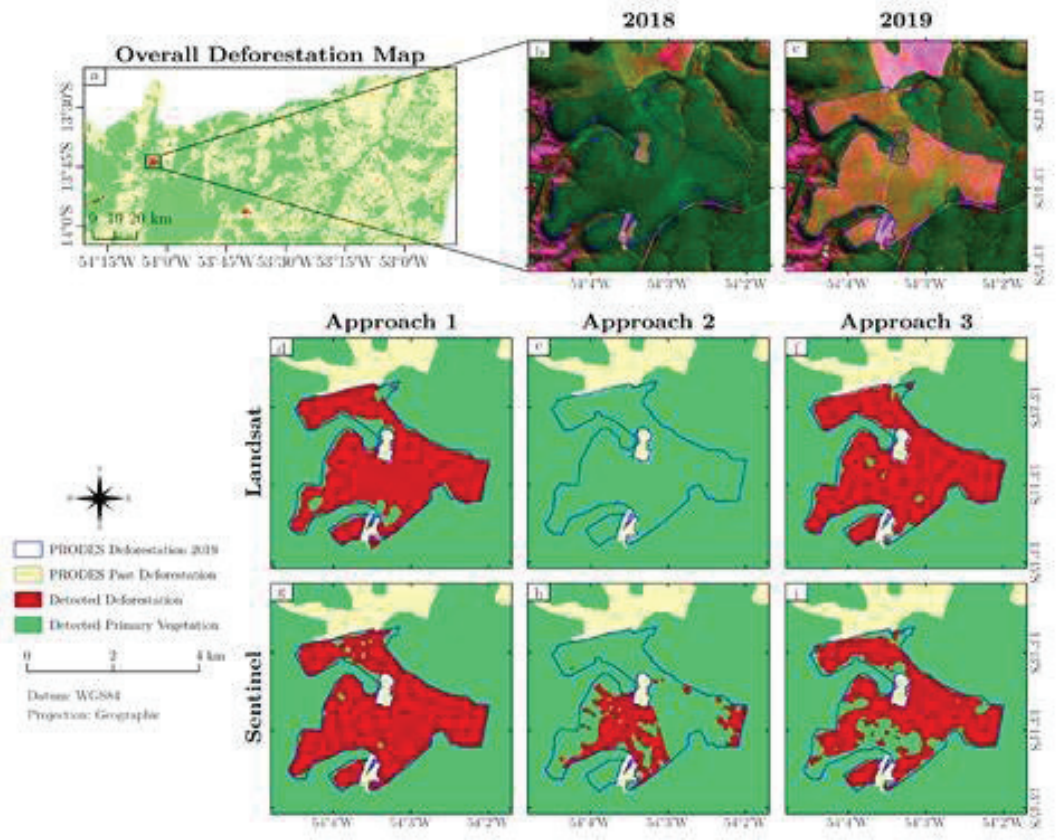

Fig. 10: Results obtained for the largest deforestation polygon in the Mato Grosso study area.

(Source: Matosak et al., 2022; Link:https://www.researchgate.net/figure/Results-obtained-for-the-largest-deforestation-polygon-in-the-Mato-Grosso-study-area-a_fig8_357707511)

Example: Mapping Flood Damage after a Tropical Cyclone

A powerful tropical cyclone strikes a coastal region. Here's how remote sensing helps:

1. **Pre-existing Satellite Images:** Access high-resolution satellite imagery taken before the cyclone to serve as a baseline reference.
2. **Post-Disaster Satellite Acquisition:** Emergency tasking of satellites ensures rapid acquisition of post-disaster imagery capturing the flooded areas.
3. **Automated Change Detection:** Software analyses the pre- and post-disaster images to identify areas with changes in water extent, indicating flood inundation.
4. **Flood Inundation Map Creation:** The change detection data is used to create a detailed map highlighting the flooded areas and their severity.

Benefits of Remote Sensing:

- **Rapid and Wide-Area Coverage:** Remote sensing allows for rapid damage assessment over vast areas, providing crucial information even in regions with limited accessibility due to the disaster itself.
- **Objective Data Collection:** Satellite data provides objective and unbiased information on the extent of the damage, aiding relief efforts and resource allocation.
- **Planning for Recovery:** Damage assessment maps derived from remote sensing data can be used for planning post-disaster recovery efforts, prioritizing reconstruction and rehabilitation needs.

10.8 Identifying Damaged Infrastructure and Locating Displaced Populations: Refining Relief Efforts with Remote Sensing

Following a disaster, identifying damaged infrastructure and locating displaced populations are critical steps for effective relief efforts. Remote sensing, with its detailed data and analysis capabilities, plays a vital role in achieving these goals.

Identifying Damaged Infrastructure:

- **Pre-existing Infrastructure Maps:** Integrating existing infrastructure maps (roads, bridges, power grids) with satellite imagery allows for pinpointing damaged areas.
- **Change Detection Analysis:** Techniques like spectral change detection can identify changes in infrastructure like collapsed buildings, damaged bridges, or flooded roads.

Locating Displaced Populations:

- **Shelter Detection:** Analysing pre- and post-disaster imagery can reveal the emergence of temporary shelters like tents or makeshift housing in open spaces.
- **Population Movement Analysis:** Monitoring changes in population density over time can help identify areas where people have been displaced from their homes due to the disaster.

Enhancing Efficiency:

- **Prioritizing Relief Efforts:** By identifying damaged infrastructure like hospitals or communication networks, relief efforts can be prioritized to ensure crucial services are restored quickly.

- **Targeted Aid Distribution:** Locating displaced populations through remote sensing helps direct aid distribution to the areas most in need, reducing logistical challenges and ensuring efficient resource allocation.

Beyond Damage Assessment:

- **Monitoring Recovery Progress:** Remote sensing data can be used to track the progress of reconstruction efforts, allowing for adjustments to relief strategies as needed.
- **Long-term Planning:** By analysing historical disaster data and identifying areas repeatedly affected, long-term risk reduction strategies can be developed.

10.9 Recovery and Reconstruction: Rebuilding with Remote Sensing's Insight

Disasters leave scars, but with effective recovery and reconstruction efforts, communities heal and rebuild. Remote sensing continues to play a valuable role in this phase, providing crucial insights to monitor progress, identify areas needing further assistance, and plan for a more resilient future.

Monitoring Recovery Progress:

- **Tracking Reconstruction Activities:** High-resolution satellite imagery allows monitoring the construction of new buildings, repair of infrastructure, and removal of debris. This helps assess the pace of reconstruction and identify any delays requiring intervention.
- **Vegetation Recovery Analysis:** Changes in vegetation health, as detected by satellite data, can indicate areas where natural regeneration is taking place or highlight areas requiring reforestation efforts.

Identifying Needs:

- **Damage Persistence Analysis:** By comparing damage assessment maps from the initial response with post-recovery imagery, we can identify areas where reconstruction efforts haven't reached or require further assistance.
- **Vulnerability Mapping:** Remote sensing data can be used to create vulnerability maps, considering factors like slope stability, flood risk, and proximity to fault lines. This helps prioritize reconstruction efforts in areas most susceptible to future disasters.

Planning for Resilience:

- **Long-term Risk Reduction:** By analysing historical disaster data and incorporating vulnerability maps, remote sensing data informs long-term planning for disaster risk

reduction. This includes identifying areas for relocation or implementing preventative measures like building seawalls or flood control channels.

- **Sustainable Reconstruction:** Remote sensing data on land cover and soil quality can guide reconstruction efforts towards sustainable practices, reducing the risk of future disasters

Planning for Reconstruction: Rebuilding with Resilience using Remote Sensing

Disasters leave a path of destruction, but the opportunity arises to rebuild stronger and more resilient communities. Remote sensing plays a crucial role in this reconstruction phase by assisting in assessing land suitability and identifying potential hazards, ultimately guiding informed decisions for a safer future.

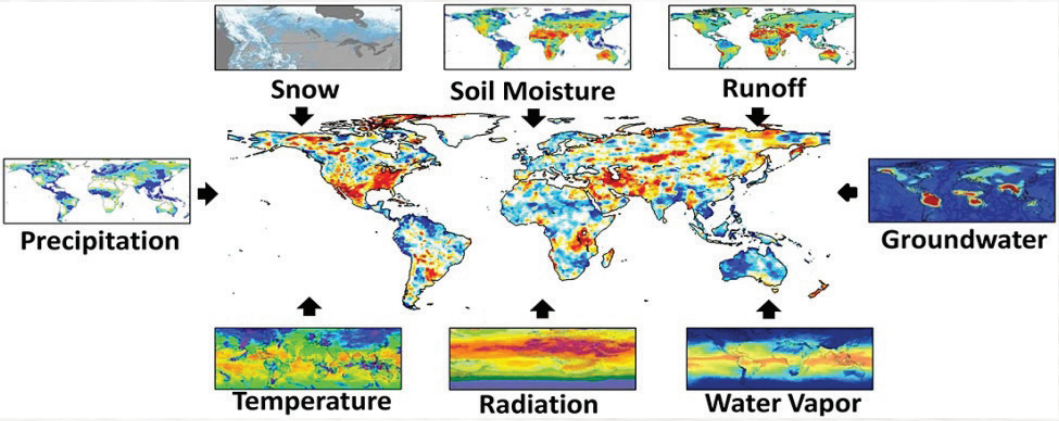

Fig. 11: Drought mapping using remote sensing (Source:https://agupubs.onlinelibrary.wiley.com)

Assessing Land Suitability:

- **Land Cover Analysis:** Analysing post-disaster satellite imagery helps determine land cover changes like landslides or soil erosion. This information is crucial for identifying areas unsuitable for reconstruction due to potential instability or environmental degradation.
- **Topography and Elevation Data:** Digital Elevation Models (DEMs) generated from LiDAR data provide insights into land suitability for reconstruction. Flood-prone lowlands or areas with steep slopes might not be ideal for rebuilding permanent structures.

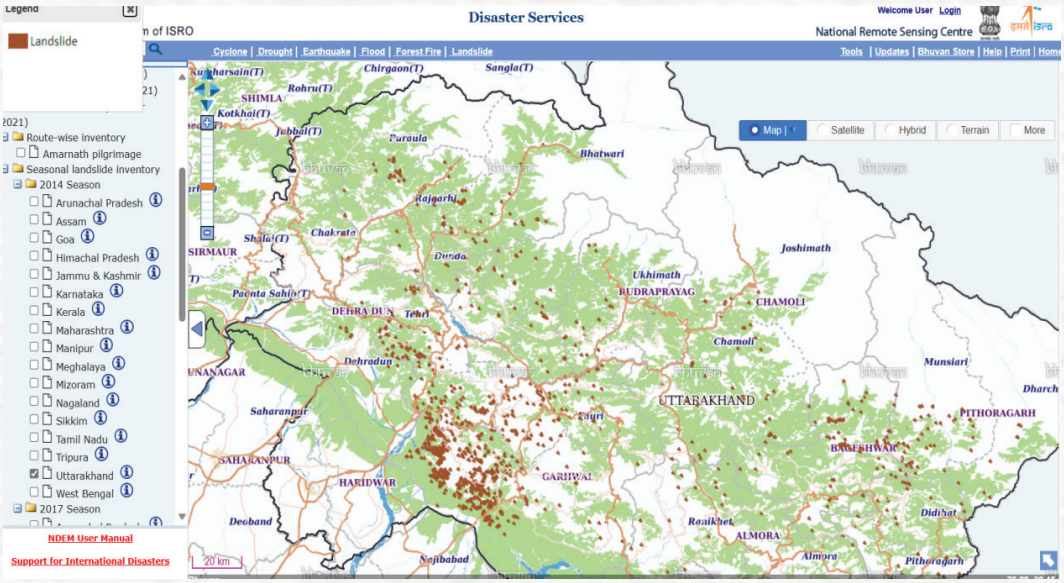

Fig. 12: Seasonal Landslide inventory of Uttarakhand *(Source: Bhuvan, NRSC)*

Identifying Potential Hazards:

- **Landslide Susceptibility Mapping:** Combining post-disaster imagery with pre-existing data on slope stability and soil composition allows for creating landslide susceptibility maps. This helps identify areas at high risk of landslides during future heavy rains or earthquakes, guiding reconstruction efforts towards safer locations.
- **Flood Risk Assessment:** Floodplain maps derived from remote sensing data can be overlaid with reconstruction plans to ensure new buildings are located outside flood-prone zones. Additionally, historical flood data can be analysed to identify areas with a higher risk of flash floods.

Building Resilience:

- **Sustainable Development:** Remote sensing data on soil quality and vegetation health can guide reconstruction efforts towards sustainable practices, minimizing environmental impact and promoting long-term resilience.
- **Community Planning:** By providing data on land suitability and potential hazards, remote sensing empowers communities to make informed decisions about reconstruction plans, prioritizing safety and long-term sustainability.

10.10 CASE STUDY

Case study 1: Mapping accessibility to oral health care in coastal India – A geospatial approach using a geographic information system (GIS)

Introduction: Since the Alma-Ata declaration in 1978, Health for All has been a fundamental principle of public health, emphasizing equitable access to healthcare services worldwide. Access to healthcare, encompassing both accessibility and utilization, plays a crucial role in reducing the burden of disease. Geographic Information Systems (GIS) provide a scientific method for assessing healthcare accessibility, aiding in the formulation of targeted healthcare plans. In India, dental healthcare faces challenges due to limited funding and a growing population, particularly in regions like Coastal Karnataka. This study aims to objectively map and analyse spatial accessibility to oral healthcare facilities in Udupi, Uttara Kannada, and Dakshina Kannada districts, investigating associations with population density and socio-economic conditions.

Conclusion: This study reveals that oral health services are concentrated in areas with higher annual income per capita, increased urbanization, and population density, leading to uneven distribution across coastal districts. Rural populations in four taluks have only one dentist for over a lakh population, predominantly relying on public centres for oral healthcare. Private clinics are also unevenly distributed. Shockingly, only 1% of the total GDP is allocated for public healthcare provision in India, with no specific allocation for dental health. With governmental support, the establishment of public health centres in inaccessible areas and meticulous planning based on geographical and economic parameters can improve accessibility to treatment.

Complete paper: Nayak et al., 2022. Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9363979/

Case study 2: Geo-Relationship between Cancer Cases and the Environment by GIS: A Case Study of Trabzon in Turkey

Introduction: Cancer is a significant global health issue, with over 11 million new cases diagnosed annually. The World Health Organization (WHO) warns that without intervention, 84 million people could die from cancer in the next decade, particularly in countries with limited resources for prevention, diagnosis, and treatment.

In Turkey, cancer ranks as the second leading cause of death, claiming approximately 52,000 lives annually, with a substantial impact on productivity and healthcare costs. The WHO's Cancer Control Program seeks to reduce cancer incidence and mortality rates and enhance patients' quality of life.

To effectively implement cancer control strategies in Turkey, accurate statistical data on cancer cases must be collected and analysed. Geographic Information Systems (GIS) play a

crucial role in mapping the spatial distribution of cancer cases, identifying high-risk areas, and exploring potential environmental risk factors.

This research focuses on Trabzon province, Turkey, examining the relationship between cancer incidence and environmental factors. Using GIS and Remote Sensing (RS) techniques, spatial databases are created, and geo-statistical maps are generated to analyse cancer density in relation to population and environmental variables. The study aims to identify any statistical correlations between land cover types and cancer types, providing valuable insights for cancer prevention and control efforts.

Result and Conclusion: GIS (Geographic Information System) has evolved beyond merely mapping diseases to elucidating the intricate connections between the environment and human health. Understanding the correlation between cancer cases and environmental factors is crucial for refining cancer management strategies and identifying causal factors. Through geo-referenced maps, GIS facilitates the analysis of cancer frequency in spatial contexts, offering valuable insights into disease patterns.

Despite its potential, securing financial support for GIS initiatives remains a challenge due to a limited understanding of its capabilities. In this study, GIS was utilized to analyse the geographical distribution of cancer types. Cancer density statistics were derived from local census data, and ecological data such as land cover and elevation were integrated and compared with cancer case locations obtained through address geocoding.

The analysis revealed that Trabzon province in Turkey exhibited cancer incidence rates consistent with WHO data, with only 23% of villages and districts exceeding expected cancer case numbers. Statistical examinations unveiled associations between breast cancer cases and residential areas along the coast and valleys with low elevation. Conversely, skin and thyroid cancer cases were less prevalent in low-elevation areas but more common in forestry areas at higher elevations.

In conclusion, GIS and spatial analysis techniques offer a comprehensive toolkit for understanding the spatial dynamics of healthcare, assessing its impact on health outcomes and access, and enhancing healthcare delivery. Epidemiologists, in particular, benefit from GIS's spatial analysis capabilities when investigating the relationships between location, environment, and disease, making it a valuable tool in public health research and planning.

Complete paper: Yomralioglu T et al., 2009. Link: https://pubmed.ncbi.nlm.nih.gov/20049256/

Suggested Activity:

- Prepare a poster/art show, explaining the various components of a remote sensing device.
- Photojournalism competition for presenting the use of remote sensing in India.
- Spatial Analysis using GIS: (Use Case)

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Glossary

- **American Red Cross (ARC) -**It is a non-profit humanitarian organization that offers emergency aid, disaster relief, and training in disaster preparedness in the United States. It is also known as the American National Red Cross.
- **Federal Emergency Management Agency (FEMA) -** The nation's capacity to anticipate, avoid, respond to, recover from, and mitigate all hazards is being built, maintained, and improved with the help of FEMA.
- A computer system for gathering, storing, verifying, and displaying information about locations on the surface of the Earth is known as a **geographic information system (GIS).**
- Monitoring of the land, the marine environment (seas, rivers, lakes), and the atmosphere is known as **"Earth Observation" (EO).**
- **Light Detection and Ranging (LiDAR)** is a technique for measuring distances that involves directing a laser at a target or surface and timing how long it takes for the light to reflect to the receiver.
- For observation and strategic planning, **UAVs** are utilized. Currently, this technology can be used in the emergency response sector to help the crew members.
- A satellite-based sensor used to analyse the Earth's surface and the climate is called the **Moderate Resolution Imaging Spectroradiometer (MODIS).**
- Understanding vegetation density and evaluating changes in plant health are both aided by the Landsat **Normalized Difference Vegetation Index (NDVI),** which is used to measure vegetation greenness.
- **NBR** is used to locate burned regions and calculate the degree of burns.

Suggestive questions:

MCQ questions carry one marks each

1. Which of the following is NOT an application of remote sensing in disaster management?
    a) Early warning of floods by monitoring weather patterns
    b) Assessing damage to infrastructure after an earthquake
    c) Evacuation planning based on real-time fire spread data
    d) Sending physical supplies to affected areas
2. Remote sensing data can be collected by:
    a) Ground-based instruments only
    b) Satellites orbiting the Earth only
    c) Both satellites and airplanes
    d) All of the above
3. Which type of remote sensing data is best suited for identifying flooded areas?
    a) Synthetic Aperture Radar
    b) Infrared imagery
    c) Microwave imagery
    d) All of the above (depending on the flood stage)
4. How can remote sensing be used in landslides?
    a) Monitoring changes in slope stability
    b) Identifying areas prone to landslides
    c) Both a and b
    d) Neither a nor b
5. Remote sensing plays a crucial role in disaster management by providing:
    a) Real-time data for rapid decision making
    b) Information on inaccessible areas

c) Cost-effective damage assessment

d) All of the above

6. Which of the following limitations is associated with remote sensing in disaster management?

a) Can provide real-time data under all weather conditions

b) May require specialized skills for data interpretation

c) Offers high-resolution imagery for detailed damage assessment (all the time)

d) Data acquisition can be expensive, depending on the source

7. How can remote sensing be used in post-disaster recovery efforts?

a) Identifying temporary shelter locations for displaced populations

b) Monitoring the effectiveness of relief efforts

c) Tracking disease outbreaks in affected areas

d) All of the above

8. LiDAR (Light Detection and Ranging) is a type of remote sensing technology that provides:

a) High-resolution imagery for mapping purposes

b) Three-dimensional data on the Earth's surface

c) Information on the chemical composition of materials

d) Real-time weather data for early warning systems

9. Remote sensing data integration with other sources of information, such as GIS (Geographic Information Systems), can help in:

a) Creating more accurate risk maps for disaster preparedness

b) Identifying vulnerable communities before a disaster strikes

c) Developing evacuation plans based on real-time traffic data

d) All of the above

10. The future of remote sensing in disaster management is likely to involve:

a) Increased use of artificial intelligence for faster data analysis

b) Development of new sensors with higher resolution and wider coverage

c) Improved accessibility of remote sensing data for local communities

d) All of the above

All short questions carry three marks each (short notes)

1. Write a short note on remote sensing. Also, what are remote sensors?
2. Enumerate the role of remote sensing in disaster management.
3. Explain two types of natural disasters with their remote sensing parameters.
4. Explain any two applications of earth resource management.

All long questions carry ten marks each (essay type, logical analysis, inferring practical situation)

1. Enumerate the different types of disasters with suitable examples.
2. With the help of examples, explain the role of remote sensing in both manmade and natural disasters.
3. Explain the application of remote sensing in earth resource management.

Suggestive PowerPoint slides for reference

WHAT IS REMOTE SENSING?

- Remote sensing is the science of drawing conclusions about objects from measurements taken at a distance, without actually coming into contact with the objects under study.
- The data collected can be of many forms: variations in acoustic wave distributions (sonar), force distributions (gravity meter), electromagnetic energy distributions (eye), etc.
- Remote sensing is a valuable tool for various aspects of disaster management, including early warning systems, damage assessment, and resource allocation.
- It helps in monitoring and predicting natural hazards, assessing the impact of disasters, and facilitating effective response and recovery efforts.
- Remote sensing data, such as satellite images and aerial photos, allow us to map the variabilities of terrain properties, which can help manage disasters through engaging the 'disaster cycle'.
- Remote sensing imagery provides a rapid method of assessing the magnitude of hazard impacts, areas most affected, and where key transport and other infrastructure links have been disrupted or destroyed.

PROCESS OF REMOTE SENSING

The Remote Sensing process of inferring surface parameters from measurements of the Electromagnetic Radiation (EMR) from the Earth's surface. EMR can either be reflected or emitted from the Earth's surface.

A. Emission of electromagnetic radiation. (The Sun or an EMR source located on the platform)

B. The Transmission of energy from the source to the object. (Absorption and scattering of the EMR while transmission)

C. Interaction of EMR with the object and subsequent reflection and emission

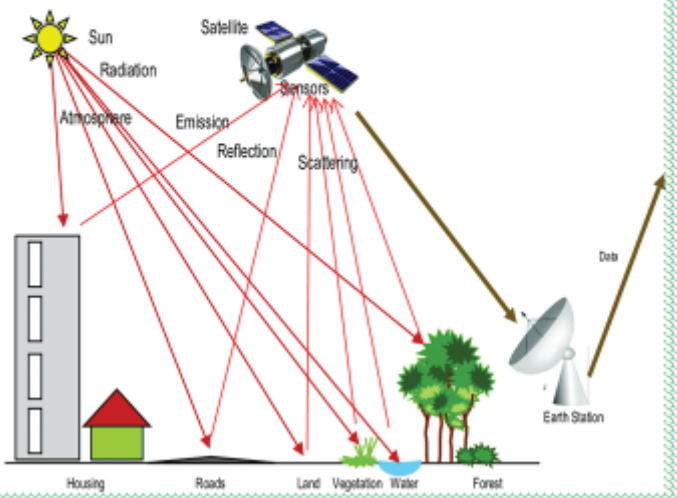
D. Transmission of energy from the object to the sensor

E. Recording of energy by the sensor. (Photographic or non-photographic sensors)

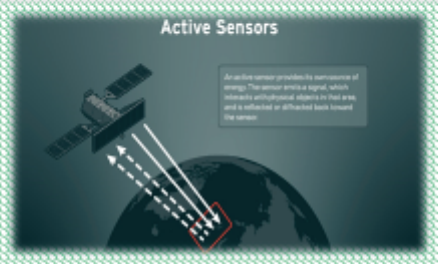
F. In Transmission of the recorded information to the ground station

G. Processing of the data into digital or hard copy image

H. Analysis of data



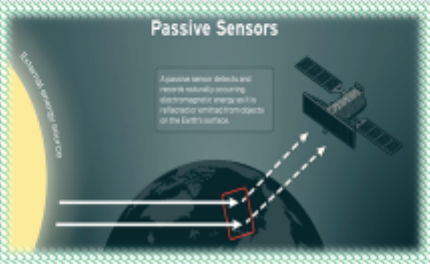
Active and Passive Remote Sensing



Active Sensor:

Have its source of light or illumination and its sensor measures reflected energy.

In the case of Active Remote Sensing, energy is generated and sent from the RS platform towards the targets. The energy reflected from the targets is recorded using sensors onboard the RS platform. Most of the microwave RS is done through Active RS.



Passive Sensor:

Measure reflected sunlight that was emitted from the sun. Passive Remote Sensing, the source of energy is that naturally available, such as the Sun. Most of the RS systems work in passive mode, using solar energy as the source of EMR. Solar energy reflected by the targets at specific wavelength bands is recorded using sensors onboard air-borne or space-borne platforms.

Remote Sensing Platforms

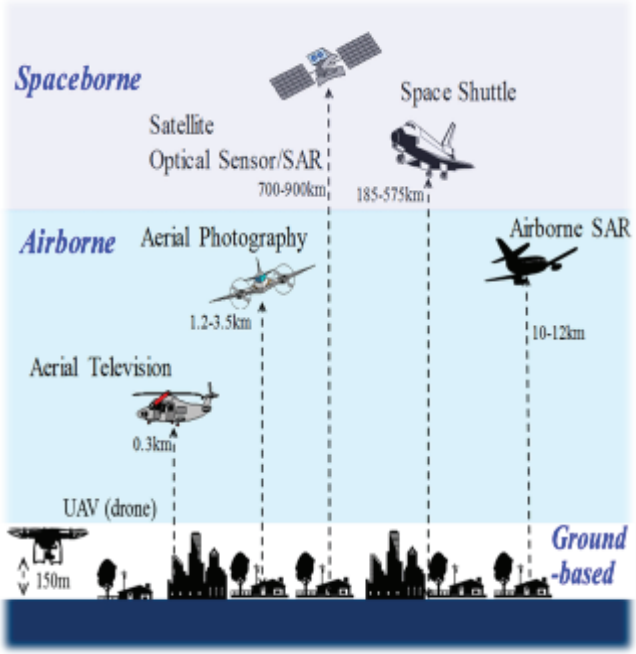
RS platforms can be classified as follows, based on the elevation from the Earth's surface at which these platforms are placed.

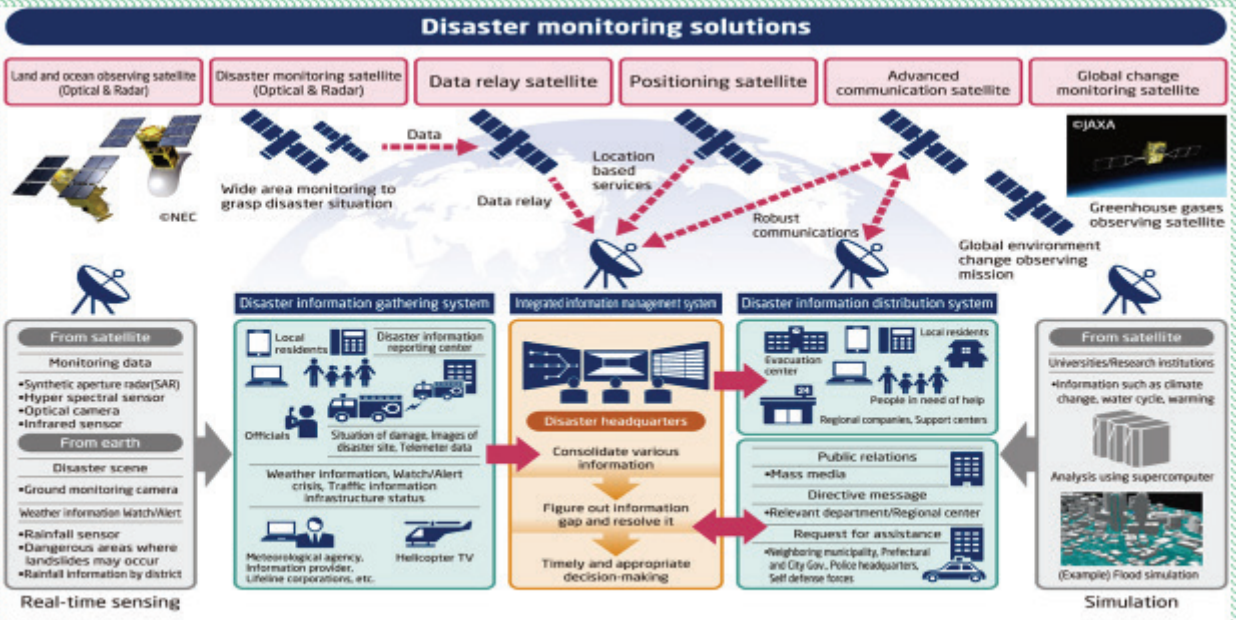
There are three types of platform:

1. **Ground borne Remote Sensing**
   - Ground-level remote sensors are very close to the ground.
   - They are used to developing and calibrate sensors for different features on the Earth's surface

2. **Airborne Remote Sensing**
   - Low altitude aerial remote sensing
   - High altitude aerial remote sensing

3. **Space-borne Remote Sensing**
   - Space shuttles
   - Polar-orbiting satellites
   - Geo-stationary satellites





SOURCE: https://www.nec.com/en/global/solutions/space/remote_sensing/images/overview_en.jpg

Case Study: Flood Mapping in the Vembanad-Kol Wetland System, India using Remote Sensing

This case study examines how remote sensing techniques can be used to map flooded areas during natural disasters. The study focuses on the devastating floods that occurred in the Vembanad-Kol Wetland System, India, in August 2018.

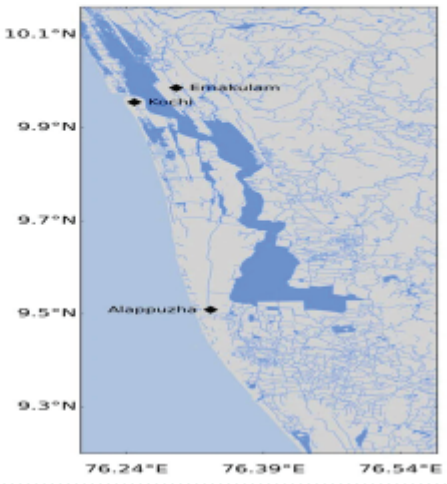
Background:

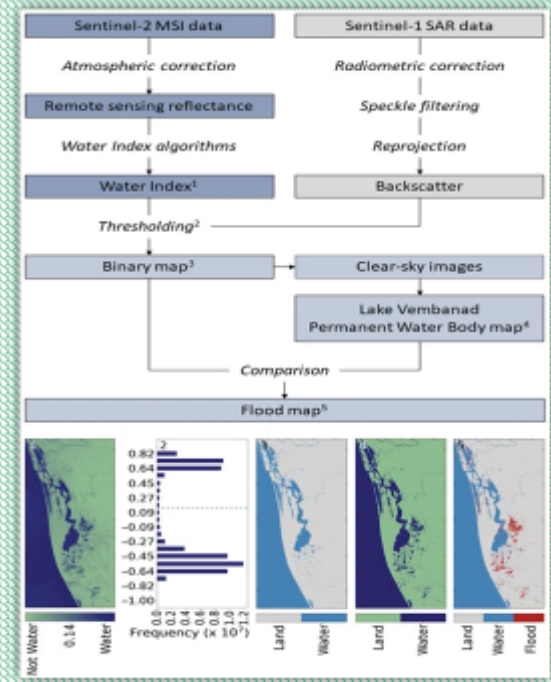
- Floods are the most common natural disaster globally, causing significant loss of life, property damage, and displacement.
- Accurate flood mapping is crucial for disaster response efforts, enabling targeted rescue missions and prioritizing healthcare to prevent disease outbreaks.
- Traditional methods like Synthetic Aperture Radar (SAR) offer flood mapping capabilities but have limited temporal coverage (revisit time).

Objective:

- Evaluate the effectiveness of using multi-spectral visible remote sensing data from Sentinel-2 for flood mapping in the Vembanad-Kol Wetland System.
- Analyze the potential of this approach to complement SAR-based techniques and improve temporal coverage.

Source: https://doi.org/10.3390/rs15215139





Methodology:

- The study employed four existing water index algorithms:
  - Normalised Difference Water Index (NDWI)
  - Modified Normalised Difference Water Index (MNDWI)
  - Water Ratio Index (WRI)
  - Automated Water Extraction Index (AWEI)
- These algorithms utilize the distinct spectral reflectance properties of water (low reflectance in visible light, high absorption in infrared) to differentiate water from land, soil, vegetation, and buildings.
- The analysis focused on Sentinel-2 Multi-Spectral Imager (MSI) data acquired in August 2018, coinciding with the flood event.
- Local knowledge of paddy field cultivation practices was incorporated to account for seasonal water logging and improve flood map accuracy.

Results:

- The study demonstrated the potential of multi-spectral visible remote sensing for flood mapping in the Vembanad-Kol Wetland System.
- The application of water index algorithms on Sentinel-2 MSI data successfully delineated flooded areas.
- This approach offered improved temporal coverage compared to SAR (approximately 5 days revisit time for Sentinel-2 vs 12 days for Sentinel-1).
- Integrating local knowledge on paddy cultivation practices further enhanced the accuracy of flood maps by excluding inundated paddy fields (considered a normal seasonal occurrence).

DISASTER	MITIGATION	PREPAREDNESS	RECOVERY	RESCUE	SATELLITE USED
VOLCANO	• Risk modelling • Hazard mapping • Digital elevation models	• Emissions monitoring • Thermal alerts	• Mapping lava flows • Evacuation planning	• Damage assessment • Spatial planning	• MODIS • AVHRR • Hyperion
FIRE	• Mapping fire - prone areas • Monitoring fuel load • Risk modelling	• Fire detection • Early warning • Predicting spread / direction of fire	• Coordinating firefighting efforts	• Damage assessment	• MODIS • SERVIR • Sentinel Asia • AFIS
LANSLIDES	• Risk modelling • Vulnerability analysis • Digital elevation models	• Monitoring rainfall • Slope stability	• Mapping affected areas	• Damage assessment • Spatial planning • Suggesting management practices	• PALSAR • IKONOS2 • InSAR • SPOT • IRS

Role of remote sensing in various disasters

DISASTER	MITIGATION	PREPAREDNESS	RECOVERY	RESCUE	SATELLITE USED
EARTHQUAKE	• Buliding stock assessment • Hazard mapping	Measuring strain accumulation	• Damage assessment • Identifying sites for rehabitilation	• Planning routes for search and rescue • Damage assessment • Evacuation planning • Deformation mapping	• PALSAR • IKONOS 2 • InSAR • SPOT • IRS
FLOODS	• Mapping flood - prone areas • Delineating flood plains • Land- use mapping	• Flood detection • Early warning • Rainfall mapping	• Damage assessment • Spatial planning	• Flood mapping • Damage assessment • Evacuation planning	• Tropical rainfall monitoring mission • AMSR-E • KALPANA -I
CYCLONES	• Risk modelling • Vulnerability analysis	Early warning Long range climate modelling	• Damage assessment • Spatial planning	• Identifying escape routes • Crisis mapping • Impact assessment • Cyclone monitoring • Storm surge prediction	• KALPANA-I • INSAT-3A • QuikScat radar • Meteosat
DROUGHT	• Risk modelling • Vulnerability analysis • Land and water management planning	• Weather forecasting • Vegetation monitoring • Crop water requirement mapping • Early warning	• Monitoring vegetation • Damage assessment	• Informing drought mitigation	• FEWS NET • AVHRR • MODIS • SPOT

DISASTER VULNERABILITY PROFILE OF INDIA

CHAPTER – 11

Disaster Vulnerability Profile of India: Earthquake & Landslide

Dr. Sujay Bandyopadhyay

Total No. of Hours: 2.5 Hours

I. Background of the topic

The frequency and intensity of natural and human-induced disasters are surprisingly increasing, which points toward staggering risks worldwide. India has been no exception in this regard and is home to numerous disaster risks, including earthquakes, landslides, floods, droughts, famines, epidemics, cold waves, etc. It is one of the world's most disaster-prone countries because of its distinctive geo-climatic conditions and socio-economic vulnerability. Out of 36 states and union territories in India, around 27 are impacted annually by exposure to disasters. According to the Annual Report (2022-23) of the National Disaster Management Authority, almost 58.6% of India's area falls under seismic vulnerability of various intensities, over 40 million hectares (12% of land) of the country is vulnerable to floods and river erosion, 8% of the total, especially the coastal states are vulnerable to cyclones, 68% of the cultivable area is susceptible to severe drought impacts, and the hilly regions are at risk from landslides and avalanches. On an average, between 1990-2000, nearly 4344 people lost their lives, and around 30 million people were affected by disasters. Thus, understanding what makes disasters in India so devastating is essential in reducing disaster casualties and increasing resilience. However, disasters like earthquakes and landslides happen when the population is unprepared, resulting in substantial human casualties. These are the deadliest forms of disasters, accounting for the maximum number of deaths. Hence, there is a need to improve the capability to mitigate the effects of these disasters.

II. Learning outcomes

At the end of the course, students will be able to:

(i) Understand the basic conceptual understanding of earthquake and landslide disasters.

(ii) Discern the compounding effects of multiple cascading hazards associated with earthquakes.

(iii) Familiarize themselves with risk mitigation and management for earthquake and landslide disasters.

III. Detailed session plan

- Interactive lecture presentation: Begin by asking the participants what they understand about earthquakes and landslide disasters in light of their own experience.
- Brainstorming: Do tell that brainstorming aims at generating ideas that could be potentially used to promote improved disaster prevention and preparedness for earthquakes and landslides.
- Group work: Form 4-5 working groups of participants and ask them to discuss the points for group discussion to solve the questions.
- Presentation and discussion: Read out/ show the PPT of the module as mentioned at the end, and ask the participants to make group presentations.

Content on the topic

11.1 Earthquake - *Introduction*

Earthquakes are probably the most common, frequent, and highly destructive natural disasters, causing significant loss of life and economic damage on a global scale. It is the shaking of Earth's surface (crust) caused by the seismic waves that are emitted due to the deformation or breaking of rocks [8]. The deformation is essentially associated with stress accumulation due to internal Earth tectonic processes generated by plate movements. When the stress goes beyond a certain limit of the strength of the rocks that form the crust, an earthquake occurs. However, earthquakes also happen due to human-induced stresses, *i.e.*, human activity (explosion, mine collapse, and reservoir-induced). Typically, an earthquake is associated with a sudden slip at the large fractures in the crust, called faults.

During an earthquake, energy in the form of seismic waves is released and radiates in all

directions from its source. The waves are fast, immediate, unpredictable in time, sudden, and sometimes strong and very destructive. There are two main types of earthquake-generated seismic waves. The first comprises P (or primary) and S (or secondary) waves, which propagate within the body of the Earth, known as body waves, while the second, consisting of Love and Rayleigh waves, propagate along the Earth's surface and cause the most destruction, known as surface waves. The location inside the Earth's surface, where waves originate during an earthquake, is called the focus or hypocentre, and the location directly above it on the surface is called the epicentre. Around the epicentre, the isoseismic lines can be drawn, which are the lines connecting all points on the surface where the seismic intensity is the same. An earthquake can occur at a range of depths; however, about 90% of continental earthquakes have a depth of the foci within 70 km. The focal depths from 0 to 70 km are considered shallow, from 70 to 300 km are considered intermediate, and greater than 300 km are considered deep earthquakes. Of the total energy released in earthquakes, almost 70-85% comes from shallow foci earthquakes, about 12-15% comes from intermediate foci earthquakes, and about 3-5% from deep foci earthquakes. Almost all deep-focus earthquakes occur in the Circum-Pacific belt, particularly in the subduction zone. The 2013 Okhotsk Sea earthquake that occurred at a depth of 609 km was the strongest deep-focus earthquake in the seismic record. For the study of earthquakes and seismic waves, a new branch of Earth Sciences emerged, which is called Seismology.

11.1.1 Causes of earthquakes

- Fault zones

Earthquakes occur when the movement takes place along a fault zone. In the fault zone, intense stresses are observed, and an observable amount of displacement occurs along the fracture of a rock when stress crosses the limit. The 2001 Bhuj earthquake (Mw 7.7) in northwestern India is a typical example caused by the movement in fault zones.

- Plate tectonics

The Earth's outermost layer consists of lithospheric slabs (both oceanic and continental lithosphere) or tectonic plates that are continuously moving due to the convection current in the mantle. The boundaries where the plates meet are essentially dynamic zones. The plate boundaries are the primary location of earthquakes. For that, the global patterns of seismicity show a narrow belt of earthquakes along the spreading, convergent, and transform plate boundaries.

- Volcanic eruptions

The volcanic eruption also results in an earthquake, but the earthquakes of volcanic origin are generally less severe and more limited in extent. Such earthquakes occur simultaneously with eruptions. They are of shallow origin and the intensity is quite high near the volcano. The 1883 eruption of Krakatoa in the Sunda Strait resulted in earthquakes and tsunamis in the coastal areas of Java and Sumatra.

- Human-induced earthquakes

These types of earthquakes are typically minor, and the tremors are caused by human activities like mining, large-scale petroleum extraction, artificial lakes (reservoirs), nuclear tests, *etc*. Many of the earthquakes around the world have been the result of the construction of dams and reservoirs in recent times. An example is the Koyna earthquake (M_w 6.6) of 1967 on 11th December in Maharashtra due to reservoir-triggered seismic activity.

11.1.2 Recording an earthquake

The seismic waves generated from earthquakes are recorded on instruments called seismographs [8]. The Chinese scholar Zhang Heng developed the world's first seismograph in 132 AD, called a seismoscope. The modern seismograph records vibrations in the ground and comprises a ground motion detection sensor, called a seismometer, coupled with a recording system. It records the movement in relation to a stationary mass on a rotating drum or magnetic tape. It also records information about the rocks through which the seismic waves travelled. The records obtained during an earthquake are called seismograms.

Locating an earthquake

To determine the location of the epicentre of an earthquake:

- Three station recordings are needed.
- Analysing the time interval between the arrival of the first P wave and the first S wave in each station at their location. The time difference between the arrivals of both waves is called lag time.
- The lag time is used to compute the distance of each station to the epicentre.

To locate the epicentre, suppose a circle is drawn around each seismic station with a radius equal to the distance to the epicentre, *i.e*., 1580 km, 1076 km and 619 km, respectively (Fig. 1). The point at which the three circles pass through is the location of the earthquake epicentre [8].

Measuring Earthquake Size

In general, two measurements describe an earthquake's size: (i) magnitude and (ii) intensity [1].

• Magnitude

The magnitude is a quantitative measure of the energy released at the hypocentre during an earthquake. There are different types of magnitude scales, but the standard one that has been

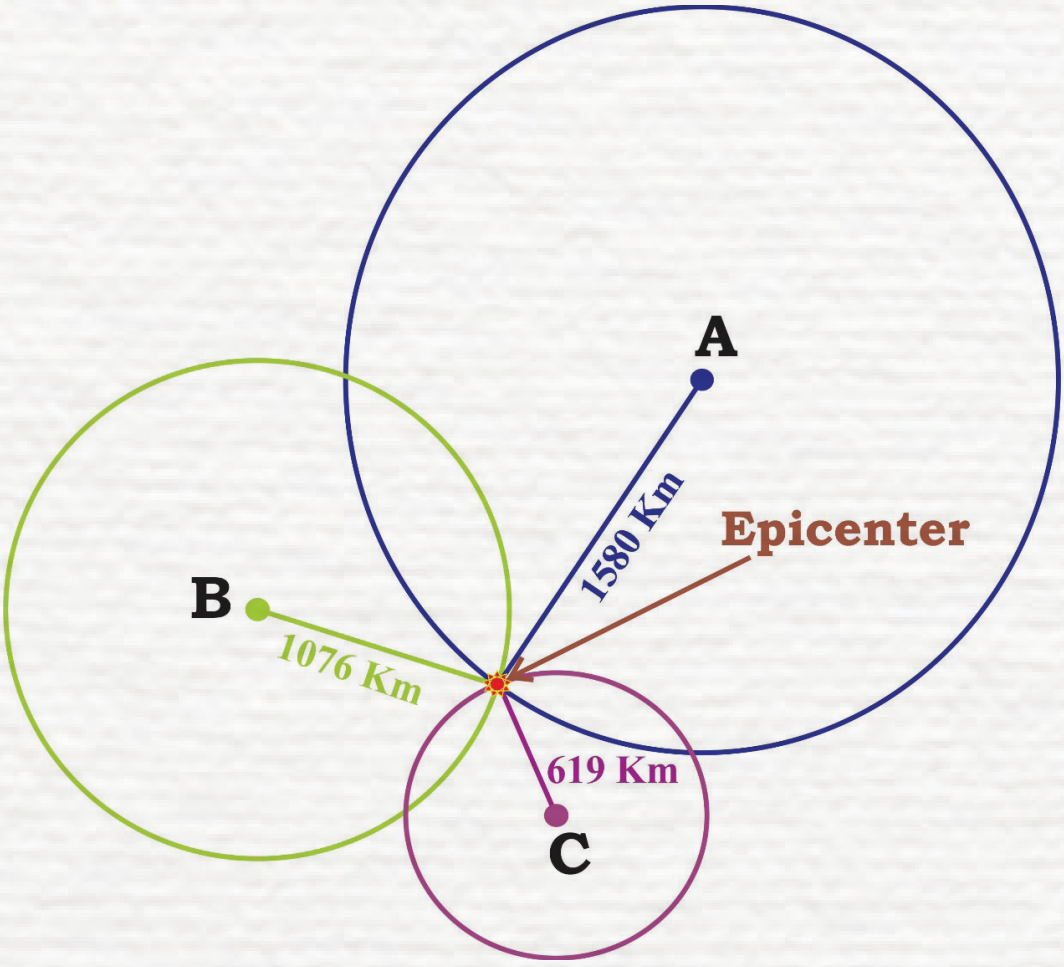


Fig. 1. The location of an earthquake can be determined by the trilateration method. The seismometers are located in A, B and C. Each circle represents the calculated distance from each seismometer to the earthquake. The red dot shows the earthquake epicentre.

most widely used is the Richter scale, devised by Charles F. Richter in 1935, a seismologist at the California Institute of Technology. The Richter scale is based on the amplitude of seismic waves - the stronger the earthquake, the stronger the seismic vibrations it causes. The Richter magnitude (M) of an earthquake is expressed as a decimal number, such as 6.7. The

most important thing to remember about Richter magnitude is that it is a logarithmic scale, meaning that an increase of 1 (one) Richter magnitude corresponds to a factor of 10 (ten) increase in wave amplitude. For instance, a magnitude 6.7 earthquake causes shaking 10 times greater in amplitude than a magnitude 5.7 earthquake and 100 times greater than a magnitude 4.7 earthquake. Each unit of Richter magnitude increase equals a tenfold increase in wave amplitude and a 32-fold energy increase. The energy release can be roughly estimated by converting the M to energy using the equation $E = 10^{1.5 \times R + 4.8}$. Although the Richter 'M' was widely used for most of the 20th century, the moment magnitude scale (M_w) is now preferred by scientists, developed in the 1970s by Japanese seismologist Hiroo Kanamori and American seismologist Thomas C. Hanks. The scale considers the seismic moment (M_o) instead of amplitudes of seismic waves and can measure significantly larger earthquakes (greater than magnitude 8). M_o is measured in units of newton-meters or dyne-cm. The measurement of M_o is based on the size of the area of the fault that moves, the average fault displacement (the distance that the fault blocks move), and the average rigidity of the rocks in the fault zone. The other standard magnitude scales are surface-wave magnitude (M_s) and body-wave magnitude (M_b). Humans usually do not feel moment magnitudes of less than 2.5. In India, the Northeast Himalayan mountain belt experienced two significant, historically documented great earthquakes of 1897 - Shillong (M_w = 8.2) and 1950 - Assam (M_w = 8.6) [2,7]. The 2004 earthquake (Mw 9.1) on the Andaman-Sumatra plate boundary is significant as a rare tsunamigenic earthquake [7].

• Intensity

The intensity of an earthquake is an evaluation of the severity of ground motion at a given location around the epicentre. It is a semi-quantitative expression used before the development of the Richter scale for describing the effects of ground shaking in terms of damage caused to buildings, dams, bridges, and other structures, as reported by witnesses. The increase in the degree of surface shaking (intensity) for each unit increase of the magnitude of a shallow crustal earthquake is unknown. Intensity is based on an earthquake's local accelerations and how long these persist, so that a single earthquake may have a much different intensity at different locations. In general, areas closest to the epicentre experience the highest intensities, and shaking diminishes in strength farther away. So, the intensity at a specific location depends on several factors. Foremost among these are (a) the total amount of energy released, (b) the distance from the epicentre, and (c) lithology and topography. The wave amplitude and destruction are greater in soft, unconsolidated materials than in crystalline rocks.

The intensity of an earthquake is measured by the Mercalli scale, which Giuseppe Mercalli first developed in 1884 and later, Adolfo Cancani modified it to expand it to a 12-degree intensity scale in 1902. Subsequently, the Modified Mercalli Intensity (MMI) scale was developed in 1931 by American seismologists Harry Wood and Frank Neumann, using California buildings as its standard. This scale is composed of increasing intensity levels ranging from I (imperceptible shaking only) to XII (complete devastation) (Fig. 2). It is designated by Roman numerals and does not have a mathematical basis. The Bhuj (Gujarat) earthquake in northwestern India, which occurred on 26 January 2001, was the most disastrous in terms of intensity in India's recent history. The casualty was over 20000, and more than 200000 were injured.

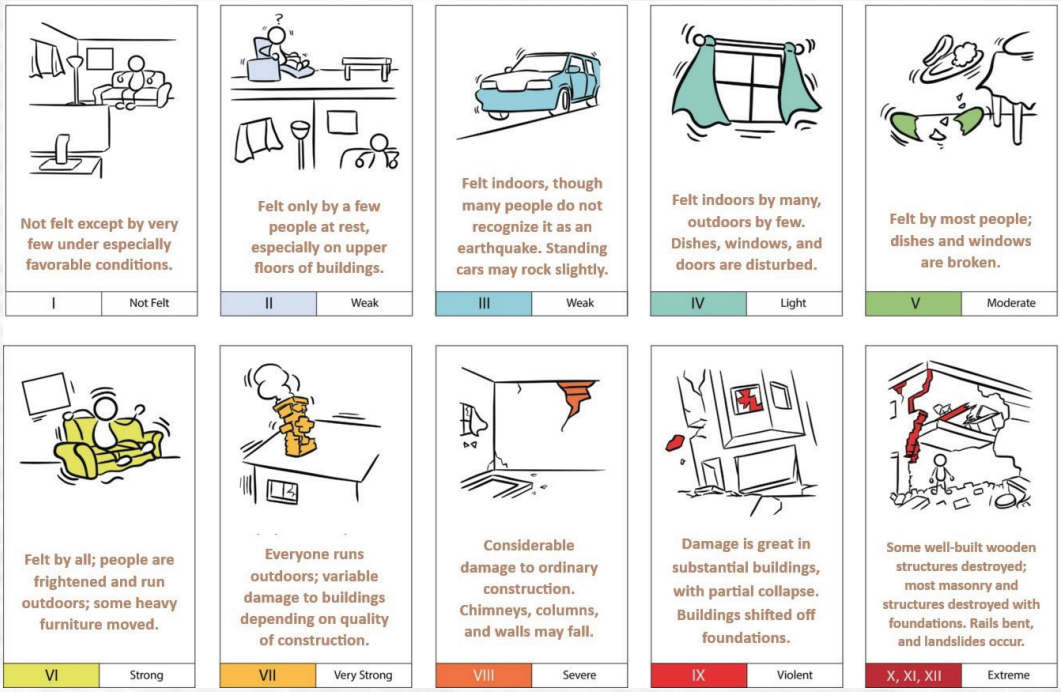


Fig. 2. The Modified Mercalli Intensity scale.

11.1.3 Compounding effects of earthquakes and cascading disasters

Different types of past disasters have highlighted that any event can trigger other events, leading to a significant increase in fatalities and damages. Thus, there is a growing demand to implement multi-type hazard and risk assessments and assess cascading effects. In this context, large-scale earthquake disasters have become significant threats to modern society. When a large earthquake occurs, usually, it is after the shaking stops that the cascading chains of hazard events occur. The chains consist of numerous combinations of ground surface rupture, strong ground motion, tsunami inundation, landslide, liquefaction, and aftershocks, and their combined effects can significantly worsen consequences compared

to individual impacts of earthquakes. Typically, a tsunami occurs when the epicentre of an earthquake is on the ocean floor, resulting in giant ocean waves and causing severe destruction to the land. Triggered by a major earthquake on the west coast of northern Sumatra, Indonesia, a massive Indian Ocean tsunami with waves up to ~30m occurred in the year 2004 on 26th December. It was one of the deadliest disasters in recent times and struck the coast of several countries of South and Southeast Asia, including the Indian east coast. Sometimes, the water-logged sediments at or near the ground surface lose their strength during earthquakes, and liquefaction occurs. Liquefaction can cause significant damage to buildings and other structures.

Earthquakes and society

• Seismic zones in India

In the last few decades, the Indian subcontinent has experienced many devastating earthquakes, and the Indian subcontinent is a significant contributor to Asian seismic zones. However, the likelihood of catastrophic earthquakes occurring at different locations is different. Thus, identifying seismic zones that exhibit the spatial entities related to quantifying the expected frequency and intensity of tremors caused by earthquakes is required. The process of seismic zoning is based on expected ground motion, expressed in terms of peak horizontal ground acceleration or peak ground velocity [4]. The task of seismic zoning is multidisciplinary, involving inputs from geologists, geophysicists, and earthquake and structural engineers. The latest revised version of the map, prepared by the Bureau of Indian Standards (BIS) in 2002, has four seismic zones: II, III, IV, and V (Fig. 3) [3]. The areas falling in seismic zone I in the previous versions are combined with those of seismic zone II, indicating that the minimum hazard level exists anywhere in the country [5]. The region falling under zone V is the most seismically active and has a higher probability of occurrence of quakes [7]. The region includes all seven North East states of India - Assam, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, and Meghalaya; Andaman & Nicobar Islands; and parts of six other states in the North/ Northwest (Jammu and Kashmir, Uttaranchal, and Bihar) and West (Gujarat).

• Earthquake warnings and forecasts

In modern times, scientists have undertaken paleoseismic studies to predict the sites where future earthquakes are most likely to happen. However, there is currently no reliable way to predict earthquakes. Identifying seismic gaps is one of the crucial methods that may indicate the site of future major earthquakes. The seismic gap is the zone of low earthquake activity

in recent times, but it has been experienced by past major earthquakes. Minor shock waves often precede major earthquakes, called foreshocks, which help in predicting an earthquake. Moreover, tilting ground and variations in rock properties are some of the changes in the Earth's crust by which one can predict earthquakes.

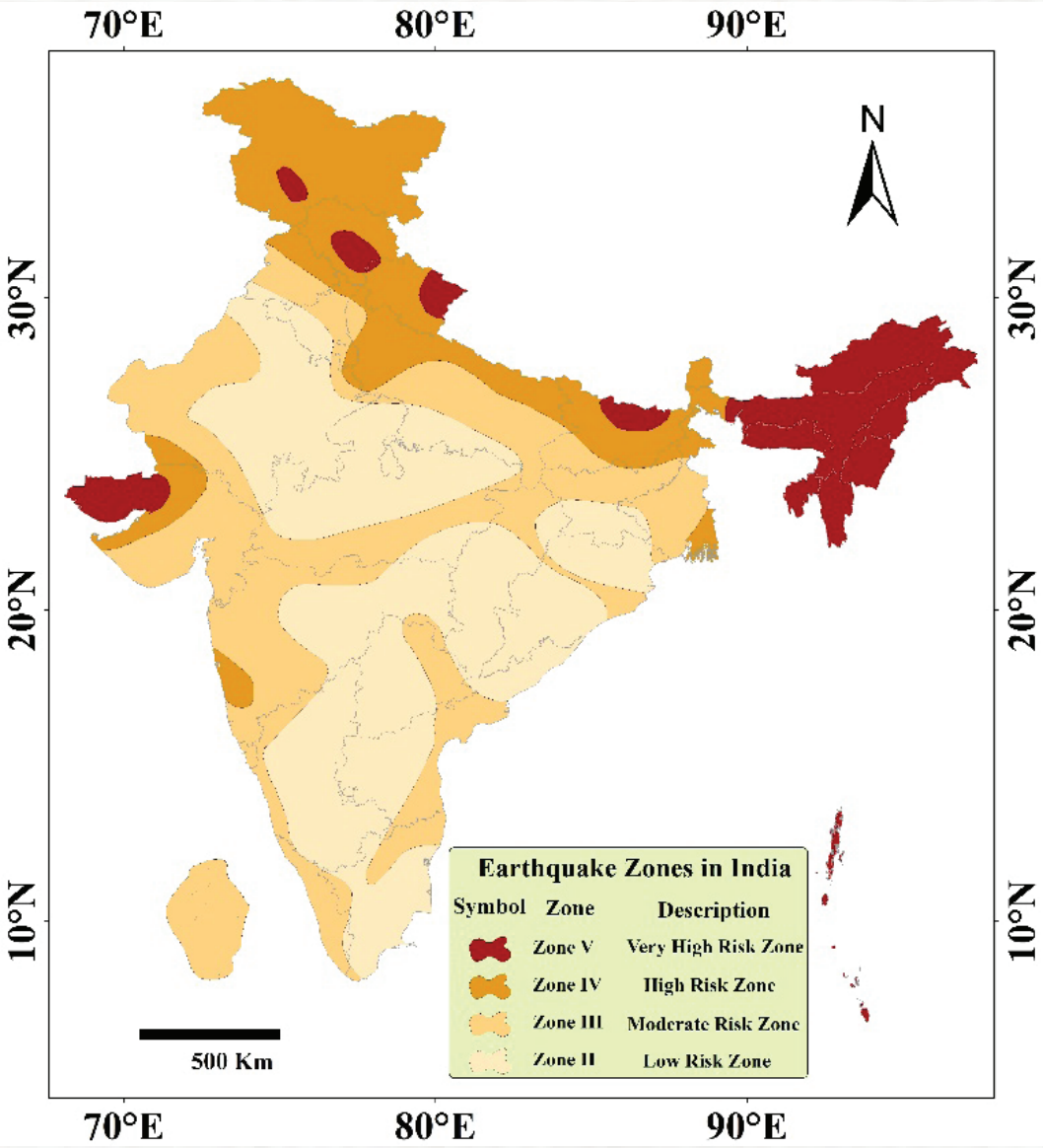


Fig. 3. Seismic zonation map of India in 2002 [3]

• Important measures to prevent and mitigate earthquake loss:

(i) The Government of India has taken a national initiative to launch the National Earthquake Risk Mitigation Project (NERMP) to understand the importance of managing such hazardous situations caused by earthquakes.

(ii) The National Building Code of India (NBC) is a comprehensive building code providing

guidelines for regulating building construction activities across the country. It considers the local seismology, accepted level of seismic risk, building typologies, and materials and methods used in construction. The regulations do not ensure that buildings suffer no damage during earthquakes of all magnitudes. However, to the greatest extent possible, they ensure that buildings are able to respond to earthquake shakings of moderate intensities without structural damage and of heavy intensities without total collapse.

(iii) The Building Materials & Technology Promotion Council (BMTPC) undertook projects for retrofitting lifeline structures. It generates awareness among the people as well as various government agencies about the need and techniques of retrofitting.

(iv) The Ministry of Panchayati Raj releases funds under the Backward Regions Grant Fund (BRGF) for meeting critical infrastructural gaps and other developmental requirements to build disaster-resilient structures.

(v) Recently, the Ministry of Earth Sciences, Government of India, launched two mobile applications, 'India Quake' and 'Sagar Vani'. The mobile application India Quake has been developed by the National Centre for Seismology to automatically disseminate earthquake parameters such as location, time, and magnitude after the occurrence of an earthquake and to avoid delay in information in the event. The Sagar Vani app has been developed by ESSO Indian National Centre for Ocean Information Services (INCOIS) to give details and alert users about tsunamis and high waves.

Points for group discussion

- An earthquake with a magnitude of 4 releases 32 times more energy than an earthquake with a magnitude of 3. How much more energy does an earthquake with a magnitude of 7 release than an earthquake with a magnitude of 5 does, and why?
- An earthquake of magnitude 6.6 hit two cities. The cities are the same size and are built with the same type of buildings. The city where the earthquake produces a maximum intensity of VI on the MMI scale loses Rs. 5000 crore in total assets. The city in which the earthquake produces a maximum intensity of VIII on the MMI scale suffers Rs. 9900 crore in damage. What might account for this great difference in the costs of the damage?
- Would an earthquake in the Chotanagpur region of India be likely to cause landslides? Explain your answer.
- The record of past earthquakes and seismic gaps is crucial for predicting future earthquake. Justify.

11.1.4 Case Study

• 2011 Earthquake

An earthquake with a moment magnitude of M_w 6.9 occurred at 18:11 hours IST on 18 September 2011, with an epicentre near the Sikkim (India)-Nepal border region. The region is located in the Alpine-Himalayan seismic belt, which is characterized by two major fault systems (Main Boundary Thrust- MBT and Main Central Thrust-MCT) associated with the collision of the Indian and Eurasian plates, thus making it seismically active. The focal depth has been estimated as 19.7 km by the United States Geological Survey (USGS). Maximum shaking was widely felt in India's north-eastern state of Sikkim, followed by Tibet, Nepal, Bhutan and Bangladesh, as well as the Indian states of Bengal, Assam, Bihar, and Meghalaya. The maximum shaking intensity attributed to this earthquake is VIII in the north and eastern parts of Sikkim, such as Chungthang, Lachung, Mangan, Phodong, Gangtok, Dikchu, and Singtam. The total death toll is about 112 people, with 60 reported fatalities in the state of Sikkim alone. Three aftershocks of magnitude 5.7, 5.1 and 4.6 were felt within 30 minutes of the earthquake. The region falls into the second-highest seismic zone of the Indian Seismic Code IS: 1893, Zone IV, with an expected shaking intensity of VIII.

• 2015 Earthquake

A magnitude of M_w 7.8 earthquake struck Nepal on 25 April and caused tremendous damage and loss. The epicentre was about 77 km northwest of Kathmandu, near Barpak Village in Gorkha district, determined by USGS. This Gorkha event was followed by numerous aftershocks of magnitude 5 or higher, causing further damage and losses. It was the largest natural disaster in Nepal's history since the 1934 Bihar-Nepal Earthquake. The ground shaking caused damage to buildings in most of the country. The report by the Government of Nepal indicates that the recorded death toll has reached close to 9000. The series of shaking destroyed numerous villages, and major landslides were triggered.

11.2 Landslide - *Introduction*

Landslides are one of the most destructive natural disasters, commonly occurring in hilly and seismically active mountains. These are serious concerns in India, particularly in mountainous regions such as the Himalayas, North-Eastern hill ranges, Western Ghats, Nilgiris, Eastern Ghats, and Vindhyans, suffering from chronic landslide problems, resulting in significant economic losses running into billions of rupees. NASA's Global Landslide Catalog (GLC) indicates that India is the top-ranked country globally in terms of landslide incidences and related casualties. The Himalayas, being the highest mountain chain in the world, are

specifically susceptible to landslides and earthquakes due to the continuous stress caused by the northward movement of the Indian plate colliding with the Eurasian plate. Around 300 - 400 fatalities occur in the Himalayan region owing to landslides every year.

Landslides are the mass movement of dislodged rock, debris, or earth materials flowing downward along the slope, including the range of motions whereby falling, sliding, and flowing under the influence of gravity. These cause a serious threat to human lives, properties, and the environment of the region. The landslides occur due to numerous geological and geomorphological characteristics of the terrain, including the triggering effect of rainfall and earthquakes. In recent times, the anthropogenic perturbation on slopes for developmental activities like expansion and widening of the road network, rampant urbanization, changes in land-use practices, and rapid deforestation have also immensely contributed to slope instability, leading to landslides. Different types of landslides occur worldwide in terms of rate of movement, type of materials, nature of movement, and presence of a lubricating agent. Their recurring nature poses ongoing challenges for the affected regions.

11.2.1 Causes of Landslides

Landslides are often triggered by intense rainfall or earthquakes, and it is observed that landslide-prone areas mostly occur in conjunction with seismic-prone and intense rainfall areas. Therefore, for early warning of landslides in India, it is pertinent to explore both the triggering factors, i.e., precipitation and seismicity.

• Natural causes

(i) Intense rainfall can elevate the groundwater table, reduce soil cohesion, and increase the weight of materials

(ii) Erosion resulting from continuous runoff over a slope

(iii) Rock decomposition and weathering

(iv) Ground vibrations generated during an earthquake

(v) Volcanic activity

• Human-induced causes

(i) Oversteepening of slopes through cutting and quarrying activities carried out for road construction

(ii) Unsuitable farming practices

(iii) Removal of forest cover through firewood collection or logging

11.2.2 Classification of landslides

Although landslides are primarily associated with mountainous regions, they can also occur in areas of generally low relief. In low-relief areas, landslides occur as cut-and-fill failures (roadway and building excavations), river bluff failures, lateral spreading landslides, the collapse of mine-waste piles (especially coal), and a wide variety of slope failures associated with quarries and open-pit mines. The most common types of landslides are given in Table 1.

Table 1. Classification of landslides [10]

<table>
<tr><td colspan="3" rowspan="3">Type of movement
Rock
Soils
Predominantly fine</td><td colspan="3">Type of material</td></tr>
<tr><td colspan="2">Debris</td><td></td></tr>
<tr><td colspan="2">Predominantly coarse</td><td></td></tr>
<tr><td colspan="3">1. Falls</td><td>Rock fall</td><td>Earth fall</td><td>Debris fall</td></tr>
<tr><td colspan="3">2. Topples</td><td>Rock topple</td><td>Earth topple</td><td>Debris topple</td></tr>
<tr><td rowspan="3">3. Slides</td><td>Rotational (Slump)</td><td rowspan="2">Few units</td><td>Rock slump</td><td>Earth slump</td><td>Debris slump</td></tr>
<tr><td rowspan="2">Translational</td><td>Rock block slide</td><td>Earth block slide</td><td>Debris block slide</td></tr>
<tr><td>Many units</td><td>Rock slide</td><td>Earth slide</td><td>Debris slide</td></tr>
<tr><td colspan="3">4. Lateral spreads</td><td>Rock spread</td><td>Earth spread</td><td>Debris spread</td></tr>
<tr><td>5. Flows</td><td></td><td></td><td>Rock flow (deep creep)</td><td>Earth flow</td><td>Debris flow</td></tr>
<tr><td></td><td></td><td colspan="2">(soil creep)</td><td></td><td></td></tr>
<tr><td colspan="3">6. Complex</td><td colspan="3">A combination of two or more principal types of movement</td></tr>
</table>

11.2.3 Landslides in India

Over the years, several major landslide incidents have occurred in various parts of the country, leading to tragic events and significant damage. Some notable incidents include Katropi-2017 in Himachal Pradesh, Laptap Pampare-2017 in Arunachal Pradesh, Mirik-2015 in West Bengal, Malin-2014 in Pune, Dasalgaon-2007 in Maharashtra, Varunavat Parvat-2003 in Uttarakhand, Amboori-2001 in Kerala, Malpa landslide-1998 in Uttarakhand, Kalimpong-1993 in West Bengal, and Kohima-1993 in Nagaland [9].

The landslides in India led to a rough estimate of ₹ 1000 million to ₹ 1500 million per annum economic loss at the current prices for the country as a whole [2,6]. In India, about 0.42×10^6 km^2 landmass areas (12.6%) are landslide-prone, excluding the permafrost regions in the north [5]. The affected areas spread over 19 odd numbers of States/ Union Territories and over 65,000 villages in hilly/ mountainous areas (Fig. 4).

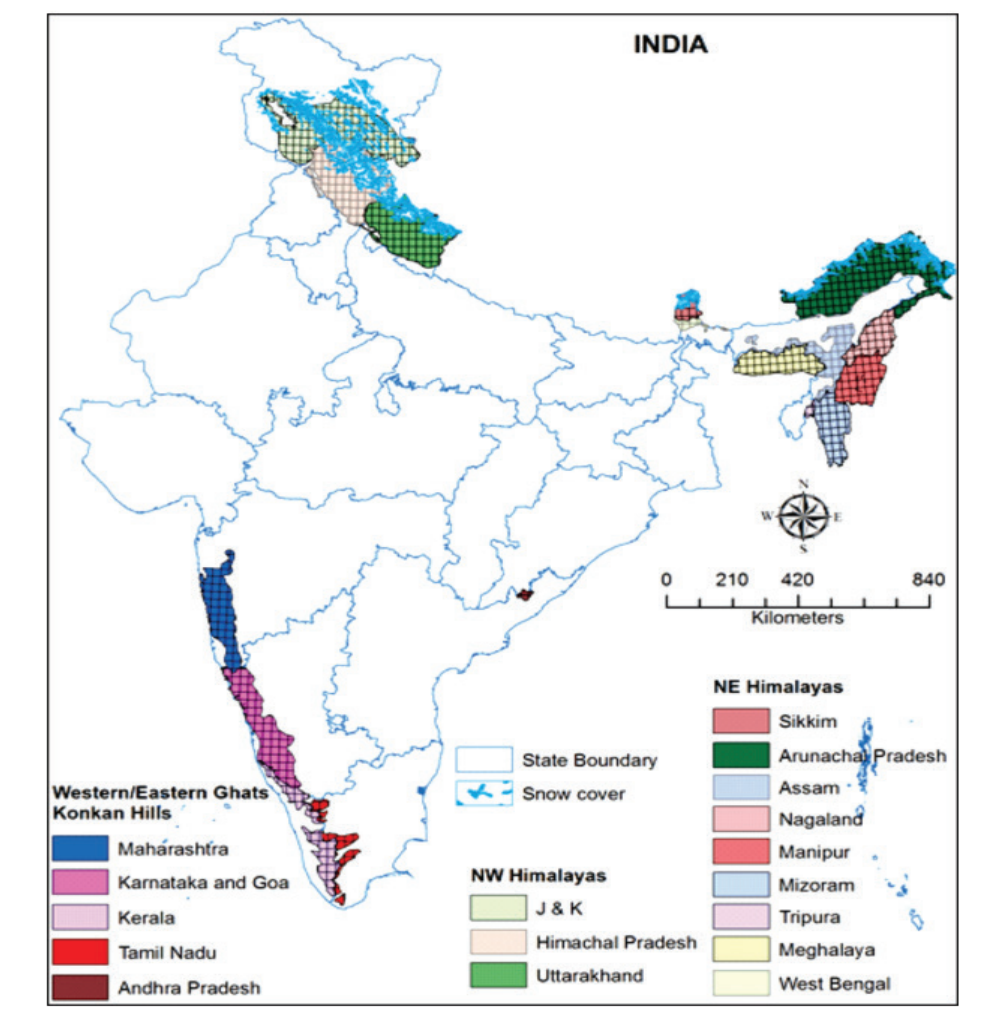


Fig. 4. Major landslide-prone states/ union territories of India [5]

11.2.4 Early warning system for landslide detection

A landslide early-warning system (LEWS) is capable of forecasting landslide occurrences that will happen. Different types of LEWS exist depending on the type of landslides, the target warning area, and the communities to be warned [5]. For developing a reliable LEWS, it is pertinent to understand the processes of mass movement and to measure quantitatively its spatial variation and temporal prediction.

• Types of LEWS

(i) *Rainfall threshold-based landslide early warning system* (RT-LEWS)

(ii) *Ground instrument-based landslide early warning system* (GI-LEWS)

(iii) *Seismicity-induced landslide early warning system* (SI-LEWS)

11.2.5 Landslide risk management and strategy

The components of landslide disaster risk reduction and management include mapping hazards, monitoring and early warning systems, awareness generation through different programmes, capacity building and training, regulations and policies, and stabilization and mitigation of landslides (Fig. 5).

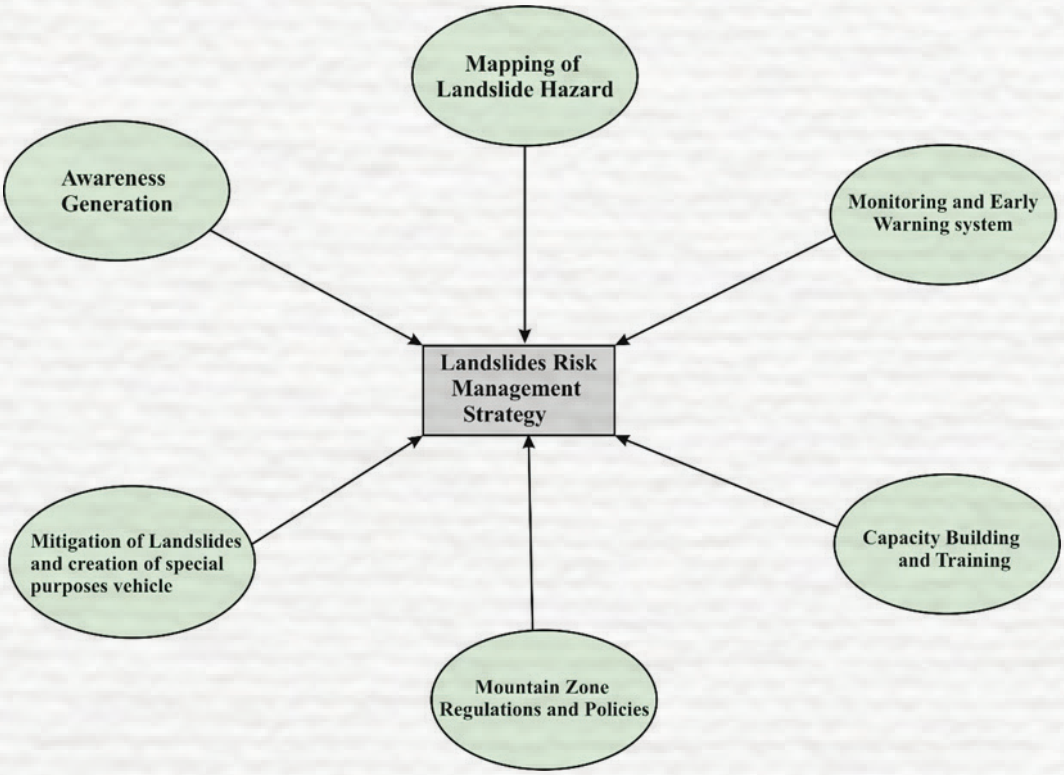


Fig 5. Flowchart for landslide risk management and strategy

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Glossary

Earthquake: It is the sudden release of strain energy in the Earth's crust, resulting in waves of shaking that radiate outwards from the earthquake source.

Epicentre: The point on the Earth's surface where the effects of a sudden movement (earthquake) are felt most strongly.

Hypocentre: The location of the source of the earthquake inside the Earth's surface, from where waves initiate, is called the focus or hypocentre

Liquefaction: Liquefaction takes place when loosely packed, water-logged sediments at or

near the ground surface lose their strength in response to strong ground shaking.

Global Navigation Satellite System (GNSS): It refers to a constellation of satellites providing signals from space that transmit positioning and timing data to GNSS receivers.

Seismographs: These are instruments used to record the motion of the ground during an earthquake.

Falls: Sudden movements of the slope materials that separate from steep slopes or cliffs.

Topples: These encompass the forward rotation and movement of huge masses of rock, debris, and earth from a slope.

Slides: These are a kind of movement where sliding material breaks away from the underlying stable materials.

Spreads: These occur when sediment (rock or soil) suddenly loses strength and starts to flow.

Flows: These are rapid movements of materials as a viscous mass.

Suggestive questions

MCQ questions carry one mark each

1. The magnitude of an earthquake:
   a. increases with a decrease in focal depth and epicentral distance
   b. increases with an increase in focal depth and decreases with a decrease in epicentral distance
   c. increases with a decrease in focal depth and increases with an increase in epicentral distance
   d. is independent of the epicentral distance and focal depth
2. Earthquakes that cause severe damage are likely to have what characteristics?
   a. a deep focus
   b. an intermediate focus
   c. a shallow focus
   d. a deep epicentre

3. As rupture along a fault initiates, waves of energy travel outward from the hypocentre in a:

   a. linear fashion
   b. a straight line path
   c. a spherical fashion
   d. none of the above

4. Which of the following is not a landslide-prone area?

   a. Himalayas and Andaman and Nicobar
   b. Steep slopes in the Western Ghats
   c. Nilgiris in the north-eastern regions,
   d. Aravalli regions in Rajasthan.

5. Which is the common term synonymous with slide?

   a. Slump
   b. Topple
   c. Spread
   d. Creep

All short questions carry three marks each (short notes)

1. Why do scientists prefer the moment magnitude scale to the Richter scale?
2. How are earthquake detection and tsunami warnings related?
3. List three changes in rock that may help in earthquake forecasting.
4. Why do landslides occur after intense rainfall?
5. Can the landslide prediction possible?

All long questions carry ten marks each (essay type, logical analysis, inferring practical situation)

1. Explain why earthquakes generally take place at plate boundaries?
2. Discuss the cascading hazards associated with a landslide.

Suggestive PowerPoint slides for reference

Earthquake and its causes

Earthquakes are the shaking of the earth's surface (crust) caused by the seismic waves that are emitted due to the deformation or breaking of rocks.

- Focus (hypocenter) - where earthquake waves originate
- Epicenter - location on the surface directly above the focus

- Causes of earthquake

-- Fault zones
-- Plate tectonics
-- Volcanic eruptions
-- Human-induced earthquakes

During an earthquake, energy in the form of seismic waves is released and radiates in all directions from its source.

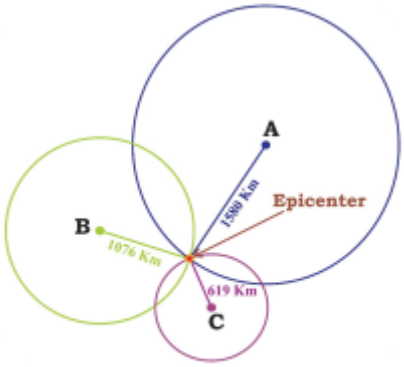
Disaster vulnerability profile of India - Regional issue: Earthquake & Landslide

Locating an earthquake

To determine the location of the epicenter of an earthquake:

- Three station recordings are needed.
- Analyzing the time interval between the arrival of the P and S waves at three stations. The time difference between the arrivals of both waves is called lag time.
- The lag time is used to compute the distance of each station to the epicenter.

To locate the epicenter, a circle is drawn around each seismic station with a radius equal to the distance to the epicenter. The point at which the three circles pass through is the location of the earthquake epicenter

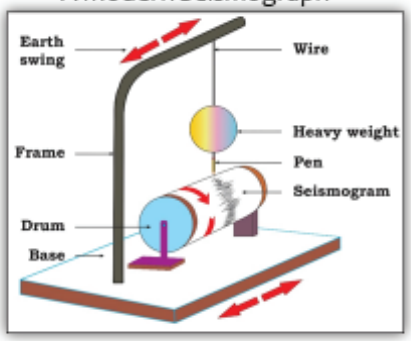


Recording Earthquake

The seismic waves generated from earthquakes are recorded on instruments called seismographs. The Chinese scholar Zhang Heng developed World's first seismograph in 132 AD, called seismoscope.

- The modern seismograph records vibrations in the ground and comprises a ground motion detection sensor, called a seismometer, coupled with a recording system.
- It records the movement in relation to a stationary mass on a rotating drum or magnetic tape. It also records information about the rocks through which the seismic waves (P or S - waves) travelled.
- The records obtained during an earthquake are called seismograms.

A Modern Seismograph



Measuring earthquake size

Two measurements describe an earthquake's size:

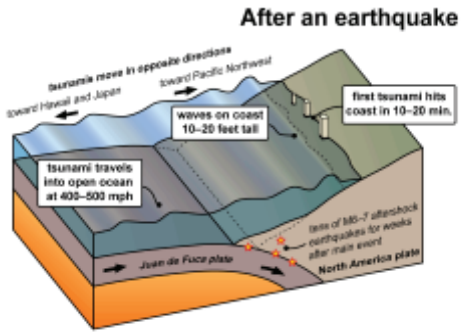
- Magnitude: It is a quantitative measure of the energy released at the hypocenter during an earthquake. There are different types of magnitude scales, but the standard one that has been most widely used is the Richter scale, devised by Charles F. Richter in 1935, a seismologist at the California Institute of Technology.

- Intensity: The intensity or destructive power of an earthquake is an evaluation of the severity of ground motion at a given location around the epicenter. The intensity of an earthquake is measured by the Mercalli scale, which Giuseppe Mercalli developed in 1902. It is a twelve-grade scale ranging from I (recorded by sensitive instruments only) to XII (complete devastation). Subsequently, the Modified Mercalli Intensity (MMI) scale was developed in 1931 by American seismologists H.O. Wood and Frank Neumann, using California buildings as its standard.

Compounding effects of earthquake and cascading disasters

- When a large earthquake occurs, usually, it is after the shaking stops that the cascading chains of hazard events occur.

The chains consist of numerous combinations of ground surface rupture, strong ground motion, tsunami inundation, landslide, liquefaction, and aftershocks, and their combined effects can significantly worsen consequences compared to individual impacts of earthquakes.



Measures to prevent and mitigate earthquake loss

- The National Earthquake Risk Mitigation Project (NERMP) by GoI aims to strengthen the structural and non-structural earthquake mitigation efforts and reduce the vulnerability in high-risk districts prone to earthquakes.

- The National Building Code of India (NBC) is a comprehensive building code providing guidelines for regulating building construction activities across the country.

- The Building Materials & Technology Promotion Council (BMTPC) undertook projects for retrofitting lifeline structures.

- The Ministry of Panchayati Raj releases funds under Backward Regions Grant Fund (BRGF) for meeting critical infrastructural gaps and other developmental requirements to build disaster resilient structures.

- Mobile applications, 'India Quake' and 'Sagar Vani'

Landslide and its causes

Landslides are the mass movement of dislodged rock, debris, or earth materials flowing downwardly along the slope, including the range of motions whereby falling, sliding and flowing under the influence of gravity.

Causes of landslide

- Natural causes:

(i) Intense rainfall, which can elevate the groundwater table, reduce soil cohesion, and increase the weight of materials; (ii) Erosion resulting from continuous runoff over a slope; (iii) Rock decomposition and weathering; (iv) Ground vibrations generated during an earthquake; and (v) Volcanic activity

- Man-made causes:

(i) Oversteepening of slopes through cutting and quarrying activities carried out for road construction; (ii) Unsuitable farming practices; and (iii) Removal of forest cover through firewood collection or logging

Landslide early warning system

A landslide early-warning system (LEWS) is envisaged as a system capable of modelling landslide occurrences and providing timely advance warning about impending danger.

- Types of LEWS

– Rainfall threshold based landslide early warning system (RT-LEWS)

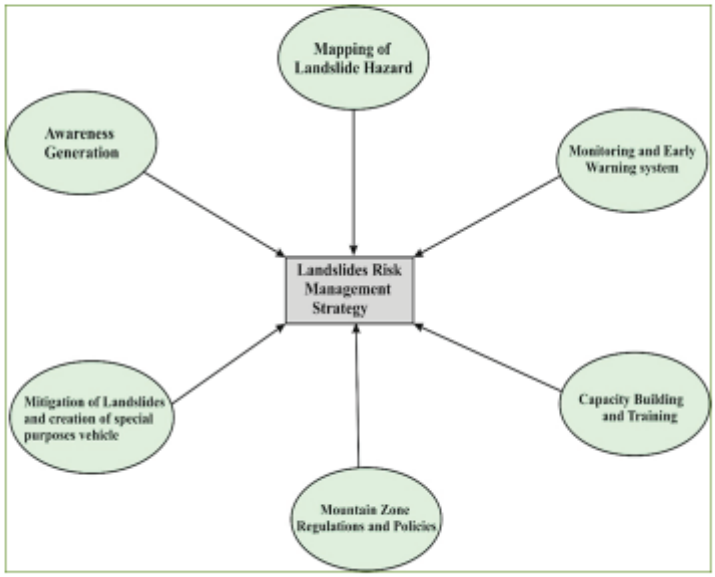
– Ground instrument based landslide early warning system (GI-LEWS)

– Seismicity induced landslide early warning system (SI-LEWS)

Classification of landslides

Type of movement			Type of material		
			Rock	Soils	Debris
				Predominantly fine	Predominantly coarse
1. Falls			Rock fall	Earth fall	Debris fall
2. Topples			Rock topple	Earth topple	Debris topple
3. Slides	Rotational (Slump)	Few units	Rock slump	Earth slump	Debris slump
	Translational	Few units	Rock block slide	Earth block slide	Debris block slide
		Many units	Rock slide	Earth slide	Debris slide
4. Lateral spreads			Rock spread	Earth spread	Debris spread
5. Flows			Rock flow (deep creep)	Earth flow	Debris flow
				(soil creep)	
6. Complex			Combination of two or more principal types of movement		

Landslide risk management and strategy



Flowchart for landslide risk management and strategy

CHAPTER- 12

Disaster Vulnerability Profile of India: Drought and Forest Fire

Dr. Bindu V. T.

Total No. of Hours: 2.5 Hours

I. Background of the topic:

Drought is a commonly recognized climate phenomenon caused by a prolonged period of relatively dry weather. It is universally recognized as the result of an erratic distribution of rainfall, but the extent and severity of the disaster are determined by several factors, including the status of surface and groundwater resources, agro-climatic features, cropping choices, patterns, the socioeconomic vulnerabilities of the local population, and so on. It may be devastating because it causes water supplies to run dry, crops to fail to develop, animals to perish, and starvation and illness to spread. Its environmental consequences include soil salinization and groundwater decreases, increased contamination of freshwater habitats, and regional extinction of animal species.

According to ISFR 2019, more than 36% of the nation's forestland is vulnerable to frequent forest fires. 6% of the country's forest cover is assessed to be very highly fire-prone, compared to about 4% of forest cover that is extremely fire-prone. The incidence of forest fires has greatly increased as a result of growing human interaction with the natural forest environment. The fire season varies from location to location depending on the vegetation type, climate, and several other factors. In our nation, forest fires are common occurrences that are frequently seen in the summer, in the period from November 2020 to June 2021. Every year, forest fires destroy valuable forest resources, including carbon that has been locked up in the biomass, having a negative influence on the flow of commodities and services from forests.

II. Learning outcomes:

1. To understand the phenomenon of drought.
2. To learn about the regional vulnerability of drought in India.
3. To study the types of forest fires that occur in India.
4. To learn about the causes and management of forest fires.

III. Pedagogy of the Session:

Mode of dealing with the session: Lecture, PowerPoint, Group discussion, Maps, and Charts

List of materials required:

- Vulnerability profile maps,
- Disaster management authority reports,
- Charts

IV. Content on the topic

12.1 Vulnerability profile of India: Drought

India is susceptible to natural and human-induced disasters because of geological, climatic, and socio-economic situations. Nearly 5,700km of coastline are vulnerable to tsunamis and cyclones; 58.6 percent is at risk of earthquakes; 68 percent is in danger of drought, landslides and avalanches. Landslides, earthquakes, droughts, avalanches, floods, heat waves, and cold waves are among the natural disasters that affect the North Indian states of Punjab, Himachal Pradesh, Uttaranchal, Haryana, Uttar Pradesh, and Bihar due to topographical and geological factors. East and North-East India are prone to earthquakes, landslides, floods, and droughts; cyclones also strike West Bengal. Central India (Odisha, Maharashtra, Jharkhand, Rajasthan, Chhattisgarh, Gujarat, M.P., and Goa) has a highly varied rainfall regime and so floods and droughts are major calamities in the region. Drought is a temporary phenomenon, as contrasted to aridity or seasonal aridity, a permanent characteristic of climate. It is a recurrence that occurs throughout every climatic condition and is characterized by fluctuation of severity, regional extent, and length. The basic cause of any drought is based on rainfall, its distribution and intensity and commonly recognized phenomenon caused by a prolonged period of dry weather. Drought causes water supplies to run dry, animals to perish, agricultural failure, and starvation. The environmental consequences include soil

salinization, groundwater decreases, contamination of freshwater, and extinction of animals. It is caused by a lack of distribution of rainfall, but extent and severity are dependent on a variety of factors, including the surface and ground water resources, agro-features, crops and patterns and local populations' socio-economic vulnerabilities.

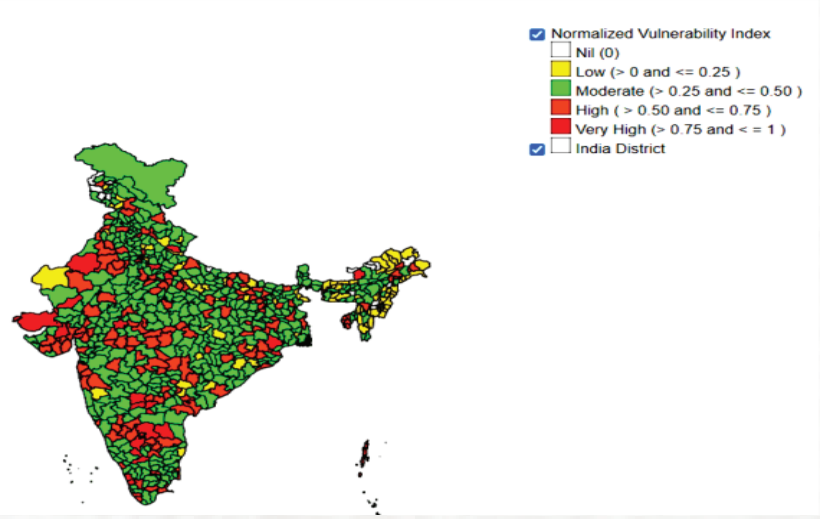


Fig. 1: Drought Normalized Vulnerability Index[4]

Source: Hazards Atlas (IMD Pune)

Drought is difficult to define precisely and universally due to its complex structure and diverse traits that emerge across different agro-climatic zones of the world. The southern and western regions are most prone to severe droughts, which occur year after year. Agricultural droughts are most prevalent in these areas. Since the 2000s, the northern, eastern, and central zones have been relatively vulnerable, dominated by climatic and agricultural droughts. The north-eastern area is 'less prone' to severe droughts.

Factors influencing droughts:

- Monthly, seasonal and regional variations in precipitations
- Overuse of groundwater resources
- Deforestation, Climate Change, Urbanization
- Inadequate conservation and storage of surface water
- Limited irrigation coverage and improper cropping patterns
- Short duration of South-West monsoon

Fig. 2: India's susceptibility to droughts[8]

Source: Manual for Drought Management (SDMA)

12.1.2 *Types of Droughts*

Drought is a gradual occurrence, having disastrous and protracted socioeconomic effects that endure for months or even years, depending on the level of water scarcity. The agro-climatic zone determines how rainfall levels affect droughts in India. 400 mm of rainfall distributed over a crop period may be enough to sustain crops in semi-arid locations, unlike in high-rainfall regions. Drought occurrence and intensity are affected by several factors- climate change, hydrological and soil conditions, its moisture, crop- agricultural practices and fodder availability. According to studies, 68% of India's cropland is vulnerable to drought, with 33% of that area being classified as "chronically drought-prone" and having less than 750 mm of annual rainfall, and 35% as being classified as "drought-prone" and receiving 750–1125 mm of mean annual rainfall. The dry, semi-arid, and sub-humid regions of western India and the peninsula make up the majority of the country's drought-prone zones.

The four drought types are:

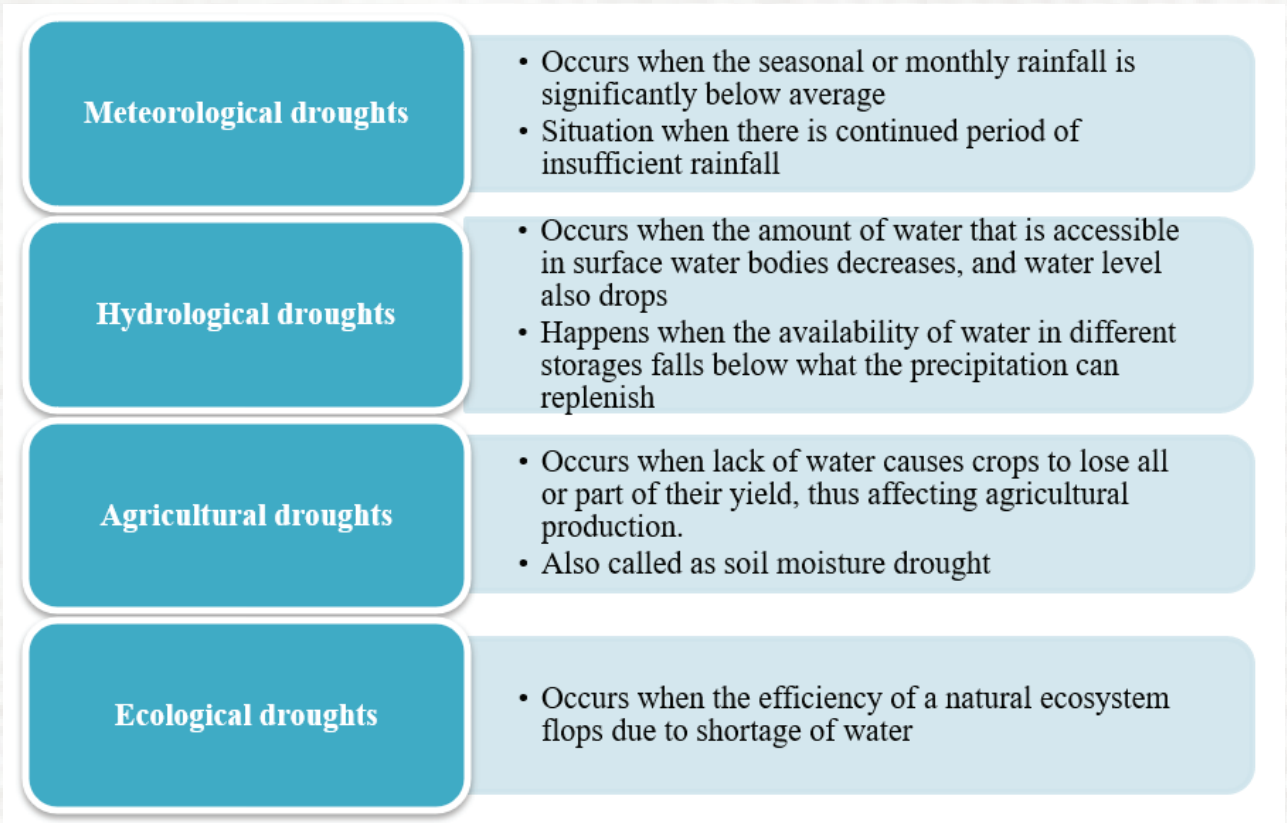


Figure 3: Types of droughts

Fig. 3: Types of Droughts[5]

Source: Management of Drought (NDMA)

Fig. 4: Causes of droughts[5]

Source: Management of Drought (NDMA)

12.1.3 *Drought hotspots in India*

Since a large proportion of India relies on agriculture and related industries for its income, our country is extremely vulnerable to the effects of climate change. In India, there are four subtypes of drought: meteorological, hydrological, ecological, and agricultural. 68% of Indian districts are vulnerable to catastrophic drought events. According to an analysis of districts that are drought hotspots conducted zone by zone, the southern and central zones are particularly vulnerable to extreme drought episodes in India. Furthermore, compared to the north and north-eastern zones, the eastern and western zones are more vulnerable to extreme drought episodes.

Table 1: Drought hotspots in India

Zone	State	District Hotspots
Central	Madhya Pradesh	Sagar, Rewa, Sidhi, Balaghat, Chhatarpur, Dewas, Jhabua
East	Odisha	Gajapati, Ganjam, Baleshwar, Khordha, Sundhargarh
	Bihar[1]	Arwal, Aurangabad, Banka, Bhojpur, Buxar, Gaya, Jamui, Jehanabad, Kaimur, Lakhisarai, Munger, Nawada and Rohtas
North	Uttar Pradesh	Aligarh, Faizabad, Auraiya, Ghaziabad, Budaun, Pilibhit, Azamgarh, Ambedkar Nagar
North-east	Assam	Goalpara, Morigaon, Nalbari, Darrang, Barpeta, Sivasagar, Cachar
	Arunachal Pradesh	West Siang
South	Karnataka	Uttarakannada, Dakshinakannada, Koppal, Gadag
	Tamil Nadu	Thiruvallur
	Kerala	Kasargod, Kozhikode, Kannur, Pathanamthitta, Malappuram
	Andhra Pradesh	Vizianagaram, West Godavari, YSR, Guntur, Nellore
	Telangana	Mahbubnagar, Hyderabad
West	Rajasthan	Jalor
	Maharashtra	Sangli, Jalgaon, Aurangabad, Nagpur, Pune, Amravati
	Gujarat	Kachchh, Rajkot, Bhavnagar, Banaskantha, Jamnagar, Surendranagar

Source: Mapping India's Climate Vulnerability (CEEW)[6]

In India, droughts are now a yearly occurrence distinguished by longer dry spells and irregular seasonal rainfall. The northern, eastern, and central zones are sensitive regions, since 2010, these regions have experienced an increase in the frequency of meteorological and agricultural droughts.

Extreme drought occurrences are least likely to occur in the northeast. Up to 68 percent of India's agricultural land is at risk from droughts, with 33 percent of that land being categorized as "chronically drought-prone" and made up of semi-arid and desert areas with annual rainfall averages of less than 750 mm. Droughts in India can be of two types: meteorological (lack of precipitation) and hydrological (lack of surface water flow). Currently, India has a standardized precipitation evaporation index (SPEI) of less than 2, severe meteorological drought of about 3%. The Indo-Gangetic Plain area has historically seen the most droughts.

1 https://www.unicef.org/india/media/2786/file/DRR-Roadmap-Bihar.pdf, Accessed on 09/09/2024.

Over 19% of India's population experienced drought between 2001 and 2013 (drought was defined in this study as a normalized difference drought index of >0.6).

The Central Water Commission (CWC) developed the following criteria to identify drought-prone areas: Drought is a scenario that occurs when annual rainfall is less than 75% of normal in assessed (20% of the years). An equivalent unit is regarded as having achieved a stage where it can sustain a fair level of protection against drought if at least 30% of the agricultural area is irrigated. According to rainfall data from 1875 to 1998, a moderate or severe drought struck a percentage of the country. It should be mentioned that during the entire 124-year period, the percentage of the country impacted by drought on three separate occasions (in 1877, 1899, and 1918) was greater than 60%. Around 68% of India's agricultural land is at various degrees of risk from drought.

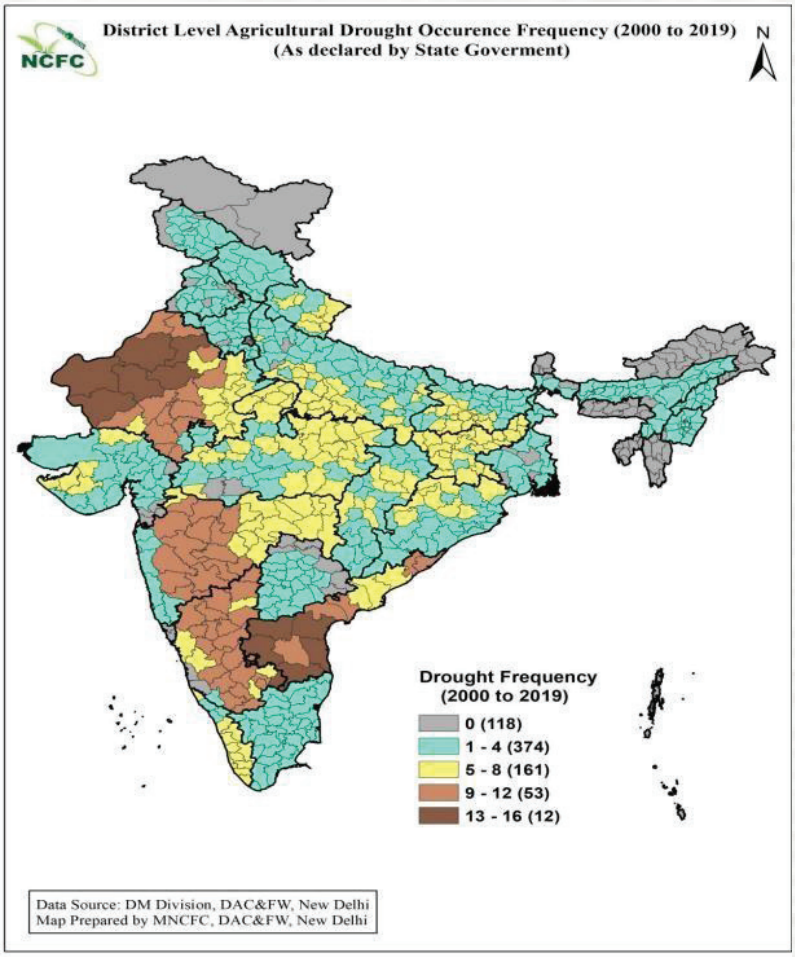


Fig.5: Drought frequency of India[8]

Source: District Level Agricultural Drought Occurrence Frequency (MNCFC)

33% of the territory is chronically drought-prone. And 35% receive rainfalls between 750 mm and 1125 mm, which is considered drought-prone. Around 50 million people are affected by drought each year, which affects over 29% of the country's entire geographic area. Nearly every year in India, droughts of varied intensities affect 20–25% of the districts. However,

catastrophic droughts of this magnitude happened on average once every 25 years, as in the years 1877, 1899, 1918, 1972, 1987, 2002, 2009, and 2016.

The 1972 drought had a negative influence on the production of food grains, while crop losses and ensuing decline in farm earnings were discovered to be the main obstacles in 1987. The National Watershed Development Programme for Rainfed Areas (NWDPRA) was started as a result of the 1987 drought, which highlighted the importance of using a watershed approach to lessen the effects of drought. Contrary to past drought episodes, the 2002 drought had a devastating effect on the country's agricultural situation during the kharif season, while low reservoir water levels decreased the irrigated areas during the rabi season. The drought damaged 300 million people's livelihoods and 56% of India's land area. The agrarian sector in the susceptible area will be negatively impacted by this surge, which will also continue to alter the microclimate by increasing dry periods and climate anomalies.

12.2 Vulnerability profile of India: Forest fire

India's 7,64,566 km^2 of recorded forest cover 2.3% India's forests and forest fire incidents and season varies from location to location depending on the climate, vegetation type, and several factors. Although the country's primary fire season is from February to June, and some areas are at risk for all year. The estimated areas that are vulnerable to fire in conditions of heavy (2.40%), moderate (7.49%), and mild fire (54.40%). Forest fires have direct and indirect impacts on the environment. Uncontrollable forest fires cause direct loss to the forest cover, damage the environment, kill wildlife, and hinder the regeneration of the forests. Most of the forest fires are caused by human beings, either by negligence or unknowingly. This environment is in danger of extinction as a result of mounting population pressure, temperature, and climate change. The incidence of forest fires has greatly increased as a result of growing human interaction with the natural forest environment. When a forest fire spreads across a large forest region in a country, the ecology and property suffer tremendous losses. In India, the effects of forest fires on the environment and society are as follows: loss of habitat, loss of timber and non-timber, global warming, loss of biodiversity, soil erosion, loss of wood, degradation of soil quality, harm to natural resources, loss of natural regeneration, ozone layer depletion and change in microclimate.

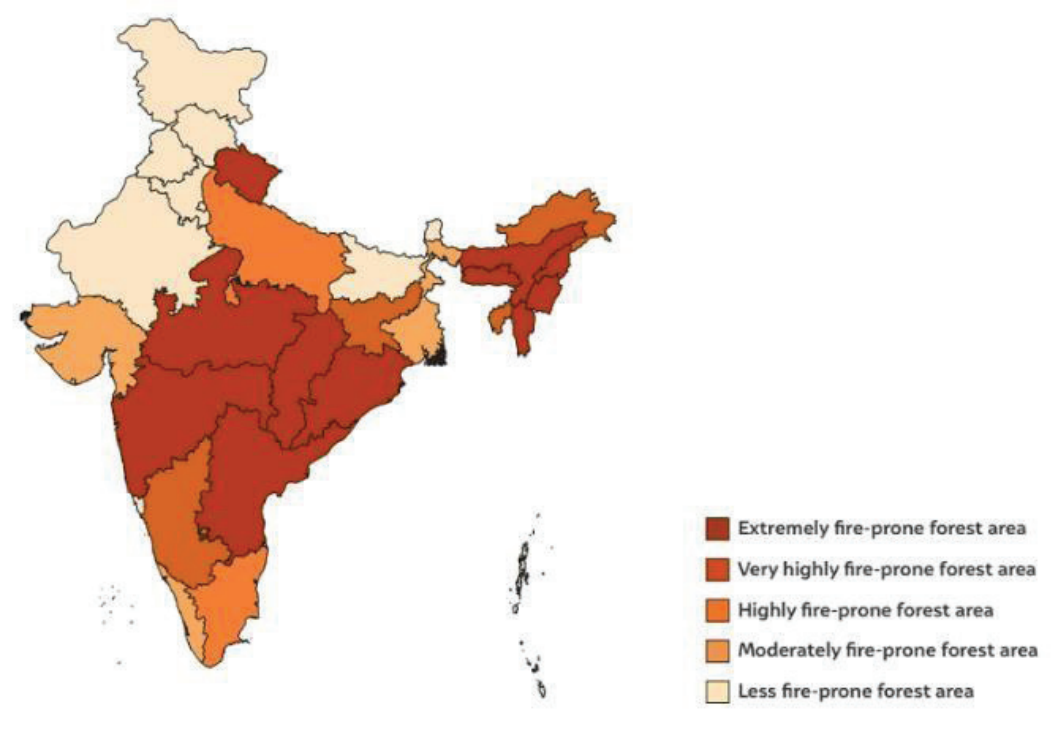


Fig. 6: Forest Fire Prone Areas of India[7]

Source: Mohanty & Vidur (2022)

According to records from the forest inventory, 35.71% of India's forests have not yet experienced any significant fires, while the remaining 54.45% of forests are occasionally exposed to fires, 7.49% are moderately frequently exposed to fires, and 2.40% are highly frequently exposed to fires. Every year, forest fires destroy valuable forest resources, including carbon that has been locked up in the biomass, having a negative influence on the flow of commodities and services from forests. High-intensity forest fire incidents are common in more than 62% of Indian states. Over the past 20 years, Andhra Pradesh, Chhattisgarh, Assam, Madhya Pradesh, Maharashtra, Manipur, Nagaland, and Uttarakhand have all had extremely high rates of forest fires.

12.2.1 *Causes of forest fire*

Madhya Pradesh, Odisha, and Chhattisgarh and Kandhamal, Gadchiroli, and Bijapur were the main affected states and districts in 2019–2020 forest fires, respectively. The frequency of forest fire events has increased by 52% despite a 1.12% increase in total forest cover (TFC). More than 79% of the hotspots for forest fires are located in the climate zones humid/temperate (Cwa) and tropical dry climate (Aw), which have dry seasons having precipitation of 60 mm or less. The major causes of forest fires are mentioned below:

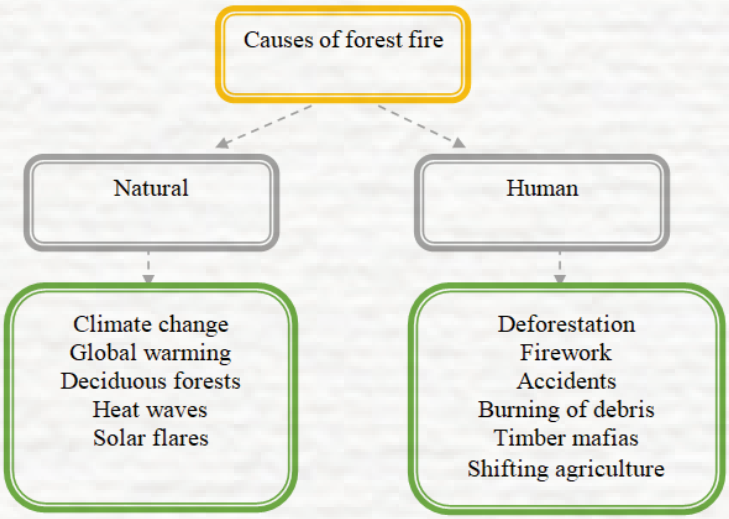


Fig. 7: Causes of forest fire[9]

Source: Forest Fire Disaster Management, NIDM

Extreme forest fire hotspots make up more than 30 percent of India's districts, which are home to over 275 million people. Drought-like conditions are present in more than 68% of Indian districts and 89% of these districts are extreme hotspots for forest fires. The majority of forest fire incidents take place in locations that are hotspots for aridity. In 2019, the Bandipur forest fire killed a forest guard and burned more than 1000 hectares of land. More than 16 people died in the Theni Forest fire, 2018. The Uttarakhand forest fire of 2016 destroyed 4,000 hectares of forest and seven lives. Also, heat is considered a component that initiates forest fires, either in natural or artificial forms. Depending on the source of heat, the causes of forest fires can be classified as below:

Natural	Anthropogenic	
	Deliberate causes	**Accidental causes**
1. Lightning	1 Shifting Cultivation	1 Collection of Non Timber Forest Produce
2. Friction of rolling stone	2 To flush growth of *tendu* leaves	2 Burning farm residues
3. Rubbing of dry bamboo clumps	3 To have good growth of grass and fodder	3 Driving away wild animals
4. Volcanic explosion	4 To settle score with forest department or personal rivalry	4 Throwing burning *bidi*/ cigarettes
.	5 To clear path by villagers	5. Camp fires by picnickers
.	6 To encroach upon the forest land	6. Sparks from vehicle –exhaust
.	7. For concealing illicit felling	7. Sparks from transformers
.	8. Tribal traditions/ customs	8. Uncontrolled prescribed burning
	.	9. Resin tapping

Fig. 8: Causes of forest fire (based on source of heat)[9]

Source: Forest Fire Disaster Management, NIDM

Major losses from extreme forest fires

Loss of timber resources, Threat to Life and Property, Impact of forest fire on eco- system, Soil erosion, Degradation of water resources, Loss of wildlife habitat, depletion of wildlife, Deteriorating Biological Environment, Loss of natural vegetation and reduction of forest cover, Global warming, Adverse impact on Health system.

Forest fires are classified into four types based on their size and characteristics are described in Fig. 9:

Types of Forest Fire

Surface Fires	➢ The most frequent type of forest fire burns the undergrowth and vegetation. ➢ It loosens forest floor debris, consumes small plants, and surface litter. ➢ It consumes the underbrush and the forest's intermediate layer.
Underground Fires	➢ These flames are classified as underground fires when they are low intensity and consume both the organic material underneath and the surface litter of the forest floor. ➢ The majority of the dense forests have a thick organic layer covering the mineral soil. By swallowing such substances, this fire spreads inside. These fires typically burn for a few meters below the surface and spread totally underground. ➢ This type of fire spreads very slowly, making it difficult to find and put out most of the time.
Ground Fires	➢ It can be difficult to tell the difference between ground and underground flames. ➢ The simmering subsurface fire transforms into a ground fire. The herbaceous growth on the forest floor and the layer of organic debris in various stages of decay is both burned by this fire, along with additional materials on or beneath the surface. ➢ They entirely kill vegetation, making them more destructive than surface fires.

Crown Fires	➢ The most erratic of all fires, crown fires quickly spread by the wind and burn the tops of trees. ➢ Surface fires almost always start these fires in the majority of instances. One of the most spectacular types of forest fires, these generally spread from top to bottom of trees or shrubs, somewhat reliant on nearby surface flames. ➢ In dense conifer stands with a strong wind, the supporting surface fire may advance faster than the crown fire. It poses a serious risk to the fire fighters becoming caught and burned because it is over the heads of ground force

Fig. 9 Types of forest fires[9]

Source: Forest Fire Disaster Management (NIDM)

12.2.2 *Forest fire management*

The process of forest fire management is provided in the below Fig:

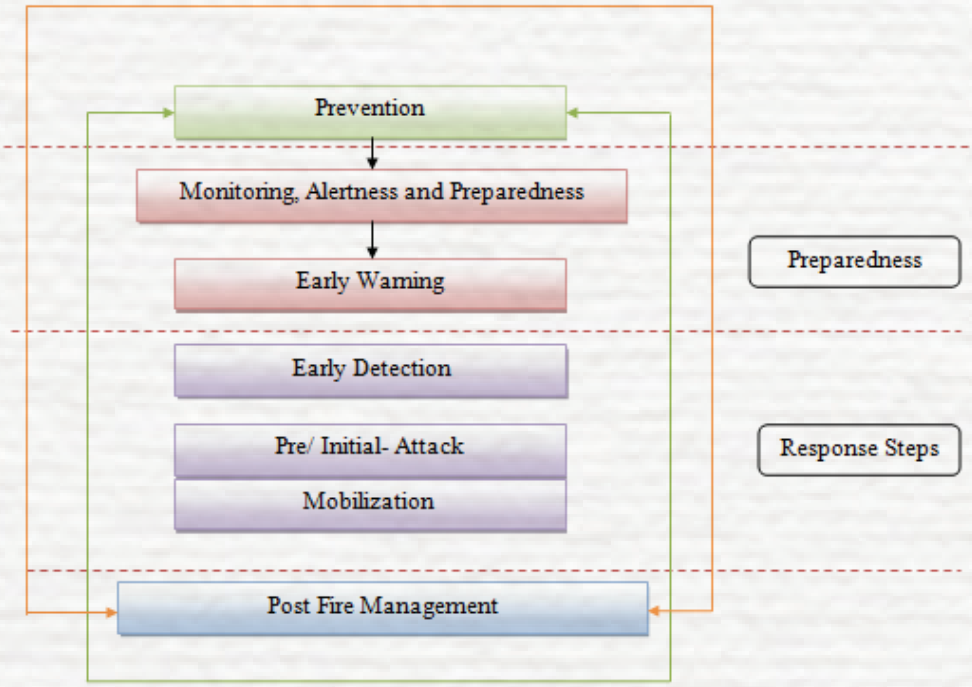


Fig. 10: Forest fire management[9]

Source: Forest Fire Risk Mitigation and Management (NIDM)

In our nation, forest fires are common occurrences from November 2020 to June 2021, the MODIS sensor detected 52,785 forest fires and the SNPP-VIIRS sensor detected 3, 45,989 forest fires. According to estimates, more than 36% of the nation's forestland is vulnerable to frequent forest fires. 6% of the country's forest cover is assessed to be very highly fire-prone, compared to about 4% of forest cover that is extremely fire-prone (ISFR 2019).

Initiatives by the Government of India for Forest Fire Risk Mitigation

1. National Action Plan on Forest Fires (2018)
    a. Forest Risk Zoning and Mapping
    b. Community Awareness
    c. Framework for biomass management
    d. Digitization of forest boundaries
    e. Forest Fire Alert System, Ground-based Detection
    f. Dedicated phone line monitoring and evaluation
2. Centrally Sponsored Scheme on Forest Fire Prevention and Management (FPM)
3. Forest Rights Act 2005

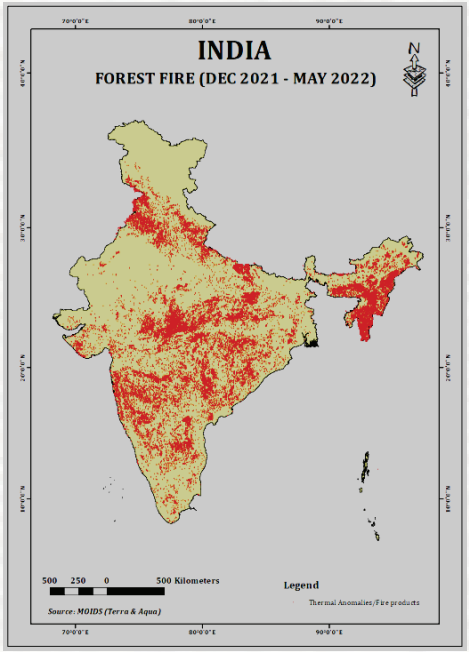


Fig. 11: Forest fire in India (Dec 2021- May 2022)[9]

Source: Forest Fire Risk Mitigation and Management (NIDM)

Table 2: Forest Fire Management in various phases

Sl. No.	Phases	Activities
1.	Mitigation & Prevention	Surveillance/ Watching on forest; Early detection of Forest Fire; Establishing preventive measures such as watchtower, equipment, community teams, etc. to control the situations; Use of indigenous knowledge and methods for fire prevention, DM Planning (unit level to state-level); Usage of IoT devices/GPS/Drone technology and Application based models
2.	Preparedness	Awareness generation; Emergency response & logistics planning; Early warning systems and communications to concerned departments, and authorities; Constitution of Community/ Volunteer teams and their training
3.	Response	Activation of fire control methods; Manpower support for large areas of fire; Affected person evacuation; Search & rescue, evacuation and First-aid; Shelter management; Relief camp management
4.	Recovery	Afforestation Activities; Managing and Taking care of the forest.

Source: Forest Fire Risk Mitigation and Management (NIDM)[9]

12.2.3 Case Study

Case study 1: Latur Drought Management 2016

Latur is one of the major drought-prone districts of Maharashtra. The 2016 drought in the Latur district was the most severe in the last three decades. Normally, the district receives water from 8 medium and 2 major irrigation projects. Due to surface water scarcity, ground water level and less rainfall, the district entirely faced a drastic drought period in which Latur's groundwater level decreased to 3m on average. The Fig. below provides the drought management in Latur (2016).

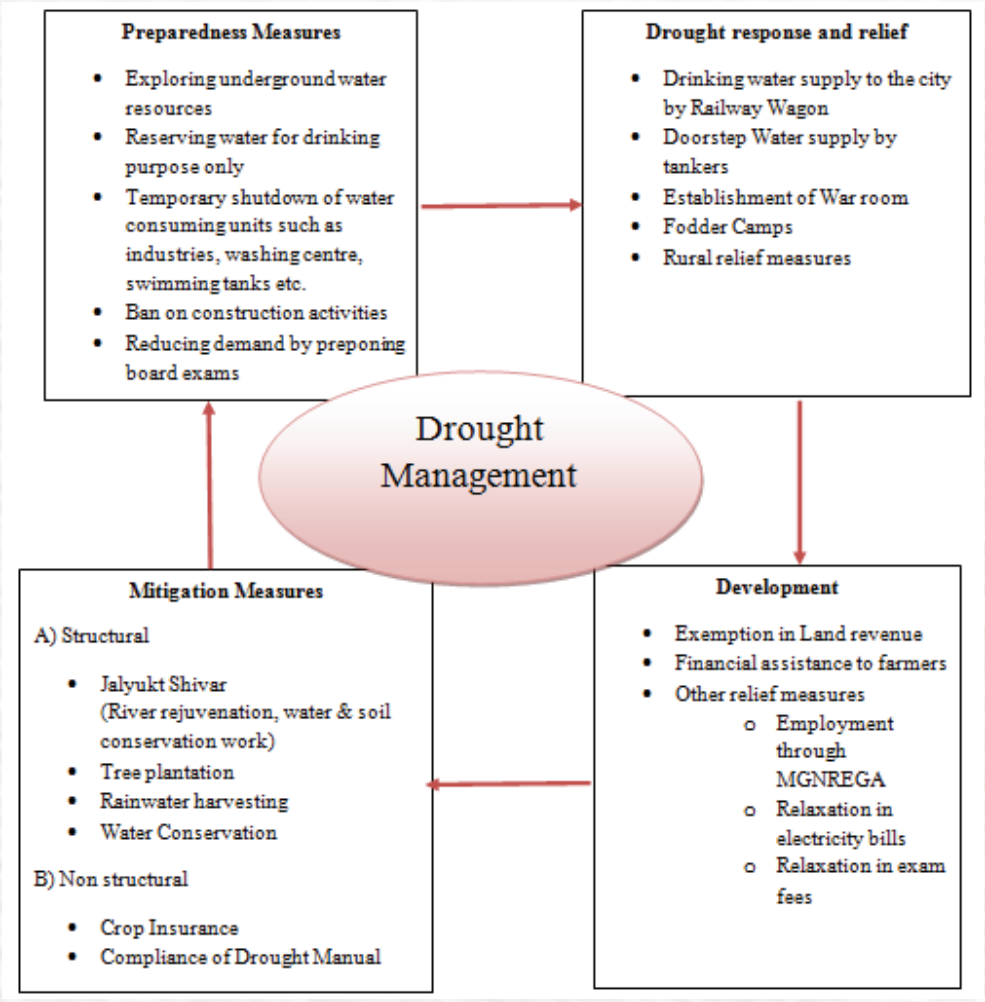


Fig. 12: Drought management in Latur (Osmania and Patel, 2020)[33]

Based on the framework, answer the following questions:

1. What are the major reasons for the drought at Latur?
2. What are the DRR measures adopted in Latur?
3. Discuss the structural and non-structural mitigation measures.

Case study 2: Forest Fire in Himachal Pradesh

Forest fire is an annual phenomenon in the state of Himachal Pradesh. Coniferous Forests and broad-leaved Forests are common in Himachal Pradesh.

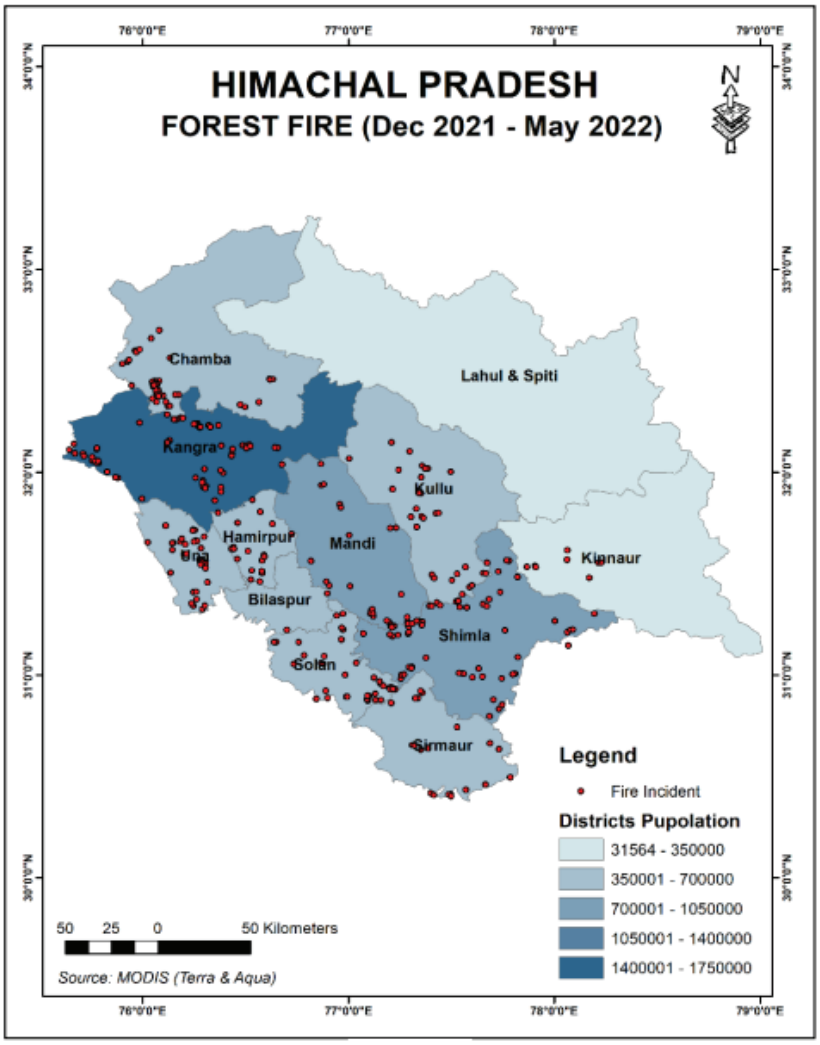


Fig. 13: Forest fire map of HP[12]

Source: MODIS

The mitigation and prevention measures of forest fire are mentioned in Fig. 13.

Based on the figure, find out:

1. What are the different mitigation measures of forest fire management in Himachal Pradesh?
2. Write 3 strategies used for the management of forest fire in Himachal Pradesh.
3. The importance of remedial measures in preventing and managing forest fire in Himachal Pradesh.

Forest Fire Mitigation and Prevention Measures in Himachal Pradesh

- **As per the Forest Fire Manual of Himachal Pradesh, p**reventive measures are those measures which help prevent the occurrence of fires or significantly reduce the chances of fire occurrence. Such measures can be further divided into:
  - Public Oriented Measures
    - Building goodwill of the locals'
    - Awareness and education of the masses
    - Restrictions on activities that can lead to forest fires
    - Putting in place reward/ punishment schemes
  - Administrative and Technical Measures
    - Forecasting the burning days based on meteorological data.
    - Putting in place fire control task teams.
    - Reduction of fire hazards on the forest floor: Various actions can be taken the reduction of fire hazards in the forests.
    - Clearing and Maintaining Fire Lines
- **Remedial Measures:** These are the measures taken to control and extinguish fires, which break out despite the preventive measures.
  - Early Detection
  - Quick Communication
  - Early Action

Strategies

Fig. 14: Forest fire mitigation and prevention measures of HP

Source: Forest Fire Risk Mitigation and Management (NIDM)[9]

12.2.4 Action Plan for Forest Fire Management in India

The Government of India's comprehensive action plan for forest fire management, part of the National Forest Policy, aims to address forest fire threats through modern management practices and community involvement. Key objectives include strengthening communication and detection systems with advanced technology, enhancing transportation and firefighting equipment, coordinating with States and UTs for systematic plans, and facilitating international technology transfer. The plan emphasizes data collection on fires, their impacts, and prevention measures, while also promoting community involvement and

awareness through Joint Forest Management committees, Village Forest Committees, and NGOs.

Despite the comprehensive plan for forest fire management in India, several challenges persist, including limited financial and human resources, which can hinder the implementation of strategies, and the need for adequate funding and staffing for forest departments. Climate change exacerbates the frequency and intensity of forest fires, necessitating the adaptation of fire management practices. Additionally, encouraging sustained community involvement is challenging, requiring trust-building and continuous support. Overall, the National Plan for Forest Fire Management combines modern technology, community involvement, and strategic planning to mitigate the impact of forest fires and protect India's valuable forest resources.

Suggested activities:

I. **Group Discussion**: El Nino and La Nina are complex weather patterns resulting from variations in ocean temperatures in the Equatorial Pacific Region. Discuss the impact of El Niño and La Niña on drought risk in India.

II. **Group exercise**

Divide into two groups and collect newspaper clippings or E-news related to

- Drought incidents in India from 2015 to 2022 and their impact.
- Forest fire incidents in India from 2015 to 2022 and their impact.

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Glossary

CWC: Central Water Commission, a premier Technical Organization of India in the field of Water Resources

Climate change: Long-term shifts in temperatures and weather patterns

Deforestation: Removal of forest land to convert it for non-forest use

DPAP: Drought Prone Area Programme, to minimize the adverse effects of drought on the production of crops and livestock and the productivity of land, water and human resources

Drought: Deficiency of precipitation for a period that causes water shortage and the area to be drier than normal conditions

El Nino: A climate pattern that describes the unusual warming of surface waters in the eastern tropical Pacific Ocean

Forest fire: Uncontrollable and unpredictable combustion of forests in an area

ISFR: India State of Forest Report is a biennial survey of India's forests and tree resources

La Nina: Periodic cooling of sea-surface temperatures across the eastern central equatorial Pacific

NWDPRA: National Watershed Development Programme for Rain-fed Areas is a special central assistance programme for the benefit of cultivators in drainage line treatment, creation of water bodies, and development of agriculture/ horticulture crops

MODIS: The Moderate Resolution Imaging Spectroradiometer (MODIS), is a 36-band spectroradiometer measuring visible and infrared radiation and obtaining data

Rainwater-harvesting (RWH): Collection and storage of rain, rather than allowing it to run off.

Seasonal aridity: Deficiency of moisture during a period of time

SNPP: Suomi-National Polar-orbiting Partnership (launched in 2011) is a weather satellite operated by the United States National Oceanic and Atmospheric Administration (NOAA)

SPEI: Standardized Precipitation Evapotranspiration Index is a multiscalar drought index based on climatic data used for determining the onset, duration and magnitude of drought conditions

Susceptibility: State of being easily affected

Urbanization: Process of shifting from rural to urban areas

VIIRS: Visible Infrared Imaging Radiometer Suite instrument observes and collects visible and infrared wavelengths across land, ocean, and atmosphere

Vulnerability index: Exposure measure to hazards for a population

Suggestive questions

MCQ questions carry one marks each

1. How much percentage of India's cultivable land is vulnerable to drought?

   a) 60% b) 68%

   c) 66% d) 67%

2. Expand DPAP

   a) Disaster Programme for Prone Areas b) Disaster-Prone Areas Programme

   c) Drought Prone Areas Programme d) Drought Programme for Prone Areas

3. Mine disasters are a type of _____.

   a) Accident-related disasters b) Industrial-related disasters

   c) Chemical-related disasters d) Geological related disasters

4. How much percentage of Indian land is categorized as "chronically drought-prone"?

   a) 33% b) 37%

   c) 32% d) 39%

5. According to the India State of Forest Report (ISFR) 2015, the estimated India's area that is vulnerable to fire is classified into the conditions of

   a) Heavy, Severe and moderate fire b) Extreme, moderate and mild fire

   c) High, moderate and mild fire d) Extreme, moderate and mild fire

All short questions carry three marks each (short notes)

1. Write a note on the various causes of drought in India?
2. List the types of forest fires?

3. Enlist the Indian districts and zones that are considered to be drought hotspots?

All long questions carry ten marks each (essay type, logical analysis, inferring practical situation)

1. Discuss the reasons for the rising incidents of forest fires in India?
2. Explain the steps that can be taken to control forest fires?
3. Describe the disaster vulnerability profile of India with examples?

Suggestive PowerPoint slides for reference

Disaster Vulnerability Profile of India – Drought & Forest Fire

Water and Climate related disasters: a) Floods and drainage management b) Cyclones c) Tornadoes and Hurricanes d) Hailstorms e) Heat wave and Cold wave f) Cloud burst g) Snow avalanches h) Droughts i) Sea erosion j) Thunder and lighting k) Tsunami	*Accident-related disasters:* a) Forest fires b) Urban fires c) Mine flooding d) Oil spills e) Major building collapse f) Serial bomb blasts g) Festival related disasters h) Electrical disasters and fires i) Air, road and rail accidents j) Boat Capsizing k) Village fire
Chemical, nuclear and industrial related disasters: a) Chemical and industrial disasters b) Nuclear disasters	*Geological related disasters:* a) Landslides and mudflows b) Earthquakes c) Dam failure/Dam bursts d) Mine disasters
Biological related disasters: a) Biological disasters and epidemics b) Pest attacks c) Cattle epidemics d) Food poisoning	

Source: NIDM (Vulnerability Profile of India); High Power Committee on Disaster Management (1999)

Vulnerability profile of India

- India is one of the top 10 disaster-prone countries in the world.
- Almost 58.6 percent of the landmass is vulnerable to earthquakes of moderate to very high intensity;
- Over 40 million hectares (12 percent of land) are vulnerable to floods and river erosion;
- Nearly 5,700 km is vulnerable to cyclones and tsunamis;
- 68 percent of cultivable land is vulnerable to drought; and hilly areas are vulnerable to landslides and avalanches.
- Numerous natural and man-made factors, including unfavorable climatic conditions, industrialization, geographic elements, population, environmental degradation, urbanization, make the country vulnerable to disasters.
- The country's natural geological setting is the fundamental cause of its enhanced susceptibility

Drought

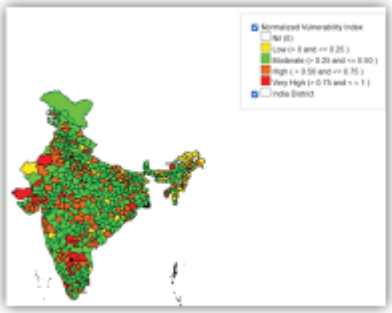
•Drought is a commonly recognized climate phenomenon caused by a prolonged duration of relatively dry weather.

•It causes water supplies to run dry, crops to fail to develop, animals to perish, and starvation and illness to spread.

•Drought is caused by a variety of factors, including farming and agronomic methods, soil types, drainage, and ground water profiles

•Types of droughts are as follows:

Meteorological droughts	• Occurs when the monthly or seasonal rainfall over an area is significantly below average • Situation when there is continued period of insufficient rainfall
Hydrological droughts	• Occurs when the amount of water that is accessible in surface water bodies decreases, and the water level also drops • Happens when the availability of water in different storages falls below what the precipitation can replenish
Agricultural droughts	• Occurs when lack of water causes crops to lose all or part of their yield, thus affecting agricultural production. • Also called as soil moisture drought
Ecological droughts	• Occurs when the efficiency of a natural ecosystem flops due to shortage of water



Drought Normalized Vulnerability Index
Source: Hazards Atlas (IMD Pune

According to research, 68% of India's cropland is susceptible to drought, with 33% of that area receiving less than 750 mm of mean annual rainfall and being labeled as "chronically drought-prone" and 35% receiving 750–1125 mm of mean annual rainfall and being labeled as "drought-prone." The country's drought-prone zones are mostly restricted to the peninsular and western India's dry, semi-arid, and sub-humid regions.

Drought is a scenario occurring in an area when the annual rainfall is less than 75% of normal in 20% of the years assessed.

Factors influencing droughts:

- Monthly, seasonal and regional variations in precipitations
- Overuse of groundwater resources
- Deforestation, Climate Change, Urbanization
- Inadequate conservation and storage of surface water
- Limited irrigation coverage and improper cropping patterns
- Short duration of South-West monsoon

- ✓ 68% of Indian districts are vulnerable to catastrophic drought events. In India, the southern and central zones are particularly vulnerable to extreme drought episodes, according to an analysis of districts that are drought hotspots conducted zone by zone.
- ✓ Furthermore, compared to the north and north-eastern zones, the eastern and western zones are more vulnerable to extreme drought episodes. Rajasthan, Andhra Pradesh, Maharashtra, Karnataka, and Tamil Nadu are most vulnerable to extreme drought conditions.

Zone	State	District Hotspots
Central	Madhya Pradesh	Sagar, Rewa, Sidhi, Balaghat, Chhatarpur, Dewas, Jhabua
East	Odisha	Gajapati, Ganjam, Baleshwar, Khordha, Sundhargarh
	Bihar	Buxar, Bhagalpur, Bhojpur, Sheohar, Saharsa, Begusarai, Arwal, Darbhanga
North	Uttar Pradesh	Aligarh, Faizabad, Auraiya, Ghaziabad, Budaun, Pilibhit, Azamgarh, Ambedkar Nagar
North-east	Assam	Goalpara, Morigaon, Nalbari, Darrang, Barpeta, Sivasagar, Cachar
	Arunachal Pradesh	West Siang
South	Karnataka	Uttarakannada, Dakshinakannada, Koppal, Gadag
	Tamil Nadu	Thiruvallur
	Kerala	Kasargod, Kozhikode, Kannur, Pathanamthitta, Malappuram
	Andhra Pradesh	Vizianmagar, West Godavari, YSR, Guntur, Nellore
	Telangana	Mahbubnagar, Hyderabad,
West	Rajasthan	Jalor
	Maharashtra	Sangli, Jalgaon, Aurangabad, Nagpur, Pune, Amravati
	Gujarat	Kachchh, Rajkot, Bhavnagar, Banaskantha, Jamnagar, Surendranagar

Causes of droughts

Source: Management of Drought (NDMA)

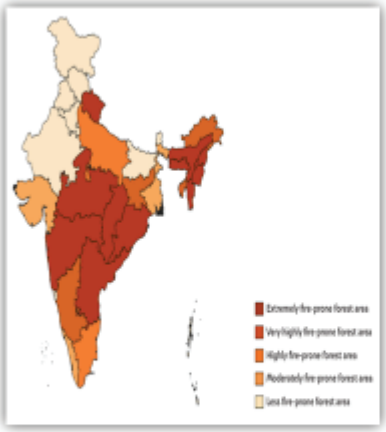
➢ Droughts in India can be of two types: meteorological (lack of precipitation) and hydrological (lack of surface water flow).

➢ Currently, India has a standardized precipitation evaporation index (SPEI) of less than 2, severe meteorological drought of about 3%.

▪Drought causes water supplies to run dry, animals to perish, agriculture failure, and starvation. And the environmental consequences include soil salinization, groundwater decreases, contamination of freshwater, and extinction of animals.

▪It is caused by a lack of distribution of rainfall, but extent and severity are dependent on a variety of factors, including the surface and ground water resources, agro-features, crops and patterns and local populations' socio-economic vulnerabilities.

Forest fire



Forest Fire Prone Areas of India
Source: Mohanty & Vidur(2022)

According to records from the forest inventory, 35.71% of India's forests have not yet experienced any significant fires, while the remaining 54.45% of forests are occasionally exposed to fires, 7.49% are moderately frequently exposed to fires, and 2.40% are highly frequently exposed to fires.

Every year, forest fires destroy valuable forest resources, including carbon that has been locked up in the biomass, having a negative influence on the flow of commodities and services from forests.

High-intensity forest fire incidents are common in more than 62% of Indian states. Over the past 20 years, Andhra Pradesh, Assam, Chhattisgarh, Odisha, Maharashtra, Madhya Pradesh, Manipur, Mizoram, Nagaland, and Uttarakhand have all had extremely high rates of forest fires.

According to estimates, more than 36% of the nation's forestland is vulnerable to frequent forest fires. 6% of the country's forest cover is assessed to be very highly fire prone, compared to about 4% of forest cover that is extremely fire prone (ISFR 2019).

The estimated areas that are vulnerable to fire in conditions of heavy, moderate, and mild fire are 2.40%, 7.49%, and 54.40%, respectively, according to the India State of Forest Report (ISFR) 2015, making up 64.29 percent of the total Recorded Forest Area.

According to their size and character, forest fires can generally be divided into four categories

Surface fires

- The most frequent type of forest fire, surface fires burn the undergrowth and dead vegetation along the forest floor.
- It is the kind of fire that consumes small plants, loose forest floor debris, and surface litter. In general, it is very beneficial for the renewal and growth of the forest.
- But as it spreads, this fire consumes not just the vegetation on the ground but also the underbrush and the intermediate layer of the forest.

Underground fires

- These flames are classified as underground fires when they are low intensity and consume both the organic material underneath and the surface litter of the forest floor.
- The majority of the dense forests have a thick organic layer covering the mineral soil. By swallowing such substance, this fire spreads inside. These fires typically burn for a few meters below the surface and spread totally underground.
- This type of fire spreads very slowly, making it difficult to find and put out most of the time. It might burn for months while obliterating the soil's vegetative layer. Muck fires are another name for this kind of fire.

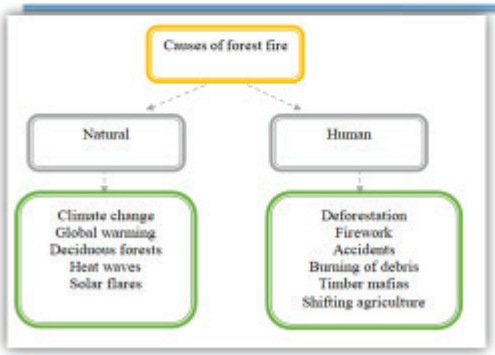
Ground fires

- It can be difficult to tell the difference between ground and underground flames. Sometimes the simmering subsurface fire transforms into a ground fire. The herbaceous growth on the forest floor and the layer of organic debris in various stages of decay is both burned by this fire, along with additional materials on or beneath the surface.
- They can entirely kill vegetation, making them more destructive than surface fires. These fires are the least spectacular and move slowly; therefore they are frequently difficult to spot. Such a fire is incredibly challenging to put out.

continued:

Crown fires

- The most erratic of all fires, crown fires quickly spread by the wind and burn the tops of trees. Surface fires almost always start these fires in the majority of instances. One of the most spectacular types of forest fires, these generally spread from top to bottom of trees or shrubs, somewhat reliant on nearby surface flames.
- In dense conifer stands with a strong wind, the supporting surface fire may advance faster than the crown fire. It poses a serious risk to the fire fighters becoming caught and burned because it is over the heads of ground force, is uncontrollable until it once more drops to the ground, and is typically moving quickly



Source: Forest Fire Disaster Management, NIDM

Major losses from extreme forest fires

Loss of timber resources, Threat to Life and Property, Impact of forest fire on eco- system, Soil erosion, Degradation of water resources, Loss of wildlife habitat, depletion of wildlife, Deteriorating Biological Environment, Loss of natural vegetation and reduction of forest cover, Global warming, Adverse impact on Health system.

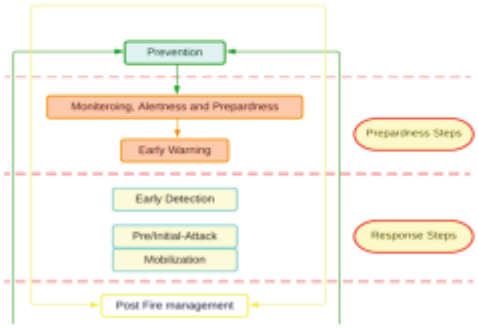
Depending on the source of heat, the causes of forest fire can be classified as below:

Natural	Anthropogenic	
	Deliberate causes	Accidental causes
1. Lightning	1 Shifting Cultivation	1 Collection of Non Timber Forest Produce
2. Friction of rolling stone	2 To flush growth of *tendu* leaves	2 Burning farm residues
3. Rubbing of dry bamboo clumps	3 To have good growth of grass and fodder	3 Driving away wild animals
4. Volcanic explosion	4 To settle score with forest department or personal rivalry	4 Throwing burning *bidi*/ cigarettes
.	5 To clear path by villagers	5. Camp fires by picnickers
.	6 To encroach upon the forest land	6. Sparks from vehicle –exhaust
.	7. For concealing illicit felling	7. Sparks from transformers
.	8. Tribal traditions/ customs	8. Uncontrolled prescribed burning
	.	9. Resin tapping

Source: Forest Fire Disaster Management, NIDM

Initiatives by Govt. of India for Forest Fire Risk Mitigation

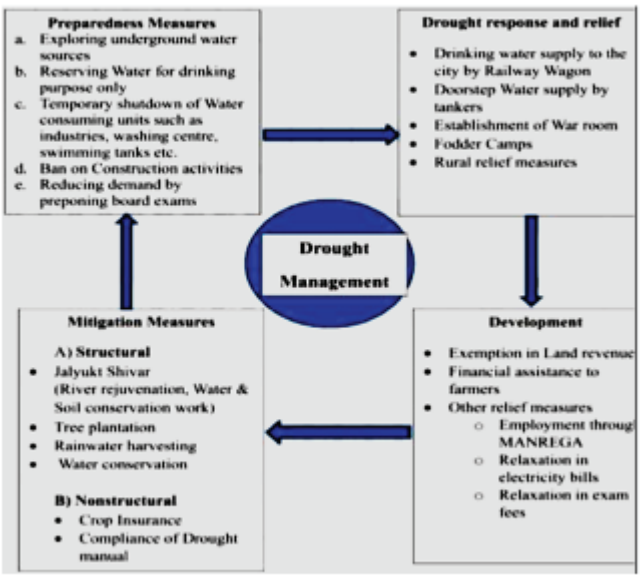
1. National Action Plan on Forest Fires (2018)
a. Forest Risk Zoning and Mapping
b. Community Awareness
c. Framework for biomass management
d. Digitization of forest boundaries
e. Forest Fire Alert System, Ground-based Detection
f. Dedicated phone line and Monitoring and evaluation



Forest fire management

Source: Forest Fire Risk Mitigation and Management (NIDM)

Case Study- Latur Drought Management 2016



Source: Drought Management in Latur (Osmani & Patel, 2020)

Latur is one of the major drought-prone districts in Maharashtra.

2016 drought in Latur district was the severe drought in last three decades. Normally the district receives water from 8 medium and 2 major irrigation projects.

Due to surface water scarcity, ground water level and less rainfall, the district entirely faced drastic drought period in 2016.

Latur's ground water level decreased to 3.29m of an average. All the ground and surface water resources were dry and poorly affected the district.

The main challenges during the period were to handle with water supply, employment, livestock support, coordinating stakeholders and providing relief to farmers.

Drought Management in Latur has undergone structural and non structural mitigation measures.

Annexure-1

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Annexure-2

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3. **Prof. Vinita Sahay, Director**, IIM Bodhgaya
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10. **Dr. Preeti Soni,** Convener, Senior Consultant, National Institute of Disaster Management

Annexure-3

TEMPLATE OF HANDBOOK ON FOUNDATION COURSE ON DISASTER RISK REDUCTION

TEMPLATE FOR EACH CHAPTER

Total No. of Hours:

I. Background of the topic: 200 words

II. Learning Outcomes: 4 objectives maximum (shall be in line with the learning outcome)

III. Session Methodology: (specify what kind of preparation/material is required to teach this topic. For example- group exercises, PowerPoint, chart paper, sticky notes, etc.)

IV. Content on the topic (Minimum 4000 words): detailed content shall be covered the whole content with case study/ examples of the specific chapter. Content must include pictography, and language must be easy to understand by a lay person and faculty of all streams.

V. Points for Group discussion with students (Need to give an example to integrate every subject into DRR, maximum 4 points, 100 words)

VI. Frame out a minimum of one group exercise for a better understanding of the subject

VII. Recent Case Study/ Local initiative/ Live example (relevance with the topic, Case study must be within the past 10 years only)

VIII. Reading / Reference material (maximum 4 related to the topic)

IX. Place pictures or PowerPoint minimum content for faculty, which they can use during class (maximum 10 slides only).

CHAPTER DESIGN TEMPLATE

Chapter Name:

Unit:

Total No. of Hours:

Background of the topic:

Learning Outcomes:

i.

ii.

iii.

iv.

Session Methodology:

i. Mode of dealing of the session

ii. Pedagogy

iii. Handouts of any

Content on the topic: 4000 words

- Content with example and referencing is must
- Insert Pictography
- Points for Group discussion
- **Case Study/ Local initiative** (Minimum two)

Suggested activity:
Assignments/ project study/ film show/ video clip/ role play etc.)

Reading / Reference material (minimum 4)

Power Point Slides for teacher (Maximum 10 slides, content and pictures)

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