
Introduction to
Disaster
Management

TABLE OF CONTENTS

Unit 1

Title: Fundamental Concepts of Disaster and Vulnerability

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Chapter 1

Myths, Maps, and Mitigation: Disaster Basics

Introduction

From the earliest known mythological records, humankind has sought meaning in the cataclysms that shaped its world. Tales of divine wrath—of floods that swallowed civilizations, of fires that rained down from the heavens, of waters rising like walls—were early attempts to make sense of forces beyond comprehension. To us, as students of disaster management, these narratives are more than myth; they represent the first collective encounters with the idea of disaster itself.

Mankind's introduction to disasters preceded understanding. In those primordial times, communities could neither predict nor mitigate the impacts of nature's extremes. Each event was both a lesson and a loss, inscribed in memory and myth alike. Yet, through these experiences, society began the long process of learning—of transforming fear into knowledge, reaction into preparedness.

Fig. 1. News Headlines on Disasters & Climate Change

Today, in an age defined by technology, population density, and environmental transformation, we face hazards of greater complexity and magnitude than our ancestors ever imagined. Our task is to decode these processes—not as divine punishment, but as interplay between natural systems and human actions. The study of disasters, therefore, becomes not just a discipline of response, but a reflection on humanity's evolving relationship with the planet itself.

The global disaster Landscape

Over the past two decades, there has been a significant increase in both the frequency and magnitude of disaster events across the world. Reports from leading global disaster management agencies suggest that this upward trend is closely linked to the impacts of climate change and rapid urbanization. Additionally, the apparent escalation in disaster numbers can also be partly attributed to advancements in data reporting, monitoring, and recording systems, which have considerably improved the accuracy and comprehensiveness of disaster documentation (United Nations Office for Disaster Risk Reduction [UNDRR], 2020; World Meteorological Organization [WMO], 2021).

Food for thought!

Is it okay to use the words hazard and disaster interchangeably?

Why?

Incidence of Disasters

According to the findings of international bodies such as the United Nations Office for Disaster Risk Reduction (UNDRR), the World Meteorological Organization (WMO), the Asian Development Bank (ADB), and the World Bank's Global Facility for Disaster Reduction and Recovery (GFDRR), the world experienced approximately 7,348 major recorded disaster events between 2000 and 2019 This represents a substantial rise from the 4,212 events recorded during the preceding two decades, 1980–1999. The near 1.8-fold increase can be largely attributed to the growing incidence of climate-related hazards including floods, storms, droughts, wildfires, and heatwaves [ADB, 2020; GFDRR, 2021; UNDRR, 2020]. Of these, floods and storms remain the most prevalent, with flooding alone accounting for about 59 percent of all disaster events worldwide.

Impacts and Human Toll

Despite the heightened frequency of disasters, the overall loss of human life has remained relatively stable, rising marginally from 1.19 million deaths during 1980–1999 to 1.23 million between 2000 and 2019 [UNDRR, 2020]. This relative stability in mortality figures reflects the substantial progress achieved in disaster risk reduction through enhanced early warning systems, improved preparedness, and more effective response mechanisms. However, the number of people affected by disasters has grown dramatically, reaching an estimated 4.2 billion during the same period. This surge underscores the heightened exposure and vulnerability of populations—particularly those in low- and middle-income countries—who continue to face the greatest risks due to socioeconomic fragility, rapid urban expansion, and inadequate resilience measures [GFDRR, 2021; WMO, 2021].

Economic Losses

The economic impact of disasters has seen significant surge in the recent times. The 1980-1999 period saw losses estimated at approximately US $1.63 trillion, while the 2000-2019 period recorded approximately double the previous at US$2.97 trillion.

What is fascinating is that annual disaster related economic losses averaged between US$70–80 billion between 1970-2000, rising to US$180 billion in the early 21st century.

Recent years have witnessed a steady climb in the disaster related economic loss figures owing to increased meteorological and seismic hazards and wildfires with the year 2023 alone recording economic damages exceeding the historical averages in some regions.

Regional Highlights

Asia has experienced the highest number of disasters and associated losses, reflecting on its large population and its exposure to frequent floods and severe storms. Asia accounts for almost a third of the global disasters and about half of the number of deaths.

North America also faces significant economic losses with fewer fatalities in comparison.

Low-income countries and small island states face disproportionately higher impacts relative to their economic capacity, highlighting vulnerability and resilience gaps.

Food for thought!

Disaster impacts and losses are largely disproportionate.

Why?

Table 1: Global Disaster Vulnerability by Hazard Type, Geographic Distribution, and Country Exposure*

Hazard Type	Population Vulnerable (%)	Geographic Hotspots	Approx. No. of Countries Vulnerable
Floods & Storms	27-30	Coastal zones, river basins	130-150
Droughts	15-17	Arid, semi-arid regions	100+
Earthquakes & Tsunami	08-Oct	Tectonic plate boundaries (Ring of Fire)	50-70
Landslides	05-Jul	Mountainous, steep slope regions	60-80
Volcanic Eruptions	01-Feb	Volcanic belts	30-40

**Note.* Data for floods and storms are adapted from UNDRR (2025) and the World Risk Report (2025); drought data from EM-DAT (2025) and PreventionWeb (2024); earthquake and tsunami estimates from WMO (2023) and World Risk Index (2025); landslides and volcanic eruptions data compiled from PreventionWeb (2024) and the Climate Risk Index (2026). Population vulnerability percentages and approximate numbers of countries at risk are synthesised from these sources to provide a comprehensive overview.

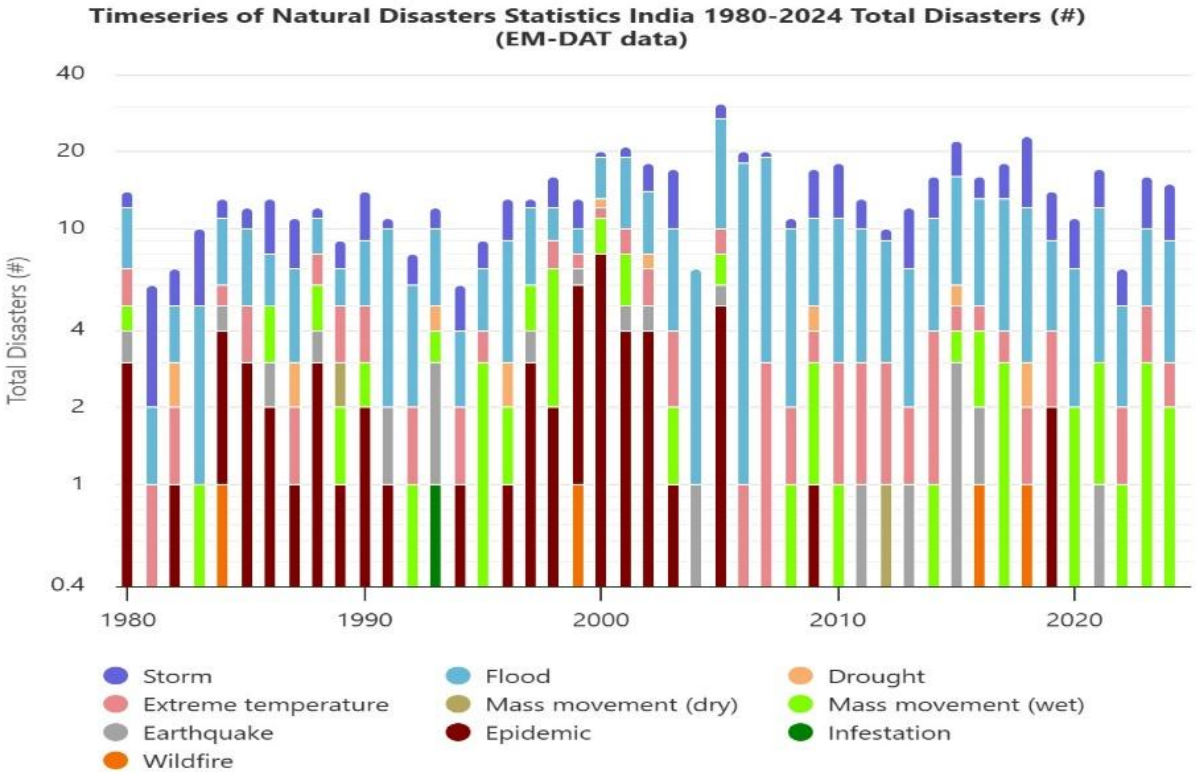

Fig.2. Timeseries of Natural Disasters Statistics India 1980-2024 total Disasters. Source EM-DAT Data

The Indian Disaster Landscape

The national scenario over the past decades shows evolving patterns in disaster incidence, impact and loss influenced by climate change, socio-economic development and enhanced management efforts.

Incidence of Disasters

India as we know is a land of diversity. As a country we have taken this so seriously that even in the hazards and disaster scenarios we haven't let go. Meaning, India is one of the most disaster-prone countries, highly susceptible to a wide range of hazards including cyclones, floods, landslides, droughts, heat waves earthquakes and a plethora of others owing to its wide and varied geography.

Climate change has its claws in deep as the nation has seen a rise in the frequency of hydro-meteorological disasters such as floods, cyclones, cloud bursts over the last few decades.

Data shows recurring floods in states like Bihar, Assam, and Uttar Pradesh, and cyclones striking the eastern coast, for instance Amphan (2020) and Tauktae (2021) with increasing intensity (Ministry of Earth Sciences, 2024; NDMA, 2023).

Impacts and human Toll

Despite increased incidence, there has been a relative reduction in mortality rates per event, attributed to improved early warning systems and disaster preparedness. However, the total number of people affected by disasters annually remains high, estimated at over 25-30 million people affected per year in the past decade, slightly higher than the previous decade (NDMA, 2023; UNDRR, 2025).

Heatwaves have emerged as a significant cause of mortality, with thousands of deaths reported during extreme temperature events in recent years (Ministry of Earth Sciences, 2024). Cyclones and floods together account for the majority of disaster deaths. Despite improvements, localized high mortality events attributed to landslides and earthquakes continue, especially in vulnerable northeastern and Himalayan regions.

Economic Losses

Economic losses from disasters in India have escalated significantly over the past decade. Cyclones and floods together account for nearly 95% of disaster-related economic losses. For instance, Cyclone Amphan alone caused losses estimated at over USD 2 billion (NDMA, 2023). The Indian economy sustains repeated damage to agriculture, infrastructure, and housing, with average annual disaster losses ranging approximately from INR 500 billion to over INR 1000 billion in recent years, nearly doubling from the previous decade (Chandrasekhar et al., 2023; EM-DAT, 2023)

Disaster Risk Management and Trends

India has moved towards a proactive holistic disaster risk reduction approach post-2005, marked by establishment of NDMA, adoption of the National Policy on Disaster Management, and integration of disaster resilience into development planning (NDMA, 2023). These efforts have contributed to better early warning dissemination, coordinated response, and reduced mortality. Nonetheless, challenges remain due to urbanization, climate vulnerability, and socio-economic disparities.

Climate change is driving more frequent and intense extreme weather events, increasing multi-hazard disaster risks and compounding the complexity of management (UNDRR, 2025). Land use changes, poor infrastructure, and ecosystem degradation exacerbates vulnerabilities for many regions,

especially floodplains and coastal communities.

Now that we have had a glance at the global and national disaster landscapes, let's see how they are managed.

The Disaster Management Cycle

Now that we've had an overview of the global and national scenario, let us have a go at it systematically.

For this we will begin with understanding the key terminologies associated with the process described by the umbrella term disaster management.

What exactly is disaster management?

Table 2. Disaster Management Definitions

Agency Name	Definition of Disaster Management
United Nations Office for Disaster Risk Reduction (UNDRR)	"The organization, planning, and application of measures preparing for, responding to, and recovering from disasters, aiming to decrease disaster impacts" (UNDRR, 2017).
National Disaster Management Authority (NDMA), India	"A continuous and integrated process of planning, organizing, coordinating, and implementing measures necessary for prevention, mitigation, preparedness, response, recovery, and rehabilitation" (NDMA, 2005, sec. 2(e)).

Both organizations explain it as a continuous and integrated process that happens in multiple stages. The standard explanation of what disaster management is turns our attention to the disaster management cycle.

The Disaster Management Cycle illustrates how disaster management is a continuous, cyclic process involving four primary and overlapping phases:

Fig. 3. Disaster Management Cycle*

*Adapted from "The Disaster Management Cycle" by GDRC, 1996

I. and Mitigation:

This phase focuses on measures to minimize risk and prevent disasters from occurring or lessen their severity. Examples of this include building codes, early warning systems, land-use plans and other similar regulations put in place by the government at the behest of statutory bodies. It aims at identifying risks and acting in advance to avoid or mitigate impacts (UNDRR, 2017).

II. Preparedness:

Activities here build operational readiness through coordinated planning, regular drills and simulations, leadership engagement at grassroot levels, community training, and developing emergency plans. This ensures resources and systems are well in place before disasters happen, facilitating an effective, efficient and quick response (UNDRR, 2017).

III. Response:

During and immediately after a hazardous incident, rapid action is necessary to protect lives, property, and the environment. This includes emergency rescue, medical care, relief distribution, and communication—

prioritized according to strategic needs (Humanitarian Innovation Guide, 2018).

IV. Recovery:

The recovery phase sees focus shifting to restoring affected communities, rebuilding infrastructure, and returning to normal or a new normal state. Lessons learnt during recovery act as base information for future mitigation and preparedness efforts, completing the cycle.

Chiefly, activities like risk assessment, exercises, capacity improvement, and leadership engagement are conducted continually to ensure the effectiveness of all phases.

This cyclical diagram emphasizes that disaster management is not linear. Instead, it is a process where recovery sets the precedent to better prevention and preparedness for the next potential disaster—highlighting the importance and never-ending nature of learning, adaptation, and continuous improvement (UNDRR, 2017; Humanitarian Innovation Guide, 2018).

Since we have come across a few more new words, let us take this opportunity to go back and examine the meaning and intention of the key terms employed. Words though pretty common, often times carry meanings that differ a sliver from the common sense in which they are used while used in association with a select discipline or subject.

Key Terminology

- **Hazard**

1. According to the United Nations Office for Disaster Risk Reduction (UNDRR) a hazard is; A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption, or environmental degradation. Hazards may be natural, anthropogenic or socio-natural in origin.
2. Integrated Research on Disaster Risk (IRDR) describes a hazard as; A process, phenomenon, or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. Hazards are classified into six families: Geophysical, Hydrological, Meteorological, Climatological, Biological, and Extraterrestrial.

According to UNDRR and the IRDR, a "hazard" is essentially any natural or human-related event or activity that can cause harm to people, damage property, disrupt society, or negatively impact the environment.

For example, imagine a heavy rainstorm causing flooding. The rainstorm itself is the hazard—it's a natural event that has the potential to cause harm. Similarly, a factory leaking toxic chemicals is also a hazard, but this one is caused by human activity. Hazards can be natural like earthquakes, storms, or diseases, or human-made like industrial accidents or pollution.

These hazards might not always lead to disaster, but they have the *potential* to cause serious problems depending on where and how they occur. For example, an earthquake in a remote area causing no injuries or damage is still a hazard, but when it hits a crowded city leading to loss of life and destruction, it becomes a disaster.

in short, they are the possible dangers around us, natural or human-made, that have the power to disrupt lives and environments. Recognizing them helps communities prepare and reduce risks effectively.

Disaster

1. According to United Nations Office for Disaster Risk Reduction (UNDRR), mitigation is the lessening or minimizing of the adverse impacts of a hazardous event, often not fully preventable but substantially lessened by various strategies and actions (e.g., hazard-resistant construction, environmental policies).

2. Integrated Research on Disaster Risk (IRDR) states that; The sustained actions and strategies taken to lessen the severity and impact of disasters through prevention, preparedness, and response.

According to the (UNDRR) and the (IRDR), a disaster is a serious disruption that affects the normal functioning of a community or society. This disruption results from a hazardous event interacting with conditions such as vulnerability and exposure, leading to widespread human, economic, material, and environmental losses. Disasters often overwhelm the affected community's ability to cope using its own resources, requiring external assistance for recovery.

To simplify, imagine a powerful storm hitting your town. The storm itself is a hazard, but the disaster occurs when the storm causes flooding, damages homes, cuts off electricity, and disrupts livelihoods. The community might struggle to respond and recover on its own because of the extent of damage. Another example is a prolonged drought that gradually leads to water shortages, crop failures, and food insecurity. This slow-onset disaster causes serious long-term disruption to daily life and the local economy.

Disasters can be sudden and intense, like earthquakes or explosions, or slow and creeping, like droughts or sea-level rise. They affect people's health, safety, property, and the environment, sometimes for months or years after the event. Understanding disasters this way helps us appreciate the need for preparedness, response, and recovery efforts that go beyond the immediate hazard to address the broader impact on society.

Prevention

It refers to activities and measures aimed at avoiding the occurrence of disaster risks altogether. It embodies the concept of completely avoiding potential adverse impacts through proactive actions such as land-use regulations that restrict settlement in high-risk zones, construction of dams or embankments to eliminate flood risks, and seismic engineering designs to ensure building safety during earthquakes (United Nations Office for Disaster Risk Reduction [UNDRR], 2017). According to the Himachal Pradesh State Disaster Management Authority (2018), prevention is the outright avoidance of adverse impacts of hazards and related disasters, highlighting the goal of stopping an incident from occurring.

Mitigation

It involves the reduction or minimizing of the adverse impacts of hazardous events when they cannot be completely prevented. It includes strategies such as engineering techniques, hazard-resistant construction, and improved environmental and social policies that reduce vulnerability and exposure (UNDRR, 2017). The National Policy on Disaster Management, India (2009) defines mitigation as measures aimed at reducing the impact of hazards and the underlying conditions that make communities vulnerable, with examples including the development and enforcement of building codes to reduce damage during disasters.

Together, prevention and mitigation form key components of disaster risk reduction frameworks both globally and nationally, focusing on proactive, technology-driven, and multi-disaster approaches to minimize disaster losses and enhance resilience (Ministry of Home Affairs, Government of India, 2009; UNDRR, 2017).

Preparedness

Preparedness refers to the knowledge, capacities, and activities developed by governments, organizations, communities, and individuals to effectively anticipate, respond to, and recover from potential disasters. This includes contingency planning, establishing early warning systems, stockpiling essential supplies, training personnel, and coordinating response efforts. Preparedness measures enable timely and effective action when a disaster strikes, minimizing harm to lives and property (United Nations Office for Disaster Risk Reduction [UNDRR], 2007; International Federation of Red Cross and Red Crescent Societies [IFRC], n.d.; United Nations Development Programme [UNDP], n.d.; World Health Organization [WHO], n.d.; Integrated Research on Disaster Risk [IRDR], 2025).

Response

Response phase encompasses the immediate actions taken before, during, or right after a disaster to save lives, protect health, ensure public safety, and meet the basic needs of those affected. It involves rapid emergency assistance, such as medical care, search and rescue, evacuation, and provision of food, water, shelter, and security. Response efforts aim to reduce the severity of disaster impacts and maintain order during the chaotic aftermath (UNDRR, 2007; IFRC, n.d.; UNDP, n.d.; WHO, n.d.; IRDR, 2025).

Recovery

Recovery refers to the process of restoring, rebuilding, and improving the community and environment after a disaster. It involves rehabilitating livelihoods, health services, infrastructure, economic activities, and social systems. Recovery efforts seek not only to return the affected area to normal but to build greater resilience and reduce future risks by integrating sustainable development and "build back better" principles (UNDRR, 2007; IFRC, n.d.; UNDP, n.d.; WHO, n.d.; IRDR, 2025).

What Is Hazard Risk

Hazard risk in disaster management refers to the likelihood or probability that a hazard will actually cause harm, damage, or loss when it interacts with exposed and vulnerable elements such as people, property, infrastructure, and the environment. It is a dynamic concept that integrates not just the nature of the hazard itself but also the vulnerability of the affected community and their exposure to the hazard. Understanding hazard risk helps in assessing potential disaster impacts and prioritizing mitigation and preparedness measures.

Risk is generally represented as a function of hazard, exposure, and vulnerability (UNDRR, 2009). The hazard component describes the physical event—such as an earthquake, flood, or toxic spill—characterized by its intensity, frequency, and duration. Exposure considers the people, assets, or systems present in areas where hazards occur and are thus susceptible to harm. Vulnerability reflects the susceptibility of these exposed elements to damage, taking into account factors like socio-economic status, building quality, preparedness, and adaptive capacity.

The United Nations Office for Disaster Risk Reduction (UNDRR) defines disaster risk as “the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community” because of the interaction between hazards, exposure, vulnerability, and capacity (UNDRR, 2009). This definition underlines that risk

is context-specific and not just the hazard alone.

National frameworks often mirror this approach. For example, the National Disaster Management Authority (NDMA) of India defines risk as the chance of harmful consequences resulting from interactions between hazard, vulnerability, and exposure (NDMA, 2016). It emphasizes that reducing vulnerability and exposure are as critical as understanding hazards in managing risk.

Effective disaster risk management relies on comprehensive hazard risk assessments. These assessments use scientific data on hazards combined with socio-economic data to identify high-risk zones and populations. Such knowledge informs disaster risk reduction strategies, including land-use planning, infrastructure strengthening, early warning systems, and community education (UN DRR, 2015; NDMA, 2016).

In summary, hazard risk constitutes the composite measure of the possibility and consequences of hazardous events impacting exposed and vulnerable communities and systems. Managing this risk is key to reducing disaster impacts and enhancing resilience globally and nationally.

Risk Calculation

Hazard risk calculation in disaster management quantifies the probability and potential severity of adverse impacts resulting from hazards interacting with vulnerable and exposed elements. The fundamental formula used to calculate risk is:

$$\textbf{Risk} = \textbf{Hazard} \times \textbf{Exposure} \times \textbf{Vulnerability}$$

Where:

- Hazard refers to the probability of occurrence and intensity of a hazardous event (e.g., frequency and magnitude of earthquakes or floods).
- Exposure indicates the people, assets, or systems present hazard-prone areas that could be affected.
- Vulnerability reflects the susceptibility or weakness of these exposed elements to suffer harm, considering structural, social, economic, and environmental factors.

Steps in Calculating Hazard Risk:

1. Hazard Assessment: Identify and characterize hazards using historical data, scientific models, and geographic information, estimating their likelihood (probability) and severity (intensity, duration). For example, seismic hazard maps show the probability of ground shaking.
2. Exposure Analysis: Map the distribution and value of population, infrastructure, economic assets, and critical services within hazard-prone zones. Geographic Information Systems (GIS) are commonly used for spatial exposure analysis.
3. Vulnerability Evaluation: Assess factors influencing susceptibility, such as building standards, emergency preparedness, socio-economic status, and community resilience. Vulnerability indices or scoring may be developed for different sectors or populations.
4. Combining Factors: Integrate hazard, exposure, and vulnerability data to estimate risk quantitatively, which can be expressed as expected losses, damage estimates, or probabilistic risk metrics (e.g., annualized expected loss).

Practical Example:

In flood risk assessment, hazard is the probability of flooding at certain depths, exposure includes the number and value of buildings in the floodplain, and vulnerability is the susceptibility of those buildings to damage at various flood depths. Multiplying these estimates yields expected flood risk values used for planning and mitigation.

Advanced Approaches:

More sophisticated models incorporate additional factors such as coping capacity, adaptive behaviour, cascading effects, and socio-economic dynamics to refine risk estimates. Probabilistic risk assessment frameworks like catastrophe modelling are widely used by insurers and policymakers.

This approach to hazard risk calculation is foundational in global and national disaster risk reduction guidelines, including those by the United Nations Office for Disaster Risk Reduction (UNDRR) and national agencies like India's National Disaster Management Authority (NDMA) (UNDRR, 2009; NDMA, 2016).

Exposure

In disaster management, exposure refers to the people, property, infrastructure, and ecosystem elements that are present in hazard-prone areas and hence are susceptible to potential harm or loss when a hazardous event occurs. It represents the physical presence of assets and populations in places where hazards may impact them (United Nations Office for Disaster Risk Reduction [UNDRR], 2009). Exposure is a critical component of disaster risk because even a severe hazard will cause limited disaster if exposure is low or absent.

Identification of exposure involves spatial and demographic analysis to determine what or who is situated in areas susceptible to hazards. This process typically uses geographic information systems (GIS) to map the location of populations, buildings, critical infrastructure, agricultural lands, and environmentally sensitive areas relative to known hazard zones such as floodplains, seismic fault lines, or cyclone paths (National Disaster Management Authority [NDMA], 2016). Data sources include census data, land use maps, satellite imagery, and infrastructure inventories.

For example, in flood risk management, exposure would include all homes, businesses, roads, and people living within a floodplain. Assessing exposure accurately is vital for effective disaster risk assessment and for prioritizing risk reduction interventions focused on protecting vulnerable populations and assets.

Thus, exposure is the element in risk calculation that quantifies what is in harm’s way, providing the physical and social context for how hazards can translate into disasters (UNDRR, 2009; NDMA, 2016).

Vulnerability

Vulnerability in disaster management refers to the characteristics and circumstances of a community, system, or asset that make it susceptible to the damaging effects of a hazard. It encompasses physical, social, economic, and environmental factors that increase the likelihood of harm when exposed to hazardous events (United Nations Office for Disaster Risk Reduction [UNDRR], 2009). Vulnerability is a key determinant of disaster risk because it influences the degree of damage and loss that occurs during disasters.

The United Nations Office for Disaster Risk Reduction defines vulnerability as “the conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards” (UNDRR, 2009).

Similarly, the National Disaster Management Authority of India (NDMA) describes vulnerability as the “extent to which a community, system or asset is likely to be damaged or disrupted by the impact of a particular hazard” (NDMA, 2016).

Identification and assessment of vulnerability involve analysing various factors, including the quality of housing, infrastructure robustness, socio-economic status, access to resources, health status, education levels, and governance systems. Social vulnerability also considers aspects such as age, gender, disability, and marginalization that can affect a community’s ability to prepare for, respond to, and recover from disasters (NDMA, 2016; UNDRR, 2009).

Vulnerability is often quantified through composite indices or scoring systems that combine different indicators relevant to the context. These may include measures of income, education, health services, building safety, and environmental conditions. Researchers and practitioners may use vulnerability mapping alongside hazard and exposure data to identify high-risk areas and prioritize interventions (UNDRR, 2015; NDMA, 2016).

In summary, vulnerability reflects how susceptible people and assets are to harm in the face of hazards and is critical to understanding and reducing disaster risk on both global and national levels (UNDRR, 2009; NDMA, 2016)

Resilience

Resilience in disaster management is a critical concept that refers to the ability of individuals, communities, institutions, systems, and societies to anticipate, prepare for, respond to, and recover from hazardous events while maintaining essential functions and structures. It embodies the capacity not only to withstand shocks but also to adapt, transform, and learn from disasters to reduce future risks and vulnerabilities.

The United Nations Office for Disaster Risk Reduction (UNDRR) defines resilience as “the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner” (UNDRR, 2009). This definition emphasizes both robustness—the capacity to endure immediate impacts—and adaptability, which includes the capability to reorganize and improve functioning post-disaster.

Globally, resilience has become a cornerstone of disaster risk reduction frameworks such as the Sendai Framework for Disaster Risk Reduction 2015-2030, which advocates for strengthening resilience across all levels of society through inclusive policies, risk-informed development, and stakeholder engagement (UNDRR, 2015). This shift in focus from reactive to proactive disaster management underlines resilience as central to sustainable development.

Nationally, agencies like the National Disaster Management Authority (NDMA) of India conceptualize resilience in similar terms, defining it as the “capacity to cope with, resist, and recover from the impacts of a hazard effectively, thereby reducing the magnitude and severity of disaster impacts” (NDMA, 2016). The NDMA emphasizes resilience-building through community participation, capacity building, infrastructure development, and integrating disaster risk considerations into planning and governance.

Identifying and strengthening resilience involves assessing resources, social networks, institutional capacities, economic stability, and governance mechanisms that enable communities to

manage risks and bounce back after disasters. Resilience measurement frameworks often examine factors such as access to knowledge, diversification of livelihoods, social cohesion, and environmental sustainability (UNDRR, 2019; NDMA, 2016).

In essence, resilience represents a dynamic and multifaceted strategy aimed at reducing disaster risk by balancing prevention, preparedness, response, and recovery within an adaptive learning system. It is foundational for transforming the way societies live with hazards in an era of increasing disaster frequency and complexity.

GLOSSARY

1. **Acceptable Risk**: The degree of human or material loss considered tolerable by a community or authorities.
2. **All Hazards Approach:** Handling all emergencies using unified management methods, covering both natural and man-made hazards.
3. **Chemical Hazards:** Hazards involving chemicals, which manifest through fire, explosion, toxicity, or corrosiveness.
4. **Command:** The organizational authority to direct resources and personnel, typically established by law or agreement.
5. **Communications:** Infrastructure and messaging channels (e.g., roads, railways, telephones) used to transmit disaster management information.
6. **Comprehensive Approach:** Addresses all aspects of disaster management—prevention, preparedness, response, and recovery.
7. **Control:** Directing activities during an operation to ensure a coordinated outcome.
8. **Coordination:** Uniting organizations and resources to meet the demands of emergencies.
9. **Coping:** The strategies and resources communities use to manage disaster impacts.
10. **Disaster Plans:** Formal strategies and arrangements for disaster prevention, preparation, response, and recovery.
11. **Disaster Risk Management:** A developmental approach focused on managing underlying risk conditions to minimize disaster occurrences.
12. **Disaster Support Plans:** Specialized plans for specific hazards, supporting national disaster strategies (e.g., for aircraft crashes).
13. **Disaster Risk Management Arrangements:** Linkages and structures connecting government, communities, and disaster management offices.
14. **ECC/EOC**: Emergency centres that manage and support disaster response.
15. **Emergency Management Team:** Personnel headed by an incident manager, responsible for emergency control.

16. **ESLO:** Liaison officers connecting and coordinating pre-, post-, and active response activities.
17. **Fire Prevention/Protection:** Steps taken to reduce fire risk and limit damages (e.g., building design, suppression systems).
18. **Hazard Analysis:** The identification and description of hazards and their community effects.
19. **Hazard Mapping:** Locating and quantifying hazards' threat levels for people and property.
20. **Integrated Approach:** Involving all agencies or departments relevant to disaster management.
21. **Lead Agency:** The organization primarily responsible for managing a specific disaster.
22. **Lifelines:** Public facilities/services (water, energy, transport) critical for supporting life.
23. **Logistics:** Activities involving supply, transport, and distribution of disaster response materials.
24. **Mitigation:** Measures—both structural and non-structural—to reduce disaster impacts.
25. **People-Centred Approach:** Views disasters as outcomes of social, economic, and environmental conditions, focusing on people’s welfare.
26. **Preparedness**: Ensuring resources and services are ready to cope with disasters.
27. **Prevention:** Measures to avert or reduce disaster effects.
28. **Public Awareness:** Informing communities about hazards and actions to protect lives and property.
29. **Recovery:** Supporting disaster-affected communities in reconstruction and restoration.
30. **Relief:** Provision of immediate basic needs and support to affected people.
31. **Resources:** Assets used to achieve disaster management objectives (e.g., equipment, supplies, capital).
32. **Response:** Actions taken before, during, and after disasters to minimize effects and aid relief.
33. **Risk Reduction:** Applying techniques to lower the chance or impact of disasters.
34. **Search and Rescue:** Locating victims and providing first aid/medical assistance.
35. **Situation Report:** Brief summaries of emerging emergency details.
36. **Stakeholder:** Any person or entity with an interest in or affected by disaster risk management.
37. **Standard Operating Procedures:** Directives on actions, timing, responsibility, and process for specific events.
38. **Support Agency:** Organizations providing needed services, personnel, or materials.

39. **Technological Disasters/Hazards**: Disasters from non-natural causes, including biological, chemical, nuclear, transport, or terrorist activity.
40. **Vulnerability:** Factors (physical, socioeconomic, political) that reduce response capability; mitigating vulnerability reduces risk.
41. **Warning Systems:** Means to alert people and organizations to hazards so actions can be taken to increase safety.

Chapter 2

Taming Trouble: How We Classify Hazards and Disasters

Table. 3. Classification of Disasters

Classification Basis	Categories / Types	Description
Nature (Origin)	Natural Hazards, Anthropogenic (Man-made) Hazards	Natural caused by environmental processes; anthropogenic caused by human actions.
Type of Agent (Peril)	Geophysical, Hydrological, Meteorological, Climatological, Biological, Extraterrestrial	Based on the type of physical, climatic, or biological agent causing the hazard.
Speed of Onset	Rapid-onset, Slow-onset	Rapid includes earthquakes, floods; slow includes drought, salinity intrusion.
Cause	Natural, Technological, Intentional	Natural hazards from natural processes, technological from accidents/industrial, intentional from human conflict or terrorism.
Physical Characteristics	Chemical, Biological, Physical	Based on hazard's physical/chemical/biological nature, e.g., chemical spills, pandemics, fires.
Impact Sector	Social, Economic, Environmental	Based on which domain is primarily affected by the disaster or hazard.

Source: Source data summarized from classifications by UNDRR, IRDR, ADB, UNISDR, OSHA, CCOHS, and related hazard frameworks from 2025.

We have seen that disaster management is cyclic process and thrives on order and hierarchy.

To make things easier, we need to systematically analyse and arrange it to be able to effectively tackle and solve the complications that arise.

There being a plethora of hazards, it is pertinent that we make order out of chaos and understand the hazards. For this we begin by classifying or grouping them based on a variety of criteria.

The table depicts the ways hazards can be classified. Let’s take a look.

Hazards and disasters can be systematically classified based on different criteria to better understand their characteristics, causes, and impacts. One common basis for classification is the or origin of the hazard. Natural hazards originate from environmental and geophysical processes, whereas anthropogenic, or man-made, hazards arise from human

activities such as industrial accidents or conflicts.

Another important classification criterion is the type of agent or peril involved. This includes groups like geophysical (earthquakes, landslides), hydrological (floods, tsunamis), meteorological (storms, cyclones), climatological (droughts, wildfires), biological (epidemics, infestations), and extraterrestrial (asteroid impacts). These categories reflect the source and mechanism generating the hazard.

Speed of onset is also decisive, distinguishing rapid-onset hazards like earthquakes and floods which occur suddenly with immediate effects, from slow-onset hazards such as droughts and salinity intrusion that develop gradually and have chronic impacts.

Cause-based classification differentiates natural hazards, technological hazards stemming from system failures, and intentional hazards due to human conflicts or terrorism. Lastly, hazards can be viewed by their impact domain: social, economic, or environmental, highlighting the different sectors they affect.

This multifaceted classification framework aids disaster risk reduction by tailoring preparedness, response, and mitigation strategies to hazard characteristics, enhancing resilience and informed policy-making. It forms the foundation for academic study and practical disaster management planning globally.

Fig.4. Integrated Research on Disaster Risk (IRDR). "Peril Classification and

This comprehensive diagram from IRDR, offers a structured overview of disasters, providing a visual guide to their classification based on event categorization and hazard family. Such classification forms the backbone of risk assessment, policy planning, and emergency management in the field of disaster science. By categorizing hazardous phenomena into **Family, Main Event, and granular-level Peril (IRDR),** this framework underlines the diversity, complexity, and interrelation of natural and anthropogenic disasters affecting societies.

Disaster Families: The Foundational Categories

The leftmost column divides disasters into six principal families, each distinguished by its underlying physical, biological, or cosmic processes.

- **Geophysical disasters** arise from solid earth processes, such as shifts and volcanic activity.
- **Hydrological hazards** originate from water movement and dynamics, including floods and landslides.
- **Meteorological events** relate to short-term atmospheric phenomena, from storms to extreme temperatures.
- **Climatological hazards** reflect longer-term climate dynamics, including droughts and wildfires.
- **Biological disasters** involve infectious agents or ecological disturbances, affecting humans, animals, or crops.
- **Extraterrestrial events** are rare yet potentially catastrophic, stemming from space phenomena like collisions or geomagnetic storms.

These families create the conceptual framework for analysing disasters, as each encompasses unique causal mechanisms and effects. Main Event Typology: Bridging and Perils

The Main Event column details representative disaster triggers within each family. For example, the Geophysical family includes earthquakes, mass movements, and volcanic activity, which may manifest in varied perils such as ground shaking, mass slippage, or pyroclastic flows. Hydrological events, such as floods and wave action, reflect the destructive capacity of water in motion, often exacerbated by meteorological factors.

Meteorological main events encompass storms, temperature extremes, and cyclones—these are typically high-intensity, short-duration phenomena. Climatological main events such as droughts and wildfires represent slow-onset, prolonged disruptions, frequently linked to changing climatic patterns and land management practices.

Biological main events underscore the role of living vectors: animal incidents, disease outbreaks, and insect infestations destabilize ecological and human systems through complex networks of transmission and exposure. Finally, extraterrestrial events, including impacts and space weather, serve as a reminder of vulnerabilities that extend beyond Earth's atmospheric and geological boundaries.

Perils: Specific Manifestations and Hazards

The richest layer of this taxonomy is perils—the specific hazardous outcomes of main events—which are crucial for emergency response, insurance assessment, and scientific research. For example:

- Geophysical perils include ash fall, liquefaction, tsunamis, and lahar flows, each presenting unique challenges for evacuation, infrastructure safety, and health risk.
- Hydrological perils highlight the diversity of flood phenomena—riverine, coastal, flash floods,

avalanches, and erosion—demonstrating that water's destructive power can be multifaceted and locally specific.

- Meteorological perils capture weather extremes, from cold waves and tornadoes to lightning and blizzard conditions. These occur with varying frequency and intensity, challenging forecasting and mitigation strategies.
- Climatological perils centre on forest and land fires, land subsidence, and glacial lake outbursts—these are characteristically large-scale often incremental in onset, complicating early warning efforts.
- Biological perils include bacterial, fungal, viral, parasitic, and prion diseases, underscoring the hazard presented by biological agents to public health agriculture.
- Extraterrestrial perils point to the infrequent but high-consequence risks of airburst, collision, shocks, and radio disturbances—reminding disaster managers of the need for international coordination and high-tech resilience planning for such threats.

Implications for Disaster Risk Reduction

This diagram encapsulates the range of hazards demanding attention in contemporary disaster risk reduction (DRR) frameworks in a nutshell. Categorization by family, main event, and peril supports:

- **Integrated hazard mapping**: By organizing disasters according to natural and anthropogenic pathways, risk managers can spatially layer and assess compound hazards, such as the intersection of flood risk, disease outbreaks, and climate change effects.
- **Policy alignment**: Governments and agencies reference such taxonomies when structuring national action plans, resource allocation, and legal definitions of disaster for compensation and relief eligibility.
- **Academic and operational clarity:** For researchers and practitioners, these distinctions clarify research scope, methodology, and intervention strategies, whether modelling earthquake, liquefaction or mapping vector-borne disease outbreaks.

The Value of in Slow- and Fast-Onset Hazards

This classification also enables the differentiation between fast-onset disasters (e.g., earthquakes, cyclones) and slow-onset hazards (e.g., drought, salinity intrusion, disease spread)—a critical nuance in modern DRR discourse. While fast-onset events demand urgent preparedness and instant response, slow-onset disasters call for sustained monitoring and adaptive management strategies. Understanding which peril belongs to which family and main event aids in developing early warning systems and tailoring risk communication to affected populations.

Let's Get a better, more detailed look at things as we proceed.

Prion Disease

A rare, fatal, and untreatable group of neurodegenerative disorders caused by misfolded proteins called prions.

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CHAPTER 3

Global DRR Roadmaps: Charting Paths Past Disaster Drama

Hazards do not choose their targets; they transcend borders, economies, and societies, reminding humanity that vulnerability is a shared condition. From earthquakes in the Pacific Ring of Fire to floods in the Himalayan foothills and droughts in sub-Saharan Africa, hazards manifest everywhere, testing the resilience of people and systems alike. Addressing these challenges requires an integrated effort that spans all levels—global, national, regional, and local—because the roots of risk and the capacity to act are distributed across this spectrum.

While the world faces common threats, every individual, community, and nation perceives them differently—through lenses shaped by geography, culture, economics, and experience. A policymaker may see governance gaps, a scientist may see data deficiencies, and a villager may see the loss of livelihood. This diversity of perspective is both a challenge and a source of strength. It underscores the need for collaboration and the exchange of wisdom across disciplines and scales, ensuring that collective knowledge informs shared solutions for a safer, more resilient world.

Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA): THE LINK

Disaster Risk Reduction (DRR) and climate adaptation have become increasingly interconnected in both policy and practice, fundamentally driven by the growing impacts of climate change that amplify disaster risks globally. The intensification of extreme weather events, sea-level rise, and changing climate patterns have transformed the nature and frequency of hazards, compelling a deeper integration of DRR and climate adaptation strategies as essential components of resilient development. Here we examine why this interconnection is critical, understand the evolving conceptual and practical convergence of these fields, and highlight implications for policy and implementation.

Risk Multiplier

Climate change acts as a risk multiplier, exacerbating existing vulnerabilities and exposure levels associated with natural and technological disasters (IPCC, 2022). For example, the increased intensity of cyclones, prolonged droughts, erratic rainfall, and heatwaves directly escalate the likelihood and severity of disasters, deeply impacting ecosystems, infrastructure, human health, and livelihoods (United Nations Office for Disaster Risk Reduction [UNDRR], 2020).
These changes alter hazard profiles and increase uncertainty in risk assessments, requiring dynamic and flexible approaches that integrate long-term climatic trends with traditional disaster risk contexts (Aitsi-Selmi et al., 2016).

Standalone vs integrated Development

Historically, DRR and climate adaptation evolved as distinct domains. DRR traditionally focused on reducing losses from sudden-onset disasters through preparedness, mitigation, and response measures, emphasizing hazard monitoring, early warning systems, and resilient

infrastructure (UNDRR, 2015). Climate adaptation, by contrast, has centered on adjusting natural or human systems to moderate or offset adverse climate impacts, with a strong orientation towards addressing slow-onset changes and variability at multiple scales (IPCC, 2022). However, increasing recognition of the overlapping objectives—reducing vulnerability and exposure—has led to calls for greater policy coherence and integration (Mysiak et al., 2016).

One fundamental reason for integration is the overlapping nature of risks posed by climate change and disasters. Many climate hazards, such as floods and storms, cause disasters whose frequency and intensity are exacerbated by climate change. For instance, sea-level rise and warming oceans increase the potential for coastal flooding and tropical cyclones, impacting millions in low-lying coastal regions and small island developing states (Mechler et al., 2019). Integrating DRR and climate adaptation allows for comprehensive risk management that considers both immediate disaster risks and gradual climate change impacts, offering enhanced protection and resilience (Few et al., 2017).

Policy frameworks increasingly reflect this convergence. The Sendai Framework for Disaster Risk Reduction (2015–2030) explicitly acknowledges climate change as a key factor influencing disaster risk and resilience efforts, advocating for integrating climate adaptation into DRR policies (UNDRR, 2015). Similarly, the Paris Agreement on Climate Change emphasizes the need for countries to enhance adaptive capacity and resilience, underscoring the role of disaster risk management in achieving climate objectives (United Nations Framework Convention on Climate Change [UNFCCC], 2015). These global instruments advocate for a united approach, recognizing that isolated strategies are insufficient to address the complex and evolving risk landscape.

Practically, integration improves resource efficiency and policy coherence by reducing duplication and fostering collaboration across sectors. Many adaptation interventions, such as ecosystem-based approaches, flood management infrastructure, and resilient agriculture practices, simultaneously reduce disaster risks while enhancing climate resilience (Shaw et al., 2014). By aligning objectives, stakeholders in government, civil society, and the private sector can pool expertise, financing, and technology to develop multi-functional, adaptable solutions that address short- and long-term vulnerabilities.

Challenges

However, the synergies are not without challenges.
Coordination complexities arise from institutional silos, where separate agencies handle climate adaptation and disaster management, impeding holistic planning and implementation (Kelman, 2021). Data and knowledge gaps also limit the ability to operationalize integrated risk assessments that reflect changing climate scenarios and disaster trends. To overcome these barriers, it is essential to develop integrated governance frameworks that support coherent visioning, joint planning, and participatory mechanisms including local communities who often face the brunt of compounded climate-disaster risks (Handmer et al., 2017).

A further rationale for the interconnectedness lies in sustainable development pathways. Both DRR and climate adaptation aim to safeguard development gains by minimizing disruption from hazards and climate variability. Building resilient infrastructure, securing livelihoods, and conserving ecosystems

are strategies that serve dual purposes of disaster risk reduction and climate adaptation, contributing directly to multiple Sustainable Development Goals (United Nations, 2015). Therefore, integrating these approaches is key to achieving resilient, inclusive development that withstands future uncertainty and complexity.

In conclusion, disaster risk reduction and climate adaptation are increasingly intertwined due to the amplifying effects of climate change on disaster risks worldwide. This interconnection enhances the effectiveness of risk management practices by fostering comprehensive, adaptive solutions that address both sudden and slow-onset hazards. Policy frameworks, including major global agreements, call for and support integration, while practical implementation highlights the benefits of coordinated efforts across governance levels and sectors. Overcoming institutional and technical challenges is necessary to realize full synergies, ensuring sustainable development and resilience in an era of escalating climate and disaster risks.

The above being said, the need for frameworks and polices are clear.

Now let's dive deep into the global frameworks and policies in place and explore all the way down.

GLOBAL DISASTER GOVERNANACE FRAMEWORKS

Table. 4. DRR And CCA Frameworks at a Glance

Year	Name of Framework/Agreement	Focus Area	Key Highlights
1992	United Nations Framework Convention on Climate Change (UNFCCC)	Climate Change	Established global framework for climate action including adaptation commitments.
2000	Millennium Development Goals (MDGs)	Sustainable Development	Includes goals linked to combating climate change impacts and reducing vulnerability.
2005	Hyogo Framework for Action (HFA) 2005–2015	Disaster Risk Reduction	First global blueprint for DRR emphasizing resilience building and risk management.
2007	Fourth Assessment Report, IPCC	Climate Science & Adaptation	Highlighted the importance of adaptation to climate change as a critical response.
2010	Cancun Adaptation Framework (UNFCCC)	Climate Change Adaptation	Formalized adaptation planning and finance in climate negotiations.

Year	Name of Framework/Agreement	Focus Area	Key Highlights
2015	Sendai Framework for Disaster Risk Reduction 2015–2030	Disaster Risk Reduction	Prioritized understanding risk, governance, investment, and preparedness; integrated climate risks.
2015	Paris Agreement (UNFCCC)	Climate Change Mitigation & Adaptation	Set global temperature goals; emphasized adaptation finance and resilience.
2015	2030 Agenda for Sustainable Development & SDGs	Sustainable Development	Includes Goal 13 on Climate Action and Goal 11 on sustainable cities and resilience.
2016	Adaptation Committee under UNFCCC	Established to oversee the implementation of enhanced climate adaptation strategies	Facilitates coherence between adaptation and disaster risk planning
2017	Global Platform for Disaster Risk Reduction	DRR Governance & Policy	Facilitates global cooperation and monitoring on DRR commitments.
2019	UN Climate Action Summit Outcomes	Climate Finance & Adaptation	Renewed commitments for accelerating climate adaptation and disaster resilience.
2021	Glasgow Climate Pact	Agreement from COP26 emphasizing adaptation finance and resilience building	Increased focus on loss and damage, and strengthening resilience globally
2022	IPCC Sixth Assessment Report (AR6)	Climate Science & Adaptation	Latest scientific evidence underscoring the urgency of adapting to increasing climate risks.
2023	Global Goal on Adaptation (under UNFCCC)	Goal to enhance adaptive capacity to climate impacts globally	Aims for measurable progress in climate resilience and risk reduction

United Nations Framework Convention on Climate Change (UNFCCC 1992)

- **Goal:** Stabilize greenhouse gas concentrations to prevent dangerous anthropogenic interference with the climate system.
- **Objectives:** Promote cooperation among countries to mitigate climate change, adapt to its effects, and share technology and financial resources.
- **Strategies**: Establish reporting obligations, create mechanisms for financial and technology transfer, and hold periodic climate conferences (COPs) to advance commitments (UNFCCC, 1992).
- Gaps: Lack of binding emission reduction targets early on; limited direct mechanisms to address disaster risk reduction, with adaptation addressed mostly through later protocols (IPCC, 2022).

Millennium Development Goals, 2000 (MDGs)

- **Goal:** Address extreme poverty and improve global development outcomes by 2015.
- **Objectives:** Reduce poverty, hunger, disease, ensure environmental sustainability, and global partnership for development. Integration of disaster risk and environmental issues was implicit in the sustainability goal.
- **Strategies:** Set specific, measurable targets across countries focusing mainly on poverty and development with limited climate-specific focus (UN, 2000).
- Gaps: DRR and climate adaptation were implicit, not explicit, and integration with climate actions was limited (UNDRR, 2015).

Hyogo Framework for Action, 2005 (HFA) 2005–2015

- Goal: Substantially reduce disaster losses globally by 2015.
- Objectives: Build the resilience of nations and communities to disasters.
- Strategies: Five priorities including risk assessment, risk governance, knowledge management, reducing underlying risk factors, and preparedness for timely response (UNDRR, 2005).
- Gaps: DRR and climate adaptation were implicit, not explicit, and integration with climate actions was limited (UNDRR, 2015).

Fourth Assessment Report, 2007, IPCC

- Goal: Provide comprehensive scientific assessment of climate change, its impacts, and potential adaptation and mitigation responses.
- Objectives: Inform policymakers with evidence-based understanding of risks and adaptation options.
- Strategies: Extensive review of climate science, vulnerability assessments, and evaluation of adaptation strategies (IPCC, 2007).
- Gaps: DRR and climate adaptation were implicit, not explicit, and integration with climate actions was limited (UNDRR, 2015).

Cancun Adaptation Framework, 2010 (UNFCCC)

- Goal: Enhance action on adaptation to reduce vulnerability to climate change impacts, especially for developing countries.
- Objectives: Support National Adaptation Plans (NAPs), strengthen resilience, promote technology transfer and finance.
- Strategies: Establish institutional mechanisms including the Adaptation Committee and Green Climate Fund to mobilize resources and enhance coordination (UNFCCC, 2010).
- Gaps: DRR and climate adaptation were implicit, not explicit, and integration with climate actions was limited (UNDRR, 2015).

Sendai Framework for Disaster Risk Reduction 2015–2030

- Goal: Substantially reduce disaster risk and losses in lives, livelihoods, and health.
- Objectives: Understand disaster risk, strengthen governance, invest in resilience, and enhance preparedness and recovery.
- Strategies: Promote a multi-hazard approach, foster inclusive governance, integrate DRR and climate adaptation, and implement “Build Back Better” during recovery (UNDRR, 2015).
- Gaps: DRR and climate adaptation were implicit, not explicit, and integration with climate actions was limited (UNDRR, 2015).

Paris Agreement, 2015 (UNFCCC)

- Goal: Limit global warming to well below 2°C, pursuing 1.5°C goals, and strengthen adaptation efforts.
- Objectives: Enhance adaptive capacity, foster resilience, and reduce vulnerability.
- Strategies: Nationally Determined Contributions (NDCs) for emission reductions and adaptation plans, financial support to developing countries, and regular review mechanisms (UNFCCC, 2015).
- Gaps: DRR and climate adaptation were implicit, not explicit, and integration with climate actions was limited (UNDRR, 2015).

2030 Agenda for Sustainable Development & SDGs, 2015

- Goal: Achieve sustainable development globally across social, economic, and environmental dimensions by 2030.
- Objectives: 17 goals including Goal 13 on climate action and integration of disaster resilience in multiple goals.
- Strategies: Mainstream climate adaptation and DRR in development planning, promote inclusive and resilient infrastructure, and monitor progress with global indicators (UN, 2015).
- Gaps: DRR and climate adaptation were implicit, not explicit, and integration with climate actions was limited (UNDRR, 2015).

Adaptation Committee under UNFCCC, 2016

- Goal: Advise on adaptation policies and enhance coherence and coordination of adaptation activities.
- Objectives: Support implementation of adaptation frameworks and promote knowledge-sharing.

- Strategies: Facilitate technical guidance, foster collaboration across parties, and integrate adaptation in national planning (UNFCCC, 2016).
- Gaps: DRR and climate adaptation were implicit, not explicit, and integration with climate actions was limited (UNDRR, 2015).

Global Platform for Disaster Risk Reduction, 2017 (GPDRR)

- Goal: Review progress and strengthen global collaboration on DRR.
- Objectives: Support Sendai Framework implementation, promote multi-sectoral and multi-stakeholder engagement.
- Strategies: Forums for knowledge exchange, partnerships, and policy alignment (UNDRR, 2017).
- Gaps: DRR and climate adaptation were implicit, not explicit, and integration with climate actions was limited (UNDRR, 2015).

UN Climate Action Summit Outcomes, 2019

- Goal: Accelerate climate action and scale-up ambition to meet Paris targets.
- Objectives: Promote net-zero emissions, finance climate resilience, and strengthen adaptation.
- Strategies: Encourage partnerships, mobilization of finance, and implementation of nationally determined commitments (UN, 2019).
- Gaps: DRR and climate adaptation were implicit, not explicit, and integration with climate actions was limited (UNDRR, 2015).

Glasgow Climate Pact, 2021

- Goal: Enhance mitigation ambition and adaptation finance to limit warming and address loss and damage.
- Objectives: Phase down coal, increase adaptation funding, and recognize responsibility for climate impacts.
- Strategies: Commitments for stronger NDCs, donor pledges for financing, and establishing mechanisms for loss and damage (UNFCCC, 2021).
- Gaps: DRR and climate adaptation were implicit, not explicit, and integration with climate actions was limited (UNDRR, 2015).

IPCC Sixth Assessment Report (AR6), 2022

- Goal: Provide the latest scientific state of climate change, impacts, vulnerability, and adaptation pathways.
- Objectives: Inform global and national policy with updated evidence on accelerating risks and effective adaptation measures.
- Strategies: Detailed scenarios, evaluation of adaptation limits, and focus on transformative solutions (IPCC, 2022).
- Gaps: Gaps: DRR and climate adaptation were implicit, not explicit, and integration with climate actions was limited (UNDRR, 2015).

Global Goal on Adaptation, 2023 (under UNFCCC)

- Goal: Achieve "enhanced adaptive capacity, strengthening resilience and reducing vulnerability to climate change".
- Objectives: Monitor measurable progress toward adaptation

across ecosystems, livelihoods, and infrastructure.

- Strategies: Use adaptation indicators, integrate climate risk into development, and foster international cooperation (UNFCCC, 2023).
- Gaps: DRR and climate adaptation were implicit, not explicit, and integration with climate actions was limited (UNDRR, 2015).

This overview captures the core aims and mechanisms of these pivotal global instruments, framing the evolution and increasing convergence of disaster risk reduction and climate adaptation governance over three decades.

YOKOHAMA STRATEGY

The Yokohama Strategy and Plan of Action for a Safer World, adopted at the World Conference on Natural Disaster Reduction held in Yokohama, Japan, from May 23 to 27, 1994, is a landmark international framework in disaster risk reduction (DRR).

It stands as one of the earliest comprehensive international frameworks dedicated to disaster risk reduction (DRR), preceding later initiatives like the Hyogo Framework for Action. The strategy recognized the urgent need for global cooperation to mitigate the impacts of natural disasters and laid foundational principles that have shaped subsequent DRR approaches.

The Yokohama Strategy emphasized five guiding principles:

(1) Risk assessment and knowledge as a basis for decision-making

(2) Disaster prevention and preparedness to reduce vulnerabilities;

(3) Involvement of multiple sectors and communities;

(4) Integration of environmental protection into disaster management; and

(5) The importance of international cooperation and technical assistance (un, 1994).

These principles underscored the holistic understanding that reducing disaster risk requires cross-sectoral collaboration, scientific and technical input, and community participation.

Among its key objectives, the strategy called for

1. Improving early warning systems,
2. Strengthening infrastructures,
3. Enhancing public awareness, and
4. Encouraging disaster mitigation measures within the sustainable development process.

It highlighted that disaster risks are closely linked to developmental processes and environmental management, emphasizing the need to incorporate disaster considerations into national development plans (UN, 1994).

The Plan of Action accompanying the Strategy outlined concrete measures for governments to adopt, including establishing dedicated national disaster reduction institutions, strengthening legislative and policy frameworks, promoting education and training, and fostering regional and international partnerships. It also promoted the role of scientific research and technological innovation in hazard monitoring and risk assessment—elements critical to integrating disaster risk management with climate change adaptation (UN, 1994).

Significance

The Yokohama Strategy’s significance lies in its early articulation of DRR as an integral part of sustainable development rather than a stand-alone emergency response. It helped set a global agenda that recognized disaster risks as manageable and preventable through prepared, collaborative efforts. This perspective paved the way for the Hyogo Framework for Action (2005–2015) and later the Sendai Framework (2015–

2030), both of which expanded on Yokohama's core ideas, especially the close linkage between environmental sustainability, development, and risk reduction.

However, gaps were notable in the implementation phase post-Yokohama, especially in reaching vulnerable populations and local governance structures effectively. The strategy's broad principles required translation into operational policies and dedicated funding mechanisms, aspects more comprehensively addressed by subsequent frameworks (Aitsi-Selmi et al., 2016; UNDRR, 2015).

Overall, the *Yokohama Strategy remains a milestone in the history of DRR for its holistic approach and emphasis on integrating disaster risk considerations into development planning, a principle increasingly relevant in the context of climate change adaptation efforts (Kelman, 2021; UN, 1994).*

Hyogo Framework for Action (HFA), 2005–2015

The Hyogo Framework for Action (HFA) 2005–2015 marked a significant milestone in the evolution of global disaster risk reduction (DRR) policy. Adopted at the World Conference on Disaster Reduction held in Kobe, Japan, in 2005, the HFA was the first comprehensive, internationally agreed-upon blueprint aimed at substantially reducing disaster losses worldwide through coordinated efforts among nations, communities, and stakeholders (UNISDR, 2005). It built upon prior efforts such as the Yokohama Strategy (1994) but was distinguished by its structured priorities, measurable objectives, and emphasis on integrating DRR into development planning.

Goals and Significance

The overarching goal of the HFA was "the substantial reduction of disaster losses, in lives and in the social, economic, and environmental assets of communities and countries" by 2015 (UNISDR, 2005, p. 1). It notably framed disasters not merely as natural events but as a product of vulnerabilities embedded in development processes, highlighting the human and economic costs when these risks are poorly managed. This represented a paradigm shift from reactive disaster management toward proactive risk reduction and resilience building.

Priority Areas

The framework delineated five strategic priorities for action:

1. Ensure that disaster risk reduction is a national and local priority with a strong institutional basis for implementation
   This priority underscored the need for countries to establish or strengthen national platforms, institutions, and legislation dedicated to DRR, ensuring clear protocols, coordination, and accountability (UNISDR, 2005).

2. Identify, assess, and monitor disaster risks and enhance early warning
   Emphasizing the role of science and technology, this priority called for systematic risk assessment, hazard mapping, vulnerability analysis, and the development or improvement of early warning systems to provide timely and accurate information (Cardona & van Aalst, 2012).

3. Use knowledge, innovation, and education to build a culture of safety and resilience at all levels
   Awareness raising, capacity building, education, and participation of communities were highlighted as essential to fostering resilience and empowering local actors who are the first responders to disasters.

4. Reduce the underlying risk factors
   This comprehensive priority linked risk reduction to

sustainable development, advocating for sensible land use, environmental protection, improved building codes, poverty reduction strategies, and governance reforms addressing vulnerability drivers.

5. Strengthen disaster preparedness for effective response at all levels The framework concluded with the imperative to enhance preparedness plans, emergency services, and recovery mechanisms to minimize disaster impacts when risks materialize.

Implementation and Impact

Countries were encouraged to develop comprehensive national and local disaster risk reduction strategies aligned with these priorities. The HFA fostered multi-stakeholder partnerships involving governments, civil society, the private sector, and international agencies, endorsing a whole-of-society approach (UNISDR, 2005).

The HFA initiated significant advances in the institutionalization of DRR, integrating risk considerations into sectoral development plans, and expanding the use of early warning systems globally. It also promoted the diversification of tools such as participatory risk assessments and community-based disaster risk management (CBDRM) (Pelling, 2011). These measures laid groundwork for more adaptive and climate-resilient development strategies, recognizing climate variability as an intensifier of risk (Kelman, 2021).

Gaps and Challenges

Despite its successes, the HFA faced criticisms and challenges. Its implementation was uneven across regions and countries owing to resource constraints, limited technical capacity, and insufficient local-level engagement in many areas (Aitsi-Selmi et al., 2016). The framework also received critique for not explicitly addressing climate change adaptation and its complex interactions with disaster risks, a key gap that subsequent frameworks like Sendai sought to fill (UNDRR, 2015).

The HFA's relatively limited emphasis on measurable targets and global monitoring frameworks made tracking progress difficult and restricted learning across countries. Finally, challenges persisted in mainstreaming DRR into development finance and planning comprehensively, especially in vulnerable developing nations (UNISDR, 2015).

Legacy

The Hyogo Framework's greatest legacy is its foundational role in reshaping disaster risk management into an inclusive, proactive, and development-oriented process. It set the stage for the Sendai Framework for Disaster Risk Reduction 2015–2030, which explicitly links DRR with climate change adaptation and sustainability objectives, offering clearer targets and enhanced integration with global climate agreements (UNDRR, 2015).

In summary, the Hyogo Framework for Action brought global attention and coherence to reducing disaster risks, transforming policy and practice by emphasizing governance, knowledge, risk reduction, and preparedness, and preparing the international community to address the increasing complexities of disaster risks amplified by climate change.

Sendai Framework for Disaster Risk Reduction, 2015–2030

The Sendai Framework for Disaster Risk Reduction (SFDRR) 2015–2030 represents the most recent and comprehensive global agreement dedicated to reducing disaster risks and enhancing resilience worldwide. Adopted at the Third UN World Conference on Disaster Risk Reduction in Sendai, Japan, in March 2015, the framework succeeded the

Hyogo Framework for Action and shifted paradigms from managing disasters to proactively managing disaster risks (UNDRR, 2015). It explicitly incorporates climate change considerations, sustainable development, and human rights, thus positioning disaster risk reduction as a critical element in global policy.

Goals and Purpose

The primary goal of the Sendai Framework is “the substantial reduction of disaster risk and losses in lives, livelihoods, and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries” by 2030 (UNDRR, 2015, p. 12). It recognizes disaster risk as a function of vulnerabilities, hazard exposure, and insufficient capacity, emphasizing the need for integrated, cross-sectoral approaches.

Targets

The Framework identifies seven global targets, including to:

- Significantly reduce mortality and the number of affected people;
- Minimize direct disaster economic losses relative to GDP;
- Reduce damage to critical infrastructure and disruption of basic services;
- Enhance international cooperation to developing countries;
- Increase availability and access to multi-hazard early warning systems;
- Promote resilience in vulnerable persons and communities (UNDRR, 2015).
-

Priorities for Action

The Sendai Framework builds on five interrelated priorities:

1. Understanding Disaster Risk: This priority stresses improving data collection, hazard mapping, risk modelling, and knowledge dissemination to ensure all stakeholders comprehend disaster risk in a holistic manner, including climate risk dimensions.
2. Strengthening Disaster Risk Governance:
   It advocates establishing robust institutional arrangements and legal frameworks at all governance levels to implement DRR policies coherently, integrating DRR into development, environment, and climate policies.
3. Investing in Disaster Risk Reduction for Resilience: Encourages public and private investment in infrastructure, health, education, and risk reduction actions, emphasizing the economic benefits of resilience and safeguarding development gains.
4. Enhancing Disaster Preparedness and “Build Back Better” in Recovery: Focuses on preparedness, response mechanisms, and recovery approaches that improve resilience and reduce future risk, embedding risk

reduction principles in reconstruction and rehabilitation.

5. Promoting Inclusive and Accessible Disaster Risk Reduction:
   Places emphasis on the rights and needs of vulnerable groups, including women, children, elderly, people with disabilities, and marginalized communities, ensuring equitable participation and access to resources (UNDRR, 2015).

Integration with Climate Change Adaptation and Sustainable Development

One of the Sendai Framework's critical innovations is its explicit emphasis on linking DRR with climate adaptation and sustainable development goals (SDGs). It acknowledges that climate change exacerbates hazards and requires integrated governance mechanisms that address underlying vulnerability and systemic risks (Kelman, 2021). This alignment has influenced national policies to merge DRR and climate resilience strategies, facilitating more coherent and cost-effective interventions (Aitsi-Selmi et al., 2016).

Implementation Mechanisms and Monitoring

The Sendai Framework has an associated Global Target Monitoring System coordinated by the United Nations Office for Disaster Risk Reduction (UNDRR), enabling countries to report progress on indicators such as mortality rates, economic losses, and early warning system coverage (UNDRR, 2020). It fosters partnerships spanning governments, UN agencies, the private sector, academia, and civil society, promoting a whole-of-society approach.

Challenges and Critiques

While widely lauded for its comprehensive scope and ambition, the Sendai Framework faces implementation challenges:

- Many developing countries struggle with inadequate data systems and financial resources to fulfil the framework's priorities (UNDRR, 2019).
- Institutional fragmentation between DRR and climate adaptation agencies can impede integrated programming.
- Measuring progress on long-term resilience outcomes remains complex due to multidimensional risk factors and socio-political contexts (Kelman, 2021).

Legacy and Future Directions

The Sendai Framework represents a progressive step in global disaster risk governance, shifting focus toward risk-informed sustainable development and climate-resilient societies. Its success depends on strengthening national capacities, enhancing science-policy interfaces, securing sustainable financing, and ensuring inclusion across all layers of society (UNDRR, 2020).

In conclusion, the Sendai Framework for Disaster Risk Reduction 2015–2030 provides a robust international blueprint for managing disaster risks with explicit links to climate change adaptation and development goals. Its emphasis on a people-centered, multi-hazard approach underscores

the evolving nature of risk in the Anthropocene era and the need for adaptive, inclusive resilience strategies.

United Nations Framework Convention on Climate Change (UNFCCC), 1992

The United Nations Framework Convention on Climate Change (UNFCCC), adopted at the Earth Summit in Rio de Janeiro in 1992, constitutes the foundational international treaty aimed at addressing global climate change. Its primary objective is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (UNFCCC, 1992). The Convention established a universal framework for international cooperation, recognizing the differentiated responsibilities and capabilities of developed and developing countries—a principle known as "common but differentiated responsibilities and respective capabilities" (CBDR-RC).

The UNFCCC laid the groundwork for subsequent climate policy by facilitating the reporting of national greenhouse gas inventories, promoting technology transfer, and encouraging capacity-building, particularly in vulnerable developing countries. Adaptation to climate change was recognized early on as a critical priority, particularly for nations most susceptible to adverse impacts such as small island developing states and least developed countries (UNFCCC, 1992). However, the Convention initially focused more extensively on mitigation efforts, with adaptation gaining prominence in later negotiations.

The UNFCCC's Conference of Parties (COP) meetings have served as the primary platform for advancing global climate negotiations, culminating in landmark agreements including the Kyoto Protocol and, later, the Paris Agreement. Despite its broad acceptance, the Convention has faced challenges related to enforcement mechanisms and balancing development priorities with emission reduction commitments (IPCC, 2022).

Paris Agreement, 2015

Adopted under the auspices of the UNFCCC at COP21 in Paris, the Paris Agreement represents a transformative milestone in global climate governance. Entering into force in 2016, it aims to hold the increase in global average temperature well below 2°C above pre-industrial levels and pursue efforts to limit the increase to 1.5°C, thereby significantly reducing climate risks and impacts (UNFCCC, 2015).

The Agreement introduces a bottom-up approach wherein countries submit nationally determined contributions (NDCs) outlining their mitigation pledges and adaptation efforts, subject to a five-year global stocktake and ratcheting mechanism to increase ambition over time. Adaptation is explicitly prioritized alongside mitigation, with commitments to strengthen adaptive capacity, foster climate resilience, and reduce vulnerability across sectors (UNFCCC, 2015).

Key elements of the Paris Agreement relevant to Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) include:

- Recognition of the importance of managing climate-induced disaster risks through integrated adaptation and mitigation strategies.
- Establishment of a global goal on adaptation focused on enhancing adaptive capacity and resilience (UNFCCC, 2023).
- Provisions for financial support, technology development, and capacity-building targeted at vulnerable countries to facilitate implementation (UNFCCC, 2015).
- Emphasis on transparency and accountability, including enhanced reporting requirements for adaptation actions and means of implementation.

The Paris Agreement explicitly acknowledges the intersection of climate change, disaster risk, and sustainable development, thus encouraging nations to integrate DRR measures within their broader climate adaptation frameworks (Aitsi-Selmi et al., 2016). This integration fosters coherent policy responses that address the increasing frequency and intensity of climate-related hazards.

However, challenges remain in translating the Agreement's ambitious targets into effective action, especially regarding adaptation finance, equitable burden-sharing, and linking local vulnerability reduction with national policy (Kelman, 2021). The Agreement's success depends considerably on sustained political will, international cooperation, and inclusive governance mechanisms.

In conclusion, the UNFCCC established the foundational global framework recognizing climate change as a critical international issue requiring concerted action, while the Paris Agreement builds upon this foundation with a more dynamic, bottom-up, and inclusive approach that elevates adaptation and disaster risk reduction as core components of climate resilience strategies.

2030 Agenda for Sustainable Development and Sustainable Development Goals (SDGs), 2015

The 2030 Agenda for Sustainable Development, adopted by all United Nations member states in 2015, represents a universal and transformative blueprint to achieve a more sustainable and equitable future globally by the year 2030. Central to this agenda are the 17 Sustainable Development Goals (SDGs), a set of integrated and indivisible objectives that address the social, economic, and environmental dimensions of development (United Nations, 2015). This agenda firmly embeds disaster risk reduction (DRR) and climate change adaptation (CCA) as critical components necessary to achieving sustainable development.

Goals and Purpose

The agenda articulates a holistic approach that recognizes the interconnectedness of development challenges. Unlike previous development frameworks such as the Millennium Development Goals (MDGs), the SDGs explicitly highlight resilience-building against natural and human-induced hazards as a prerequisite to sustainable progress.

Several SDGs directly address or indirectly emphasize DRR and CCA:

- Goal 11: Sustainable Cities and Communities — aims to make cities inclusive, safe, resilient, and sustainable, incorporating efforts to reduce disaster risks and protect vulnerable populations in urban settings.
- Goal 13: Climate Action — calls for urgent action to combat climate change and its impacts through mitigation, adaptation, and resilience strategies.

Additional goals such as Goal 1 (No Poverty), Goal 2 (Zero Hunger), Goal 6 (Clean Water and Sanitation), and Goal 15 (Life on Land) also intersect with climate and disaster risk issues, underscoring the multi-sectoral nature of vulnerability and resilience (UNDESA, 2019).

Integration of DRR and CCA in the SDGs

The 2030 Agenda explicitly recognizes that disasters and climate change exacerbate pre-existing vulnerabilities and threaten development gains. Consequently, it advocates for systematic incorporation of risk reduction and adaptation strategies into development planning, policymaking, and implementation at all governance levels (UNDRR, 2017).

Resilience-building is a cross-cutting principle—efforts to strengthen infrastructure, safeguard ecosystems, enhance social protection, and promote sustainable livelihoods are viewed as essential to achieving the SDGs amidst increasing climate risks and disaster frequency. This reflects an understanding that isolated sectoral approaches cannot address the complex, systemic risks faced globally (UNDRR, 2017).

Targets and Indicators Related to DRR and CCA

The SDGs include specific targets and indicators assessing progress on disaster and climate resilience. For example, SDG 11.5 seeks to significantly reduce the number of deaths, people affected, and economic losses due to disasters by 2030. SDG 13.1 focuses on strengthening resilience and adaptive capacity to climate-related hazards and natural disasters in all countries (United Nations, 2015).

Monitoring mechanisms have been established to track progress, relying on data collection, reporting, and evaluation coordinated by the UN Statistical Commission in collaboration with member states and international organizations.

Policy and Implementation Implications

The agenda encourages countries to develop and implement integrated policies that bridge DRR and CCA with development priorities, emphasizing local ownership and participatory governance. Capacity-building, technology transfer, financial mobilization, and knowledge sharing are also promoted as key enablers (UNDESA, 2019).

The inclusive nature of the SDGs demands attention to vulnerable groups often disproportionately affected by disasters and climate change, including women, children, indigenous peoples, and marginalized communities (United Nations, 2015).

Challenges and Gaps

Despite advances in global commitment, the inherent complexity of aligning DRR and CCA within multifaceted development agendas poses challenges. Issues include inadequate financing, fragmented institutional arrangements, data gaps, and limited capacity at sub-national levels (UNDRR, 2019). In addition, the COVID-19 pandemic has underscored vulnerabilities and diverted resources, creating setbacks in achieving resilience targets under the agenda (United Nations, 2020).

Conclusion

The 2030 Agenda for Sustainable Development and the SDGs establish a landmark policy framework embedding disaster risk reduction and climate adaptation as essential pillars of sustainable development. Through integrated targets and multi-sectoral approaches, it offers a cohesive vision that recognizes managing disaster and climate risks is indispensable for safeguarding development gains and promoting resilient societies globally.

Indian National Frameworks for Disaster Risk Reduction and Climate Resilience: Evolution and Development

1. Pre-Disaster Management Era: Response and Relief Focus (Before 2000)

In the decades following India's independence in 1947, disaster management was primarily reactive and sectorally fragmented. Responsibility predominantly lay with the Ministry of Agriculture, which managed agricultural disasters such as droughts, pest outbreaks, and hailstorms. The ministry's response was concentrated on relief efforts and the restoration of agricultural inputs to affected farmers, reflecting a sectoral approach that lacked comprehensive coordination or a national disaster management framework (Himachal Pradesh Agriculture Department, n.d.). Disaster management during this period was characterized by limited institutional mechanisms, focusing largely on the immediate aftermath of disasters rather than risk reduction or preparedness.

The Disaster Management legislative approach of 1967 embodied this reactive stance, centering on relief distribution without addressing the underlying causes of disaster risk. Meanwhile, initiatives like the Indian Disaster Preparedness Programme (IDPP) in the 1980s and 1990s introduced community-level preparedness, marking early efforts toward more proactive engagement; however, these lacked nationwide institutional backing and scale (Chakrabarti, 2000).

Recognizing the limitations of a fragmented, response-centric approach, a significant administrative reform occurred in 2002 when the disaster management division was shifted from the Ministry of Agriculture to the Ministry of Home Affairs (MHA). This transfer marked a critical shift toward a more centralized, coordinated disaster management structure at the national level. It laid the foundation for the institutionalization of disaster risk reduction (DRR) beyond sectoral confines, allowing for comprehensive policies encompassing preparedness, mitigation, and capacity building (Comptroller and Auditor General of India [CAG], n.d.).

From this foundation, India's disaster management framework progressed through various stages toward integration with climate resilience strategies. The development trajectory reflects increasing awareness of the multifaceted nature of risk—encompassing social, economic, environmental, and climatic dimensions—and highlights the country's efforts to align with evolving international best practices.

2. National Policy on Disaster Management (2009)

A landmark in India's DRR policy landscape, the National Policy on Disaster Management (NPDM) was promulgated in 2009 following the enactment of the Disaster Management Act, 2005. The NPDM marked a significant shift from response-oriented practices to a structured approach emphasizing risk reduction through mitigation, preparedness, and capacity development (National Disaster Management Authority [NDMA], 2009).

Key objectives included:

- ✓ Institutionalizing disaster management at national, state, district, and local levels.
- ✓ Integrating disaster risk management into development planning and environmental management.
- ✓ Strengthening early warning systems, risk assessments, and public awareness.
- ✓ Encouraging community participation and involvement of NGOs and private sectors.

The policy specifically recognized the increasing impacts of climate variability and encouraged alignment with climate adaptation measures (NDMA, 2009). However, the implementation faced challenges related to coordination across diverse sectors and states.

3. National Policy on Climate Change and National Action Plan on Climate Change (NAPCC), 2008

Preceding the NPDM, the Government of India launched the NAPCC in 2008 as the country's principal policy instrument for addressing climate change. The NAPCC consists of eight national missions targeting mitigation and adaptation in sectors vulnerable to climate change, such as agriculture, water resources, forestry, and sustainable habitats (Government of India, 2008).

Adaptation-focused missions such as the National Water Mission and the National Mission on Sustainable Agriculture aim to enhance resilience to climate-induced hazards, thereby contributing indirectly to DRR objectives. The NAPCC institutionalized climate concerns within sectoral strategies, representing a parallel but increasingly convergent pathway with disaster management frameworks.

4. National Disaster Management Plan (NDMP), 2016

The NDMP operationalizes the NPDM by outlining detailed strategies for preparedness, mitigation, response, and recovery for various hazards, including those exacerbated by climate change (NDMA, 2016). It emphasizes integrating disaster risk considerations into developmental plans at all levels.

Notable features include:

- ➢ Hazard- and vulnerability-specific risk assessment frameworks using modern technologies such as GIS and remote sensing.
- ➢ Focus on multi-hazard early warning systems.
- ➢ Sector-specific mitigation strategies, including for cyclones, floods, droughts, and earthquakes.
- ➢ Emphasis on community preparedness and inclusion of vulnerable groups.

The NDMP explicitly acknowledges climate hazards as critical drivers of disaster risk, advocating for convergence between DRR and climate adaptation initiatives at state and district levels. However, resource constraints and varying capacities across states affect uniform adoption (NDMA, 2016).

5. State-Level Disaster Management Plans and Climate Adaptation Programs

Following national frameworks, states have developed their disaster management plans aligning with NDMA guidance. Many states with high vulnerability, such as Odisha, Gujarat, and Kerala, have pioneered integrating climate change adaptation into DRR planning, adopting coastal zone management, drought preparedness, and flood control programs tailored to local contexts (Government of Odisha, 2018; Gujarat State Disaster Management Authority, 2020).

These decentralized efforts underscore the necessity of localized risk assessments and capacity-building, which remain critical gaps nationally. States leveraging geospatial technologies for risk monitoring and community-based approaches exemplify evolving best practices in India's DRR and climate resilience trajectory.

6. National Guidelines and Sectoral Integration (Post-2015)

India's DRR and climate resilience frameworks have increasingly emphasized mainstreaming risk reduction within key sectors such as urban development, agriculture, health, and infrastructure post-2015, influenced by global frameworks like the Sendai Framework and the SDGs (UNDRR, 2015).

For instance, the Smart Cities Mission incorporates disaster resilience elements by promoting safe urban planning, resilient infrastructure, and sustainable resource management (Ministry of Housing and Urban Affairs, 2016). Similarly, the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) addresses water resource efficiency with climate adaptation in mind.

Sector-specific guidelines issued by NDMA and allied ministries aim to foster coordinated implementation, enhance early warning dissemination, and promote climate-resilient livelihoods.

7. Future Directions and Challenges

Despite significant progress, challenges remain in institutional coherence, implementation capacity, financing, and integrating indigenous knowledge in DRR and climate resilience. India's varied hazard profiles, socio-economic disparities, and complex governance systems necessitate adaptive, multi-level approaches emphasizing community participation, innovation, and sustained political commitment (Kelman, 2021).

Enhanced data availability, private sector engagement, and leveraging digital technologies (e.g., AI, satellite monitoring) are promising avenues for strengthening disaster and climate risk governance in India's evolving framework landscape.

In short, India's national frameworks for disaster risk reduction and climate resilience have matured from rudimentary, reactionary approaches to comprehensive, multi-sectoral strategies embedded within development and climate policies. The journey reflects an increasingly sophisticated understanding of risk as systemic and interlinked with climate challenges. Continued policy refinement, capacity enhancement, and decentralized implementation will be critical to sustaining resilient and adaptive development pathways in India's diverse hazard environment.

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CHAPTER 4

From Chaos to Foresight: How India Learned & Crafted its Disaster Governance

Rule, Law, and Guidelines in Disaster Management

Disaster management frameworks at the global level operate through a range of regulative instruments that include rules, laws, and guidelines. It is vital to distinguish these because of their differing nature, authority, and application in reducing disaster risk and enhancing preparedness. The United Nations (UN), chiefly via the United Nations Office for Disaster Risk Reduction (UNDRR) and other bodies, provides foundational definitions and frameworks that guide these distinctions (UNDRR, 2023).

Laws

These are formally enacted legal statutes or legislative acts that are binding on all parties within their jurisdiction or scope of influence. According to UN definitions, laws require compliance and establish enforceable rights, duties, and institutional frameworks—for example, the Disaster Management Act at the national level or international treaties like the Tampere Convention (UN General Assembly Resolution 59/2122). They create legal mandates for disaster risk reduction (DRR), preparedness, response, and recovery, outlining roles and responsibilities for states and other actors (UNDRR, 2023; UN General Assembly, 2004).

Rules

Rules in the UN context, refer to specific provisions or regulations issued under or pursuant to laws. They provide detailed procedures, operational protocols, or technical standards necessary for the application and enforcement of laws. Although they share binding characteristics with laws, rules are subordinate and more specific, facilitating uniform implementation across agencies and jurisdictions (UNDRR, 2023; MHA, 2024).

Guidelines

Guidelines are non-binding recommendations or best practices issued by authorities such as the UNDRR or national disaster management authorities. These serve as advisory frameworks that help governments, organizations, and stakeholders to strategically plan and implement disaster risk reduction measures. While voluntary, guidelines are influential in shaping policy and practice and fostering coherence across multiple sectors and scales (UNDRR, 2015; IFRC, 2007).

In the previous chapter, we've seen the measures and frameworks in place to combat disaster risk from global to grassroot levels. Now it is time for us to delve into the legislation in place to reduce disaster risk in the Indian disaster landscape.

As mentioned before, disaster governance took place in 2 evident phases. One post-independence, prior to 2005; and the second phase post 2005 making 2005 a watershed year for the disaster governance scenario. Before this as mentioned in the previous chapter, India had a largely reactive response and no prior preparedness or plans.

The paradigm shift in disaster management legislation in India that occurred around 2002 marked the transition from a primarily responsive, relief-centric approach to a more proactive, holistic framework emphasizing preparedness, mitigation, and institutional coordination. This shift was accelerated by major disasters like the Orissa Super Cyclone in 1999 and the Bhuj Earthquake in 2001, which revealed

significant weaknesses in disaster response and management systems.

Key elements of this paradigm shift include:

- ✓ Moving from post-disaster relief to pre-disaster preparedness and risk reduction.
- ✓ Establishing dedicated institutional structures for disaster management at national, state, and district levels.
- ✓ Recognizing disaster management as a continuous process involving prevention, mitigation, preparedness, response, and recovery.
- ✓ The Disaster Management Division was placed under the Ministry of Home Affairs in 2002, indicating the elevation of disaster management as a central governmental priority.
- ✓ This shift laid the groundwork for the National Disaster Management Act, 2005, which formalized the structural and functional framework for disaster governance in India, including the creation of the National Disaster Management Authority (NDMA) and corresponding state and district authorities.

Thus, 2002 represents the preparatory and structural reorientation phase that ultimately culminated in the comprehensive legal framework established by the Disaster Management Act, 2005, signifying a fundamental transformation in how India manages disasters.

Disaster Management ACT 2005

The Disaster Management Act, 2005, is a landmark legislation in India that provides a comprehensive legal and institutional framework for disaster management across the country. It was enacted on December 23, 2005, to shift disaster management from a reactive, relief-centric approach to a proactive, coordinated, and multi-stakeholder system encompassing prevention, preparedness, response, and recovery (NDMA, 2025).

Objectives and Scope

The Act aims to:

- ❖ Provide effective disaster management for natural and man-made disasters.
- ❖ Establish institutional mechanisms at national, state, and district levels.
- ❖ Promote a holistic approach integrating mitigation, preparedness, response, and rehabilitation.
- ❖ Ensure coordinated actions across various ministries, departments, and agencies (iPleaders, 2022; NDM India, 2025).

The Act applies to the entire territory of India and covers all types of disasters.

Institutional Framework

- **National Disaster Management Authority (NDMA):** The apex body chaired by the Prime Minister responsible for laying down policies, plans, and guidelines. It coordinates disaster management efforts and approves the National Plan (Section 3, 6).
- **State Disaster Management Authorities (SDMAs):** Chaired by the Chief Ministers or Lieutenant Governors that prepare State Disaster Management Plans in alignment with national guidelines (Section 14).
- **District Disaster Management Authorities (DDMAs):** Established at the district level with the District Collector as the

Chairperson, responsible for planning, organizing, and implementing disaster management at the grassroots level (Section 25).

- **National Executive Committee (NEC):** Comprises secretaries from key ministries and assists NDMA in executing its functions (Section 8).

Key Provisions and Functions

- Preparation and implementation of disaster management plans at national, state, and district levels (Section 11, 23, 28).
- Capacity building, training, public awareness, and community participation in disaster preparedness (Section 11).
- Provision for funds and resources to effectively respond to emergencies (Section 46).
- Establishment of the National Disaster Response Force (NDRF) under NDMA with a mandate for specialized response to threatening disaster situations (Section 44).
- Powers to the Central Government to take measures for disaster management and to issue guidelines to authorities (Section 6, 72).
- Penalties for offenses such as false warnings, misappropriation of relief funds, and obstructing disaster management efforts (Section 52-55).

Phases of Disaster Management Under the Act

- **Mitigation:** Measures to reduce disaster risks and their impacts.
- **Preparedness:** Building capacities through training, planning, and awareness.
- **Response:** Immediate actions during and after disaster events.
- **Recovery:** Rehabilitation, reconstruction, and restoring normalcy

Significance in Disaster Governance

The Disaster Management Act of 2005 marked a major turning point in how India deals with disasters. It set up dedicated bodies at national, state, and district levels with clear roles and legal authority to handle all aspects of disaster management. The Act shifted focus from just responding to disasters to actively reducing risks and preparing in advance. It encourages coordination among different government departments and integrates disaster risk reduction into development planning. By empowering authorities with necessary powers, resources, and guidelines, it has created a more organized and effective system for managing disasters throughout the country. This Act truly transformed India’s disaster governance into a proactive and comprehensive framework.

National Policy on Disaster management, 2009

The National Policy on Disaster Management (NPDM), approved on October 22, 2009, sets out a comprehensive framework for disaster management in India. It promotes a holistic, proactive, and technology-driven approach focusing on disaster prevention, mitigation, preparedness, and response. The policy aims to build a safer and more resilient India by fostering a culture of prevention, readiness, and resilience at all levels, through education, innovation, and knowledge-sharing. It emphasizes community involvement, integration of disaster risk reduction into development plans, and ensuring transparency and accountability across all disaster management activities.

Objectives

- Promoting a culture of prevention, preparedness and resilience at all levels through knowledge, innovation and education.
- Encouraging mitigation measures based on technology, traditional wisdom and environmental sustainability.
- Mainstreaming disaster management into the developmental planning process.
- Establishing institutional and techno-legal frameworks to create an enabling regulatory environment and a compliance regime.
- Ensuring efficient mechanism for identification, assessment and monitoring of disaster risks.
- Developing contemporary forecasting and early warning systems backed by responsive and failsafe communication with information technology support.
- Promoting a productive partnership with the media to create awareness and contributing towards capacity development.
- Ensuring efficient response and relief with a caring approach towards the needs of the vulnerable sections of the society.
- Undertaking reconstruction as an opportunity to build disaster resilient structures and habitat for ensuring safer living.
- Promoting productive and proactive partnership with media in disaster management.

Key Areas

The National Policy on Disaster Management (NPDM) covers several key areas to create a safer, disaster-resilient India. These include:

- Prevention and Mitigation: Taking measures to avoid disasters or minimize their impact.
- Preparedness: Planning and actions taken before a disaster happens to ensure readiness.
- Response: Immediate efforts during a disaster, such as evacuation, rescue, and relief.
- Rehabilitation and Reconstruction: Restoring normal life and rebuilding affected areas after a disaster.
- Capacity Development: Training disaster management professionals as well as educating the public.
- Knowledge Management and Research: Gathering, analysing, and sharing disaster-related information.
- Institutional and Legal Framework: Establishing the necessary bodies and laws to support effective disaster management.
- Financial Arrangements: Ensuring proper funding to carry out disaster management activities.

The NPDM closely aligns with the Disaster Management Act of 2005 and aims for a comprehensive, integrated approach addressing all facets of disaster management to build resilience across India. It emphasizes transparency, community involvement, and integration of disaster risk reduction into developmental planning to create a sustainable and inclusive system.

National Disaster Management Plan, 2019

The National Disaster Management Plan (NDMP) 2019 is built around five key pillars that guide India's disaster resilience efforts:

1. **Conformance to National Legal Mandates**: Ensuring alignment with the Disaster Management Act, 2005, and the National Policy on Disaster Management, 2009.

2. **Participation in Global Frameworks:** Actively contributing to international goals like the Sendai Framework for Disaster Risk Reduction, Sustainable Development Goals (SDGs), and the Paris Climate Agreement (COP21).

3. **Prime Minister's Ten Point Agenda:** Addressing contemporary national priorities in disaster risk reduction as outlined by the Prime Minister.

4. **Social Inclusion:** Emphasizing the inclusion of vulnerable groups and promoting equitable disaster risk management.

5. **Mainstreaming Disaster Risk Reduction (DRR):** Integrating DRR into development plans and policies at all levels to build resilience.

OBJECTIVES

The National Disaster Management Plan (NDMP) 2019, in line with mandates from the Disaster Management Act 2005 and the National Policy on Disaster Management 2009, integrates India's commitments to global frameworks and the Prime Minister's Ten Point Agenda for Disaster Risk Reduction (DRR). The broad objectives of the NDMP include:

1. Enhancing understanding of disaster risks, hazards, and vulnerabilities.
2. Strengthening disaster risk governance across all levels—local to central.
3. Investing in disaster risk reduction through structural, non-structural, financial measures, and comprehensive capacity building.
4. Improving disaster preparedness for effective response.
5. Promoting "Build Back Better" principles during recovery, rehabilitation, and reconstruction.
6. Reducing disaster risk and losses in lives, livelihoods, health, and assets across economic, physical, social, cultural, and environmental domains.
7. Increasing resilience, preventing new disaster risks, reducing existing ones, and managing residual risks.
8. Implementing integrated and inclusive measures across economic, legal, social, health, cultural, educational, environmental, technological, political, and institutional sectors to reduce hazard exposure and vulnerabilities.
9. Empowering local authorities and communities as active partners in disaster risk management.
10. Enhancing scientific and technical capabilities in disaster management.
11. Developing capacities at all levels for effective multi-hazard response and community-based disaster management.
12. Clarifying roles and responsibilities of Ministries and Departments engaged in disaster management.

13. Fostering a culture of disaster risk prevention and mitigation across all levels.
14. Mainstreaming disaster management in developmental planning and processes.
15. Ensuring social inclusiveness, gender sensitivity, and empowerment in DRR efforts.
16. Building resilience in vulnerable communities to prevent disaster-induced poverty and protect livelihoods.
17. Mainstreaming DRR and climate adaptation strategies within the agriculture sector, promoting sustainable farming.
18. Providing special focus on DRR for agriculture and livestock.
19. Strengthening health systems to develop community capacities for coping and recovery.
20. Integrating DRR into all levels of healthcare to enhance system resilience.
21. Promoting disaster-resilient educational institutions.
22. Encouraging women's leadership and participation in DRR.
23. Mainstreaming DRR in water resource management to reduce water-related hazards.
24. Strengthening resilience of critical infrastructure, both new and existing.
25. Incorporating DRR considerations into financial and fiscal instruments.
26. Mainstreaming DRR into rural and urban development projects and schemes.
27. Enhancing disaster risk modelling, assessment, mapping, monitoring, and multi-hazard early warning systems.
28. Conducting comprehensive multi-hazard disaster risk surveys and developing regional disaster risk assessments and maps, including climate change scenarios.
29. Implementing ecosystem-based approaches for managing shared resources like river basins, mountains, and coastlines.
30. Promoting effective use of science, technology, and traditional knowledge in all aspects of DRR (National Disaster Management Plan, 2019).

India's Institutional Setup for Disaster Governance

India's institutional setup for disaster governance is structured to ensure a coordinated and comprehensive approach to disaster risk reduction, preparedness, response, and recovery across multiple administrative levels. This setup is legally mandated by the Disaster Management Act, 2005, and operationalized through various bodies at the national, state, and district levels.

Key Institutional Components

1. **National Disaster Management Authority (NDMA)**:

- Established under the Disaster Management Act, 2005, the NDMA is the apex body for disaster management in India.
- Chaired by the Prime Minister, it is responsible for formulating policies, plans, and guidelines for disaster management.
- The NDMA coordinates with ministries, departments, and agencies to ensure effective

implementation of disaster risk reduction (DRR) measures and emergency response plans.
- It also oversees capacity building, public awareness, and early warning dissemination.

2. **National Executive Committee (NEC):**
- Composed of secretaries from key ministries, the NEC assists the NDMA in executing disaster management functions at the national level.
- It plays a critical role in coordinating preparedness and response efforts during disaster situations.

3. **State Disaster Management Authorities (SDMAs):**
- Established in each state, usually chaired by the Chief Minister, the SDMAs are responsible for disaster management planning and coordination within the state.
- They prepare State Disaster Management Plans aligned with the national framework and oversee implementation.

4. **District Disaster Management Authorities (DDMAs):**
- Constituted at the district level with the District Collector or District Magistrate as the chairperson.
- They are responsible for planning and coordinating disaster management at the grassroots level, ensuring state policies are implemented locally.

5. **Crisis Management Group (CMG) and Sectoral Agencies:**
- CMGs are set up for specific disasters or emergencies, like chemical or nuclear accidents, to coordinate specialized response.
- Various sectoral agencies, such as meteorological departments, health, agriculture, and engineering departments, contribute technical expertise and support.

6. **National Disaster Response Force (NDRF) and State Disaster Response Forces (SDRF):**
- The NDRF is a specialized force constituted under the NDMA, trained and equipped for disaster response.
- State governments have their own SDRF units for rapid response.

Governance and Coordination

- Disaster governance in India follows a decentralized model, empowering local authorities and communities.
- Coordination mechanisms exist vertically between national, state, and district levels, and horizontally across sectors and agencies.
- Legal backing through the Disaster Management Act, 2005, mandates clear roles, responsibilities, and accountability in disaster management.
- Emphasis is placed on capacity building, technological

integration, community participation, and mainstreaming disaster risk reduction into development planning.

This institutional architecture enables India to address the multifaceted challenges of disaster risk while fostering resilience through preparedness, response, and recovery efforts at all governance levels.

Issue Specific Laws in India

Apart from the overarching Disaster management Act 2005, India also has hazard specific laws enacted to accommodate and address the unique nature of risks posed by various types of Hazards. These specialized laws and rules provide sector-specific safety, preparedness, and response mechanisms for different kinds of hazards.

Chemical Disasters

1. **Environment (Protection) Act, 1986:** This Act empowers the central government to take necessary measures for protecting and improving the environment. It regulates pollutant discharge, hazardous substance handling, and environmental safety. It serves as an umbrella legislation for environmental protection and pollution control, including chemical safety (Ministry of Environment, Forest and Climate Change, 1986; CPCB, 2025).

2. **Manufacture, Storage and Import of Hazardous Chemical Rules (MSIHC), 1989:** Framed under the Environment Protection Act, these rules regulate the safe manufacture, storage, transport, and import of hazardous chemicals to prevent accidents and protect human health and the environment. They impose strict safety and reporting requirements on industries handling hazardous substances (Ministry of Environment, 1989; Intertek, 2024).

3. **Chemical Accidents (Emergency Planning, Preparedness, and Response) Rules, 1996:** These rules lay down the framework for emergency planning, preparedness, and response to chemical accidents. They mandate risk assessment, emergency plans, and community awareness involving industries, government agencies, and local communities to minimize accident impacts (Ministry of Environment, 1996; Corpseed, 2024).

4. **Factories Act, 1948 (as amended):** A key labour law regulating working conditions, health, and safety of workers in factories. It includes provisions to prevent industrial accidents and hazardous process regulation, mandating safety measures and penalties for violations in factories manufacturing or handling chemicals (Ministry of Labour, 1948; Ipleaders, 2022).

5. **Public Liability Insurance Act, 1991:** This Act ensures immediate relief and compensation to victims of accidents involving hazardous substances irrespective of negligence. It mandates industries to maintain public liability insurance to cover potential damages from accidents caused by hazardous chemicals (Ministry of Law, 1991; Lawbhoomi, 2025)

6. **Explosives Act, 1884:** This Act regulates the manufacture, possession, transport, and sale of explosives. It prescribes licensing, safety standards, and penalties to prevent accidents involving explosive materials, which are often chemicals used in industries (Ministry of Commerce, 1884; DGFASLI, 2024).

These laws cover safe handling, storage, transport, and emergency response for hazardous chemicals and industrial accidents. Dedicated crisis groups are mandated at central and state levels to plan for chemical hazards.

Nuclear and Radiological Emergencies

A. **Atomic Energy Act, 1962:** This act empowers the central government to regulate the development, control, and use of atomic energy for peaceful purposes. It also sets standards for controlling radioactive substances, safe handling, and the disposal of nuclear waste to prevent radiation hazards and ensure public safety. It is central to the licensing and oversight of all nuclear installations in India, mandating emergency preparedness protocols at nuclear facilities (Atomic Energy Act, 1962; iPleaders, 2020).

B. **Civil Liability for Nuclear Damage Act, 2010:** This law makes nuclear plant operators strictly responsible for any nuclear damage, meaning victims do not have to prove fault to get compensation. Operators must have insurance or financial security in place to cover such incidents, up to a set limit. If claims go beyond this limit, the government steps in to ensure victims receive compensation. This framework ensures that people affected by a nuclear incident can access financial relief promptly and effectively, regardless of who was at fault.

C. **Rules under Atomic Energy Regulatory Board (AERB):** The AERB issues rules and safety codes on emergency preparedness, which require facilities to formulate emergency response plans, classify emergencies, conduct periodic drills, and define on-site and off-site emergency actions. These rules provide technical and operational guidelines for nuclear safety and coordination with disaster authorities (AERB, 2023).

These laws regulate nuclear installations, emergency preparedness, and compensation mechanisms in the event of a nuclear or radiological incident.

Biological Disasters

I. **Biological Diversity Act, 2002:** This act looks to facilitate for the conservation and sustainable use of India’s biological diversity and prohibits transfer of biological resources without approval. It governs access, biosecurity, and containment in case of biological hazards, indirectly helping manage risks associated with biological disasters

II. **Epidemic Diseases Act, 1897:** One of India’s oldest health laws, this act grants powers to central and state governments to take special measures, including quarantine, isolation, and regulation of movement, to prevent and control epidemic outbreaks. It was crucial during the COVID-19 pandemic for enforcing lockdowns and containment zones (NMJI, 2024)

III. **Disaster Management Act, 2005 (for pandemic management):** The Disaster Management Act, 2005, provides the legal framework for comprehensive disaster management in India, including pandemic situations. During the COVID-19 pandemic, the Act was invoked to enable the central and state governments to take timely and coordinated actions for containment, preparedness, and response. The Act empowers authorities to enforce lockdowns, seal districts, regulate movement, and implement quarantine measures aimed at minimizing disease spread. It also allows for the creation and utilization of dedicated disaster response funds to support relief efforts. Provisions under sections 51 to 60 specifically address offenses such as disobedience of government orders, false claims, and misuse of relief resources, with penalties including fines and imprisonment. The Act's invocation during the pandemic ensured legal backing for nationwide directives and helped enforce compliance, contributing to India’s management of the crisis (iPleaders, 2020; NDMA, 2023; Hindustan Times, 2022)

IV. **National Disaster Management Authority (NDMA) guidelines:** The National Disaster Management Authority periodically releases guidelines for

management of biological disasters, including biosafety, response protocols, and community engagement strategies (NIDM, 2023).

These provide the legal basis for containment, quarantine, and disease control during biological hazards and pandemics.

Floods, Cyclones, Earthquakes, and Other Natural Hazards

- **Ganga Flood Control Commission (GFCC) and related policies:** The GFCC, established in 1972, is responsible for flood management in the Ganga basin. Its role involves master planning, appraisal of flood management schemes, assessment of waterways, negotiations with neighbouring countries, and monitoring funded projects to reduce flooding impacts (PRS, 2025).

- **Coastal Regulation Zone (CRZ) Notifications under Environment Protection Act:** Introduced in 1991, India's Coastal Regulation Zone (CRZ) notifications set rules for activities up to 500 meters from the high tide line along the country's coasts. These regulations divide coastal areas into four main categories (CRZ-I to CRZ-IV), each with specific restrictions or allowances for development. The aim is to safeguard ecologically sensitive zones, prevent coastal erosion, and lower risks from cyclones and other coastal hazards—making the CRZ framework essential for environmental protection and disaster management in vulnerable coastal regions.

While there is no single natural hazard-specific law, several executive orders, regulatory frameworks, and guidelines exist for these hazards at both central and state levels.

These hazard-specific laws and rules complement the Disaster Management Act, 2005, creating a layered legal framework addressing the diverse risk landscape in India.

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CHAPTER 5

Eyes in the Sky, Brains on the Ground: Geo-Tech vs Disasters

What is remote sensing?

Remote sensing is the science and technology of acquiring information about the Earth's surface or other objects without being in direct contact with them. It involves using sensors, typically mounted on satellites or aircraft, to detect and measure electromagnetic radiation that is either reflected or emitted by the objects of interest. This data collection happens remotely, from a distance, by capturing energy in various regions of the electromagnetic spectrum such as visible light, infrared, or radar signals.

The remote sensing process generally includes several key elements: a source of energy (like the sun) illuminates the target; the electromagnetic radiation interacts with the atmosphere and the target; sensors record the reflected or emitted energy; this data is transmitted and processed into images; and finally, analysis of these images yields valuable information about the target. Remote sensing can capture data over large areas quickly, making it suitable for monitoring environmental changes, natural disasters, land use, and more. It is also closely integrated with Geographic Information Systems (GIS) for detailed spatial analysis and decision-making.

Remote sensing is critically important in disaster management due to its ability to provide timely, accurate, and spatially extensive data that supports all stages of disaster management. Below are the key benefits of remote sensing in disaster management,

Rapid Data Collection: Remote sensing enables quick acquisition of large-scale data over affected regions, which is essential for timely disaster assessment and response (Singh et al., 2025).

Real-time Monitoring: It supports near real-time monitoring of natural hazards such as floods, wildfires, hurricanes, and landslides, allowing early warning and immediate action (Patel & Kumar, 2024).

Pre-Disaster Risk Mapping: Remote sensing data helps identify vulnerable areas and generate hazard maps that guide disaster preparedness and mitigation strategies (Sharma & Verma, 2023).

Damage Assessment: Post-disaster, remote sensing provides an efficient means to assess the extent and severity of damage, facilitating resource allocation and recovery planning (Reddy et al., 2025).

Spatial Coverage: Unlike ground surveys, remote sensing covers inaccessible or large areas uniformly, which is vital during emergencies when ground access may be limited (Kumar & Singh, 2024).

Multi-Spectral Analysis: The ability to capture data across various spectral bands allows detection of features invisible to the human eye, such as thermal anomalies or vegetation stress, indicating disaster impacts (Gupta & Joshi, 2023).

***Integration with GIS*:** Remote sensing data integrates well with Geographic Information Systems (GIS) to analyse spatial relationships and support decision-making in disaster contexts (Desai & Mehta, 2025).

Cost-Effectiveness: Remote sensing reduces the need for extensive fieldwork and manual surveys, saving time and resources while improving overall disaster management efficiency (Patel & Kumar, 2024).

Long-Term Monitoring: It facilitates monitoring of slow-onset disasters like drought, desertification, or salinity intrusion over time, supporting sustainable management efforts (Sharma & Verma, 2023).

Supports Early Warning Systems: By continuously monitoring environmental parameters, remote sensing strengthens early warning system capabilities to alert communities before disasters strike (Singh et al., 2025).

These advantages demonstrate why remote sensing is indispensable in modern disaster management frameworks, providing crucial data to protect lives, property, and the environment effectively.

What is GIS?

Geographic Information System (GIS) is a computer-based tool that captures, stores, analyses, manages, and visualizes spatial or geographic data. It allows users to create layered maps and spatial models that represent the physical world and related phenomena, facilitating spatial analysis and decision-making across diverse fields.

What it does

What capabilities of GIS makes it necessary and almost indispensable to the field of disaster management at the various stages of the disaster management cycle.

Spatial Data Integration: GIS integrates various data sources (satellite imagery, surveys, sensor data) into comprehensive spatial databases, enabling a holistic understanding of disaster scenarios (Desai & Mehta, 2025).

Hazard and Risk Mapping: It helps produce detailed maps identifying hazard-prone zones, vulnerable populations, and critical infrastructure, guiding preparedness and mitigation efforts (Patel & Kumar, 2024).

Real-Time Situational Awareness: During disasters, GIS provides dynamic updates affected areas, resource locations, and response activities, supporting coordinated emergency management (Kumar & Singh, 2024).

Resource Management and Allocation: By analysing spatial data, GIS aids in efficient allocation of rescue teams, medical aid, and relief materials to high-need areas (Sharma & Verma, 2023).

Scenario Modelling and Simulation: GIS supports simulation of disaster impacts and response strategies, helping planners evaluate potential outcomes and optimize contingency plans (Gupta & Joshi, 2023).

Damage Assessment and Recovery Planning: Post-disaster, GIS techniques enable detailed damage evaluation and monitoring of recovery progress over time (Reddy et al., 2025).

Public Communication and Awareness: Visual map products from GIS enhance communication with the public and decision-makers, facilitating awareness and informed choices before, during, and after disasters (Singh et al., 2025).

Integration with Remote Sensing: GIS complements remote sensing by analysing and visualizing satellite or aerial data for enhanced disaster risk management (Desai & Mehta, 2025).

Supports Sustainable Development Goals (SDGs): GIS aids in aligning disaster management with SDGs by ensuring resilient infrastructure and sustainable urban planning (Patel & Kumar, 2024).

Cost-Effectiveness and Efficiency: GIS reduces the time and resources needed for data analysis and decision-

making compared to manual methods, improving disaster management efficiency (Kumar & Singh, 2024).

These advantages make GIS an indispensable technology in modern disaster management, empowering stakeholders to make informed decisions that save lives and reduce economic losses.

Three contemporary geomatics technologies—Remote Sensing (RS), Geographical Information Systems/Science (GIS), and Global Navigation Satellite Systems (GNSS)—have significantly enhanced hazard reduction. RS is particularly effective in gathering geometric and physical information across larger areas. GNSS is employed for precise monitoring of deformations at various scales, from global to regional and engineering structures, in real-time or post-processing modes. GIS serves as a robust tool for managing large volumes of spatial data in both vector and raster formats, offering numerous spatial analysis functionalities and the ability to display data in diverse ways. GIS and RS have been foundational platforms for the development of several disaster management systems.

GIS and data gathering:

Data integration is one of the strongest points of GIS. The following data are required for efficient mapping, prediction and damage assessment of several disasters.

· Data on the disastrous phenomena, their location, frequency, magnitude etc.

· Data on the environment in which the disaster might take place: Topography, geology, geomorphology, soils, hydrology, land use, vegetation etc.

· Data on the elements that might be destroyed if the event takes place: infrastructure, settlements, population, socio-economic data

Role of Geo-informatics in disaster management with regard to specific scenarios:

Floods

· **Flood Mapping and Modelling**: GIS Helps in creating accurate floodplain maps by integrating various spatial data such as elevation, land use, and hydrological data. Flood models can be developed to simulate different flood scenarios. RS: Provides high-resolution imagery that aids in mapping and monitoring flood-affected areas.

· **Early warning system:** GIS integrates real-time data from sources like weather stations and river gauges for early warning systems, analysing and triggering alerts based on predefined thresholds. RS monitors weather patterns and provides real-time imagery for assessing flood conditions, with infrared and microwave sensors detecting changes in water levels.

· **Risk Assessment and Vulnerability Analysis:** GIS Helps in assessing the vulnerability of different regions to floods by analysing factors like topography, land use, population density, and infrastructure. RS: Provides data for identifying changes in land cover and land use, helping to assess how human activities may contribute to or mitigate flood risks.

· **Disaster Response and Recovery:** GIS Assists in coordinating emergency response efforts by providing real-time maps of affected areas, evacuation routes, and the location of emergency shelters and resource allocation.

· **Infrastructure Planning and Management:** GIS Supports planning and design of flood control infrastructure, such as levees, dams, and stormwater management systems. It helps in optimizing the location and design of these structures. RS: Monitors

the condition of infrastructure over time and identifies areas prone to erosion or structural damage.

Earthquake

· **Hazard Mapping and Risk Assessment:** GIS is used to create hazard maps that depict seismic risk based on factors such as fault lines, historical earthquake data, and geological features. Satellite imagery can help identify land-use patterns, population density, and infrastructure, aiding in the assessment of potential vulnerabilities.

· **Fault line mapping:** GIS is employed to map and analyse fault lines, which are critical in understanding earthquake-prone areas. Aerial imagery and satellite data can be used to identify surface rupture patterns and changes in landscape associated with fault movement.

· **Earthquake monitoring:** GIS integrates real-time seismic data to create maps that visualize earthquake activity. Satellite-based interferometric synthetic aperture radar (InSAR), can detect ground deformations caused by seismic events.

· **Emergency response and management:** GIS integrates real-time seismic data to create maps that visualize earthquake activity.

· **Damage Assessment:** GIS is used to collect and analyse data on the extent of earthquake damage, aiding in the prioritization of recovery efforts. High-resolution satellite imagery is valuable for assessing infrastructure damage and changes in the landscape.

· **Land-Use Planning and Zoning:** GIS is applied to develop land-use plans and zoning regulations that take seismic risks into account, helping to reduce vulnerability. Remote sensing data contributes to the assessment of urban growth and changes in land cover that may impact earthquake resilience.

· **Early Warning Systems:** GIS is integrated into early warning systems to provide spatial information on the location and magnitude of earthquakes. Remote sensing technologies contribute to the rapid assessment of ground movements, supporting timely alerts and response.

· **Post-Earthquake Recovery and Reconstruction:** GIS facilitates the planning and coordination of post-earthquake recovery efforts by providing spatial information on damaged infrastructure, population displacement, and resource allocation. Remote sensing aids in monitoring the progress of reconstruction activities and assessing the effectiveness of implemented measures.

Cyclone

· **Risk Assessment and Vulnerability Mapping:** GIS can be used to analyse spatial data related to population density, infrastructure, and environmental factors to identify vulnerable areas. Remote sensing helps in collecting high-resolution imagery to assess land cover changes, urban development, and other factors that contribute to vulnerability.

· **Early Warning Systems:** Remote sensing satellites provide real-time monitoring of weather patterns and can track the development and movement of cyclones. GIS is used to integrate meteorological data, topography, and other relevant information to create early warning models and maps.

· **Evacuation Planning:** GIS helps in identifying safe evacuation routes and locations for emergency shelters. Remote sensing data can assist in monitoring the progress of evacuation efforts and assessing the effectiveness of evacuation plans.

· **Damage Assessment:** After a cyclone, GIS is used for rapid damage assessment by overlaying pre- and post-

cyclone satellite imagery to identify affected areas. Remote sensing data, including high-resolution imagery, can provide detailed information on the extent of damage to infrastructure, agriculture, and other assets.

· **Resource Allocation and Management:** GIS is utilized for optimal allocation of resources during cyclone response efforts. This includes managing the distribution of relief supplies, deployment of personnel, and coordination of rescue operations. Remote sensing helps in monitoring the availability of resources and assessing the impact of the cyclone on critical infrastructure.

· **Environmental Impact Assessment:** GIS and remote sensing aid in evaluating the environmental impact of cyclones on ecosystems, water bodies, and coastal areas. Long-term monitoring using remote sensing can help in assessing the recovery and resilience of natural habitats.

· **Community Awareness and Education:** GIS can be employed to create maps and visualizations that help communities understand their vulnerability to cyclones. Remote sensing data can be used to generate educational materials, such as satellite imagery showing the evolution of cyclones, to raise awareness among the public.

Landslides & Avalanches

· **Risk Assessment and Mapping:** GIS integrates spatial datasets like topography, land cover, soil types, and historical landslide occurrences to assess landslide susceptibility. Satellite imagery and aerial photography offer valuable information on land cover changes, slope movements, and other indicators of landslide risk.

· **Early Warning Systems:** GIS is employed to develop early warning systems by integrating real-time monitoring data, such as rainfall, ground movement, and soil moisture, with existing spatial information. This allows for the timely prediction and notification of potential landslide events.

· **Monitoring and Surveillance:** Satellite and unmanned aerial vehicle (UAV) imagery provide a means for continuous monitoring of landslide-prone areas. This facilitates the detection of subtle changes in the landscape that may precede a landslide.

· **Post-Event Assessment:** After a landslide event, GIS is used to assess the extent of damage, identify areas of concern, and plan for reconstruction and rehabilitation efforts.

· **Climate Change Impact Assessment:** GIS and RS are employed to assess the impact of climate change on landslide susceptibility. Changes in precipitation patterns, temperature, and extreme weather events can influence the frequency and intensity of landslides.

Biological Disasters

Map-based information is crucial, and COVID-19 is an excellent illustration of this. The COVID-19 global pandemic is aided by GIS technology in the healthcare sector. Using an IGIS-based COVID-19 response and monitoring solution, the struggle will be waged by mapping out the data that is already accessible, such as the number of COVID positive patients, hospital infrastructure, quarantine centres, and hotspots. Additionally, the effective distribution of vaccinations will be largely dependent on the GIS Real-Time Spatial Mapping and Analysis skills.

AI, ML and Integration to GIS

Artificial Intelligence

Introduction to Artificial Intelligence

Artificial Intelligence (AI) is a field within computer science that focuses on

creating machines and computer systems capable of performing tasks that usually require human intelligence. These tasks include learning, reasoning, problem-solving, understanding natural language, and perceiving the environment. AI systems are designed to simulate human cognitive functions and adapt to new data, allowing them to operate autonomously or with minimal human intervention (IBM, 2024; Impacteers, 2025).

Types of Artificial Intelligence

AI is broadly categorized into two types:

- Artificial Narrow Intelligence (ANI): AI systems designed to perform specific tasks effectively, such as voice assistants (e.g., Siri, Alexa) or recommendation engines used by streaming services. These systems work within a limited scope and cannot perform beyond their specific programming.
- Artificial General Intelligence (AGI): A more advanced, theoretical form of AI capable of understanding, learning, and applying knowledge across a broad range of tasks with human-like intelligence (Datacamp, 2025; IBM, 2024).

Core Technologies Behind AI

Two key technological approaches underpin AI:

- Machine Learning (ML): ML enables systems to learn from large datasets and improve their performance over time without being explicitly programmed for every task.
- Deep Learning: A subset of machine learning that uses artificial neural networks designed to mimic the human brain's functioning to analyse complex data and recognize patterns (Impacteers, 2025; IBM, 2024).

AI Applications in Disaster Management

AI has significant potential to transform disaster management by enhancing data analysis, early warning, decision-making, and response strategies. Its ability to process large volumes of diverse and complex datasets—such as weather data, satellite imagery, and social media signals—helps in predicting hazards, assessing risks, and optimizing emergency response operations.

For example, AI algorithms can detect patterns indicating impending natural disasters like floods or cyclones, improve hazard vulnerability mapping through integration with geographic information systems (GIS), and support logistics in disaster relief efforts. These capabilities contribute to faster, more accurate, and proactive disaster risk reduction and management (PMC, 2025; Thesai, 2025).

Summary

Artificial Intelligence enables machines to replicate human intelligence through learning and adaptive processes. Its growing role in disaster management offers transformative benefits in forecasting, risk assessment, and emergency response effectiveness. Understanding basic AI concepts and their application in this field is essential for students preparing to manage the complex challenges of modern disasters.

Machine learning

Introduction to Machine Learning

Machine Learning (ML) is a specialized field within artificial intelligence focused on developing computer systems that can learn from data and improve their performance over time without being explicitly programmed for each task. Instead of following pre-set instructions, ML algorithms recognize patterns and relationships in large datasets to make predictions or decisions (IBM, 2025; DataCamp, 2024).

Types of Machine Learning

There are three main types of machine learning:

- Supervised Learning: This approach uses labelled data to train models. The algorithm learns to predict outcomes based on input-output pairs. For example, predicting flood risks based on historical meteorological data involves supervised learning.
- Unsupervised Learning: The model analyses unlabelled data to find underlying patterns or clusters. This is useful in hazard mapping where risk zones are identified through feature similarities without predefined labels.
- Reinforcement Learning: Here, the algorithm learns optimal actions through trial and error by receiving feedback from the environment in the form of rewards or penalties. This method is applied in optimizing disaster response logistics (DataCamp, 2024; Interaction-Design.org, 2025).

Machine Learning Applications in Disaster Management

In disaster management, ML techniques are invaluable due to their ability to handle vast and complex datasets such as satellite images, sensor readings, and historical disaster records. Machine learning aids in early warning systems, hazard prediction, damage assessment, and enhancing emergency preparedness and response strategies.

For example, ML algorithms can analyse weather data to predict floods, classify satellite imagery to assess damage post-disaster, or optimize evacuation routes based on real-time conditions. These capabilities improve disaster resilience and reduce response times (PMC, 2025; IJMSRT, 2025).

Integration of Artificial Intelligence and Geographic Information Systems (GIS)

Artificial Intelligence (AI) and Geographic Information Systems (GIS) integration is transforming the landscape of disaster management by enhancing the analysis, prediction, and response capabilities using spatial data. This synergy leverages AI's ability to analyse vast, complex datasets and GIS's spatial visualization and mapping power to support more effective disaster risk reduction, preparedness, and recovery efforts (PMC, 2025; Thesai, 2025).

How AI Enhances GIS Capabilities

AI technologies, especially machine learning and deep learning, automate and improve GIS data processing, pattern recognition, and predictive modelling. These enhanced GIS systems can rapidly analyse satellite imagery, sensor data, social media feeds, and historical disaster records to detect early warning signs, assess vulnerabilities, and map risks with higher accuracy and speed than traditional methods (Cambridge, 2023; Esri, 2025).

For example, AI-driven GIS can:

- Automate detection of changes in land use or damages to infrastructure post-disaster.
- Support real-time disaster monitoring and early warning systems by identifying anomalies in environmental data.
- Optimize resource allocation and emergency response routes through predictive analytics and spatial modelling (Tandfonline, 2025; PMC, 2025).

Applications in Disaster Management

The integration helps address diverse challenges in disasters by providing actionable spatial intelligence. AI-powered GIS supports:

- Risk assessment: High-resolution hazard mapping and vulnerability analysis.
- Early warning: Predicting extreme weather events like floods and cyclones using AI algorithms coupled with GIS spatial data.
- Response and recovery: Efficient damage assessment and coordination of relief efforts using real-time geospatial information (Thesai, 2025; PMC, 2025).

Challenges and Future Directions

While AI-GIS integration offers transformative benefits, challenges include ensuring data quality, dealing with ethical considerations in AI decision-making, and overcoming computational demands. Collaborative development involving domain experts is crucial for responsible and effective use.

Looking ahead, advances such as AI conversational assistants for GIS, digital twins simulating disaster scenarios, and edge computing for real-time spatial data processing are poised to further revolutionize disaster management practices (VC4, 2025; Cambridge, 2023).

Artificial Intelligence (AI) integrated with Geographic Information Systems (GIS) and Remote Sensing (RS) technologies provides substantial improvements across all stages of the disaster management cycle—mitigation, preparedness, response, and recovery. These advanced tools allow real-time analysis, improved prediction accuracy, and better decision-making, crucial for minimizing disaster impacts. The following sections break down the advantages supported by recent studies

Mitigation

Mitigation focuses on reducing disaster risks and impacts before a hazard occurs. AI-enhanced GIS and RS support mitigation by:

- Enabling detailed and continuous risk and vulnerability mapping through analysis of satellite images and spatial data layers, facilitating identification of high-risk zones (PMC, 2025; Thesai, 2025).
- Automating detection of land use changes, deforestation, and environmental degradation using AI algorithms, which help reduce hazard susceptibility (Cambridge, 2023).
- Supporting scenario simulations and digital twins modelling to assess potential disaster impacts and inform resilient infrastructure planning (Esri, 2025).

Preparedness

In the preparedness stage, the goal is to develop capacity and readiness for disasters. AI-GIS-RS integration aids by:

- Enhancing early warning systems through AI-powered analysis of real-time sensor, weather, and remote sensing data to predict events like floods, storms, and landslides with increased accuracy and lead time (PMC, 2025).
- Improving evacuation planning and drills by modelling population movement, transportation networks, and hazard spread dynamically on GIS platforms (Tandfonline, 2025).
- Streamlining resource allocation and inventory management with AI-assisted spatial optimization techniques, ensuring readiness of relief materials (VC4, 2025).

Response

During disaster response, timely and informed decisions are vital. AI with GIS and RS enhances response efforts by:

- Rapidly analysing satellite imagery and drone data using AI

to assess damage, identify blocked routes, and locate stranded populations, thus prioritizing rescue operations efficiently (Thesai, 2025; IJMSRT, 2025).

- Integrating multi-source data like social media feeds, weather updates, and satellite images in GIS platforms to provide emergency managers with a comprehensive situational awareness dashboard (PMC, 2025).
- Facilitating communication and coordination among agencies via AI-driven platforms that optimize logistics and deployment in real-time (Esri, 2025).

Recovery

The recovery phase involves restoring communities and infrastructure to normal conditions. AI-GIS-RS support recovery by:

- Monitoring rebuilding progress and environmental restoration through periodic remote sensing data analysis, tracked and assessed by AI for accuracy (Cambridge, 2023).
- Assessing long-term impacts on ecosystems, water resources, and urban areas via AI-enhanced GIS models to guide sustainable recovery planning (PMC, 2025).
- Identifying lessons learned and improving future disaster resilience by analysing spatial-temporal disaster data comprehensively with AI tools (Thesai, 2025).

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Unit 2

Title: Disaster Intervention Practices

Dr. C. Lakhmanan

Chapter 6

1. PRINCIPLES OF COMMUNITY-BASED DISASTER RISK REDUCTION (CBDRR)

Principles of CBDRR are ideals that serve as the foundation of all actions included in a CBDRR intervention. The actions at the local level, irrespective of the location, vulnerability, level and type of hazards, must be included as part of CBDRR. The key principles of CBDRR may be listed as follows:

i. Community participation
ii. Social Equity
iii. Mainstreaming into other developmental activities
iv. Sustainability
v. Partnerships
vi. Respect for the local knowledge and traditional coping mechanisms

i. Community participation

The nature of disaster risk reduction (DRR) activities may vary across the hazards. It may also vary over a period of time contingent upon economic, social and infrastructural developments in the locality. It is necessary to encourage participation of all in the community in all activities of disaster risk reduction. People's participation is essential in bringing in the necessary cultural changes for conducting different components of disaster management. The community members must be engaged in DRR programmes at every step, from identification of risks to articulating appropriate strategies and solutions for reducing them by addressing the principal causes of vulnerability. Community ownership also fosters effective and meaningful participation of various groups within the community in the design of interventions and management and implementation of the same. Community knowledge has been proved to be vital to CBDRR interventions, especially in relation to traditional early warning signs, locations of safe and vulnerable areas, experiences of past disasters, traditional coping mechanisms and social relations. There must be transparency for community ownerships to be effective in the management of CBDRR activities. Transparency ensures that local level power dynamics are balanced and all groups within the community are able to effectively participate in the programme design and implementation. The effective participation of community in disaster management is central to the success of processes such as needs assessments, selection of

beneficiaries, decision to choose relief items, procurement procedures, delivery of items, and reviewing progress of a particular intervention as well as its monitoring. Government developmental programmes usually facilitate community engagement, which can be built upon for a CBDRR intervention.

ii. Social Equity

Social equity in CBDRR interventions is a legal requirement as well as a moral imperative. Literature is replete with evidence on disaster vulnerability of traditionally marginalized groups such as the economically weaker sections, elderly, women and children, and the differently-abled. These groups need to be meaningfully included in CBDRR interventions for effective design and implementation, which must ensure their social inclusion and realization of optimum human potential.

iii. Mainstreaming into other developmental activities

Mainstreaming DRR within development continues to be slow and challenging. CBDRR prepares communities to use mainstream Government development programmes and schemes to address their DRR and CCA priorities. It needs to be strategically ensured that all the ongoing development efforts are planned with a DRR perspective; this would ensure that development investments are sustained and lead to long-term vulnerability reduction, both now and in future.

iv. Sustainability

CBDRR is inherently futuristic in nature and therefore socio-economic and environmental sustainability must be inherently engrained in these interventions so that new risks are not born out of present interventions. Ecological, social and economic implications of interventions must be assessed and weighed from a community perspective before they are implemented. Community education must be skill based, with practical approaches on disaster management for the community to access it and imbibe the learning in their lives.

v. Partnerships

The changing nature of risk and the community's lack of awareness of it necessitates a strong partnership between the community and the local government. Working in partnership with communities at risk leads to the local capacity and coping mechanisms to respond. Increasing awareness of risks within communities inspires more people to get involved to prevent the loss of their own livelihoods. The rationale for multi-stakeholder partnerships in

DRR is clear and compelling given the complex nature of disaster risks demanding partnerships from stakeholders belonging to different disciplinary and institutional groups.

vi. Respect for the local knowledge and traditional coping mechanisms

CBDRR processes capitalize on existing capacities and traditional coping mechanisms rooted in cultural practices of the community, including traditional wisdom, local knowledge and resources, shared values and coping mechanisms. When threatened by a hazard, indigenous communities often respond by making use of all the traditional knowledge and local practices, which have evolved over generations and will continue to adapt to future changes. These are critical building blocks for systemic solutions to local hazards and must be included in response preparedness actions at the community level (IOM, Papua New Guinea, 2015). The fundamental principle of CBDRR involves a bottom-up approach, involving processes arising from the communities themselves. Development is based on community needs and its aspirations for safety, and appropriate actions to address these issues. The principles of CBDRR will only be effective when the various institutions involved in the CBDRR process uphold the same. These principles are reflected in the institutional framework, processes and practices adopted for enhancing CBDRR. The following chapter outlines the policy framework and the respective roles of various institutions at the government and the community level therein to uphold these principles.

2. HAZARD-WISE COMMUNITY-BASED DISASTER RISK REDUCTION GUIDELINES

Community-Based Disaster Risk Reduction (CBDRR) guidelines are essential for building resilience and minimizing the impacts of both natural and man-made disasters. CBDRR empowers local communities to identify risks and take proactive measures, ensuring that responses are timely and appropriate to their specific context. Key action points across the four phases of disaster management include ‘preparedness’, which involves awareness campaigns, mock drills, and the creation of emergency action plans; ‘response’, where trained local responders can ensure prompt evacuations, provide first aid, and secure essential resources; and ‘recovery’, which focuses on rebuilding livelihoods, restoring services, and ‘mitigation’, where communities can engage in risk assessment and implement hazard-resistant infrastructure incorporating lessons learned into future mitigation efforts. By involving communities at every stage, CBDRR promotes ownership and sustainability of disaster management efforts, ultimately saving lives and resources.

These guidelines have been framed for some common hazards. There may be other local hazards for which the guidelines can be applied through appropriate changes.

2.1. Flood

Flood risk management is critical for protecting communities in India from the impacts of floods, which are common due to the country's diverse climate and geography. Effective management involves preparedness, response, recovery, reconstruction, and mitigation. These guidelines aim to empower communities to take an active role in managing flood risks, ensuring resilience, and minimizing losses.

2.1.1. Preparedness

Risk Assessment and Mapping: Flood risk assessments and mapping are crucial for identifying vulnerable areas and populations. This process involves using past data and records related to floods to create detailed maps that show the areas more prone to flooding and guide planning and response efforts.

Public Awareness Campaigns: Public awareness campaigns and community meetings are essential to educate residents about flood hazards and safety measures. These initiatives should include distributing informational materials, organizing workshops and meetings, and using local media to reach diverse segments of the community, ensuring that everyone understands how to respond during a flood.

Evacuation Plans and Drills: Community involvement in the development and practice of evacuation plans, including routes and shelters, is a key factor in ensuring readiness. Regular drills should be conducted to familiarize residents with evacuation procedures, with special attention given to accommodating the needs of vulnerable groups, such as the elderly and people with disabilities.

Early Warning Systems: Establishing early warning systems is crucial for providing timely alerts and allowing communities to evacuate safely and efficiently. These systems should integrate modern technology, like mobile alerts and community loudspeakers, to ensure that warnings reach even the most remote areas promptly.

Training of Emergency Responders: Training community volunteers and emergency responders in flood safety is not just about learning, it's about empowerment. This training can enhance local capacity to manage disaster events effectively. It should cover basic rescue techniques, first aid, and the use of emergency equipment, empowering volunteers to act swiftly and confidently in crisis situations.

Pre-positioning of Emergency Supplies: Pre-positioning of emergency supplies in strategic locations ensures ready availability of essential resources during floods. Supplies like food, water, medical kits, and blankets should be stored in easily accessible areas, such as flood centres and community centres, to facilitate quick distribution when needed.

2.1.2. Response

Activating Disaster Response Plans: When floods occur, promptly activating disaster response plans is essential to protect lives and property. This involves immediately mobilizing resources and personnel, including Home Guards, Civil Defence, and Aapda Mitras, to implement response measures and ensure the safety of affected individuals.

Coordinated Efforts: Coordinated efforts among local authorities, NGOs, and community organizations are necessary to ensure a unified and effective response. These entities must work together seamlessly, sharing information and resources to maximize efficiency and cover all affected areas, particularly remote and hard-to-reach locations.

Providing Essential Services: Providing essential services such as food, water, shelter, and medical care to affected communities is a priority. Relief camps should be set up quickly, stocked with necessities, and staffed by trained personnel to address immediate needs and prevent further hardship.

Establishing Temporary Sanitation and Hygiene Facilities: Temporary sanitation and hygiene facilities must be established to prevent disease outbreaks. These facilities should include clean water access, latrines, and waste disposal systems, reducing the risk of waterborne diseases in flood-affected areas.

Providing Psychological Support and First Aid: Psychological support should be provided to help affected individuals cope with trauma and stress. Counselling services and support groups can be organized within relief camps to offer emotional assistance and promote mental wellbeing among survivors.

Effective Communication and Coordination: Effective communication and coordination among all stakeholders, including the establishment of a centralized communication centre, are critical for managing the response. This center should serve as the hub for disseminating information, coordinating relief efforts, and facilitating communication between government agencies, NGOs, and the affected community, ensuring that everyone receives accurate and timely updates.

2.1.3. Recovery and Reconstruction

Conducting Damage and Need Assessment: After the floodwaters recede, conducting thorough damage and needs assessments is crucial for prioritizing recovery efforts. This

involves detailed surveys to identify the extent of damage to infrastructure, houses, and livelihoods, ensuring that recovery plans address the most urgent needs first.

Rebuilding Infrastructure: Rebuilding infrastructure, such as roads, bridges, schools, and healthcare facilities, should incorporate flood-resistant designs to enhance resilience. This includes using materials and construction techniques that withstand future flooding, helping to minimize damage and disruption in subsequent events.

Involving Local Community in Recovery Planning: Community involvement in recovery planning ensures that local needs and preferences are met, promoting community-led initiatives for reconstruction. By engaging local residents in decision-making processes, authorities can develop recovery projects to meet the community needs, generating a sense of ownership and empowerment.

Mobilisation of Financial Resources: Mobilizing financial resources from government agencies, NGOs, and international donors is essential to support recovery efforts. Effective coordination and transparent management of these funds are critical to ensuring that resources are allocated efficiently and equitably across affected areas.

Providing Technical Assistance: Providing technical assistance to local builders and artisans in flood-resistant construction techniques can enhance the quality and sustainability of rebuilding efforts. Training programs should be organized to equip local workers with the skills needed to implement innovative building practices, thereby improving communities' resilience to future floods.

2.1.4. Mitigation

Flood Protection Structures: Implementing structural measures such as protection structures can significantly reduce flood risks. These structures help manage water flow and protect vulnerable areas from flooding, and their construction should be guided by careful planning to ensure they are effective and sustainable.

Supporting Eco-system Restoration: Restoring ecosystems, such as wetlands and floodplains, plays a vital role in natural flood mitigation. These natural landscapes act as buffers by absorbing excess water during floods, reducing the impact on nearby communities and enhancing biodiversity and ecological health.

Flood Plain Zoning: Enforcing floodplain zoning regulations is essential to prevent construction in high-risk flood areas. Strict adherence to these regulations helps minimize potential damage by ensuring that new developments are built in safer locations and with designs that can withstand flooding.

Integration of Risk into Planning: Integrating flood risk considerations into local development plans and policies can help communities plan for the future. By incorporating flood risk assessments into urban planning and land-use decisions, communities can reduce vulnerability and promote sustainable growth.

Promoting use of Flood-Resistant Technology and Material: Promoting sustainable practices, such as using flood-resistant construction materials and designs, can enhance resilience. Encouraging the adoption of these practices among builders and homeowners can significantly reduce the damage caused by future floods and support long-term community resilience.

Continuous Community Education: Continuous community education about flood risks and mitigation strategies engenders a culture of preparedness and resilience. Regular workshops, training sessions, and informational campaigns can help keep communities informed about the latest strategies for flood risk reduction and empower them to take proactive measures.

By following these guidelines, communities in India can strengthen their resilience to floods and reduce the impacts of such disasters. Active community involvement, supported by effective planning and resource allocation, is key to successful flood risk management.

2.2. Cyclone

Community-based Disaster Risk Reduction (CBDRR) is essential for effective cyclone disaster management, as it empowers communities to proactively prepare for, respond to, and recover from cyclones. By involving households and communities in risk identification, the development of early warning systems, and the implementation of evacuation plans, CBDRR significantly reduces the potential for damage and loss of life. Moreover, CBDRR encourages community-driven initiatives related to preparedness and mitigation which are vital in mitigating the impacts of cyclones. By placing communities at the forefront of their own risk reduction strategies, CBDRR not only builds resilience and self-reliance but also ensures long-term sustainability, ultimately safeguarding lives and livelihoods. Additionally, CBDRR is inclusive by design, addressing the specific needs of vulnerable groups—such as women, children, and the elderly. These guidelines are designed to empower communities to actively manage cyclone risks, ensure resilience, and minimize losses.

2.2.1. Preparedness

Enhanced Focus on Early Warning Systems: Highlight the importance of decentralized early warning systems that engage local communities in monitoring and disseminating warnings. Stress the need for real-time data collection and the use of modern technology (like mobile apps and SMS alerts) to ensure that warnings reach even the most remote areas promptly.

Encourage community-led monitoring systems where residents can report weather changes or hazards, enhancing the accuracy and timeliness of warnings. Integrate traditional knowledge with scientific methods to create a robust, locally relevant early warning network.

Integration with National and Regional Systems: Advocate for the integration of community based early warning systems with national and regional meteorological services to ensure a seamless flow of information. This includes regular training for community members on interpreting warnings and understanding their implications. Suggest establishing clear communication channels between local communities and disaster management authorities to ensure a quick response based on early warnings.

Decentralized and Participatory Planning: Preparedness planning for cyclones should adopt a decentralized and participatory approach, beginning at the village level and scaling up to the district level. This approach fosters localized responses, leveraging community partnerships through techniques such as Participatory Rural Appraisal (PRA) and focused group discussions. It is essential to engage Urban Local Bodies (ULBs), Panchayati Raj Institutions (PRIs), NGOs, Self-Help Groups (SHGs), and other Community-Based Organizations (CBOs) in these planning efforts. Special emphasis must be placed on including vulnerable groups, who are often the most affected by cyclones. Planning should integrate historical knowledge of past disasters and traditional coping strategies to ensure the plans are both contextually relevant and practical for the communities involved.

Augmented Community-Level Preparedness: Emphasize the need for regular community mock drills and exercises that prepare people for cyclone scenarios. These drills should be tailored to local vulnerabilities and include special provisions for the elderly, children, and people with disabilities. Advocate for the involvement of schools, NGOs, and other community-based organizations in these drills to foster a community-wide culture of preparedness. This includes providing training in search and rescue operations, medical preparedness, and the development of detailed disaster management plans at the block and village levels.

Developing Local Leadership in Disaster Preparedness: Promote identification and training of local leaders who can act as disaster response coordinators. These leaders should have the knowledge and resources to guide their communities during cyclones. Suggest the formation of community disaster management committees that include representatives from all sections of the community. These committees should be responsible for creating and updating local disaster preparedness plans.

Resource Mapping and Community Assets: Encourage communities to conduct resource mapping to identify local assets that can be utilized during a disaster. This includes safe shelter buildings, vehicles for evacuation, and local healthcare providers. Highlight the importance of maintaining a stockpile of essential supplies like food, water, first-aid kits, and communication tools that can be quickly mobilized during a cyclone.

Inclusivity and Participation: Reinforce the need for inclusive planning that actively involves vulnerable groups in decision-making processes. This ensures that the specific needs of women, children, the elderly, and people with disabilities are met in disaster preparedness efforts. Recommend the development of community-specific evacuation routes and shelter plans, considering the unique geographical and social contexts of each area.

2.2.2. Response

Prompt Activation of Disaster Response Plans: Activate disaster response plans upon receiving a severe cyclone warning to protect lives and property promptly. This involves immediately mobilizing resources and personnel, including Home Guards, Civil Defence, Aapda Mitras, and other first responders. These teams must be prepared to swiftly implement response measures and ensure all affected individuals' safety.

Evacuation and Search & Rescue Operations: Evacuate communities in areas likely to be impacted by the cyclone and relocate to designated safe zones. Search and Rescue (SAR) teams must immediately evacuate marooned or stranded individuals. Provide temporary shelters for evacuees and comprehensive humanitarian assistance is a critical component of the response effort.

Provision of Essential Supplies and Services: Supply the affected communities with food, water, clothing, and other non-food items to meet their basic needs. Temporary sanitation and hygiene facilities should be established to maintain public health. In addition, basic first aid and medical assistance must be made available, alongside psychological first aid and counseling services, with a particular focus on vulnerable groups such as children, women, the elderly, and people with disabilities.

2.2.3. Recovery and Reconstruction

Community-Led Recovery and Decision-Making: Plan recovery and reconstruction in consultation with the community in the aftermath of a devastating cyclone. Communities must actively engage in planning and decision-making processes to ensure that their needs and priorities are accurately reflected in the recovery efforts. Empowering communities to take charge of their recovery fosters ownership and ensures that reconstruction efforts align with local realities.

Rapid Damage Assessment and Debris Clearance: Conduct damage and loss assessment, with the participation of community leaders, and create detailed maps of the affected areas. The clearance of debris and rubble must be undertaken swiftly, emphasizing recycling and reusing materials where possible to minimize waste and promote sustainable recovery practices.

Restoration of Critical Infrastructure: Restore water and sanitation services immediately. At the same time, the restoration of critical infrastructure, such as roads, bridges, and schools, must be prioritized. These efforts should incorporate disaster-resilient designs and materials to ensure the rebuilt infrastructure is better equipped to withstand future cyclones. The same principles should apply to housing reconstruction, where community-led efforts should be supported to rebuild homes using resilient construction methods.

Health and Sanitation Restoration: Restore health and sanitation services as quickly as possible, including medical care and vaccinations. All affected individuals must have access to safe water and sanitation facilities. When necessary, psychological support and counselling should be provided to victims, particularly those in need of trauma care, to help them recover emotionally from the disaster.

Livelihood Restoration and Economic Recovery: Restore the livelihoods of the affected communities. The State and local governments should support the revival of livelihoods in affected communities, including agriculture, small businesses, and other vital economic activities. Such support may be extended through cash transfers, small grants, and subsidized loans. Where appropriate, vocational training should help people rebuild their livelihoods and promote early economic recovery.

2.2.4. Mitigation

Structural Mitigation Measures: Implement structural mitigation measures effectively, as they can significantly reduce cyclone risks by protecting vulnerable areas from the impacts of cyclones. Construction of cyclone-resistant buildings, including schools, hospitals, and shelters, using reinforced materials and designs is critical in mitigating cyclone risks. Existing social housing that lacks cyclone- and flood-resilient features should be retrofitted to withstand high winds and flooding. Additional structural measures, such as installing storm shutters, impact-resistant doors and windows, and constructing multi-purpose cyclone shelters in coastal villages and areas prone to frequent cyclones, should be prioritized. Reinforce public utilities and critical infrastructure such as bridges, culverts, and power lines with cyclone resistant features. Along vulnerable coastlines, constructing sea walls, dunes, and other coastal protection structures is essential. Community-led mangrove reforestation and other coastal

protection initiatives should be actively supported, as they provide natural barriers against cyclone impacts.

Non-Structural Mitigation Measures: Reduce cyclonic risks through non-structural mitigation efforts. This includes establishing early warning systems and emergency communication networks to ensure timely dissemination of information. Communities should regularly conduct cyclone drills and evacuation exercises to practice response plans, while public awareness campaigns and education programs are necessary to keep communities informed and prepared.

Environmental Conservation Measures: Conserve non-structural mitigation. Initiatives such as mangrove restoration and coastal afforestation should be prioritized, as these natural defences can reduce the severity of cyclone impacts. Relevant agencies must ensure the enforcement and monitoring of Coastal Regulation Zone (CRZ) guidelines, alongside implementing flood control measures, such as floodplain zoning and wetland restoration. Additionally, a strong techno-legal framework must be maintained in town-planning and country-planning rules to support disaster risk reduction.

Empowering Communities in Mitigation Efforts: Empower communities. State, district, and local administrations should support communities in taking ownership of mitigation efforts by supporting community-based initiatives. The formation of cyclone mitigation teams and other grassroots-level efforts must be encouraged. Risk transfer mechanisms, such as multihazard insurance for life and property, should be emphasized to provide financial protection to communities during a disaster.

2.3. Earthquake

Community-Based Disaster Risk Reduction (CBDRR) for earthquakes in the seismic zones is of paramount importance. It not only empowers local communities to manage their own risks and build resilience but also fosters a sense of responsibility and ownership. Engaging people in identifying hazards, assessing risks, and developing strategies creates a culture of preparedness, significantly reducing the damage and casualties caused by earthquakes. This approach encourages social cohesion derived from collective preparedness, safe construction, and public awareness, which are essential for building resilient communities capable of withstanding and recovering from earthquakes. As with all hazards, the CBDRR for earthquakes has four distinct stages: a. preparedness, b. response, c. recovery and reconstruction, and d. mitigation. One crucial aspect of preparedness is early warning for earthquakes, an emerging area of science that is still experimental. The sections below elaborate on all the four aspects.

2.3.1. Preparedness

Community Earthquake Drills: Regular earthquake drills in schools, public offices, and community centres are critical to familiarizing people with evacuation routes, procedures, and assembly points. These drills should simulate realistic scenarios to test response times and coordination among community members, ensuring everyone knows what to do during an actual earthquake.

Capacity Building of Response Teams: Train community volunteers, police, fire brigades, civil defence, and first responders in search and rescue, first aid, and trauma management. Regular refresher training and simulations are essential to keep their skills sharp and ensure they are equipped with the latest techniques and tools for disaster response.

Public Awareness Campaigns: Conduct workshops, distribute pamphlets, and use local media to inform communities about earthquake risks and safety measures during and after earthquakes. Integrate these campaigns with school curricula and community events to ensure wide reach and sustained awareness among all age groups and social segments.

Resource Mapping and Stockpiling: Identify critical resources such as hospitals, schools, and shelters. Ensure these places have emergency supplies, including food, water, and medical kits, and conduct regular checks to maintain the quality and availability of supplies, while identifying additional local resources that can be quickly mobilized in an emergency.

Inclusive Emergency Planning: Engage vulnerable groups, such as women, children, and persons with disabilities, in emergency planning. Develop tailored evacuation strategies that consider the specific needs of these groups, ensuring that emergency services and resources are accessible to all, particularly during and after a disaster.

Seismic Hazard Maps: State and district authorities should create and update seismic hazard maps, ensuring that communities understand high-risk areas and can plan accordingly. These maps should be disseminated widely through public platforms, schools, and local authorities to enable better-informed community preparedness and infrastructure planning.

2.3.2. Response

Activation of Emergency Operation Centres (EOCs): Following an earthquake, local authorities must activate EOCs at the district, and sub-district levels to coordinate response activities and ensure effective communication. These centres should be equipped with modern communication systems, real-time data monitoring tools, and have predefined roles for officials to expedite decision-making during the response phase.

Evacuation Management: Implement pre-identified evacuation routes and safe zones. Facilitate search and rescue operations and provide food, medical assistance, and psychological

support to evacuated individuals. Special provisions should be made for vulnerable populations, ensuring safe and efficient transportation for the elderly, disabled, and children to designated shelters.

Debris Management: Clear debris and dispose of it at designated locations. Restoring water and sanitation services should be a priority. Additionally, establish temporary debris recycling sites to manage waste efficiently and explore options for using cleared debris in reconstruction efforts.

Restoration of Communication Channels: Quickly re-establish communication channels, such as radios or satellite phones, to ensure coordination between responders and higher authorities. Mobile communication units should be deployed to areas where networks have been disrupted, ensuring continuous flow of information and emergency alerts to the public.

Damage and Needs Assessment: Deploy teams to assess infrastructure damage and immediate needs such as food, medical care, and shelter. Work with central and state agencies to ensure updated norms are enforced and monitored. Develop a centralized database to log damage reports, enabling targeted and prioritized response efforts.

2.3.3. Recovery and Reconstruction

Community-Led Recovery: Engage communities in recovery planning, focusing on their needs and priorities. Create maps of affected areas and provide temporary shelters while permanent housing is reconstructed. Involve community members in decision-making processes to ensure the recovery reflects local knowledge, cultural practices, and long-term sustainability goals.

Rebuilding Infrastructure: Ensure that all reconstruction efforts follow earthquake resistant building codes and standards. Restore essential services like water, electricity, and transportation networks, incorporating disaster-resilient designs. Additionally, use the reconstruction phase as an opportunity to upgrade infrastructure to more resilient and ecofriendly models that can better withstand future disasters.

Housing Reconstruction: Support community-led housing reconstruction efforts using disaster-resilient designs and materials. Facilitate access to technical expertise and financial assistance, ensuring that housing reconstruction includes provisions for vulnerable groups and adheres to sustainability principles to reduce future risks.

Livelihood Restoration: Provide training and resources to restore livelihoods, support small businesses, and offer economic recovery assistance. Implement programs like small loans and seed grants to help families restart their livelihoods. Partner with local businesses and vocational institutions to offer skill development programs that enhance income generation opportunities and improve long-term economic resilience.

Monitoring and Evaluation: Regularly monitor and evaluate recovery progress, making adjustments as needed to ensure effectiveness. Establish transparent reporting mechanisms and involve local communities in the evaluation process to ensure accountability and continuous improvement of recovery strategies.

2.3.4. Mitigation

Hazard Identification and Risk Assessment: Educate communities on earthquake risks and mitigation strategies. Conduct regular risk assessments and awareness campaigns. Involve local experts and community leaders in the assessment process to ensure that risk reduction measures are locally relevant, feasible, and aligned with traditional knowledge and practices.

Enforcement of Building Codes: Ensure all new constructions comply with earthquake resistant standards. Regularly inspect buildings and implement retrofitting measures where necessary. Additionally, incentivize compliance through subsidies or financial assistance for retrofitting older structures, especially in high-risk areas, to improve community resilience.

Strengthen Critical Infrastructure: Retrofit schools, hospitals, bridges, and dams to withstand earthquakes. Establish local seismic monitoring stations to provide real-time data. Moreover, prioritize upgrading critical lifeline infrastructure such as power grids, water supply systems, and transportation networks to ensure continued service during and after seismic events.

Zoning Regulations: Implement zoning regulations to prevent construction in high-risk areas such as fault lines or unstable ground. Engage local communities in mapping areas at risk and take appropriate mitigation actions. Integrate zoning enforcement with community land-use planning and sustainable development practices to reduce long-term vulnerabilities.

Non-Structural Measures: Secure heavy furniture, appliances, and hazardous materials. Foster partnerships between communities, governments, and the private sector to leverage resources and expertise for risk mitigation. Launch public awareness campaigns focusing on low-cost non-structural measures households can implement, ensuring widespread adoption across various income groups. By following these guidelines, communities can effectively reduce their vulnerability to earthquakes and promote resilient development.

2.4. Landslide

The community-Based Disaster Risk Reduction (CBDRR) approach helps to reduce landslide risks by enabling communities to understand, identify, and mitigate these hazards. Engaging local communities in monitoring terrain stability, mapping hazard zones, and developing early warning systems promotes self-reliance and resilience. The guidelines provided here are aimed at empowering communities to take proactive steps in managing landslide risks, ensuring reduced damage and casualties, and promoting sustainable recovery and development.

2.4.1. Preparedness

Preparedness involves both setting up early warning systems and educating communities to effectively respond to landslide risks. Local administrations play a critical role in facilitating this preparedness. Preparedness focuses on equipping communities with the knowledge and skills to respond effectively to landslide risks.

Early Warning: Early warning systems help communities receive timely alerts about potential landslide events, allowing them to take precautionary measures.

Risk Assessment and Monitoring: Assess the landslide risks based on rainfall patterns, soil stability, slope conditions, and historical data. Regularly monitor conditions in high-risk zones to detect changes that might indicate an increased risk of landslides.

Installation of Sensors and Monitoring Tools: Install rain gauges, soil moisture sensors, and other monitoring tools to track environmental changes. These systems collect real-time data on rainfall, soil movement, and slope conditions, which can help issue timely alerts.

Community-based Early Warning Systems: Establish community-based systems to disseminate early warnings. Ensure that alerts from monitoring tools are communicated promptly to at-risk communities through sirens, messaging systems, or other means.

Rainfall and Soil Moisture Monitoring: Regularly monitor rainfall and soil moisture levels to determine when landslide risks are elevated. Issue warnings when conditions reach critical thresholds that may lead to landslides.

Public Awareness Campaigns: Conduct regular community education programs focusing on landslide warning signs, such as soil movement and cracks in the ground. Promote awareness about actions to take when these signs appear, and ensure communities understand the risks and necessary responses.

Emergency Preparedness Planning: Develop community-level emergency plans, identifying safe zones and evacuation routes. Regularly conduct drills to ensure the community is prepared for quick evacuations in the event of a landslide.

Training for First Responders: Train local volunteers and community members in basic search and rescue techniques, first aid, and emergency shelter management. This training ensures a swift and effective community response following a landslide.

Community Preparedness Teams: Establish community-based preparedness teams to organize evacuation drills, ensure the functionality of early warning systems, and facilitate community response during emergencies.

2.4.2. Response

Activation of Drought Response Committees: Promptly activate district-level committees upon the declaration of a drought. These committees should oversee relief measures, coordinate with various agencies, and ensure that interventions are community-driven and context sensitive. They should include representatives from local communities to ensure the needs of vulnerable populations are addressed.

Emergency Water Supply Management: Deploy emergency water distribution through tankers or establish community water points. Prioritize areas with critical water shortages and ensure safe drinking water and sanitation are available to avoid secondary health crises, especially among vulnerable groups such as children, pregnant women, and the elderly.

Food and Fodder Distribution: Leverage the Public Distribution System (PDS) to provide essential food relief. Set up fodder banks to prevent livestock losses due to starvation. Closely monitor the distribution of food and fodder to ensure it reaches the most affected areas, avoiding wastage and ensuring equitable access.

Employment and Income Support Programmes: Expand employment opportunities through schemes like MGNREGA to support livelihoods affected by crop failure. Focus on drought related infrastructure projects, such as building water conservation structures, which enhance long-term resilience and reduce future drought risks.

Health Monitoring and Assistance: Set up mobile health clinics to monitor and treat malnutrition and waterborne diseases, with a special focus on vulnerable populations. Ensure that children, pregnant women, and the elderly receive timely medical assistance.

Nutrition for Women and Children: Address the increased risk of malnutrition during droughts, especially among women and children. Implement supplementary nutrition programs to provide fortified food and essential nutrients to pregnant and lactating women and children under five. Collaborate with local health workers to distribute ready-to-eat meals, therapeutic food, and supplements to meet nutritional needs, preventing long-term health impacts. Special care should be taken to provide meals at schools and community centres to ensure children do not face hunger during drought emergencies.

2.4.3. Recovery

Agricultural Recovery: Provide farmers with seeds, fertilizers, and other inputs for the next planting season, ensuring they have the resources to resume cultivation as soon as conditions improve. Offer financial assistance through existing relief schemes, such as low-interest loans and direct grants, to help farmers recover their lost income, rebuild their assets, and sustain their livelihoods during the recovery phase. Special focus should be given to marginal and small farmers, who are often the most vulnerable during droughts.

Rejuvenation of Water Sources: Restore and improve critical water infrastructure such as wells, irrigation canals, and reservoirs that may have been depleted or damaged during the drought. Prioritize projects that enhance groundwater recharge through the construction of check dams, percolation tanks, and rainwater harvesting systems, ensuring a more reliable and sustainable water supply for agricultural and domestic use in the long term. Engaging local communities in these efforts can ensure better maintenance and sustainability of these resources.

Rebuilding Agricultural Systems: Promote the adoption of drought-resilient crops, such as millets and pulses, which require less water and are more resilient to climate variability. Encourage the use of sustainable farming techniques, including crop rotation, soil moisture retention, and agroforestry, to improve long-term resilience to droughts. Provide technical support through agricultural extension services, and offer subsidies or low-interest loans to make these practices financially viable for farmers, particularly in drought-prone areas.

Rehabilitation of Grazing Lands: Collaborate with local communities to rehabilitate degraded grazing lands by planting drought-tolerant grass species and adopting soil conservation measures to restore pasture health. Promote rotational grazing, where livestock are moved between pastures, allowing overgrazed areas time to recover. This helps ensure sustainable livestock management and improves the productivity of grazing lands, contributing to long-term livestock recovery and resilience.

2.4.4. Mitigation

Sustainable Water Management: Implement long-term water management strategies that focus on large-scale rainwater harvesting, creating ponds, check dams, and tanks to capture runoff and store it for use during dry periods. Promote groundwater recharge techniques such as constructing percolation pits, underground reservoirs, and restoring traditional water bodies. Ensure reservoirs are optimally utilized by controlling water release based on crop cycles and drinking water needs. Introduce community-led water auditing to monitor consumption patterns, ensuring that water use is efficient and equitable. Such audits encourage transparency and foster collective responsibility for sustainable water management at the village and district levels.

Drought-Resilient Crop Planning: Promote the cultivation of less water-intensive crops such as millets, pulses, and drought-tolerant varieties of traditional crops to reduce agricultural water demand while maintaining soil fertility and ensuring food security. Agroforestry systems, which integrate trees with crops and livestock, should be encouraged to reduce evaporation from the soil, increase biodiversity, and enhance resilience. Encourage crop diversification,

where farmers plant a mix of short and long-duration crops, to minimize economic losses during droughts. This diversification provides a safety net for farmers by reducing dependency on a single crop and spreading risk.

Afforestation and Soil Conservation: Implement large-scale afforestation programs in drought-prone areas to stabilize the soil, reduce erosion, and increase its water retention capacity. Reforestation and agroforestry practices should focus on planting native tree species that are well-adapted to the local climate and require less water. Build community nurseries that encourage local participation in tree planting, ensuring a consistent supply of saplings. These nurseries not only create green jobs but also foster a sense of ownership within the community. Alongside afforestation, promote soil conservation techniques such as contour bunding, mulching, and cover cropping to enhance soil structure and prevent moisture loss.

Capacity Building for Drought Risk Reduction: Train local officials, farmers, and community leaders in modern drought risk management techniques, including the use of technology for better forecasting and early warning systems. Organize workshops and training programs focused on sustainable agricultural practices, water conservation methods, and community mobilization. Encourage the use of mobile applications, GIS mapping, and satellite data to improve drought prediction and monitoring at the grassroots level. Capacity-building initiatives should also include training communities in financial literacy, ensuring they understand how to access drought insurance schemes or government relief programs during periods of drought.

Drought Risk Mapping and Zoning: Conduct detailed vulnerability assessments at the district and village levels by analysing historical rainfall patterns, water availability, soil conditions, and cropping patterns to identify areas most at risk of drought. Develop zoning regulations that classify regions based on their drought risk, guiding land use, water management, and agricultural activities. Integrate climate projections into these assessments to anticipate future drought risks under changing climate conditions. These zoning regulations should inform local planning authorities to restrict water-intensive activities in high-risk areas and encourage investments in drought-resilient infrastructure and farming practices.

2.5. Chemical (Industrial) Risk Management

Community-Based Disaster Risk Reduction (CBDRR) plays a crucial role in managing chemical (industrial) disasters. By involving local communities in identifying potential risks, developing emergency response plans, and conducting regular drills, CBDRR minimizes the impact of chemical disasters on human health and the environment. This approach also promotes community-led initiatives like awareness campaigns, emergency alert systems, and

environmental monitoring, reducing the risk of chemical accidents. CBDRR encourages collaboration between communities, industries, and authorities, ensuring a shared responsibility in preventing and mitigating chemical disasters. Moreover, it empowers communities to hold industries accountable for safety practices, creating a culture of transparency and accountability. These guidelines aim to empower communities and local authorities to actively manage chemical (industrial) risks, ensuring resilience and minimizing losses.

2.5.1. Preparedness

Hazard Mapping and Risk Assessment: Conduct comprehensive hazard mapping of industrial areas that store or use hazardous chemicals. Assess the proximity of these areas to vulnerable populations like schools and hospitals and identify potential exposure risks. Involve local communities in understanding these risks and implementing local safety measures.

Public Awareness Campaigns: Raise awareness about the risks associated with industrial chemicals and educate nearby communities, workers, and local leaders on how to respond during emergencies. Collaborate with schools, local organizations, and civil society groups to spread information and ensure widespread community engagement.

Emergency Response Training: Train local first responders, including fire services, police, and medical personnel, in chemical disaster management. This training should include hazardous material (HAZMAT) protocols, the use of personal protective equipment (PPE), and decontamination procedures. Organize joint exercises with agencies like NDRF, SDRF, and Civil Defence to improve coordination.

NGO and Community Capacity Building: Build the capacity of local NGOs and community representatives to recognize chemical hazards and report unsafe practices. These groups should participate in Local Crisis Groups (LCGs) and help disseminate warnings and assist authorities in response efforts during an incident.

Community Evacuation Drills: Conduct regular evacuation drills in industrial zones to ensure that communities understand evacuation routes, assembly points, and procedures for avoiding chemical exposure. These drills should be inclusive, considering the needs of vulnerable populations like the elderly and disabled.

Stockpiling Emergency Equipment and Medical Supplies: Ensure district health centres are stocked with essential supplies such as decontamination agents, antidotes for specific chemicals, respiratory masks, and PPE. This preparation will enhance the local community's ability to respond effectively in case of a chemical incident.

Corporate-Led Initiatives: Utilize corporate initiatives like Corporate Social Responsibility (CSR) programs to strengthen local preparedness. Chemical industries should collaborate with nearby communities to improve safety awareness and preparedness measures, enhancing overall disaster risk management.

2.5.2. Response

Immediate Evacuation and Shelter Management: Implement rapid evacuation procedures for communities in the event of a chemical accident. Ensure that shelters have sealed rooms, food, and medical supplies to protect evacuees from chemical exposure.

Activation of Incident Command Systems (ICS): Activate local ICS to coordinate response efforts between fire services, police, health officials, and industry representatives. This unified command structure ensures quick decision-making and effective resource deployment.

Hazardous Material Containment and Decontamination: Deploy HAZMAT teams to contain chemical spills and initiate decontamination processes. Use specialized equipment and techniques to neutralize chemicals and prevent further spread, with support from NDRF and SDRF if necessary.

Medical Treatment and Triage: Set up emergency medical camps near affected areas to provide immediate treatment for chemical exposure. Hospitals should be equipped to handle chemical-related injuries and provide specialized care, including antidotes for toxic substances.

Public Information and Communication: Use real-time communication channels such as social media, local radio, and public address systems to inform the public about evacuation routes, shelters, and safety instructions. Clear and timely communication can reduce panic and improve community response.

2.5.3. Recovery and Reconstruction

Damage and Environmental Impact Assessment: Conduct detailed assessments of the physical damage and environmental impact of the chemical disaster. Use advanced technologies like drones and GIS to evaluate contamination in air, water, and soil, and develop long-term remediation strategies.

Rehabilitation of Contaminated Areas: Work with environmental experts to clean up contaminated areas. This may include soil remediation, water treatment, and the safe disposal of hazardous materials to prevent further exposure risks for the community.

Restoration of Livelihoods: Implement programs to help those affected by the disaster, particularly workers in the impacted industry and nearby communities. Provide financial aid, job training, and employment opportunities to facilitate economic recovery.

Medical and Psychological Support: Establish long-term health monitoring and provide medical care to those exposed to harmful chemicals. Offer psychological support and trauma counselling to help individuals cope with the aftermath of the disaster.

Rebuilding Infrastructure and Housing: Rebuild damaged infrastructure, including roads, public buildings, and homes, with an emphasis on safety. Consider relocating vulnerable populations away from high-risk industrial zones to reduce future risks.

2.5.4. Mitigation

Strict Enforcement of Safety Regulations: Ensure that industrial facilities comply with safety standards through regular inspections and equipment upgrades. Enforce zoning regulations to maintain safe distances between residential areas and industrial sites.

Development of Early Warning Systems: Implement early warning systems to detect chemical accidents in real-time. Equip nearby communities with alarms and automated systems that can alert them quickly to potential hazards.

Capacity Building for Industrial Workers: Provide continuous training for industrial workers on safe chemical handling, emergency response, and spill prevention. Promote a safety-first culture within industrial operations.

Promoting Safer Technologies: Encourage the adoption of cleaner, safer technologies in industrial processes. Support investments in automation, leak detection systems, and less toxic alternatives to hazardous chemicals.

Risk Reduction through Land-Use Planning: Integrate risk reduction measures into land-use planning. Create buffer zones between industrial areas and communities to minimize the impact of potential chemical disasters.

Sustainability through Multi-Stakeholder Partnerships: Establish partnerships among local communities, NGOs, industry, and government agencies to promote long-term chemical disaster risk management. These partnerships should focus on preparedness, response coordination, and ensuring transparency and accountability from all stakeholders.

2.6. Epidemic

Community-Based Disaster Risk Reduction (CBDRR) plays a key role in managing epidemic risks. It helps communities detect, respond to, and recover from outbreaks efficiently. By involving local communities in activities like disease surveillance, contact tracing, and health education, CBDRR strengthens a community's ability to manage epidemics. Local involvement is crucial for reducing disease spread and minimizing the epidemic's impact. Moreover, CBDRR encourages initiatives such as vaccination programmes and social distancing, which are vital for building resilience against epidemics. Engaging communities in

these efforts builds trust, cooperation, and collective action, which saves lives and reduces social and economic harm. These guidelines empower communities to actively manage epidemic risks, ensuring their preparedness and minimizing losses.

2.6.1. Preparedness

Preparedness focuses on actions that anticipate and prevent epidemic outbreaks, aiming to minimize their impact. Key activities include:

Surveillance Systems for Early Detection: Set up community-based health surveillance to monitor and report any signs of disease. Train community health workers to recognize unusual patterns of illness and report them promptly.

Community Health Education: Run awareness campaigns on hygiene, sanitation, vaccination, and disease prevention. Educate people about how diseases spread, the early symptoms, and when to seek medical help.

Vaccination and Immunization Programs: Ensure that high-risk populations are vaccinated. Mobilize vaccination drives in coordination with local health authorities and follow routine immunization schedules. Establish mobile vaccination units can help reach remote and underserved populations more effectively.

Training of Health and Emergency Response Teams: Train local health workers, volunteers, and officials on epidemic preparedness and response protocols. This training focuses on isolation measures, proper hygiene, and emergency medical care.

Stockpiling Medical Supplies and Equipment: Build a stockpile of essential medical supplies like protective gear, disinfectants, and medicines. Ensure that local health centres have the resources to handle an outbreak. Regularly updating and rotating stockpiles ensures that supplies remain practical and ready for immediate use.

2.6.2. Response

A quick and coordinated response is critical once an epidemic occurs. Key response actions include:

Activation of Emergency Health Committees: Immediately activate local health committees to mobilize healthcare resources and coordinate with higher health authorities. Local governments must be represented in setting up health committees.

Isolation and Quarantine Measures: Implement isolation and quarantine protocols to prevent further disease spread. Prepare community-based facilities for quarantine or organize home quarantine strategies. Seek the help of local governments, NGOs, and the private sector to set up these facilities.

Rapid Testing and Diagnosis: Set up local testing and diagnostic centres to identify cases quickly and coordinate with district labs to ensure fast sample processing. Mobile testing units can be deployed to remote or high-risk areas to ensure widespread and timely access to diagnostic services.

Community Hygiene and Sanitation: Promote good hygiene practices like regular hand washing, disinfecting public spaces, and safely disposing of medical waste. Public awareness campaigns about the importance of hygiene and sanitation should be coupled with providing necessary resources, such as hand-washing stations and waste disposal units in high-traffic areas.

Medical and Psychological Support: Deploy mobile health units to care for the infected. Provide psychological support to help communities manage stress and anxiety during the outbreak. Establishing hotlines or telemedicine services for mental health support can ensure continuous access to psychological care, especially in isolated or quarantined areas.

2.6.3. Recovery and Reconstruction

Post-epidemic recovery focuses on rebuilding health systems and restoring community wellbeing. Key activities include:

Rehabilitation of Health Systems: Strengthen local healthcare infrastructure, ensuring that clinics and hospitals are better equipped for future epidemics. Investment in telemedicine infrastructure and digital health records can improve the efficiency of healthcare delivery, particularly in underserved or remote areas.

Rebuilding Livelihoods: Provide livelihood support to those affected economically by the epidemic, particularly those who lost jobs or income during quarantine. Establishing skill development and job retraining programs can help individuals transition into new economic opportunities and increase resilience against future disruptions.

Mental Health and Counselling Programs: Offer mental health services at the community level to help individuals cope with emotional and psychological impacts. Provide support to families that have experienced loss or trauma. Community-based mental health programs should integrate culturally sensitive approaches and peer support networks to ensure they are accessible and effective.

Capacity Building for Health Workers: Train health workers on lessons learned from the epidemic and how to improve future responses. Provide continuous medical education for frontline workers. Incorporating digital tools and remote learning platforms can ensure that health workers in rural areas receive timely and up-to-date training.

Restoration of Education and Social Services: Reopen schools and ensure students who missed out on education during the epidemic can catch up. Work with social services to support vulnerable populations, including orphans and the elderly. Developing blended learning models that combine in-person and online education can provide a flexible and resilient approach to continuity of education.

2.6.4. Mitigation

Mitigation involves long-term measures to reduce the risk and impact of future epidemics. Key activities include:

Strengthening Public Health Infrastructure: Build or improve health facilities, especially in rural and remote areas, to better detect and treat infectious diseases.

Water, Sanitation, and Hygiene (WASH) Initiatives: Improve access to clean water, sanitation, and hygiene in vulnerable communities to reduce disease transmission.

Health Education Campaigns: Launch long-term campaigns to promote healthy behaviours such as regular hand-washing, vaccination, good nutrition, and disease prevention.

Strengthening Disease Surveillance: Expand disease surveillance networks at local, district, and state levels. Train health workers and community leaders to detect and report early signs of outbreaks.

Research and Development for Epidemic Prevention: Encourage collaboration between local authorities and research centres to improve understanding of diseases and develop new treatments or vaccines for common illnesses.

3. CONCLUSION

As the essence of effective CBDRR practice, the importance of the active participation of the local population needs to be widely recognized and so also the efforts made to strengthen local capacities for disaster preparedness and response. It is heartening to note that reducing disaster risks through systematic efforts by the communities is now becoming a reality. The causal factors of disasters are undergoing constant analysis and measures are being undertaken for reduced exposure to hazards, lessening of vulnerability of people and property, efficient management of land, environment, and better preparedness to face adverse events.

It is imperative that CBDRR must take into the account the diversities in the community, including the vulnerabilities and capacities of the residents and acknowledge the wealth of knowledge that each member of the community can provide in terms of past disasters. Communities are the key partners in risk management; governments and NGOs can help target limited resources, define gaps and build on the strengths of each community to help build greater resilience. To sum up, CBDRR planning emphasizes community participation,

inclusivity, and ownership throughout all phases, ensuring that the needs and capacities of local communities are taken into account.

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Chapter 7

FIRST-AID AND EMERGENCY PROCEDURES

FIRST-AID

INTRODUCTION

During a disaster, there will definitely be victims, because an event is still not considered disaster if there are no victims, such as deaths, damage to property, social structure, infrastructure or environmental damage. Sometimes the number of victims is not the direct result of the disaster but victims can still fall because of inappropriate first aid. Therefore, we should improve our understanding regarding the principles and procedures as well as skills in dealing with disaster victims. Immediately after a sudden or forewarned disaster, while panic and total confusion still rules, we should keep calm and thoughtful in coping. The steps we take to help victims will very much affect their future condition. First aid administered accurately and quickly will be very important for the victim's survival.

1. Objectives of first aid

The main objectives of first aid are as follows:

Prevent the worsening of the conditions of victims

Many fatalities happen because victims received help too late or because of ignorance of people at the scene in administering first aid, e.g., if a victim suffers a wound that is bleeding a little, try as quickly as possible to stop the bleeding in order to prevent a serious blood shortage. Use a sterile bandage otherwise an infection may further worsen the victim's condition.

Prevent additional victims

During a disaster situation there can be a large number of victims. The purpose of first aid is to prevent this number from growing and the victims' conditions from worsening, e.g., when helping someone is drowning in a river, the helper should be able to swim and understand the condition of the river current. This is to prevent the helper from also drowning and increasing casualties.

Facilitate further handling

First aid is only a temporary measure and therefore will still need further aid from competent officials and agencies such as midwives, medical aides, doctors, and hospitals. Therefore, when administering first aid, refrain from methods that could complicate further aid

treatments, e.g., do not put strange ointments on the wound because it will have to be cleaned once the person gets, and this would definitely take up valuable time.

Mitigate the victim's suffering

By administering first aid, hopefully physical suffering such as pain and panic can be minimized. Give encouragement, e.g., help will be coming soon; the wound is not so serious; wrap a burn with young banana leaves.

2. Components of first aid

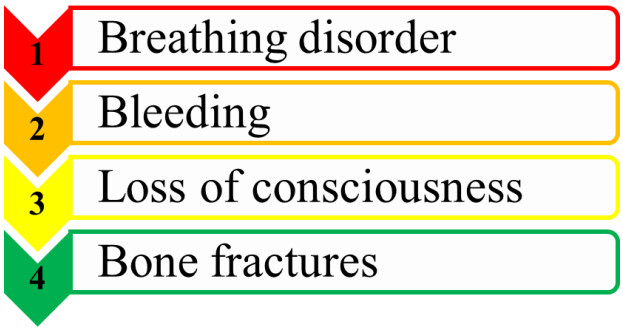
Victim: The main aid component is victim as the person who needs help

Helper: A helper is someone whose condition is better than the victim's, with willingness and ability to apply first aid.

Sickness/injury: Sickness/injury is a condition which makes a victim suffer, it may include physical or psychological sickness. What should be known regarding sickness/injury is the injury/sickness type, treatment principles, and methods of administering first aid.

Priority attention: During an emergency situation the total number of victims is usually higher than the number of helpers, so helpers should establish the priority of the victims to help first.

- Select victims most able to be helped
- Give precedence to victims needing minor treatment so they can assist others.
- Give more attention to patients with a high level of fear and panic in order to prevent a disruption of the aid process
- Whenever there are victims in a buried position/covered by something and must be located, those found first should be helped immediately.
- Whenever a deceased victim is found, wait and focus on finding other safe victims.
- Get victims who can participate actively involved in searching for help.
- When a victim is found with multiple injuries/sickness, apply help in this order



HOW TO DEAL WITH INJURIES

Competence: Participants will be able to understand the principles and procedures, as well as how to use the tools suitable for administering first aid.

Quality Input:

- First Aid Kit
- Alternative First Aid equipment
- Rehearsal equipment

Activities for first aid

1. Bleeding wounds

During certain disasters, a bleeding wound may occur, e.g., piercing by flying building material during a cyclone, being struck down by building debris, scratching by a sharp object. Keep in mind that a bleeding wound can be quite dangerous and should straightaway be treated because of several factors:

- Whenever there is a loss of blood exceeding 20% of the total blood in a human body, this may cause unconsciousness and when no immediate help is given could result in death.
- Blood outflow from a wound. A wound represents a window for viruses or bacteria to enter the body; therefore, the wound should be covered immediately to prevent an infection.

Internal bleeding

Internal bleeding occurs when there is an internal body wound, although no blood has left the body. Body parts that often experience internal bleeding are the thoracic cavity, the stomach cavity and the head cavity.

Applying aid is through calming the victim, and by taking him/her a clinic or hospital as quickly as possible, because the treatment is limited to those with special competence.

Internal bleeding symptoms:

- Stomach cavity bleeding is indicated by enlarged, hard and stiff stomach.
- Thoracic cavity bleeding is indicated by short-windedness.
- Head cavity bleeding by decreasing consciousness and may result in paralysis.

External bleeding

External bleeding occurs when skin is scratched and blood seeps out of the body through the wound/scratch.

External bleeding symptoms:

- Scratches and wounds on skin
- Bleeding of wound
- Pain
- Dizziness caused by too much blood loss

Although the body has the ability to stop bleeding, it is necessary to apply first aid against a bleeding wound. The main way to do this is through:

- exerting pressure on the wound
- placing a bandage on the wound
- exerting pressure and placing a bandage (tourniquet) on the wound
- exerting pressure on internal blood centre points, for instance by the neck side, underneath the upper arm
- even when there is no more bleeding, the wound should still be covered to prevent bacteria/germs from entering through the open skin.

2. Treatment of wounds

A wound is usually treated by bandaging.

Locate wound position

Wounds in different locations demand different treatment, therefore it is most important when a victim is still conscious not to move a lot and to remain in a seating or standing position (position of head should be the highest).

Pay attention to the human body's anatomical shape

During the treatment of a wound, the body's anatomy has to be noticed, because it will affect the bandaging method. It comprises three basic shapes:

- cylindrical, e.g., arm, thigh, calf, neck, body.
- round, e.g., head.
- joint, e.g., elbow, heel, and knee.

Identify size of the wound (extent and intensity of blood outflow)

The size of a wound determines the treatment method, even though it follows the same principles. Cover wound and stop the bleeding. There are four methods to stop bleeding: applying pressure, bandaging, bandaging and applying pressure (tourniquet) and total bandaging.

When trying to stop bleeding, do not bind too loose as blood will not stop but also do not bind too tight, as this will stop blood from flowing to the wounded area. Therefore, it is necessary to ask a victim, whether the bandage is too loose or too tight. When no response can be obtained from the victim, the bandage tightness is done in such a way that the pulse can still be felt beneath the bandage.

3. Burns

A burn may occur because of fire from an electrical short-circuit, a stove or machinery.

Intensity level of a burn

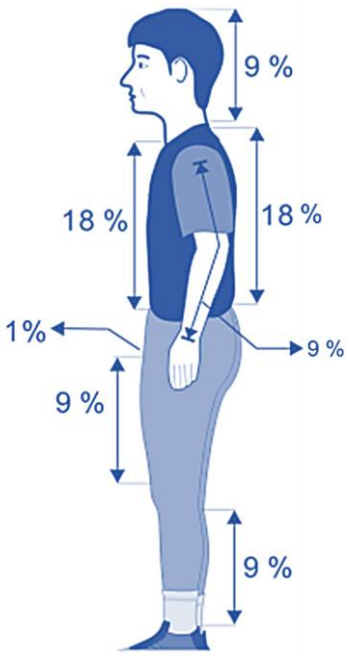
The intensity level is established in 2 ways, i.e., percentage of the burned body part and the degree of extent and depth of burned skin.

Percentage

Based on burned body parts, the percentages of burned body surface can be observed in picture 1 as follows:

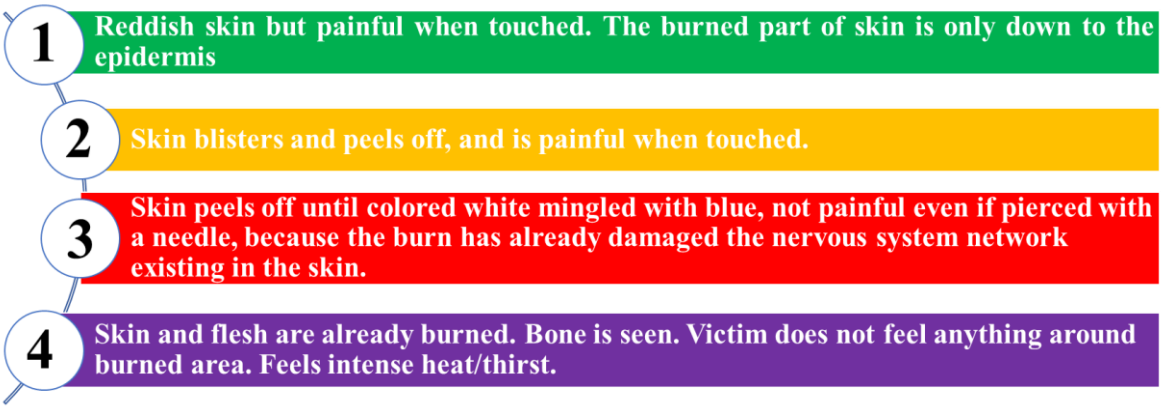
- Head until neck 9%,
- Left or right arm 9%,
- Front body part (stomach and chest) 18%,

- Back body part (back) 18%,
- Upper left leg 9%,
- Upper right leg 9%,
- Lower right leg 9%,
- Lower left leg 9%,
- Genitals 1%,



Degree

The degree refers to the depth level of burn suffered by a victim. Four degrees of burn depth exist, and the symptoms are as presented as follows:



Burn symptoms

The presence of a burn can be observed from the combination of symptoms as follows:

- Red coloured skin
- Blistered skin
- Peeling off skin
- Painful when touched
- Feeling very hot
- Flesh gets burned until the bones can be seen
- Stinging smell
- Feeling very thirsty
- Not bleeding

Principles of first aid against burns

i. Stop deepening process of the burn. Most effective: pouring or soaking the wound with cold and clean water.

ii. When a burn causes skin to peel off, immediately cover the wound with a clean cloth, avoid smearing with anything else to prevent risk of infection that may complicate further treatment. Cover the wound using a sterile cloth, for instance an already washed and ironed clean handkerchief or clean plastic.

iii. After the wound is covered, a bandage may be applied. Bandaging a burn is different than bandaging a bleeding wound. During bandaging a burn, it is important to be sure that the wound is covered rather than the tightness of the bandage.

iv. After the wound is covered, try to get further treatment.

4. Broken bone

A broken bone wound refers to a wound which occurs on a bone, in the form of cracking, breaking or sticking out of the body. Broken bones are injuries most common during earthquakes. The cause of a broken bone is for instance being struck by building debris, trampled on, getting squeezed.

Types of broken bone wounds

Fractured bone	A bone experiences trauma/impact it may cause the bone to crack, but not break apart.
Closed broken bone	A bone breaks, but is still inside the body.
Open broken bone	A bone breaks and sticks out through the skin.

Symptoms of broken bone wounds

Several symptoms easily recognizable are among others:

- Black and blue
- Swollen
- Very painful when touched or moved
- Change in form
- Broken neck bone can be noticed when there are wounds on both head and neck
- Broken backbone can be noticed when there is a difference in the length of the legs
- Broken rib-bone is followed by breathing difficulties.

Principles of first aid against broken bone wounds

The first aid principle to address a broken bone wound is through the fixation to rest/minimize activity of the two joints that flank the broken bone. This is necessary to prevent friction of the broken bone. Friction of a broken bone can aggravate the wound.

Treatment of broken bone wounds

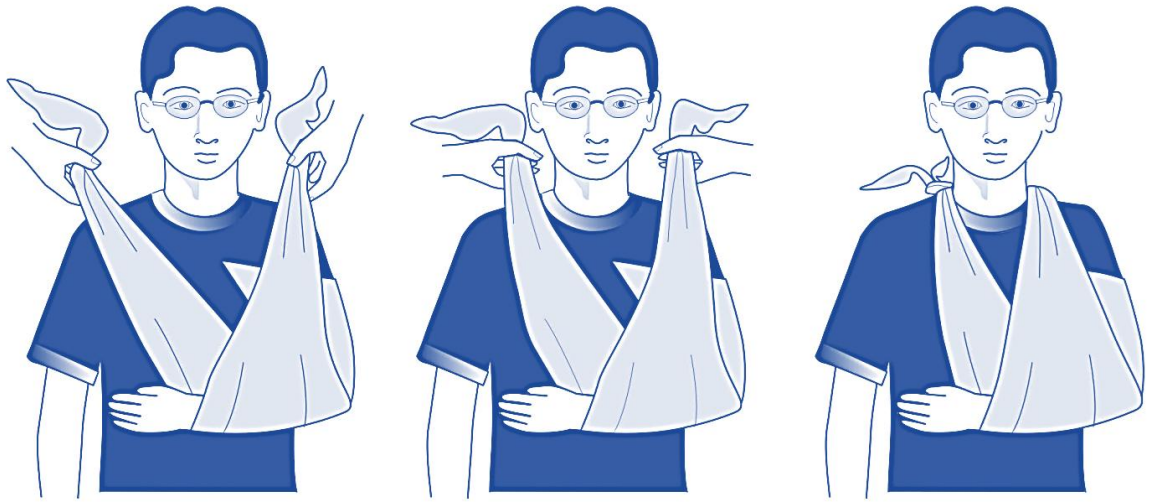
Treatment of a broken bone wound (fixation) is known as splint bandaging. Fixation is done by applying two splints comprising of wood lined with thin cloth/sponge. The splints, each two centimetre in length are meant to flank the fracture location, which are then bound with a rope, and tightened to support the broken body part and prevent it from suspending.

Treating a broken neck is by propping up the neck to prevent any movement, whether left and right, to and fro, as well as turning around.

A broken back does not need first aid, but needs special aid from competent persons. What should be exercised is to make victim remain in a lying down position, and to make use of a flat and hard palanquin when transferring the victim to a different location.

When treating a victim with a broken collarbone, no splints are needed, only a shoulder binder to retain its position and prevent the victim from stooping. In the case of an open broken bone, first step is to cover the wound, and thereafter conduct a fixation against the broken bone.

In treating broken bone wounds, do not try to restore the bone to its original position, by pressing, pulling or reinserting the stuck-out bone. If no splints are available, part of the victim's body can be utilized as a splint. For instance, in the case of a broken lower arm, fixation can be done by binding the broken arm to the victim's body.



5. Evacuation techniques for persons with injuries

Definition

Evacuation is defined as transferring a victim from one place to another with the hope of receiving further aid, in order of his/her condition not aggravated or to prevent hazards from other threats for instance aftershocks, landslides or fires.

Objectives of evacuation

The objectives of an evacuation are to protect victims from the surrounding conditions against possible aftershocks, and to receive further aid when deemed necessary.

Evacuation requirements

An important requirement for evacuation is the stable condition of the victim, for instance breathing is normal again; bleeding has stopped; victim is conscious again. The above-mentioned requirements may be ignored if the area where the victim is currently located is still unsafe from hazards, for instance fire hazards.

Evacuation method

To evacuate in a simple manner is to transfer a victim by carrying, with or without support tools. The transferring of a victim may be well exercised by 2 to 6 persons. In a specific situation, evacuation may be carried out alone, for instance from inside a very narrow collapsed building. Keep in mind that the evacuator should rely on his ability to transfer a victim. If he/she is apparently unable, he/she should seek help.

Evacuation equipment

Evacuation equipment are tools that can be used for transferring a victim to a safer place. The use of evacuation equipment should be adapted to the total number of helpers and to the injury/sickness condition of the victim. For transport we know two tools usually used i.e. a long board and a drag bar, both functioning as palanquins. Other than these two standard tools, there are also simple tools by utilizing surrounding objects such as a door, ladder, sofa, chair, blanket, stocking or a rice/fertilizer bag.

Recognizing support tools to provide aid

Support tools for administering aid are used if the patient's condition needs administering aid with support tools, because there are many cases where a patient does not need a support tool, e.g. getting knocked or bruised, ignited by fire, getting slightly scratched and bleeding has already stopped by itself, etc. However, there a lot of cases where the use of support tools is required to help disaster victims exist.

In this module standard support tools are introduced, i.e. support tools in line with medical standards for helping disaster victims. These tools can be purchased, or self-made, but most important is that these tools are capable of providing ease to patients and helpers in coping with disaster cases.

Recognizing surrounding objects that can be used for administering aid

During a disaster situation, although the preparation is already thought adequate, quite often the tools already prepared prove to be insufficient or inappropriate. This condition demands the ability to use surrounding objects as replacements for standard tools for treating victims. Although very different when compared to standard equipment, these replacement tools can be utilized to administer aid. Samples of replacement tools include:

Standard tool/material	Replacement objects
Palanquin	Ladder, blanket, chair, bag, stocking
Splints	Banana branch, wood, bamboo, cardboard box
Dressing cloth	Handkerchief, clean cloth
Burn wound cover	Young banana leaf, sterile cloth, sterile plastic
Mask	Stocking, towel, sarong
Triangle cloth	Midrib of banana leaf, raffia rope, a torn piece of cloth, belt, shoelace
Medicines	Several types of medicine plants around us, for instance banana tree sap, vanilla leaf sap, papaya leaves, lamtoro leaves, balsam.

EMERGENCY PROCEDURE

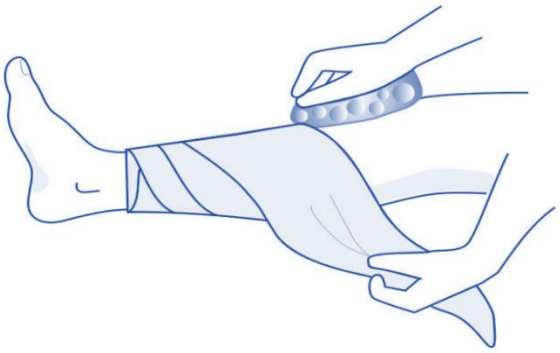
Treatment of bleeding wounds

The principle of treating bleeding wounds is to as quickly as possible stop blood outflow, because it can be fatal if blood outflow exceeds 20% of the total blood in the body. The next principle is to as quickly as possible cover the wound, because open skin presents an entrance for bacteria and other germs to the body. A sterile cloth should be used when applying a bandage to prevent the wound from catching an infection, or one should apply disinfectant to the wound if available. Another important point is that the bandage applied to a wound should not be too tight, because this might obstruct other body parts, or too loose, because otherwise the bleeding will not stop. If the victim is conscious, please ask him/her about the bandage tightness, but if the victim is unconscious one should check for pulse signs around the wound area.

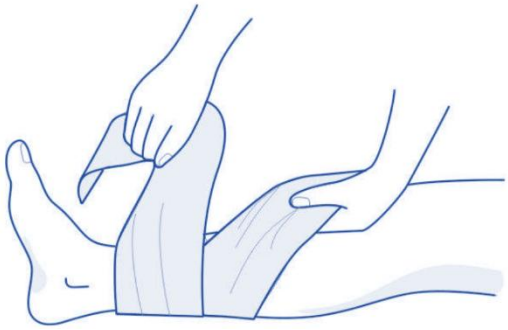
Bleeding wound treatment on cylindrical body parts

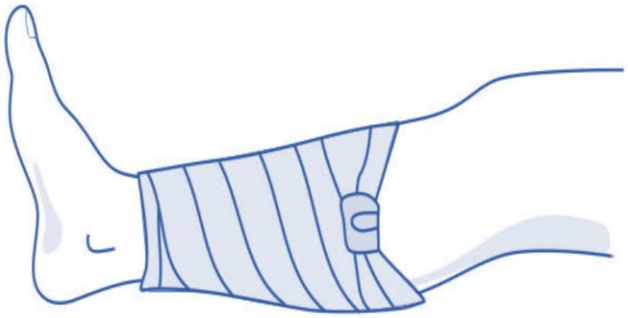
1. Clean the wound with disinfectant or medicine of the same sort.
2. Prepare a triangle cloth (bandage).
3. Cover the wound with the bandage, tie it with a slipknot.

4. If the wound is large, apply a sterile pressing tool on wound, or use a pressing tool in the shape of a cardboard box or a piece of wood if the wound is large and bleeding rapidly.



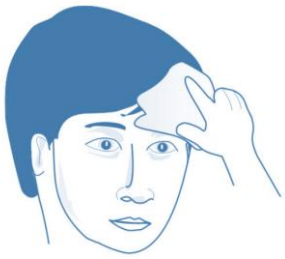
5. After applying a pressing tool, bind the wound straightaway using the next method.





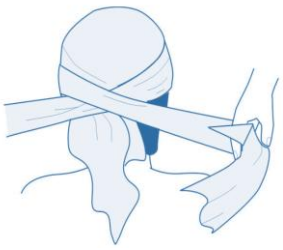
Bleeding wound treatment on round body parts

1. Determine if the wound needs a pressing tool or not, if considered necessary apply a pressing tool.



2. Prepare an already folded bandage.
3. Start binding starting from the wound area.

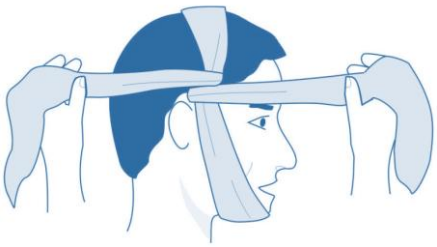
4. Bind around the head in circles, upon arriving opposite of the wounded area, cross the bandage.



5. After crossing, tie bandage in shape of a parcel (not in the direction of first binding) until arriving at the position of the wound. When reaching the same position as the wound, tie with a slipknot.

6. If a wound exists on the chin or upper forehead, a triangular cloth is needed to prevent the bandage from coming loose.

7. After the wound is pressed, tie a pair of strings from bottom to behind the head, going above the ears. Then tie with a slipknot.



8. Tie another pair of strings to the direction of behind the head via below the ears. Make sure binding is not too loose and not too tight.

Bleeding wound treatment on the joint area

1. For instance, a wound exists on the knee.
2. Prepare pressing tool and a tying bandage which is already tied-up.

3. Bandage the wound starting from the wound area; pull both ends of the bandage to behind the knee, cross them

4. After crossing, pull both tying strings up front to below the knee, cross them again.

5. After having crossed, pull the tying strings to behind the knee, and after crossing pull tying strings again up front of the knee in the direction of above the knee. Check the tightness of the tying strings.

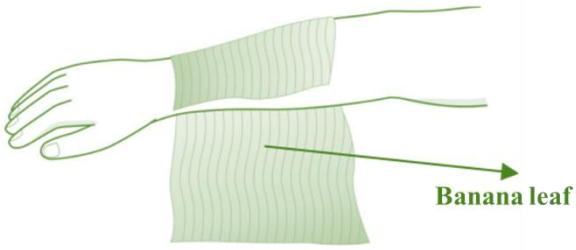
Treatment of Burns

The first process of administering aid to a burn victim is to prevent the burn from deepening, by pouring cold fluid onto the wound, i.e. clean water or antibiotic medicine. This is necessary because in general, a burn tends to undergo a deepening process if no appropriate measures are taken.

Avoid adding any substances to the wound because it may complicate further treatment. After having carried out the measure as good as possible, cover the wound straight away. This is necessary to prevent germs or dirt from entering through the open skin. It is suggested that before covering with cloth, one should first cover the wound with a sterile substance, cold and not sticking against the wound, because if the wound is immediately covered with cloth, when replaced the cloth will stick to the wound. The internal part of a coiling young banana leaf is suitable to function as a layer.

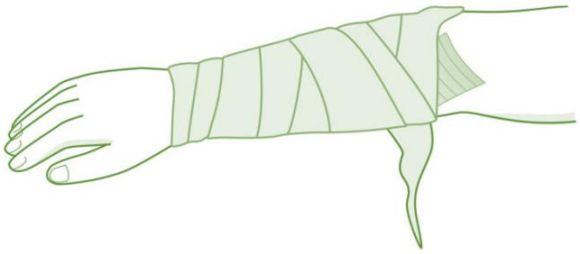
Treatment of burns on cylindrical body parts

1. After having tried best to prevent the wound from deepening, cover the wound with a sterile substance, cold and not sticking against the wound, e.g. the internal part of a still coiling, young banana leaf. After having layered the wound, cover it with a folded bandage like a ribbon with sufficient width, starting from the wound area



2. Pull both ends of the bandage to behind the wound, until the bandage is fully used, and finish with tying up both bandage ends with a slipknot.

3. The covering does not have to be tight, but should cover the whole wound area.



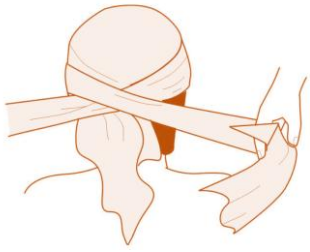
Treatment of burns on round body parts

2. Repeat activity 1 mentioned in "Bleeding wound treatment on cylindrical body parts", but

3. Let bandage still take the shape of a triangle, position the tip of the triangle to behind the wound.

4. Then pull both bandage ends to behind the wound, make sure that the bandage tip is covered.

5. Pull again both bandage ends to the direction of the wound, tie up with a slipknot.



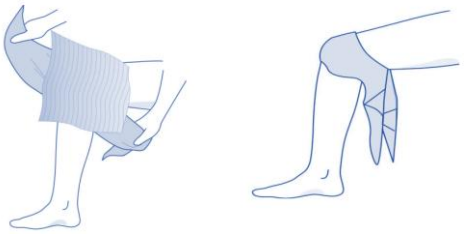
6. Make sure that the wound and surrounding area is fully covered, although the binding should not have to be too tight.

Treatment of burns on the joints

1. The principle used is by repeating activity 1 of "*Bleeding wound treatment on cylindrical body parts*", and *treatment of bleeding wounds on the joints*.

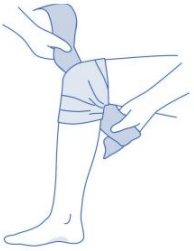
2. Form a triangle like a ribbon (similar to activity 2 of "*Bleeding wound treatment on cylindrical body parts*").

3. Bandaging starts from the wound area, pull the cover ends to behind the wound, then pull again up front to the direction of above the wound.

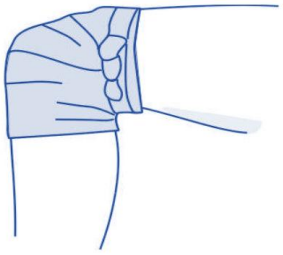


4. Pull the strings to behind the wound, and return up front to the direction of below the wound.

5. When there is no more string left, tie it up with a slipknot, if there are still string ends, tie them up until behind the wound



6. The bandage if seen from behind the wound is like the number eight. Make sure that the wound and surrounding area is fully covered.



Treatment of broken bone wounds

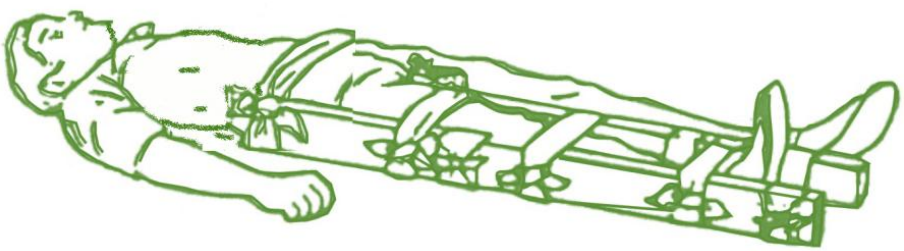
The main principle in dealing with a broken bone is to minimize the movement of the broken bone, with the aim of preventing friction between the two broken bone tips, because it may worsen the fracture, and squeeze the muscle/tissue sticking to the bone.

In several cases of broken bones, i.e., a broken neck or a broken backbone, it is suggested to administer first aid as little as possible, because aid should only be given by those specialized, what can be done is to let victim rest and minimize victim's movement especially around the area of the broken bone.

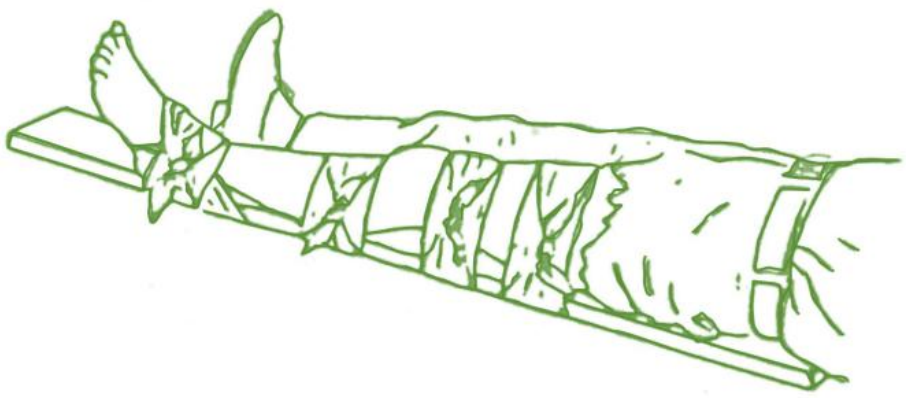
In all broken bone cases, particularly in the case of an open broken bone, it is not allowed to restore or try restore the bone position, either through massaging, pulling or pressing, what is important is just to rest the broken bone. Should there be wounds around the broken bone area, which are bleeding or a burn wound, these should be attended to first before attending to the broken bone wound.

Treatment of broken bones on cylindrical body parts (legs and arms)

1. When a victim suffers from a broken thigh, lay down the victim with straight legs.
2. Prepare five bandages already folded in the shape of ribbons.
3. Fasten one splint against the outer side of victim's leg, tie bandage from the splint's upper end around the victim's waist, fasten another splint along the inner side of the victim's leg.



4. Insert 4 bandages under victim's leg, and fasten on the hip, above the knee, below the knee and above the heel. Tie up bandages starting from top to bottom.



5. When there is only 1 splint, the healthy leg can replace another splint.

Treatment of broken collarbone wounds

1. Ask the victim to stand up, with his/her chest expanding and with his/her hands on his/her hips.
2. Install special collarbone splints according to order.
3. Lower victim's hands, victim can now be taken to the hospital.
4. If no special collarbone splint available, utilize a bandage to pull the collarbone.
5. Place victim's position like in "Treatment of broken bones on cylindrical body parts (legs and arms)"
6. Drape bandage from behind the neck, pull bandage ends to the back via both the victim's armpits, then tie up both bandage ends with a firm knot
7. Pull one remaining bandage up/to the bandage behind victim's neck, then pull firmly and tie up to the other bandages end.

Treatment of open broken bone wounds

1. For example, a victim suffers from broken left thigh and bone fragments are sticking out
2. Place the victim in the most comfortable position and comfort him/her to help ease the pain
3. Do not change the position of the legs, do not try to insert back the stuck out bone.
4. Cover stuck out bone straightaway with a sterile cloth if bleeding occurs on the wound area, the bleeding wound should be treated first through covering and bandaging it.
5. Place a pair of splints of 1 meter length underneath the broken leg and above the broken leg

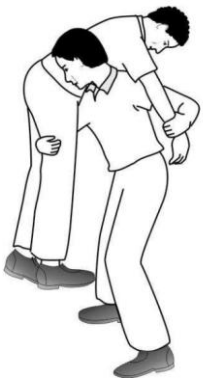
6. Bind the splint and the leg above the area of the broken thigh
7. Bind splint and leg below the area of the broken thigh
8. Binds splint and leg where the two legs meet
9. Bind both splints at the end of each splint.

Evacuation Procedures

The objective of an evacuation is to protect a victim from the possibility of further disaster or to provide further aid to the victim. In the case of a helper, consideration should be given to the physical strength of carrying a victim, the victim's weight, the number of helpers, and the surrounding environment, where the victim should be carried to as well as knowledge of the types of wounds and their dealing methods. Whereas in the case of the victim, consideration should be given to when to evacuate after his/her condition becomes stable, i.e. not suffering from breathing problems and the wound is already treated. However, which is to be done first, to treat or to evacuate? The answer is, if the surrounding condition is safe, wound treatment should take precedence, but if the surrounding condition warrants evacuation, it should be affected immediately, for instance in a situation where there is hazard like fire, flood or earthquake aftershocks, then most important will be how to save the victim first without dealing with the wounds suffered.

Carrying technique

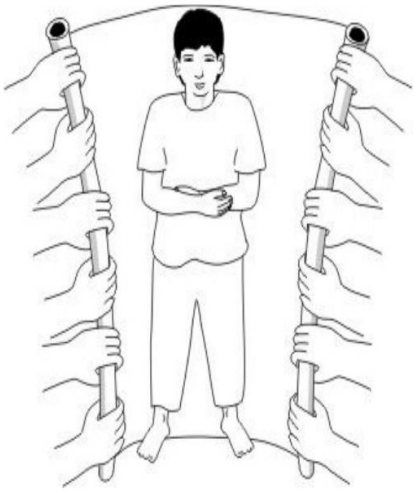
1. The helper's position is in line with the victim's, exactly by the neck, waist and knee of the victim.
2. The helper is in a squatting position next to the victim with his right knee standing, whereas his left leg is resting on the floor.
3. One hand under the victim and one hand above the victim depending on strength. The strong hand is to be placed under the victim's body
4. Count one, two, three, as command to start carrying the victim, when the victim's position is above the knee of the helper, the position of the hands should be switched from above to below



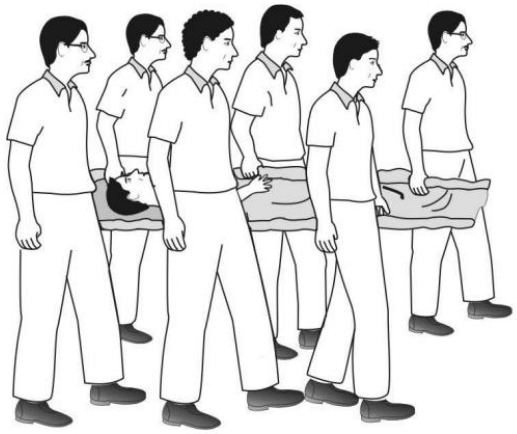
5. Count one, two, three, as a command to stand up.
6. Count one, two, three, as a command to embrace the victim's body against the helper's body, there after the victim is moved by walking.
7. The lowering method is done in the same manner, but done the other way around.

Helping a victim using a stretcher out of cloth

1. Spread the cloth longer and wider than the victim's body.
2. Place victim on the cloth.
3. Total helpers are six, two in front (next to the victim's head), two in the middle (next to the victim's waist), and two behind (next to the victim's calf), the tallest helpers should be positioned by the head.
4. Remaining cloth at victim's side is rolled towards the victim's body.
5. The helpers are squatting, facing in the direction of the victim's head (in the same line as victim's position) with inner knees upright (near the victim) and outer knees resting on the floor
6. The hands near the victim take hold of the rolled cloth.
7. Count one, two, three, as command to lift the victim, so that the victim's position is above the helpers' knees



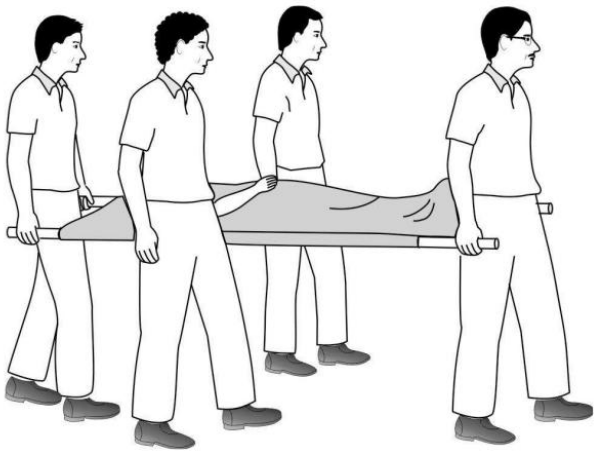
8. Count one, two, three as a command to stand up.
9. Count one, two, three as a command to lower the victim down to the helper's waists.



10. Lowering the victim is done in the same manner, but done the other way around.

Making a stretcher out of a sarong/sack/undershirt

1. Take two straight canes/bamboo of 2 m length 2.
2. Place them parallel to each other and insert the sarong/ underneath.
3. Place the victim in between the two canes above the sarong/sack/undershirt.
4. Helpers hold the cane tips so that 4 persons are needed.

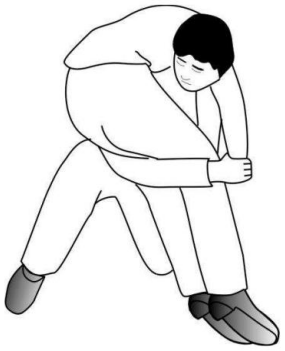


5. Position of the helpers is similar to evacuation with a stretcher from cloth.

Evacuation of a victim by one person in an open space

1. Evacuation is done by carrying the victim.
2. The Victim is lying in a facing downwards position.
3. Helper squats by the head, placing both hands on the victim's back through the armpits, then gradually raises the victim to the chest and then to the shoulders.

4. Then stand up with the victim's stomach leaning against helper's shoulder, one helper's hand holding the victim's body and the other helper's hand holding one of victim's hands



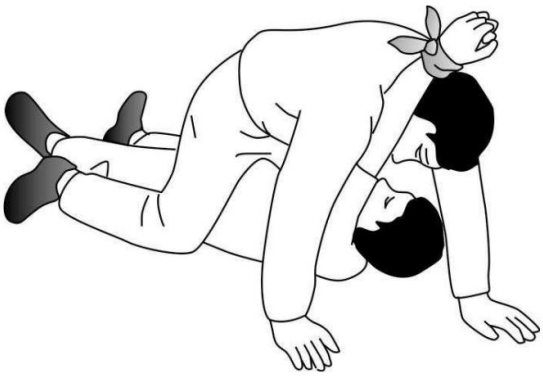
5. If the victim can stand up, the helper stands opposite of the victim.
6. Helper stops and places victim's stomach on his shoulder, with other hand holds victim's hand.

7. The helper carries the victim on his shoulder, and holds one of the victim's hands above his shoulder.
8. The lowering method is similar to the picking up, but done the other way around and then the victim is put to rest on his/her back.
9. This method is not allowed to be exercised with a victim that has a broken backbone or a broken neck bone.

Evacuation of a victim by one helper out of a debris covered room

Put the victim to rest on his/her back, bind both hands in front of the body

1. The helper crawls above the victim's body, the victim's bound hands are draped around the helper's neck.
2. The victim is evacuated by being dragged underneath the helper



3. This method is not allowed with a victim who has a backbone injury or a broken neck
4. When the situation is no longer dangerous, the victim's injuries should receive treatment first, especially breathing and bleeding problems.

Treatment of unconscious victims

1. Put victim to rest on his/her back, straighten the legs and hands alongside the body, it is suggested to loosen victim's clothes.
2. Make sure that victim is still breathing. Bring your cheek closer to victim's nose to feel any breathing. Listen to victim's sighs. Look to detect any movement of chest.
3. Place one of victim's hands under his/her buttock (e.g. right arm under right buttock).

4. Bend one leg opposite the hand underneath the buttock (e.g. the hand underneath the buttock is the right hand, thus leg bended should be left leg, and so is the opposite).

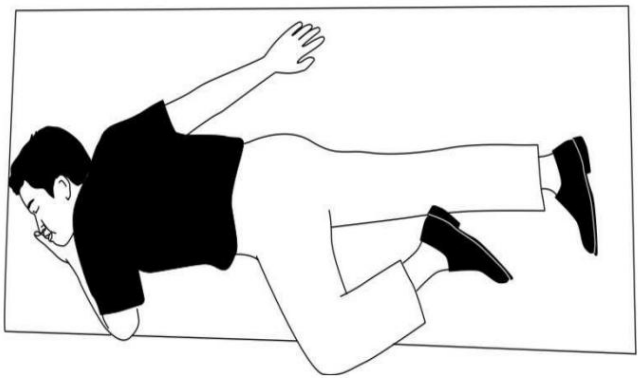
5. Arrange victim to slant to the hand underneath the buttock (e.g. right hand underneath the buttock, thus victim should slant to the right)

6. Arrange left leg position until the knee and place foot sole firmly on the floor.

7. Move right hand (from underneath the buttock) to the back of the body so that it is not pinned under the body.

8. Place left hand back under the right cheek. Tilt victim's head upward so that breathing is smooth

9. The victim is in final stable position.



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Chapter 8

Psychosocial Support in Disaster Management

Introduction

Psychosocial support represents an essential dimension of disaster intervention practices, focusing on the mental, emotional, social, and spiritual well-being of individuals and communities affected by disasters. While physical rehabilitation and infrastructure restoration are critical, the invisible psychological wounds left by disasters often persist much longer and can impede both individual and societal recovery. Psychosocial support is therefore an integral component of comprehensive disaster risk reduction (DRR) strategies and humanitarian response frameworks. It aims not only to alleviate immediate distress but also to foster resilience, restore social functioning, and rebuild community cohesion.

In the context of disaster management, psychosocial support encompasses a range of interventions designed to help affected populations cope with trauma, loss, displacement, and uncertainty. These interventions include psychological first aid (PFA), counselling, community-based support, rehabilitation programs, and capacity building for responders. The approach integrates psychology, sociology, social work, and public health, ensuring that disaster response addresses the holistic needs of survivors. International organizations such as the World Health Organization (WHO), International Federation of Red Cross and Red Crescent Societies (IFRC), and United Nations Office for Disaster Risk Reduction (UNDRR) have recognized psychosocial support as a core component of humanitarian assistance.

Understanding Psychosocial Impact of Disasters

Disasters—whether natural or man-made—can have profound effects on the psychosocial well-being of individuals and communities. These effects range from acute stress reactions and anxiety to chronic disorders such as depression, post-traumatic stress disorder (PTSD), substance abuse, and suicidal behaviour. The psychosocial impact depends on the type, magnitude, and duration of the disaster, as well as the individual's coping mechanisms, social support systems, and cultural context.

Immediately following a disaster, individuals may experience shock, disbelief, confusion, and fear. As time progresses, feelings of grief, anger, hopelessness, and survivor's guilt may emerge. Community structures, relationships, and traditional coping networks often break down, leading to increased social isolation. Displacement, loss of livelihood, and the

destruction of familiar environments further exacerbate psychological distress. Children, elderly individuals, persons with disabilities, and marginalized groups are often disproportionately affected.

From a community perspective, disasters can erode trust, weaken social capital, and disrupt cultural identity. Entire communities may experience collective trauma, which manifests through behavioural changes such as aggression, substance use, or apathy. Psychosocial interventions, therefore, aim to restore a sense of normalcy, belonging, and purpose.

Concept of Psychosocial Support

The concept of psychosocial support is centered on promoting the resilience and well-being of individuals, families, and communities during and after crises. It recognizes that disasters and emergencies affect people not only physically but also psychologically and socially, disrupting their sense of safety, stability, and belonging. Psychosocial support, therefore, encompasses a range of actions and processes designed to help individuals and communities recover emotionally, regain a sense of normalcy, and rebuild their social structures. It is not limited to clinical mental health care but extends to strengthening social relationships, community solidarity, and coping mechanisms that enable people to face adversity with confidence and hope.

At its core, psychosocial support is based on the understanding that human beings are social and emotional entities whose mental well-being is deeply intertwined with their environment and community. When disasters strike, individuals may experience fear, loss, trauma, or disorientation, while communities may face fragmentation, displacement, and loss of social cohesion. Effective psychosocial support thus integrates both psychological care—addressing emotions, thoughts, and behaviours—and social interventions—fostering supportive networks, collective activities, and cultural practices that promote recovery.

The guiding principles of psychosocial support, as described in trauma psychology literature, are safety, calmness, connectedness, self-efficacy, and hope. Safety refers to creating an environment in which individuals feel physically protected and emotionally secure. Calmness involves restoring emotional stability and reducing stress through reassurance, structure, and comfort. Connectedness emphasizes the importance of interpersonal relationships, family bonds, and community networks in healing and recovery. Self-efficacy focuses on empowering individuals to regain control over their lives and make meaningful

decisions. Hope, the final principle, is essential for inspiring optimism and motivation to rebuild and move forward after loss or trauma.

The purpose of psychosocial support extends beyond immediate emotional relief; it aims to restore emotional balance, rebuild social networks, and encourage adaptive coping. It also plays a crucial role in reintegrating individuals into daily routines, promoting collective recovery, and fostering participation in the rebuilding process. The long-term objective is to help individuals and communities not merely return to pre-disaster conditions but to emerge stronger and more resilient against future challenges.

Psychosocial support functions across three interconnected levels—individual, community, and institutional. At the individual level, interventions may include counselling, therapy, and activities that promote self-expression, problem-solving, and emotional regulation. These interventions help individuals process their experiences, cope with loss, and regain confidence. At the community level, psychosocial support seeks to strengthen social bonds through participatory activities, community gatherings, cultural rituals, and mutual help networks. Such initiatives encourage solidarity, trust, and collective healing, ensuring that no one feels isolated or forgotten. At the institutional level, psychosocial support becomes part of a broader disaster management framework through the development of supportive policies, coordination mechanisms, and capacity-building programs. Governments, humanitarian organizations, and mental health institutions work together to ensure that psychosocial considerations are integrated into preparedness, response, and recovery phases of disaster management.

Ultimately, the concept of psychosocial support is grounded in the belief that healing after disaster is both an emotional and social process. It highlights the need to address human suffering holistically—acknowledging that rebuilding lives involves not only repairing damaged infrastructure but also nurturing minds, relationships, and communities. Through compassion, participation, and empowerment, psychosocial support helps transform vulnerability into resilience and despair into hope, ensuring that recovery is both sustainable and humane.

Phases of Psychosocial Intervention in Disasters

The phases of psychosocial intervention in disasters represent a systematic and holistic approach to addressing the mental, emotional, and social needs of affected individuals and communities throughout the disaster management cycle. Each phase—preparedness, response,

recovery, and rehabilitation and development—plays a distinct yet interconnected role in promoting resilience and long-term well-being. Psychosocial interventions are not confined to the aftermath of a disaster; rather, they begin well before an event occurs and continue long after the immediate crisis has subsided, ensuring that individuals and communities are psychologically equipped to face future challenges.

In the preparedness phase, psychosocial support emphasizes proactive measures aimed at building awareness, capacity, and resilience before a disaster occurs. This phase involves training responders, educators, healthcare workers, and community leaders in the fundamentals of psychosocial care and crisis communication. Such training helps ensure that these individuals can respond appropriately to the emotional and social needs of disaster-affected populations. Preparedness also includes developing culturally sensitive communication materials that respect local beliefs, customs, and languages. These materials help normalize conversations around mental health, reduce stigma, and encourage people to seek help when needed. Another critical component of preparedness is the identification of vulnerable populations—such as children, the elderly, persons with disabilities, and marginalized groups—who may require specialized support during and after a disaster. Establishing clear referral mechanisms for mental health and social services is equally important to ensure that individuals in distress are connected with appropriate care providers without delay. Community awareness campaigns, media outreach, and school-based mental health education also strengthen psychological readiness and promote collective responsibility in disaster preparedness.

The response phase begins immediately after a disaster strikes and focuses on addressing the urgent emotional and psychological needs of survivors. This phase prioritizes the delivery of Psychological First Aid (PFA)—a compassionate, practical approach designed to reduce initial distress and foster short-term and long-term adaptive functioning. PFA is not about offering clinical therapy; rather, it centres on ensuring physical safety, providing emotional comfort, listening without judgment, and helping survivors connect to support networks and resources. In the chaotic aftermath of a disaster, trained personnel, volunteers, and community leaders serve as key agents in delivering this assistance. Their presence and reassurance provide survivors with a sense of stability and security amid uncertainty. Effective communication is vital during this stage, as clear, empathetic information helps dispel rumours, reduce panic, and guide people toward safe behaviours and available services. Community mobilization also plays a central role in the response phase. Encouraging affected individuals

to participate in relief activities not only empowers them but also fosters solidarity and mutual support, which are essential for emotional recovery.

The recovery phase extends beyond the immediate response and focuses on long-term emotional healing, social reconstruction, and the restoration of normal life. This phase involves organized psychosocial interventions such as individual and group counselling, peer support sessions, and community-based rehabilitation programs. Schools, community centres, and healthcare institutions often serve as focal points for these activities, providing accessible and familiar environments for survivors to share their experiences and rebuild their confidence. Recovery also includes re-establishing social and family networks, which may have been disrupted by displacement or loss. Rebuilding trust within communities is another key objective, as social cohesion is critical for collective resilience. Livelihood restoration, skill development programs, and educational initiatives further contribute to psychosocial recovery by offering individuals a sense of purpose and stability. Importantly, ongoing monitoring and assessment of psychosocial needs ensure that interventions remain relevant and effective as the recovery process evolves.

The rehabilitation and development phase marks the integration of psychosocial principles into long-term development planning. In this phase, psychosocial interventions are no longer viewed as temporary relief measures but as integral components of sustainable community development, education, and health systems. Institutionalizing psychosocial support means embedding mental health and well-being into policies, governance frameworks, and capacity-building programs. Community volunteers and local leaders are trained to provide ongoing psychosocial assistance, thereby ensuring that mental health services are available at the grassroots level. Partnerships between government agencies, non-governmental organizations, and educational institutions further strengthen this system by creating multi-sectoral support networks. This stage also emphasizes the importance of research, evaluation, and knowledge-sharing to enhance the effectiveness of future interventions. By mainstreaming psychosocial care into development agendas, communities are better prepared to cope with future disasters, reduce vulnerability, and promote overall resilience and social stability.

In summary, psychosocial intervention in disasters is a dynamic, multi-phased process that evolves from preparedness through recovery and into long-term development. Each phase builds upon the previous one, ensuring continuity and sustainability in addressing emotional and social well-being. While the preparedness phase focuses on building capacity and

awareness, the response phase prioritizes immediate emotional support and crisis stabilization. The recovery phase emphasizes healing and social reintegration, and the rehabilitation and development phase ensures institutional and community-level sustainability. Collectively, these phases embody a comprehensive approach to disaster management that acknowledges the central role of mental health and social connectedness in human recovery and resilience.

Psychological First Aid (PFA)

Psychological First Aid (PFA) represents the cornerstone of immediate psychosocial response following disasters. It is a humane, evidence-informed approach that helps reduce initial distress and encourages adaptive coping. Unlike clinical therapy, PFA focuses on offering safety, comfort, empathy, and practical support to affected individuals. It involves listening attentively, assessing immediate needs, and connecting survivors to available resources and services. The approach follows global standards outlined by WHO, UNICEF, and IFRC, which emphasize the principles of do no harm, cultural sensitivity, and respect for human dignity. Key actions in PFA include ensuring physical safety, providing emotional comfort, facilitating communication, and linking survivors to social networks and essential services. Typically, trained volunteers, health workers, and community members deliver PFA in shelters, hospitals, and relief camps during the initial response phase.

Community-Based Psychosocial Support (CBPS)

Community-Based Psychosocial Support (CBPS) focuses on strengthening the social fabric of communities affected by disasters. It is built on the understanding that communities possess inherent resilience rooted in shared values, traditions, and cultural practices. CBPS programs engage local leaders, teachers, youth, and social groups to organize collective healing activities such as community dialogues, remembrance events, and mutual support initiatives. These interventions help normalize emotions, reduce stigma, and encourage solidarity. In many cultural contexts, rituals, festivals, and community gatherings play a therapeutic role in collective recovery. Rebuilding shared spaces such as schools, places of worship, and community halls becomes symbolic of hope and renewal. Active community participation in planning and decision-making enhances ownership, sustainability, and long-term resilience of psychosocial programs.

Psychosocial Support for Specific Groups

Different population groups experience disasters uniquely, necessitating tailored psychosocial interventions.

Children and Adolescents: Children are among the most vulnerable in disaster situations, often facing fear, trauma, and separation from caregivers. Psychosocial programs for children include play therapy, art-based activities, storytelling, and establishing safe spaces to restore routine and security. Teachers and caregivers play a crucial role in early detection of distress and in providing reassurance and stability.

Women: Women often bear disproportionate burdens during disasters due to caregiving responsibilities, loss of livelihood, and exposure to gender-based violence. Women-centered psychosocial support includes creating women-friendly spaces, offering counselling and livelihood training, and establishing peer support groups that promote empowerment and social inclusion.

Elderly and Persons with Disabilities: Older adults and persons with disabilities face unique challenges, including loss of mobility, dependence, and isolation. Tailored interventions focus on ensuring accessibility, inclusion, and dignity. Regular home visits, assistive devices, and volunteer networks contribute to their psychosocial well-being.

Responders and Relief Workers: First responders and humanitarian workers are susceptible to burnout, compassion fatigue, and secondary trauma. Providing peer counselling, rest breaks, and debriefing sessions helps maintain their emotional resilience and ensures sustained response capability.

Integration of RS–GIS in Psychosocial Support Planning

Remote Sensing (RS) and Geographic Information Systems (GIS) provide innovative tools for strategic planning and monitoring of psychosocial interventions. By mapping affected populations, shelters, and damaged infrastructure, RS–GIS helps identify priority areas for mental health and psychosocial support (MHPSS). GIS-based analyses integrating demographic and socio-economic data can pinpoint vulnerable zones and estimate service demand. Moreover, RS–GIS supports the monitoring of recovery trends, showing spatial variations in community resilience and the reach of psychosocial programs over time. This integration enables decision-makers to allocate resources more effectively, enhance coordination, and ensure equitable delivery of psychosocial care in disaster-affected regions.

Case Studies

2004 Indian Ocean Tsunami:

In Tamil Nadu, Sri Lanka, and Indonesia, community-based psychosocial programs were implemented through collaboration among local NGOs, health workers, and religious leaders. Activities like trauma counselling and play therapy for children significantly reduced post-traumatic stress and restored community cohesion.

2011 Japan Earthquake and Tsunami:

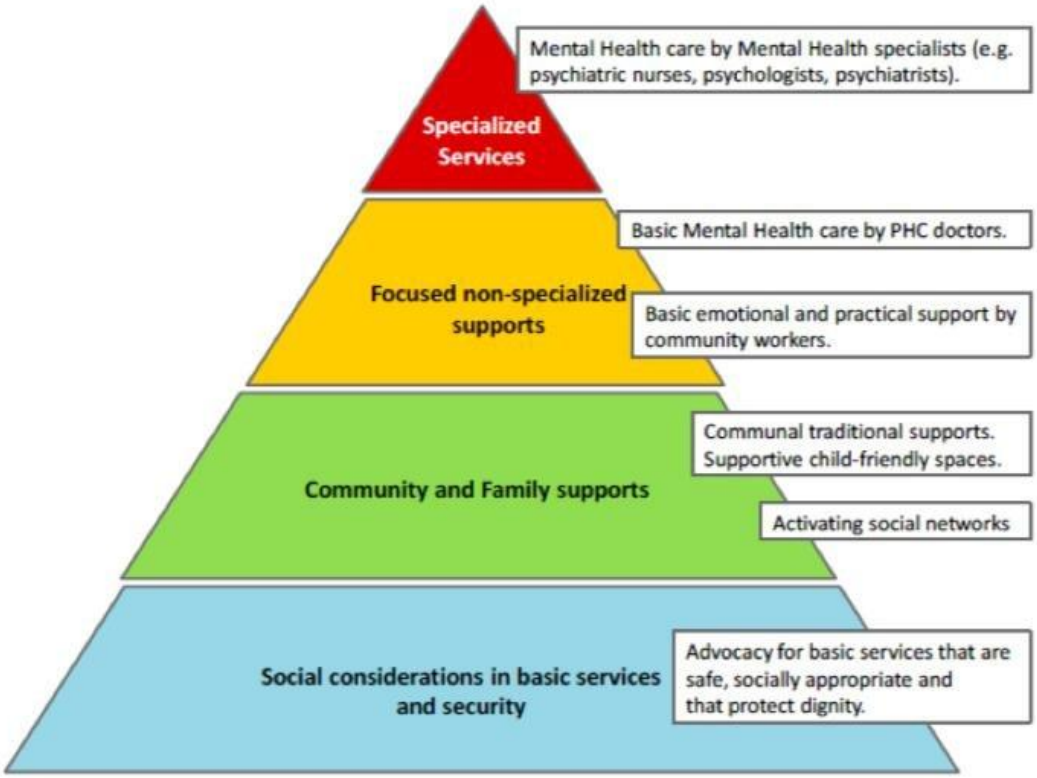
Japan incorporated psychosocial care into its national disaster response framework. Mobile mental health teams visited evacuation centres to provide counselling and psychological screening, while digital platforms facilitated information sharing and peer support.

2015 Nepal Earthquake:

Nepal's psychosocial approach emphasized community resilience through local healing rituals, group discussions, and volunteer-led outreach. GIS mapping of affected villages helped target interventions and ensure equitable service delivery across remote mountainous areas.

Challenges in Psychosocial Support Implementation

Despite increased recognition, psychosocial support often faces challenges such as a shortage of trained professionals, cultural stigma surrounding mental health, and limited integration of psychosocial services in national disaster policies. Funding constraints, fragmented coordination among agencies, and difficulties in measuring psychosocial outcomes also hinder effectiveness. Addressing these issues requires multi-sectoral collaboration, capacity building, and the inclusion of psychosocial considerations in Disaster Risk Reduction (DRR) and health policies. Enhancing community engagement and awareness remains essential for breaking stigma and promoting mental well-being.



Best Practices and International Frameworks

Several global frameworks guide the implementation of psychosocial interventions in disaster contexts. The Inter-Agency Standing Committee (IASC) Guidelines on Mental Health and Psychosocial Support provide an international standard for coordinated response. The Sendai Framework for Disaster Risk Reduction (2015–2030) identifies mental health as a core element of resilience-building. WHO's Mental Health Gap Action Programme (MH GAP) advocates for integrating psychosocial services within primary healthcare systems to ensure accessibility even during crises. National frameworks in countries like Japan, Norway, and India exemplify the integration of psychosocial care with disaster management authorities. The

inclusion of psychosocial indicators in Post-Disaster Needs Assessments (PDNA) further institutionalizes mental health support in long-term recovery planning.

Conclusion

Psychosocial support stands as a vital pillar of disaster intervention, complementing physical and material aid with emotional and social healing. It transforms disaster response from short-term relief to sustainable recovery by nurturing hope, dignity, and resilience. The incorporation of RS–GIS, artificial intelligence, and culturally grounded community engagement enhances the precision and inclusivity of psychosocial interventions. Future strategies must prioritize preparedness through training and awareness, destigmatize mental health discussions, and mainstream psychosocial care across all phases of disaster management. Ultimately, the goal of psychosocial support is not merely to help people survive disasters but to empower them to rebuild their lives with strength, purpose, and collective resilience.

Unit 3

Title: Disaster Management

Dr. C. K. Muthukumar

Chapter 9

Components of Disaster Management: Rescue, Relief, Mitigation, Rehabilitation, Reconstruction

Phases of Disaster

The concept of the Disaster Management Cycle has been incorporated into disaster management efforts over the past few years, especially since the Yokohama Conference (1994). Hitherto, disaster management had been perceived as a short-term relief undertaking, which lasted till sometime after a disaster. Other purposive activities undertaken in the pre- or post-disaster stages on the part of civil society or the government towards mitigating the impact of disasters or tackling long-term vulnerabilities and dealing with newer threats in the wake/ aftermath of a disaster were not included in disaster management activities. They were rather classified, developmental activities or 'social action' on the part of civil society actors(s), motivated by philanthropic concerns.

The concept of Disaster Management Cycle integrates isolated attempts on the part of different actors, government and nongovernment, towards vulnerability reduction or disaster mitigation, within the enveloping domain of disaster management, as phases occurring in different periods in the disaster management continuum, though essentially relating to/comprising disaster management. This has facilitated a planned approach to disaster management in that post-disaster recovery and pre-disaster mitigation planning are perceived as integrated/related activities and not separate. Thus, prevention, mitigation and preparedness form pre-disaster activities in the Disaster Management Cycle and, response, comprising relief, recovery and rehabilitation, are post-disaster activities. Whilst emergency relief and rehabilitation are vital activities, successful disaster management planning must encompass the complete realm of activities and situations that occur before, during and after disasters.

These phases can best be represented as a cycle, which, if followed through public policy, can obstruct future development of disasters by impeding the vicious cycle of cause and effect. These activities are implemented at specific times, the length of any one phase depending on the type of disaster, its breadth and scale. Therefore, one of the key issues in disaster management planning is the allocation of resources at all stages of the disaster cycle, which optimises the total effectiveness of risk reduction activity and maximizes the overall impact of disaster management.

This approach has imparted a more holistic perception to disaster management and has served to integrate disaster management with development planning in that most pre-disaster activities involve activities for vulnerability reduction, like poverty reduction, employment provision etc., which are also mainstream development concerns. Thus, disaster management cycle implies development is essentially/conceptually related to disaster management.

Stages in Disaster Management

Disaster Management efforts are geared towards disaster risk management. Disaster Risk Management "implies the systematic process of using administrative decisions, organisation, operational skills, and capacities to implement policies, strategies and coping capacities of the society

and communities to lessen the impact of natural hazards and related environmental and technological disasters. These comprise all forms of all activities, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects to hazards" (UNISDR, 2004).

There are three key stages of activities in disaster management:

1) Before a disaster: to reduce the potential for human, material, or environmental losses caused by hazards and to ensure that these losses are minimised when disaster strikes;

2) During a disaster: to ensure that the needs and provisions of victims are met to alleviate and minimise suffering; and

3) After a disaster: to achieve rapid and durable recovery which does not reproduce the original vulnerable conditions.

Common perception of disaster management, as explained earlier, is limited to emergency relief and post-disaster rehabilitation. This is so because these two elements are by far the strongest in terms of high-profile visibility, political support and funding provision. Instead of allocating funds before an event to reduce future disasters, action normally only takes place after an event has occurred. The situation is similar to that of preventive health care, where curative medicine is relatively well funded, whilst preventive medicine is not.

The focus on emergency relief also depends on risk perception; that is, whether there is a belief that the disaster could be avoided. If disasters were believed to be of such a scale that it is believed nothing could be done to reduce either the phenomenon or the risk involved, and risk mitigation would not be pressed for/attempted. However, once the belief develops that disaster losses are exacerbated by human agency and could be curbed thereby, disaster risk mitigation would be attempted.

The Disaster Management Cycle

The different phases of disaster management are represented in the disaster cycle diagram overleaf. The Disaster Cycle consists of three stages:

The Disaster Event

This refers to the real-time event of a hazard occurring and affecting the 'elements at risk'. The duration of the event will depend on the type of threat; for example, ground shaking may only occur for a few seconds during an earthquake, while flooding may take place over a longer period. Disasters have a tremendous modifying impact on the physical landscape. Within a few minutes, an entire region is reduced to rubble in the event of an earthquake. The recent Tsunami has permanently altered the physiography of affected coastal areas in Sri Lanka, the Andaman and Nicobar Islands. The impact leads to loss of life and property in affected areas; losses being directly correlated to the vulnerability of the region, physical and socio-economic. Physically weak structures, especially in illegal/informal settlements, give way easily and cause large-scale losses.

Vulnerability is also socio-economic. Weaker sections of society, viz., women, children, the aged and handicapped, mentally infirm, etc., suffer a lot more than their stronger counterparts. Studies have also unearthed a positive correlation between poverty and vulnerability. The poor inhabit the most hazardous physical areas because they are easier to procure and offer added advantages, like proximity to the sea for fishermen or fertile soil for farmers near flood-prone areas, etc., which makes them prone to losses, both of assets and life. The poor also lack the resilience to recover from shock in the aftermath of a disaster. For example, fishermen lose their boats, street-side vendors, the homeless, orphans, widows and beggars fall easy prey to epidemics and insidious activities of unsocial elements like thieves, robbers, pimps, etc

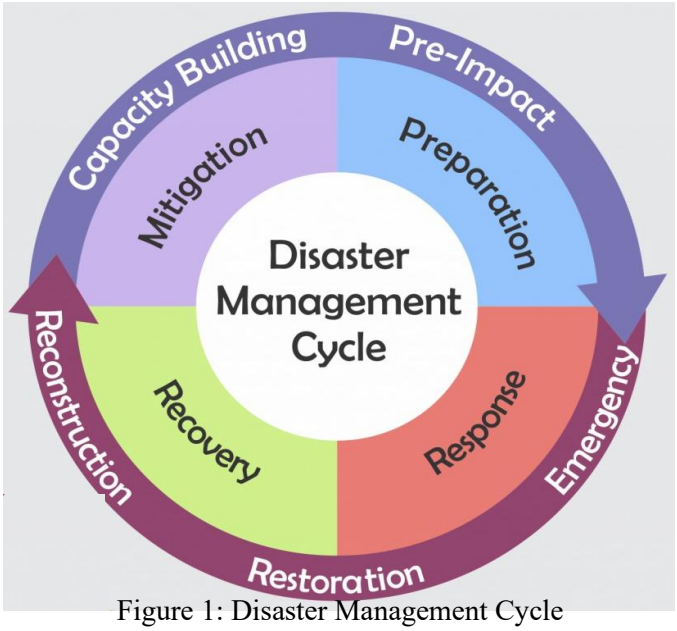


Figure 1: Disaster Management Cycle

This brings to light the need for a multi-faceted response to disasters, which takes account of all social, political and economic ramifications. Issues to be addressed range from physical, relating to damaged structures and physical vulnerability of areas and infrastructure, to social and economic vulnerability of weaker sections that suffer more relative to other, better placed. The following diagram is a vivid description of the disaster cycle.

Prevention

The best way to address a disaster is by being proactive. This means identifying potential hazards and devising safeguards to mitigate their impact. Although this stage in the cycle involves putting permanent measures into place that can help minimize disaster risk, it's important to acknowledge that disasters can't always be prevented.

Prevention involves scenarios such as the following:

- Implementing an evacuation plan in a school, for example, showing teachers how to lead students to safety in the event of a tornado or fire
- Planning and designing a city in a way that minimizes the risk of flooding, for example, with the use of locks, dams or channels to divert water away from populous areas

Developing Skills for Prevention

During the prevention stage, strong analytical skills help leaders identify potential threats, hazards and high-risk areas. Problem-solving abilities are also invaluable in identifying the best ways to avoid or diminish the likelihood of catastrophic events.

Mitigation

Mitigation aims to minimize the loss of human life that would result from a disaster. Both structural and non-structural measures may be taken.

- A structural measure means changing the physical characteristics of a building or an environment to curb the effects of a disaster. For example, clearing trees away from a house can ensure that dangerous storms don't knock down the trees and send them crashing into homes and public buildings.
- Non-structural measures involve adopting or amending building codes to optimize safety for all future building construction.

Developing Skills for Mitigation

Planning is an important skill during the mitigation stage; the disaster-management leader will need to develop strategies and structural changes that can help mitigate potential threats. Spreading awareness is also critical, as community members must be made aware of the steps they can take to prepare for all contingencies

Preparedness

Preparedness is an ongoing process in which individuals, communities, businesses and organizations can plan and train for what they'll do in the event of a disaster. Preparedness is defined by ongoing training, evaluation and corrective action, ensuring the highest level of readiness.

Fire drills, active-shooter drills and evacuation rehearsals are all good examples of the preparedness stage.

Developing Skills for Preparedness

During the preparedness stage, it's important to be skilled in training people to respond to disasters. It's important to stay organized, which is the best way to ensure readiness. Oral and written communication skills prepare laypeople and emergency-response personnel for action in worst-case scenarios.

Disaster Response

A disaster is a catastrophic event that has a severe and transformative impact. Its consequences are both physical and social/human. Communication is disrupted; infrastructure is negatively affected, with many buildings collapsing entirely, critical facilities being disturbed, economic losses occurring, and employment ranging from temporary to permanent being lost. Development experiences significant setbacks; law and order deteriorate; social fabric is disturbed, as parochial tendencies related to caste, communal, linguistic, and other lines emerge. Most importantly, lives are lost. Disaster response must address all these challenges. It involves restoring physical facilities, rehabilitating affected populations,

restoring lost livelihoods, and reconstructing damaged infrastructure. There are valuable lessons to learn from disaster response. Retrospectively, it highlights flaws in policy and planning related to infrastructure location and type, as well as social schemes aimed at improving the social status of the underprivileged, especially regarding access to resources. The aftermath of a disaster is a time for evaluation, revealing system weaknesses within the administrative setup.

A disaster is the ultimate test of administrative efficiency, judging factors such as positive environmental impact, preparedness, procedural simplicity, logistics, speed, and expertise. Important lessons for the future can be derived. A strong infrastructure and service support base are fundamental and critical, yet often lacking in poor third-world countries. Disasters exacerbate existing vulnerabilities caused by inadequate health and hygiene arrangements, inefficient municipal administration, top-down policy approaches, poor institutionalization of development planning at the local level, implementation bottlenecks, unchecked poverty, unresponsive administration, and inadequate informational and logistical systems.

Such critical evaluation as also articulation of displeasure on the part of the people through the electoral mechanism is not as effective in third world countries where elections are fought less on 'rational' criterion and more on ascriptive 'traditional'/'charismatic', criteria, which shifts attention/ focus away from performance to rhetoric which are designed to excite inherent social differentiations based on caste, language or community, etc., which is political demagoguery.

Disaster event brings to the fore such inherent failings of a system; hence is explained the reliance on outside aid is often found misdirected and misused due to a lack of familiarity with local circumstances in recipient countries and rampant corruption in disbursements due to poor administrative infrastructure. Since the Risk Perception of disasters is low in developing countries, pressure for policy in this regard is not strong enough. Hence, pressure for disaster management policy/planning in developing countries is articulated externally, that is, on the part of external/ international bodies like the International Red Cross and Red Crescent Societies, and the UNDP, the ISDR, etc., based in the United Nations, which may not always be guided by local concerns.

Hence, proactive planning for disaster response on the part of governments, especially in developing countries, concerning administrative reforms is imperative to protect development and/lessen the disaster potential of a catastrophe, natural or man-made or otherwise, by way of policy interventions to ensure:

- Better institutional preparedness;
- Countering contrary pulls such as lack of social cohesion owing to irrational differentiations that effectively impede response, in the sense of self-help and 'communitarianism'; and
- Long- term mitigation policy to counter vulnerabilities, structural and non- structural by enabling legal provisions and honest implementation of the same.

Significance of Response

Response has an immediate mitigation impact. Disaster losses can be minimised to a large extent by effective response on the part of government and civil society. The sheer impact of disasters on life and property endorses the significance of response. Globally, natural disasters account for nearly 80 per cent of all disaster-affected people. The insurance industry estimates that natural disasters represent 85 percent of insured catastrophe losses globally.

World Disasters Report (2003) focuses on ethics in humanitarian aid. It looks at how humanitarian agencies and governments can best help disaster-affected communities to recover, to become stronger and more resilient. It addresses issues like how the gaps between short-term relief and longer-term recovery can be bridged. There is growing concern over the politicization of disaster relief. "Millions of the world's most vulnerable remain beyond the reach of humanitarian assistance and protection. Saving lives alone is not sufficient. Respecting people's dignity and livelihoods is equally important. Humanitarian organizations bear two responsibilities. They must operationalise humanitarian principles by developing field indicators to put principles into practice and disseminate good practice in humanitarian judgement." Acting in tandem with local communities, particularly the vulnerable segments, this could be done.

There is also criticism of over-reliance on high-profile aid operations to save lives when long-term investment in disaster mitigation at the local level has proven to be much more effective. No international aid effort was necessary when the worst hurricane since 1944 hit Cuba in 2001 but only five people died. Local mechanisms were in place to evacuate 700,000 people from Havana and other threatened areas. Of the 53,000 people rescued from the flood waters in Mozambique's two great floods, local people saved 34,000 (IRCRCS).

In 1996, 40 million disaster-affected people depended on humanitarian assistance, a 60 per cent increase over the average figure of 25 million in the 1980s. In the first half of this decade, over US$ 30 billion was spent on humanitarian assistance. The average cost of natural disasters over the past 25 years stands at over US$ 87 billion a year (CRED, 1999). The average amount spent on humanitarian response is US$ 3 billion a year. Compared to expenditure on disaster mitigation, the average annual global military spending is around US$ 780 billion (UNDP, 1998, in India Disasters Report, 2005). The World Disasters Report of 2002 states that thousands of lives are lost and millions of people are left weakened each year because of donor reluctance to invest in measures that reduce the impact of disasters. Last year alone, the lives of 170 million people worldwide were disrupted by disasters.

Investing in mitigation issues like building long- term resilience of vulnerable communities would better serve the purpose of disaster management. There are reports of widespread corruption/leakage in disaster relief disbursements. Besides, business interests press on public policy, as there are huge profits involved in reconstruction activities. It is also asserted that disaster mitigation as part of the development process can minimise economic losses from disasters. However, Disaster Mitigation refers to a future perspective of development. Immediate concern of minimising disaster losses can be attended only by efficient and quick disaster response.

Governments have been known to suffer political losses in the follow- up elections after a disaster. For example, the Polish government suffered terrible election loss after alleged disastrous handling of the disaster situation, following extensive flooding of Central Europe in 1997. Unprecedented downpour lasted two weeks from July 5 onwards and affected large masses of people in Poland and the Czech Republic. In total more than 100 people were killed, countless rendered destitute and about 160,000 people in Poland and the Czech Republic, respectively, had to be evacuated. While the Czech and Polish governments were cash-strapped, Germany's handling of the situation was much better due to its better financial position (Parasuraman & Unnikrishnan, 2005, India Disasters Report). Hence, preparedness, understood as readiness of the administrative apparatus in terms of logistics such as medical supplies, hospitals, doctors, temporary shelters etc., is crucial for disaster response.

Issues in Disaster Response

The keyword in disaster response is coordination between actors involved, viz., the government and civil society, including international donor organisations. For effective coordination, local government infrastructure has to be strong as response effort is channelized/ concentrated at the local level. Unfortunately, local governance has not been sufficiently institutionalized in India. That makes service delivery inefficient. Common administrative problems, like maintenance of health and hygiene in their respective areas, good drainage, and open spaces in settlement vicinities, largely go unattended. This creates vulnerability to disease owing to system failure, manifested as water accumulation following floods, physical vulnerability of informal settlements, where most deaths are reported during catastrophes like earthquakes etc. Coupled with institutional failure, there are negative sociological dynamics like rural to urban migration, which exacerbate problems like congestion and poor basic services in urban areas and possibly, ethnic and communal tensions.

Civil society is contributing significantly to all aspects of disaster management cycle, particularly, relief. Civil society is the new hope of the new world order in the face of state and market failure in different respects. It is being seen as the answer/alternate / counterpoise to globalisation and weakening states. Civil society is hence, the buffer against state excesses and the market; the latter now developing in collusion with state governments, hence sharing interests with it, especially in the third world. In the newfound nexus, citizen could be a mute spectator, unless there are optional protection mechanisms. Civil society, in this respect offers new hope in that it has fought successfully for human causes round the world, such as landmine ban, protection of environment etc. It has also successfully challenged arbitrary political regimes such as Marcos's in Philippines. However, there is the darker side, which should not be overlooked. The civil strife in Rwanda involved civil society organisations in a negative way (Rieff, 1999). Besides, civil society is an inseparable/organic entity of a culture; the members therefore could be as indoctrinated as any with flawed perceptions. Also, perceiving civil society as an alternative to State (roll back of state) would be a fundamental error, as all said and done, State remains the principal agency for citizens' welfare and it is to it that people turn in distress situation.

Also, civil society organisations work systematically only under the aegis of the state. Left alone, they are an amorphous entity; potentially perhaps, chaotic. Also, their international linkages/origin make them suspect with regard to national security.

Behavioural aberration on their part in the sense of being generally non-cooperative with and distant from the state is also discomfiting. During the Marathwada earthquake, non-government organisations were seen to leave work midway and withdraw. They were also not organised and systematic to the desired degree. They even messed up, creating unnecessary chaos in the recent Muzaffarabad earthquake. As articulated in the India Disasters Report, 2005, crises in Marathwada and other places in India showed that the involvement of local people and civil society groups in rescue and relief was not a clearly defined process.

According to Parasuraman and Unnikrishnan in the India Disasters Report (2005), the specific arenas where civil society participation is desirable should be specifically laid down to avoid chaos and confusion in emergencies. Those are: training project staff, information dissemination, programme monitoring, housing, and social and economic rehabilitation measures. They, in turn, must be given adequate room to explore and innovate. The agencies must submit a time-bound plan of action, outline their approach unambiguously, clearly defining their specific roles, articulating a programme management strategy, and must establish that they have the necessary resources to see things through.

The converse picture is equally important. Attitudinal change on the part of the governments to reinforce participation is also required. The response in the Marathwada earthquake exhibited that the government views rescue and relief work as a piecemeal business; the responsibility of its revenue department, and therefore, public support need not be factored into it. In the absence of a well-defined process of involving people, spontaneous involvement has often gone misdirected and is viewed as an obstruction by the authorities. The overall perspective of the administration is to view people as passive recipients of government largesse rather than as valuable partners in any undertaking. This is retrograde and undemocratic. The general perception is that people impede disaster response, not facilitate it. The result is too many isolated, ill- coordinated efforts on the part of individuals and government and non-government agencies, with a lack of proper coordination between them.

Institutionalisation/strengthening social capital during normal times to be tapped in readiness during emergencies in the form of organised collective effort at the level of society is the right policy stance in this regard. The desideratum of the discussion is that government and civil society and the private corporate sector should operate in tandem for effective disaster response.

The most desirable virtue in ‘good governance’ that is often asserted/reiterated in public administration literature is people’s participation. But it is rather confusing as to participation, in what way? Studies suggest that participation succeeds only when it is invoked by the state, such as government planners eliciting people’s opinion on the choice of site for relocation or local craftsmen in structure design and/or implementation. Even where major effort is on the part of people in the form of self-help, the catalytic state role would be no less significant. One cannot even say with any degree of

assurance that the state has weakened since the 'roll back' got underway. Hence, guarded optimism about civil society activism is needed. It is a welcome development but needs to be tempered with justifiable criticism.

Recovery

The recovery phase involves the implementation of actions to promote sustainable redevelopment (reconstruction, rehabilitation) following a disaster. It covers long-term measures like rebuilding houses, assets, infrastructure, school buildings, hospital buildings, and other public buildings. It is a process undertaken by a disaster-affected community to fully restore itself to its pre-disaster level. Recovery is the activity that returns infrastructure systems to minimum operating standards and guides long-term efforts designed to return life to normal or improved levels after a disaster. Recovery is also sometimes used to describe the activities that encompass the three overlapping phases of emergency relief, rehabilitation and reconstruction. The chief behavioural attribute required in recovery is resilience. As highlighted in the World Disasters Report, 2004, community resilience is a big factor in disaster recovery. Recovery is used to describe the activities that encompass the three overlapping phases of emergency relief, rehabilitation and reconstruction.

Emergency Relief

Emergency relief refers to the period immediately following the disaster when steps are taken to meet the needs of survivors for shelter, water, food, and medical care. Activities undertaken during and immediately following a disaster include immediate relief, rescue, damage and needs assessment, and debris clearance. Rescue and relief are critical elements of response. As expressed in the India Disasters Report (2005), voluntary effort on the part of people, if recognised and institutionalised as supplementary to official government effort, could substantially minimise loss of life if not property to that extent. This would necessitate institutional/ organisational improvements by way of better delegation to field agencies, improvements in decision-making and communication processes, incorporation of indigenous traditional knowledge on warning signs, a cartographic knowledge of safe and unsafe areas, survival methods, and traditional forms of insurance built around kinship and families. The most crucial aspect in relief and rescue is communication across involved agencies. Disaster zone is often equated with a war zone, where communication is the critical factor, often, crucial, in fact, the deciding factor between success and failure.

Rehabilitation

Rehabilitation implies activities that are undertaken to support the victims' return to normalcy and re-integration in regular community functions. It may include the provision of temporary housing and public utilities as interim measures to assist longer-term recovery through permanent housing and infrastructure. Besides physical elements, rehabilitation programmes also include economic rehabilitation through livelihood recovery and support actions and finding alternate employment options for those who cannot get back to their original occupations due to irreparable damage.

Rehabilitation also includes psycho-social rehabilitation for those who are badly traumatised and need support in terms of psychosocial counselling or even medication in some cases.

Rehabilitation therefore includes the provision of temporary employment and restoration of lost livelihoods. Actual strategy adopted in rehabilitation would be dictated by circumstances, condition of the physical landscape, state of economic activity, whether relocation of affected communities is necessary, or whether resumption of normal life could take place in that region itself. It is important to incorporate past lessons in rehabilitation. Vulnerability mapping is recommended for identifying areas where access is to be completely restricted and the safe areas for viable construction activity.

Rehabilitation policies suffer due to short-term perspective, in that they are pursued as unplanned, ad-hoc measures. Rehabilitation is not factored in wider development strategy. A study conducted by the UNDP in the 1980s which focused on disaster mitigation efforts in Bangladesh, Ethiopia, and Ecuador, concluded that disaster preparedness and prevention is most effective only when it is built into the larger scheme of sustainable development, which enhances social opportunity and economic growth. Desired approach was followed in Marathwada with conspicuous benefits. Those affected by the later Uttarkashi earthquake, or the even more recent Jabalpur earthquake suffered for lack of policy in this regard.

Also, people are expected to access regular government welfare schemes for relief in disaster situations, which is difficult, given the exigent circumstances. Crucial factor in rehabilitation as borne out by experiences from past disasters is training of personnel in various aspects of rehabilitation, such as special concerns of widows and orphans, with respect to health and livelihood requirements, besides community participation in damage and loss assessment and vulnerability analysis.

Reconstruction

Reconstruction attempts to return communities to improved pre-disaster functioning. It includes the replacement of buildings, infrastructure and lifeline facilities such as roads, bridges and communication links, so that long-term development prospects are enhanced rather than reproducing the same conditions that made an area or a population vulnerable in the first place. Mitigation measures can effectively be incorporated into reconstruction since there is generally" openness" to change and improved safety following a disaster event. Hence, this is mainly the technocrat's arena of function/action.

Post-modern thinking, as also referred to earlier, is impacting urban planning in a major way. Instead of 'modernist' emphasis on uniformity, diversity is being lauded as the desired virtue. Accordingly, indigenous knowledge is being incorporated in modern engineering technology to produce viable structures in earthquake, flood and cyclone-prone areas. Physical vulnerability of structures causes maximum disaster casualties. Hence, stress is also on retrofitting old structures with a view to making them disaster-resistant besides making new ones with disaster-resistant technology. Also, instead of the old cluster approach to housing, which, as more in consonance with industrialisation would be changed for more differentiated housing and open spaces, which would provide for more

aesthetic and safer cities. From a social perspective, modern cities have increased isolation and alienation of human beings. This has led theorists in the West to talk about 'social capital' as it is increasingly getting scarcer in modern societies that are getting 'atomised'. Social capital is an intangible resource that invests in social ties, which proves an invaluable resource in recovery during emergencies. In simple terms, it means people reaching out to each other and helping rebuild lives. Isolation is counter-effective to social capital.

Development

The inclusion of development as a phase in the disaster cycle is intended to ensure that, following the natural disaster, societies factor hazard and vulnerability considerations into their development policies and plans in the interest of overall progress. The rationale behind the use of the expression 'disaster management cycle' is that disaster and its management are a continuum of inter-linked activities. It is sometimes also referred to as the 'disaster-development cycle', implying that disasters are periodic phenomena and occur regularly in such a way that there is development, followed by a disaster, then back to development till the next disaster. Yet, such expressions are slightly deceiving in that they suggest that the periodic occurrence of disasters is something inevitable, always requiring the same response.

On the contrary, if effective prevention and preparedness measures are implemented, natural disasters may be avoided by limiting the adverse impact of inevitable natural phenomena. Sustainable development is another term that is useful in this context, implying development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts of 'needs' in particular, to the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organisation on the environment's ability to meet the present and the future needs.

Illustration of Disaster Cycle through Case Study

The processes covered by the disaster cycle can be illustrated through the case of the Gujarat Earthquake of 26 January 2001. The devastating earthquake killed thousands of people and destroyed hundreds of thousands of houses and other buildings.

The State Government, as well as the National Government, immediately mounted a large-scale relief operation. The help of the Armed Forces was also taken. Hundreds of NGOs from within the region and other parts of the country, as well as from other countries of the world, came to Gujarat with relief materials and personnel to help in the relief operations. Relief camps were set up, food was distributed, mobile hospitals worked around the clock to help the injured; clothing, beddings, tents, and other commodities were distributed to the affected people over the next few weeks.

By the summer of 2001, work started on long-term recovery. House reconstruction programmes were launched, community buildings were reconstructed, and damaged infrastructure was repaired and reconstructed. Livelihood programmes were launched for the economic rehabilitation of the affected people. In about two years, the state had bounced back and many of the reconstruction projects had

taken the form of developmental programmes aiming to deliver even better infrastructure than what existed before the earthquake. Good road networks, water distribution networks, communication networks, new schools, community buildings, health and education programmes, all worked towards developing the region.

The government as well as the NGOs laid significant emphasis on safe development practices. The buildings being constructed were of earthquake resistant designs. Older buildings that had survived the earthquake were retrofitted in large numbers to strengthen them and to make them resistant to future earthquakes. Mason and engineer training programmes were carried out at a large scale to ensure that all future construction in the State is disaster resistant. Since the state is also drought and cyclone affected, building construction for cyclone resistant housing was propagated in the coastal areas, and water harvesting systems were given a thrust for drought mitigation.

A preparedness programme was taken up in earnest by the government and the NGOs. Community awareness campaigns were carried out on dos and don'ts for different kinds of disasters. These told people what to do and what not to do before, during and after a disaster. School safety programmes were taken up under which, teachers, students and parents were trained on how to prepare for a disaster and how to respond to one. Disaster management plans were prepared for the state, districts, local areas and schools. A system of drills and plan updating was established. All of this contributed to a higher level of preparedness in the state.

Subsequently, hazardous events struck the state again. There was a cyclone warning in 2004, which was responded to with a very efficient evacuation implemented by the government and the NGOs. The community was already aware of the evacuation plan and was trained how to react. Similarly, major floods hit the state in June-July 2005. Once again, the role allocation was clear to all the concerned stakeholders in the government as well as the NGOs and the community too knew how to help the relief teams help them. Losses were minimised, and the relief and rehabilitation process went off smoothly

This case study shows how there was a disaster event during the earthquake, followed by immediate response and relief, then by recovery, including rehabilitation and retrofitting, then by developmental processes. The development phase included mitigation activities and finally preparedness actions to face future disasters. Then disaster struck again, but the impact was less than what it could have been, primarily due to better mitigation and preparedness efforts. The disasters were again followed by response and recovery, and the cycle goes on.

Risk Reduction: Mitigation and Preparedness

The Risk Reduction is chronologically the latest paradigm for mitigating the impact of disasters. The precursor to the Risk Reduction approach is the Total Disaster Risk Management Approach (TDRM). Guzmann (2005) explains the essentials of the approach. The TDRM approach is the immediate forerunner of the Risk Reduction Framework, which is currently being emphasised. In the Isephan Typhoon in 1959, Japan suffered heavy losses. A ferryboat sank in Bangladesh in a cyclone on

May 3, 2002, killing 450 passengers. These disasters could have been prevented if close cooperation between the concerned organisations had been achieved.

The TDRM Approach The strategic objectives of the TDRM Approach, as explained in the Regional Workshop on TDRM, held in 2001 at Kathmandu, organised by the Asian Disaster Reduction Centre (ADRC) and OCHA, Kobe, are as follows:

1) "To address holistically and comprehensively the various concerns and gaps in the different phases of the disaster management cycle by considering the underlying causes of disasters (that is, the conditions of disaster risks) and the contextual factors in disaster risk and its management.

2) Enhancement of local capacity and capability, especially in disaster risk management as part of a decentralised approach and build a reliable database for policy reference.

3) To promote multilevel, multidimensional and multidisciplinary coordination and collaboration among stakeholders in disaster reduction and response. This broadening involvement of various sectors previously less concerned with disaster reduction and response is a positive development."

The proposed implementation strategies for the TDRM Approach are the following:

1) Achieving effectiveness in disaster reduction and response through multilevel, multidimensional and multidisciplinary cooperation and collaboration, engaging all concerned stakeholders/organisations and political actors. Emphasis is on networking which can harness positive organisational potential by complementing in strategic areas and bridging knowledge gaps.

2) Making decisions based on reliable disaster risk information derived from hazard mapping and vulnerability assessment. The TDRM Approach attaches great importance to hazard mapping and vulnerability assessment as a fundamental tool for generating reliable disaster risk information, which serves as basis for making decisions on disaster reduction and response interventions, including the best use of limited resources.

3) Enhancing coordination and integration of stakeholders' action through good communication and efficient exchange of relevant and reliable information exchange of critical disaster risk information, which could enhance coordination and integration of stakeholders' actions in disaster reduction and response. However, ensuring the availability and accessibility of accurate and reliable disaster risk information when required entails an efficient system for information sharing. In this regard, an efficient disaster risk management information system is important. Moreover, it should be effectively linked to local early warning systems, local authorities and the media, to ensure effective use of disaster risk information for public awareness and education, among other important activities such as strategizing for quick response.

4) Ensuring that appropriate enabling mechanisms are in place, including policy, structure, capacity building, and resources.

The following enabling mechanisms support the successful implementation of the TDRM Approach:

1) Policy:

Establish a clear and comprehensive policy that defines the objectives and commitment of the government, organisation, or community to disaster reduction and response efforts. This may assume the form of a law, policy guidelines, or promulgated plans, or protocols. A policy developed through a strategic and consultative planning process could effectively address the identified gaps in the disaster management cycle.

2) Structures and systems:

Establish organisational structures and systems that facilitate and ensure coordination of stakeholders' action and puts contributions in place. This involves the establishment and strengthening of focal points and coordination bodies.

3) Capacity-building:

The enhancement of national and local capacity to establish and implement disaster reduction and response measures, especially for vulnerable sectors and communities. This is a regular undertaking.

4) Resources:

The identification and provision of resource requirements, including funds and trained human resources. This includes the means to access and use authorised fund appropriations for disaster reduction and response. These enabling mechanisms are more effective when sustained by institutional enthusiasm, political commitment, focal points and committed advocates in government.

5) Implementation:

Implement the disaster risk management process from the national level to the community level in continuation. The disaster risk management process is a process for good decision-making and for ensuring the best use of limited resources. It applies standard principles, process and techniques of risk management to disaster management. The process presents a framework and a systematic method for identifying and managing disaster risks in six systematic steps, as under:

- Establish the disaster risk context
- Identify the disaster risks
- Analyse the disaster risks
- Assess and prioritise the disaster risks
- Treat the disaster risks
- Lastly, monitor, review and communicate

In general, this process aids decision makers in determining possible outcomes of risks and undertakes appropriate measures to control or mitigate their impact based on reliable information and the available resources. In this regard, disaster risk management promotes good disaster management practice and, therefore, should be implemented in all sectors.

Pertinence of TDRM for Disaster Management Cycle

Based on the above explanation, the TDRM Approach is a purposive approach that addresses holistically and comprehensively the various concerns and gaps in the different phases of the disaster management cycle. It focuses on the underlying causes of disasters, the conditions of disaster risks and the vulnerability of the community. It also emphasises multi-level, multi-dimensional and multi-disciplinary cooperation and collaboration in achieving effective disaster reduction and response. This approach intends to integrate, complement, and enhance existing disaster reduction and response strategies. Moreover, the TDRM Approach could serve as a framework for policy action in identifying and addressing the gaps in existing policies, programs, structures, systems and resources towards more efficient and effective implementation of disaster reduction and response activities. Of fundamental importance in the TDRM Approach is hazard mapping and vulnerability assessment. This diagnosis helps ensure good decisions in choosing appropriate interventions and in ensuring the best use of limited resources.

Overall, the TDRM Approach presents a creditable disaster management strategy by way of enhanced efficiency in disaster reduction and response, and cost effectiveness through sound allocation of limited resources. The challenge at hand is to explore opportunities and initiatives to pilot the TDRM Approach at the provincial and community levels. It is also crucial to build consensus and political commitment at the highest level for adopting the TDRM Approach as a strategy to address effectively, the prevalence of disaster risks, the current state of disasters, and the existing gaps in the disaster management cycle. Reducing the risk of disasters involves activities, which either reduce or modify the scale and intensity of the threat faced or by improving the conditions of 'elements' at risk. Although the term 'prevention' is often used to embrace the wide diversity of measures to protect persons and property, its use is not recommended since it is misleading in its implicit suggestion that natural disasters are preventable. The use of reduction to describe protective or preventive actions, which lessen the scale of disasters, is therefore preferred. Even with effective preparedness and mitigation measures being in place it is realistic to expect some level of damage from extreme natural forces.

Risk Reduction is the end to which the TDRM is geared. Chronologically, the earlier approaches to disaster management have been the comprehensive approach, based on factoring articulated risks in public policy; the integrated approach, stressing inter-sector administrative coordination and organising work, within organisations, with a disaster management orientation, through required modifications in structure, such as, rearranging hierarchy to promote team work, specialist expertise, etc.; the prepared community approach, stressing harnessing social capital to build disaster resilience through training workshops, organising volunteer effort et al and the developmental relief approach, implying administering relief with a long-term development perspective, such as, building pucca roads, where communication is found wanting and not some temporary arrangement as a kuccha pathway. The TDRM incorporates all articulated concerns and gears it towards the 'end' objective of Disaster Risk Reduction.

Risk reduction can take place in two ways:

1) Long-term Mitigation

Mitigation embraces all measures taken to reduce both the effect of the hazard itself and the vulnerable conditions in order to reduce the potency of a future event. Therefore, mitigation activities can be focused on the hazard itself or the elements exposed to the threat. Examples of mitigation measures which are hazard specific, include; modifying the occurrence of the hazard, for example, water management in drought prone areas, avoiding the hazard by siting people away from the hazard and strengthening structures to reduce damage when a disaster occurs.

In addition to these physical measures, mitigation should also be aimed at reducing the physical, economic and social vulnerability to threats and the underlying causes for the same. Therefore, mitigation may incorporate addressing issues such as land ownership, tenancy rights, wealth distribution, etc.

Some common mitigation measures are:

- Hazard Assessment
- Vulnerability Analysis
- Risk Assessment
- Vulnerability Reduction/mitigation strategies (structural and non-structural)
- Integration of disaster risk reduction activities in all development activities
- Disaster-resistant buildings and infrastructure
- Awareness among the community
- Preventing habitation in risk zones.

2) Short-term Preparedness

This protective process embraces measures which enable governments, communities and individuals to respond rapidly to disaster situations to cope with them effectively. Preparedness includes the formulation of viable emergency plans, the development of warning systems, the maintenance of inventories and the training of personnel. It may also embrace search and rescue measures as well as evacuation plans for areas that may be 'at risk' from a recurring disaster.

Preparedness, therefore, encompasses those measures that are taken before a disaster event, which are aimed at minimising loss of life, disruption of critical services, and damage when the disaster occurs. All preparedness planning needs to be supported by appropriate legislation specifying clear allocation of responsibilities and budgetary provisions for specific activities.

Some common preparedness measures are:

- Forecasting and warning systems for different disasters
- Emergency management plans for responsible agencies (for monitoring, alert and evacuation, immediate disaster assistance, deployment of search and rescue teams and distribution of relief material, etc.)
- Community awareness and education

- Preparation of disaster management plans for the community
- Mock drills, training and rehearsals.

Chapter 10

Institutional framework: Disaster Management Act, 2005; National and State Disaster Management Authorities.

Disaster Management Act, 2005

The Disaster Management Act provides for the effective management of disasters and for matters connected therewith or incidental thereto. It provides institutional mechanisms for drawing up and monitoring the implementation of the disaster management. The Act also ensures measures by the various wings of the government for the prevention and mitigation of disasters and prompt response to any disaster situation.

Containing 11 chapters and 79 sections, the Act received the assent of the President of India on 23rd December 2005.

The Act provides for the setting up of a National Disaster Management Authority (NDMA) under the Chairmanship of the Prime Minister, State Disaster Management Authorities (SDMAs) under the Chairmanship of the Chief Ministers, and District Disaster Management Authorities (DDMAs) under the Chairmanship of Collectors/District Magistrates/Deputy Commissioners. The Act further provides for the constitution of different Executive Committees at the national and state levels. Under its aegis, the National Institute of Disaster Management (NIDM) for capacity building and the National Disaster Response Force (NDRF) for response purposes have been set up. It also mandates the concerned Ministries and Departments to draw up their own plans in accordance with the National Plan. The Act further contains provisions for financial mechanisms such as the creation of funds for response, the National Disaster Mitigation Fund, and similar funds at the state and district levels for disaster management. The DM Act, 2005, also envisages specific roles to be played by the local bodies in disaster management.

National Disaster Management Authority (NDMA)

The Prime Minister of India chairs the National Disaster Management Authority, which has a maximum of nine members, including a Vice-Chairperson. The Chairperson of the National Authority may designate one of the members nominated under clause (b) of sub-section (2) to be the Vice-Chairperson of the National Authority. All members will serve a five-year term. The NDMA is responsible for establishing policies on disaster management and guidelines that various ministries, departments of the Government of India, and state governments must follow to implement measures for disaster risk reduction. It has also set forth guidelines for state authorities to develop their own state plans.

Meetings of the National Authority

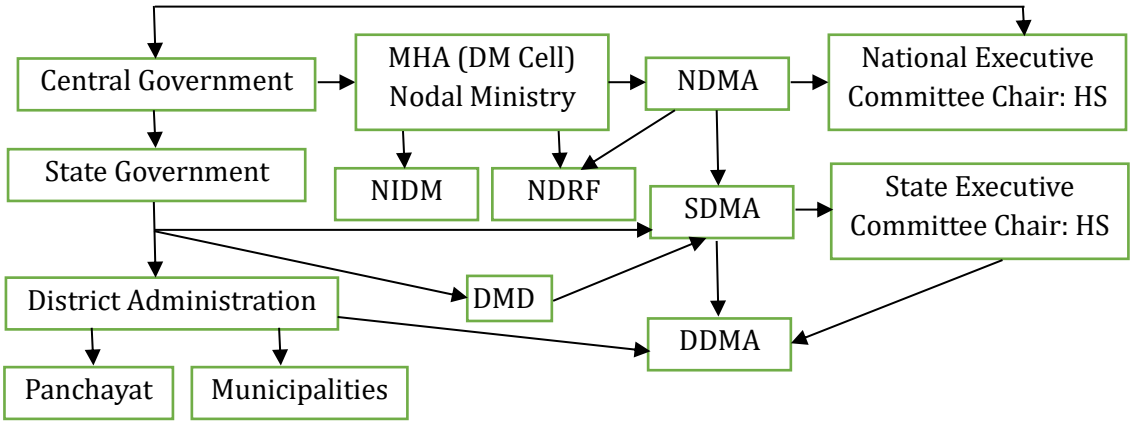
The National Authority shall meet as and when necessary and at such time and place as the Chairperson of the National Authority may think fit. The Chairperson of the National Authority shall preside over the meetings of the National Authority. If for any reason the Chairperson of the National Authority is unable to attend any meeting of the National Authority, the Vice-Chairperson of the National Authority shall preside over the meeting.

Appointment of officers and other employees of the National Authority

The Central Government shall provide the National Authority with such officers, consultants and employees, as it considers necessary for carrying out the functions of the National Authority

Powers and functions of NDMA

- Lay down policies on disaster management; Legal Institutional Framework, DM Act 2005
- Approve the National Plan
- Approve plans prepared by the Ministries or Departments of the Government of India in accordance with the National Plan
- Lay down guidelines to be followed by the State Authorities in drawing up the State Plan
- Lay down guidelines to be followed by the different Ministries or Departments of the Government of India for the purpose of integrating the measures for the prevention of disasters or the mitigation of their effects in their development plans and projects
- Coordinate the enforcement and implementation of the policy and plan for disaster management
- Recommend provision of funds for mitigation
- Provide such support to other countries affected by major disasters as may be determined by the Central Government
- Take such other measures for the prevention of disaster, or the mitigation, or preparedness and capacity building for dealing with the threatening disaster situation or disaster as may be considered necessary
- Lay down broad policies and guidelines for the functioning of the National Institute of Disaster Management



The Central Government to take measures.

Subject to the provisions of this Act, the Central Government shall take all such measures as it deems necessary or expedient for disaster management. In particular and without prejudice to the generality of the provisions of sub-section (1), the measures which the Central Government may take under that sub-section include measures with respect to all or any of the following matters, namely:

(a) coordination of actions of the Ministries or Departments of the Government of India, State Governments, National Authority, State Authorities, governmental and non-governmental organisations in relation to disaster management;

(b) ensure the integration of measures for prevention of disasters and mitigation by Ministries or Departments of the Government of India into their development plans and projects;

(c) ensure appropriate allocation of funds for prevention of disaster, mitigation, capacity-building, and preparedness by the Ministries or Departments of the Government of India;

(d) ensure that the Ministries or Departments of the Government of India take necessary measures for preparedness to promptly and effectively respond to any threatening disaster situation or disaster;

(e) cooperation and assistance to State Governments, as requested by them or otherwise deemed appropriate by it;

(f) deployment of naval, military and air forces, other armed forces of the Union or any other civilian personnel as may be required for this Act;

(g) coordination with the United Nations agencies, international organisations and governments of foreign countries for this Act;

(h) establish institutions for research, training, and developmental programmes in the field of disaster management;

(i) such other matters as it deems necessary or expedient for the purpose of securing effective implementation of the provisions of this Act.

The Central Government may extend such support to other countries affected by a major disaster as it may deem appropriate.

Responsibilities of Ministries or Departments of the Government of India.

It shall be the responsibility of every Ministry or Department of the Government of India to

(a) take measures necessary for the prevention of disasters, mitigation, preparedness and capacity building in accordance with the guidelines laid down by the National Authority;

(b) integrate into its development plans and projects, the measures for prevention or mitigation of disasters in accordance with the guidelines laid down by the National Authority;

(c) respond effectively and promptly to any threatening disaster situation or disaster in accordance with the guidelines of the National Authority or the directions of the National Executive Committee in this regard;

(d) review the enactments administered by it, its policies, rules and regulations, with a view to incorporating therein the provisions necessary for prevention of disasters, mitigation, or preparedness;

(e) allocate funds for measures for prevention of disaster, mitigation, capacity-building and preparedness;

(f) assist the National Authority and State Governments for—

(i) drawing up mitigation, preparedness and response plans, capacity-building, data collection and identification and training of personnel in relation to disaster management;

(ii) carrying out rescue and relief operations in the affected area;

(iii) assessing the damage from any disaster;

(iv) carrying out rehabilitation and reconstruction;

(g) make available its resources to the National Executive Committee or a State Executive Committee for the purposes of responding promptly and effectively to any threatening disaster situation or disaster, including measures for

(i) providing emergency communication in a vulnerable or affected area;

(ii) transporting personnel and relief goods to and from the affected area;

(iii) providing evacuation, rescue, temporary shelter or other immediate relief; (iv) setting up temporary bridges, jetties and landing places;

(v) providing, drinking water, essential provisions, healthcare, and services in an affected area;

(h) take such other actions as it may consider necessary for disaster management.

Disaster management plans of Ministries or Departments of Government of India.

Every Ministry or Department of the Government of India shall

(a) prepare a disaster management plan specifying the following particulars, namely:

(i) the measures to be taken by it for prevention and mitigation of disasters in accordance with the National Plan;

(ii) the specifications regarding integration of mitigation measures in its development plans in accordance with the guidelines of the National Authority and the National Executive Committee;

(iii) its roles and responsibilities in relation to preparedness and capacity-building to deal with any threatening disaster situation or disaster;

(iv) its roles and responsibilities in regard to promptly and effectively responding to any threatening disaster situation or disaster;

(v) the present status of its preparedness to perform the roles and responsibilities specified in sub-clauses

(iii) and (iv); (vi) the measures required to be taken in order to enable it to perform its responsibilities specified in sub-clauses (iii) and (iv);

(b) review and update annually the plan referred to in clause (a);

(c) forward a copy of the plan referred to in clause (a) or clause (b), as the case may be, to the Central Government which Government shall forward a copy thereof to the National Authority for its approval.

Every Ministry or Department of the Government of India shall

(a) make, while preparing disaster management plan under clause (a) of sub-section (1), provisions for financing the activities specified therein;

(b) furnish a status report regarding the implementation of the plan referred to in clause (a) of sub-section (1) to the National Authority, as and when required by it.

Constitution of the advisory committee by the National Authority.

The National Authority may establish an advisory committee composed of experts in disaster management with practical experience at the national, state, or district level to provide recommendations on various aspects of disaster management. The members of the advisory committee shall receive allowances as determined by the Central Government in consultation with the National Authority.

National Executive Committee (NEC):

The Central Government shall, immediately after the issue of a notification under sub-section (1) of section 3, constitute a National Executive Committee to assist the National Authority in the performance of its functions under this Act.

The National Executive Committee shall consist of the following members, namely:

(a) The Secretary to the Government of India in charge of the Ministry or Department of the Central Government having administrative control of the disaster management, who shall be Chairperson, ex officio;

(b) the Secretaries to the Government of India in the Ministries or Departments having administrative control of the agriculture, atomic energy, defence, drinking water supply, environment and forests, finance (expenditure), health, power, rural development, science and technology, space, telecommunication, urban development, water resources and the Chief of the Integrated Defence Staff of the Chiefs of Staff Committee, ex officio.

The Chairperson of the National Executive Committee may invite any other officer of the Central Government or a State Government to take part in any meeting of the National Executive Committee and shall exercise such powers and perform such functions as may be prescribed by the Central Government in consultation with the National Authority. The procedure to be followed by the National Executive Committee in exercise of its powers and discharge of its functions shall be such as may be prescribed by the Central Government.

Powers and functions of the National Executive Committee

The National Executive Committee shall assist the National Authority in the discharge of its functions and have the responsibility for implementing the policies and plans of the National Authority

and ensuring the compliance of directions issued by the Central Government for the purpose of disaster management in the country.

Without prejudice to the generality of the provisions contained in sub-section (1), the National Executive Committee may

(a) Act as the coordinating and monitoring body for disaster management;

(b) Prepare the National Plan to be approved by the National Authority;

(c) Coordinate and monitor the implementation of the National Policy;

(d) Lay down guidelines for preparing disaster management plans by different Ministries or Departments of the Government of India and the State Authorities;

(e) Provide necessary technical assistance to the State Governments and the State Authorities for preparing their disaster management plans in accordance with the guidelines laid down by the National Authority;

(f) Monitor the implementation of the National Plan and the plans prepared by the Ministries or Departments of the Government of India;

(g) Monitor the implementation of the guidelines laid down by the National Authority for integrating measures for prevention of disasters and mitigation by the Ministries or Departments in their development plans and projects;

(h) Monitor, coordinate and give directions regarding the mitigation and preparedness measures to be taken by different Ministries or Departments and agencies of the Government;

(i) Evaluate the preparedness at all governmental levels for the purpose of responding to any threatening disaster situation or disaster and give directions, where necessary, for enhancing such preparedness;

(j) Plan and coordinate specialised training programme for disaster management for different levels of officers, employees and voluntary rescue workers;

(k) Coordinate response in the event of any threatening disaster situation or disaster;

(l) Lay down guidelines for, or give directions to, the concerned Ministries or Departments of the Government of India, the State Governments and the State Authorities regarding measures to be taken by them in response to any threatening disaster situation or disaster;

(m) Require any department or agency of the Government to make available to the National Authority or State Authorities such men or material resources as are available with it for emergency response, rescue and relief;

(n) Advise, assist and coordinate the activities of the Ministries or Departments of the Government of India, State Authorities, statutory bodies, other governmental or non-governmental organisations and others engaged in disaster management;

(o) Provide necessary technical assistance or advise the State Authorities and District Authorities for carrying out their functions under this Act;

(p) Promote general education and awareness in relation to disaster management; and

(q) Perform such other functions as the National Authority may require it to perform.

State Disaster Management Authority (SDMA)

The State Disaster Management Authority (SDMA) is responsible for drawing the disaster plan for its respective state. It consists of the Chief Minister, who is the chairperson, and 8 members appointed by the Chief Minister.

The SDMA is mandated under section 28 to ensure that all the departments of the State prepare disaster management plans as prescribed by the National and State Authorities.

The State Authority shall consist of the following members, namely

(a) The Chief Minister of the State, who shall be Chairperson, ex officio;

(b) other members, not exceeding eight, to be nominated by the Chairperson of the State Authority;

(c) The Chairperson of the State Executive Committee, ex officio.

The Chairperson of the State Authority may designate one of the members nominated under clause (b) of sub-section (2) to be the Vice-Chairperson of the State Authority.

The Chairperson of the State Executive Committee shall be the Chief Executive Officer of the State Authority, ex officio:

Provided that in the case of a Union territory having Legislative Assembly, except the Union territory of Delhi, the Chief Minister shall be the Chairperson of the Authority established under this section and in case of other Union territories, the Lieutenant Governor or the Administrator shall be the Chairperson of that Authority: Provided further that the Lieutenant Governor of the Union territory of Delhi shall be the Chairperson and the Chief Minister thereof shall be the Vice-Chairperson of the State Authority.

The term of office and conditions of service of members of the State Authority shall be such as may be prescribed.

Meetings of the State Authority

The State Authority shall meet as and when necessary and at such time and place as the Chairperson of the State Authority may think fit. The Chairperson of the State Authority shall preside over the meetings of the State Authority. If, for any reason, the Chairperson of the State Authority is unable to attend the meeting of the State Authority, the Vice-Chairperson of the State Authority shall preside at the meeting.

Appointment of officers and other employees of the State Authority

The State Government shall provide the State Authority with such officers, consultants and employees as it considers necessary for carrying out the functions of the State Authority.

Powers and functions of State Authority.

Subject to the provisions of this Act, a State Authority shall have the responsibility for laying down policies and plans for disaster management in the State. Without prejudice to the generality of provisions contained in sub-section (1), the State Authority may—

(a) Lay down the State disaster management policy;

(b) approve the State Plan in accordance with the guidelines laid down by the National Authority;

(c) approve the disaster management plans prepared by the departments of the Government of the State;

(d) lay down guidelines to be followed by the departments of the Government of the State for integration of measures for prevention of disasters and mitigation in their development plans and projects and provide necessary technical assistance therefor;

(e) coordinate the implementation of the State Plan;

(f) Recommend provision of funds for mitigation and preparedness measures;

(g) review the development plans of the different departments of the State and ensure that prevention and mitigation measures are integrated therein;

(h) Review the measures being taken for mitigation, capacity building and preparedness by the departments of the Government of the State and issue such guidelines as may be necessary.

The Chairperson of the State Authority shall, in the case of an emergency, have the power to exercise all or any of the powers of the State Authority, but the exercise of such powers shall be subject to ex post facto ratification of the State Authority.

State Executive Committee (SEC)

The State Government shall, immediately after issue of notification under sub-section (1) of section 14, constitute a State Executive Committee to assist the State Authority in the performance of its functions and to coordinate action in accordance with the guidelines laid down by the State Authority and ensure the compliance of directions issued by the State Government under this Act.

The State Executive Committee shall consist of the following members, namely:

(a) the Chief Secretary to the State Government, who shall be Chairperson, ex officio;

(b) Four Secretaries to the Government of the State of such departments as the State Government may think fit, ex officio.

The Chairperson of the State Executive Committee shall exercise such powers and perform such functions as may be prescribed by the State Government and such other powers and functions as may be delegated to him by the State Authority.

The procedure to be followed by the State Executive Committee in exercise of its powers and discharge of its functions shall be such as may be prescribed by the State Government.

Constitution of sub-committees by the State Executive Committee

The State Executive Committee may, as and when it considers necessary, constitute one or more sub-committees for the efficient discharge of its functions. The State Executive Committee shall, from amongst its members, appoint the Chairperson of the sub-committee referred to in sub-section (1).

Any person associated as an expert with any sub-committee may be paid such allowances as may be prescribed by the State Government.

Functions of the State Executive Committee (SEC)

The State Executive Committee shall have the responsibility for implementing the National Plan and State Plan and act as the coordinating and monitoring body for the management of disasters in the State.

Without prejudice to the generality of the provisions of sub-section (1), the State Executive Committee may—

(a) coordinate and monitor the implementation of the National Policy, the National Plan and the State Plan;

(b) examine the vulnerability of different parts of the State to different forms of disasters and specify measures to be taken for their prevention or mitigation;

(c) lay down guidelines for preparation of disaster management plans by the departments of the Government of the State and the District Authorities;

(d) monitor the implementation of disaster management plans prepared by the departments of the Government of the State and District Authorities;

(e) monitor the implementation of the guidelines laid down by the State Authority for integrating of measures for prevention of disasters and mitigation by the departments in their development plans and projects;

(f) evaluate preparedness at all governmental or non-governmental levels to respond to any threatening disaster situation or disaster and give directions, where necessary, for enhancing such preparedness;

(g) coordinate response in the event of any threatening disaster situation or disaster;

(h) give directions to any Department of the Government of the State or any other authority or body in the State regarding actions to be taken in response to any threatening disaster situation or disaster;

(i) promote general education, awareness and community training in regard to the forms of disasters to which different parts of the State are vulnerable and the measures that may be taken by such community to prevent the disaster, mitigate and respond to such disaster;

(j) advise, assist and coordinate the activities of the Departments of the Government of the State, District Authorities, statutory bodies and other governmental and non-governmental organisations engaged in disaster management;

(k) provide necessary technical assistance or give advice to District Authorities and local authorities for carrying out their functions effectively;

(l) advise the State Government regarding all financial matters in relation to disaster management;

(m) examine the construction, in any local area in the State and, if it thinks that the standards laid for such construction for the prevention of disaster is not being or has not been followed, may direct the District Authority or the local authority, as the case may be, to take such action as may be necessary to secure compliance of such standards;

(n) provide information to the National Authority relating to different aspects of disaster management;

(o) lay down, review and update State-level response plans and guidelines and ensure that the district-level plans are prepared, reviewed and updated;

(p) ensure that communication systems are in order and the disaster management drills are carried out periodically;

(q) perform such other functions as may be assigned to it by the State Authority or as it may consider necessary

Chapter 11

Economic Instruments: Insurance, Compensation, and Recovery Mechanisms

Introduction

Disaster management in India and Tamil Nadu encompasses a multi-layered approach to mitigate risks from natural calamities such as floods, cyclones, droughts, earthquakes, and tsunamis, which cause significant economic losses-estimated at over ₹50,000 crore annually nationwide. Economic instruments play a pivotal role in building financial resilience, shifting from reactive post-disaster relief to proactive risk financing. These include insurance (risk transfer mechanisms), compensation (immediate financial aid to affected individuals and communities), and recovery mechanisms (structured funds and programs for rehabilitation and reconstruction). At the national level, the framework is governed by the Disaster Management Act, 2005, which established the National Disaster Management Authority (NDMA) and emphasizes integration of fiscal tools like the National Resilience Fund (NRF). In Tamil Nadu, a cyclone- and flood-prone state, the Tamil Nadu State Disaster Management Authority (TNS DMA) coordinates these under the Tamil Nadu State Disaster Management Plan (TNS DMP) 2023, focusing on localized implementation. The 15th Finance Commission recommendations have been instrumental, advocating for pre-disaster interventions like parametric insurance and risk pooling to reduce fiscal strain.

National Level: Economic Instruments in India

India's disaster risk financing (DRF) strategy has evolved from ex-post reliance on budgetary reallocations and debt to ex-ante tools, as per the Sendai Framework for Disaster Risk Reduction (SFDRR) and the National Disaster Management Plan (NDMP) 2019. Key challenges include low insurance penetration (under 1% for catastrophe risks), funding gaps in relief, and over-dependence on central aid, leading to delays in recovery. The Asian Development Bank (ADB) supports pilots for insurance solutions, assessing gaps in states and proposing national reinsurance pools.

1. Insurance Mechanisms

Insurance serves as a primary risk transfer tool, enabling quick payouts to offset losses from property, crops, and livelihoods. Key initiatives:

- **Parametric Insurance Models:** Trigger-based payouts (e.g., based on rainfall thresholds for droughts or wind speeds for cyclones) for automatic, rapid claims. Pilots cover floods, cyclones, and crop losses, targeting farmers, MSMEs, and informal workers. The 15th FC recommends scaling these for infrastructure protection.
- **Crop Insurance:** Pradhan Mantri Fasal Bima Yojana (PMFBY), launched in 2016, provides subsidized coverage (2% premium for farmers) against yield losses from disasters. It insured 5.6 crore farmers in 2023, with claims exceeding ₹1.3 lakh crore since inception.
- **Catastrophe Risk Insurance Pools:** Proposals for a national-level pool (inspired by Caribbean Catastrophe Risk Insurance Facility-CCRIF) to cover earthquakes and cyclones. State-level schemes, like those in Odisha, are being expanded.
- **Micro-Insurance and Livelihood Protection:** For vulnerable groups, including fisher folk and urban poor. The Insurance Regulatory and Development Authority of India (IRDAI) mandates non-life insurers to offer disaster products; however, penetration remains low due to awareness gaps and high premiums.
- **Challenges and Reforms:** Low adoption (e.g., only 25% farmers insured under PMFBY) due to delays in payouts. ADB's TA project (2020-2025) designs district-level pilots in two states, recommending policy reforms for reinsurance access.

2. Compensation Mechanisms

Compensation provides immediate ex-post relief to minimize human suffering and economic disruption, funded through dedicated relief funds. It is needs-based, assessed via damage surveys.

- **National Disaster Response Fund (NDRF):** Apex fund under NDMA, with ₹36,000 crore corpus (2024), for immediate relief (e.g., ₹4 lakh ex-gratia for deaths, ₹1.3 lakh for cattle loss). Allocations are calamity-specific; in 2023, ₹5,000 crore disbursed for floods/cyclones.
- **Prime Minister's National Relief Fund (PMNRF):** Discretionary fund (₹2,000 crore annually) for unforeseen calamities, providing aid like medical support and temporary shelters.

- **State Disaster Response Funds (SDRF):** Matching central-state contributions (e.g., 75:25 ratio); used for compensation up to 50% of NDRF norms. In 2023, SDRFs disbursed ₹10,000 crore nationwide.
- **Assessment Process:** Inter-Ministerial Central Teams (IMCTs) evaluate damages within 72 hours; payouts via Direct Benefit Transfer (DBT) to reduce leakages.
- **Coverage Gaps:** Focuses on relief (food, shelter) over long-term compensation; CAG audits highlight delays (e.g., 30% pendency in claims).

Mechanism	Funding Source	Key Coverage	Annual Allocation (₹ crore, approx.)
NDRF	Central Budget	Ex-gratia, relief items	5,000-7,000
PMNRF	Voluntary Contributions	Medical, urgent aid	1,500-2,000
SDRF	Central + State	State-specific compensation	10,000 (total states)

3. Recovery Mechanisms

Recovery focuses on "Build Back Better" (BBB), restoring infrastructure and livelihoods with resilience enhancements. Emphasized in NDMP for economic stability.

- **National Resilience Fund (NRF):** Proposed capex-driven fund (₹1 lakh crore over 5 years) for mitigation (e.g., embankments, early warning systems) and reconstruction. Rules-based disbursement linked to performance metrics.
- **Centrally Sponsored Schemes (CSS):** Funds like MGNREGA (₹1 lakh crore annually) for livelihood recovery; AIBP for irrigation restoration post-floods.
- **Contingent Credit and Bonds:** Access to World Bank/ADB lines (e.g., ₹5,000 crore rapid credit for 2023 floods); catastrophe bonds for sovereign risk transfer.
- **Livelihood and Eco-DRR Programs:** Vocational training, CSR-linked funds for entrepreneurship in affected areas; ecosystem restoration (e.g., mangroves) to reduce future risks.
- **Fiscal Impacts:** Disasters increase state liabilities by 5-10% via borrowing; 15th FC allocates 1% of divisible pool (₹1.6 lakh crore, 2021-26) for DRF.

Tamil Nadu Level: Economic Instruments in Tamil Nadu

Tamil Nadu, vulnerable to cyclones (e.g., Cyclone Gaja 2018 caused ₹10,000 crore losses) and floods (e.g., 2023 Chennai floods), has a robust framework under TNS DMA

(chaired by Chief Minister) and TNS DMP 2023. The Revenue and Disaster Management Department coordinates, with district-level authorities (DDMAs) for implementation. Economic tools align with national schemes but emphasize coastal resilience, with state funds like the Chief Minister's Public Relief Fund (CMPRF) supplementing SDRF.

1. Insurance Mechanisms

- **State-Level Parametric and Crop Insurance:** TN integrates PMFBY with local pilots; 2023 coverage for 1.2 crore farmers, claims ₹2,500 crore for cyclone/flood losses. Parametric models for fishers (e.g., wind-speed triggers for boats).
- **Property and Livelihood Insurance:** Micro-insurance via cooperatives for coastal districts (Nagapattinam, Cuddalore); TNDRF (Tamil Nadu Disaster Response Force) links with insurers for quick payouts.
- **Reforms:** TNS DMP 2023 promotes public-private partnerships for cyclone pools; ADB pilots include TN for district products.

2. Compensation Mechanisms

- **Tamil Nadu SDRF:** ₹1,500 crore annual corpus (75:25 central-state); 2023 disbursements: ₹800 crore for floods (e.g., ₹5,000 per affected family, ₹50,000 for hut repairs).
- **CMPRF:** ₹500 crore fund for ex-gratia (₹2 lakh for deaths, ₹10,000 for injuries); DBT-enabled for speed.
- **District-Level Aid:** DDMAs assess via rapid surveys; e.g., Coimbatore DDMA's 2023 plan allocates for monsoon relief.
- **Special Schemes:** Tamil Nadu Agricultural Labourers-Farmers Social Security Scheme (2006) provides compensation for crop/livelihood losses.

Mechanism	Key Coverage	2023 Disbursement (₹ crore)
TN SDRF	Relief, ex-gratia	800
CMPRF	Urgent aid, deaths	300
PMFBY (TN)	Crop losses	2,500 (claims)

3. Recovery Mechanisms

- **Rehabilitation Funds:** Post-Gaja (2018), ₹3,000 crore for housing/infrastructure under BBB; TNS DMP mandates pre-approved frameworks.
- **Livelihood Programs:** MGNREGA integration for 1 lakh jobs in recovery; eco-DRR via mangrove restoration in 13 coastal districts.

- **State Resilience Initiatives:** Anna University's Centre for Disaster Management supports risk assessments; funding via 12th FYP (₹500 crore for mitigation).
- **Challenges:** Delays in central funds; 2023 floods highlighted need for faster reinsurance.

Challenges and Reforms

- **Common Challenges:** Low insurance uptake, fiscal volatility (e.g., 8% GDP loss from disasters), and urban vulnerabilities. In TN, coastal urbanization exacerbates flood compensation needs.
- **Reforms:** 15th FC's four pillars (insurance, pooling, reinsurance); NDMA's push for AI in claims; TN's 2023 policy for CSR in DRR. Global lessons (e.g., TCIP in Turkey) inform sovereign bonds.

Chapter 12

Structural and Non-Structural Measures for Risk Mitigation

Introduction

Risk mitigation in disaster management involves proactive strategies to reduce the vulnerability of communities, infrastructure, and ecosystems to hazards, thereby minimizing potential losses in lives, property, and livelihoods. It is a key component of the disaster management cycle, focusing on long-term prevention rather than just response and recovery. Measures are broadly categorized into structural and non-structural approaches. Structural measures involve physical constructions or engineering interventions to directly resist or modify the impacts of hazards. In contrast, non-structural measures rely on policies, education, planning, and behavioural changes to reduce risks without altering the physical environment. These approaches are complementary, as emphasized by frameworks like the Sendai Framework for Disaster Risk Reduction, which advocates for integrating both to build resilience.

Structural Measures

Definition

Structural measures refer to any physical construction, engineering techniques, or technologies designed to reduce or avoid the impacts of hazards by enhancing resistance and resilience in structures or systems. In civil engineering, "structural" specifically means load-bearing elements, excluding non-load-bearing parts like cladding. These measures can be engineered (using modern technology) or non-engineered (based on traditional or indigenous knowledge).

Types and Examples

Structural measures are often hazard-specific but can be adapted across contexts. They include both large-scale infrastructure and smaller-scale interventions.

Engineered Measures:

- Earthquake-resistant buildings with base isolation systems, shear walls, or retrofitting (e.g., post-2001 Gujarat earthquake updates in India).
- Flood control structures like dams, levees, floodwalls, reservoirs, detention basins, retention ponds, embankments, dykes, polders, bunds, or channel improvements to confine or divert floodwaters (e.g., along the Brahmaputra River in Assam, India).

- Cyclone shelters and multipurpose shelters (e.g., in Odisha, India, which reduced casualties during the 1999 Super Cyclone).
- Tsunami walls, ocean wave barriers, river gates, and tsunami forests.
- Drought mitigation through wells, irrigation systems (e.g., for boro rice crops), and storage basins.
- Floodwater diversion and storage systems, such as canals, pipes, or wetlands for controlled release (adopted in at least 16 U.S. states since 2010).
- Low Impact Development (LID) or Green Infrastructure (GI), including green roofs and permeable pavements to mimic natural hydrology (implemented in most U.S. states).

Non-Engineered Measures:

- Indigenous designs like dhajji-dewari wooden frames in Kashmir for earthquake resistance.
- Elevated houses on stilts in flood-prone areas like Assam, India.
- Protective mangrove planting or afforestation for coastal protection and watershed management.
- Community structures like johads (traditional rainwater harvesting ponds) for flood risk reduction and water conservation.
- Floodplain and stream restoration to store stormwater and reduce erosion (legislated in 10 U.S. states since 2010.

Benefits

- Provide direct protection against hazards, potentially saving lives and reducing economic losses (e.g., cyclone shelters in Odisha).
- Engineered measures offer advanced, scalable solutions when properly maintained.
- Non-engineered measures are cost-effective, culturally appropriate, and sustainable using local resources.
- Align with federal programs like FEMA's Hazard Mitigation Assistance (HMA) for funding.

Limitations

- High initial costs and maintenance requirements; failures can occur (e.g., aging dams and floodgates).
- May alter ecosystems or create false security if not integrated with non-structural measures.

- Less flexible for evolving hazards like climate change-induced floods.

Non-Structural Measures

Definition

Non-structural measures are strategies that do not involve physical construction but use knowledge, practices, agreements, or policies to reduce disaster risks and impacts. They focus on prevention through awareness, regulation, and community engagement.

Types and Examples

These measures emphasize planning, education, and policy to modify human behavior and land use.

Legislative and Policy Measures:

- Building codes and land-use planning laws (e.g., National Building Code of India, Coastal Regulation Zone notifications).
- Floodplain zoning and management to restrict development in high-risk areas.
- Seismic microzoning mapping and vulnerability assessments for earthquakes.
- Property buyouts, permanent relocations, and subdivision regulations (e.g., New Jersey's Blue Acres program).
- State-level resiliency funds and plans (e.g., Connecticut's 2019 SB 1062 for coastal resiliency).

Financial Mechanisms:

- Insurance schemes (e.g., Pradhan Mantri Fasal Bima Yojana in India for crop losses).
- Tax incentives, microfinance, and grants for risk reduction (e.g., U.S. states appropriating funds for hazard mitigation).

Education and Awareness:

- Public campaigns (e.g., NDMA's "Do's and Don'ts" in India), school programs, and professional training.
- Flood forecasting, warning systems, and evacuation planning.
- Use of satellites for tectonic monitoring and disaster preparedness plans.

Community Participation:

- Local committees, participatory vulnerability assessments, and integration of indigenous knowledge.
- Changes in cropping patterns for flood-prone areas and institutional arrangements for response**.**

Benefits

- Low-cost and broad-reaching, with high returns on investment (e.g., education saving lives).
- Promote sustainability and equity by involving communities.
- Flexible for policy adaptation, as seen in 19 U.S. states enacting flood legislation in 2019.

Limitations

- Effectiveness depends on enforcement, compliance, and public buy-in.
- Slower to implement and may not address immediate physical threats alone.

Comparison of Structural and Non-Structural Measures

Aspect	Structural Measures	Non-Structural Measures
Focus	Physical resistance and modification	Behavioral, policy, and planning changes
Cost	High initial and maintenance	Generally low, with long-term savings
Timeline	Medium to long-term implementation	Short to medium-term, ongoing
Examples	Dams, shelters, retrofitting	Zoning, education, insurance
Sustainability	Can impact ecosystems if not eco-friendly	Promotes resilience and community involvement
Integration Example	Bihar, India: Embankments + zoning + warnings	U.S. states: Buyouts + green infrastructure

Integration and Best Practices

Structural and non-structural measures should be integrated for comprehensive risk mitigation, as standalone approaches have limitations. For instance, in Bihar's flood-prone areas, combining embankments and raised platforms (structural) with zoning, early warnings, and community committees (non-structural) reduced losses in 2019 floods. Best practices include mainstreaming into development plans (e.g., India's Smart Cities Mission), conducting cost-benefit analyses, ensuring community involvement, and aligning with international standards like the Sendai Framework. Policy makers should evaluate based on cost, efficacy, and feasibility, incorporating climate adaptation (e.g., Hawaii's 2019 sustainability updates). Regular assessments using tools like seismic mapping and public awareness campaigns enhance overall resilience.

Chapter 13
Role of Media, Education, and Civil Society

Role of Media in Disaster Management

Media is usually defined as an impersonal means of communication by which written, visual, or auditory messages, or sometimes a combination of such messages, are transmitted directly to the audience. In simpler terms, the word "media" refers to the means of communication that reach large numbers of people across communities, cities, or countries, through written or printed words, sound and voice, visual images, or a combination of these.

By the definition itself, we understand that media is all organised means of reaching a large number of people, quickly, timely, effectively and efficiently. There are two main characteristics of media.

i) It can reach millions of people in a short time, even instantaneously.

ii) Audio media transcends the limits of illiteracy and the visual media can be effective in a multilingual society as well.

iii) It is cost-effective and generally user-friendly.

iv) Generally, media provide one-way communication, i.e., to the receiving people.

Television, radio, newspaper, magazines, audio and video, as well as movies, are examples of media. These are very useful in the multilingual, traditional and largely illiterate society in India.

Types of Media

Media may be of various kinds, but in disaster management, the following types of media are important:

i) Print Media

Print Media (newspapers, etc.) have made tremendous progress in India since 1780, when the first Indian newspaper, The Bengal Gazette, appeared. After Independence, the mass media assumed great significance. As per official records, more than 25000 different newspapers, magazines and bulletins are being published from various states in the country in various languages.

ii) Broadcast Media

They comprise radio and television. Messages are transmitted by these media through satellite and received by viewers and listeners at distant places in the country very quickly. Radio and TV reach a greater number of people than print media. In disaster warning and creating awareness, broadcast media are most effective, especially in a large multilingual country like India with a low level of literacy. Broadcast media are sometimes termed as Electronic Media, although the latter term would include audio-video cassettes.

iii) Display Media

This comprises the following:

a) Hoardings or Billboards or illuminated signs which can be displayed at busy public places like bus stands, railway stations, parks, etc.

b) Wall paintings and posters in common places, including railway stations, airports, provide specific awareness.

c) Small panels on lamp posts or inside or outside buses, railway compartments, taxis, etc.

d) Banners

e) Window displays

f) Sky balloons at trade fairs

g) Small handbills, leaflets.

h) Exhibitions and Fairs where special pavilions may be arranged to deal with the theme of disaster management.

Importance and Role of Media

Media has a very important role in disaster management. In this context, it performs major functions mentioned below:

i) Surveillance of the environment, which means the collection and distribution of information concerning events in the climate/environment. Several climatic factors are potentially related to the natural disasters, which can be communicated regularly and more frequently at the time of a disaster.

The best example is a cyclone. The media can play a very important role in the dissemination of information, such as the formation of depression on the sea, its movement towards the coast, areas likely to be affected, etc.

ii) Disaster Awareness Education to the masses can be given by the media. Today we have about 50% illiterate people in India, but most of them do have access to the radio or television.

iii) Long-term preparedness and mitigation strategies can be explained effectively to the masses through various media.

iv) Media help in policy formulation by conducting public debates or surveys, or polls.

Why Media Covers Disaster News?

This is because disasters are unusual, sudden events that cause enormous loss of lives and property. It brings many dramatic and traumatic stories. It depends on how the news is delivered by the journalists. Most of the time, they try to find. fault in providing relief to the victims and highlighting the impact on the affected community. Sometimes this news encourages international fundraising and creates more public sympathy for the affected people. the amount, depth and period of coverage will depend on the scale and frequency of the disaster, the speed with which the information can be obtained, and the amount of interest in the public on the subject. The media have a strong impact on the perception of and response to disasters. Thus, the role of media in a disaster is multipurpose and can be broadly classified into three categories:

a) Informative

b) Suggestive

c) Analytical

1. Informative Role

Media can play an informative role in all three situations:

i) Pre-disaster

ii) At the time of disaster, and

iii) Post-disaster

In a Pre-disaster situation, knowledge of the disaster vulnerability of the community is very important. In the monsoon season, rainfall predictions, water level in different rivers, water flow rate, possible breach of embankment, etc., are pieces of information extremely useful for the people living in the highly vulnerable areas. The media can highlight some of the important mitigation measures that the community should take up in the vulnerable zones of a natural disaster.

Similarly, some of the success stories of water-shed management in drought mitigation, can be useful in other drought affected areas of the country. Himalayan region is highly vulnerable to a number of natural disasters (viz. Earthquake, Landslides, Flash Floods, Avalanches etc.), A concept of Environmental protection, ecological balance and sustainable development in this region will certainly help in disaster reduction in the region. Awareness in this regard can be generated by the media only through informative reporting.

At the time of a disaster, accurate information should be the first aim of a journalist. It needs cooperation between local officials and the media. Most of the time, the local officials are unable or unwilling to give information, because of sensitivity or security reasons or the news is still unconfirmed. In such cases, journalists should depend on reliable sources/agencies working in relief/or the unbiased local community so that right information may reach the people and other national and international agencies. However, the media has to ensure balanced reporting so as to avoid unnecessary panic and rumours.

In a post-disaster situation, the informative role of the media is to provide correct information about the continuing impacts of the disaster and the actual needs of the affected people so that the rehabilitation and reconstruction programmes can be tailored accordingly. The media helps to keep a check on various agencies that undertake rehabilitation programmes.

2. Suggestive Role

In a disaster situation, there could be many mitigation measures available. Sometimes it is difficult to find the most suitable option for a specific disaster. For example, a Flood is a very common natural disaster. Many states are prone to this disaster, like Assam, U.P., Bihar, and West Bengal. In this context, the media has a significant role in providing suitable suggestions for political attention and public understanding for the most acceptable options. Similarly, the media has a role in checking activities that might aggravate the adverse impacts of disasters.

In the process of rehabilitation and reconstruction, media can be used to muster expert opinion and solutions, e.g.,

- models of houses,
- suitable building material,
- suitable topography for building new houses

Do's and Don'ts in the construction work.

Similar suggestions can be provided in the retrofitting of weaker structures and houses in earthquake-vulnerable areas.

3. Analytical Role

The most critical role of the media is analytical. This approach can be applied in the analysis of

disaster preparedness,

disaster mitigation,

disaster relief

disaster rehabilitation

There are preparedness plans for each disaster. After the disaster, the effectiveness of the plan and lessons learnt from the disaster should be analysed constructively. It will certainly improve the plan for future use. Similarly, if there are different mitigation approaches used by the Government and non-governmental Organisations, the media can highlight both and strive to evolve a balance of approach. These types of success stories can be replicated in other parts of the country in similar situations.

The analytical role of media is especially helpful in rehabilitation and. reconstruction work after a landslide or earthquake disaster. The Latur earthquake rehabilitation of more than 50 villages is a good example of this kind. The media can give views of various role players about the success or failure of their programme so that it can be a lesson for the authorities and the mistakes committed once are not repeated in similar circumstances.

Factual and Ethical Reporting

Sincere journalists try to give accurate facts and figures. They try to get quick access to the disaster area and the affected people and follow all norms and ethics or faithful reporting without fear or favour. Others might be interested in "news" or "stories", and might concentrate on failures only. Such reportage might produce a saleable copy but most of the time it does not yield productive results.

Newspapers reporting of a disaster is very interesting. Suppose, there is an earthquake which has killed a few hundred or few thousand persons. It will be a front-page news. Or a cyclone killing thousand persons will get front page coverage. On the second day, the news will be on the third or fourth page, about the rehabilitation work and response from various sections of the society. If there is a VIP visit in the area, news may again come on the front page on the third/fourth day of disaster. After that generally there is no follow up. There are no expert analyses.

Media has great responsibility particularly in disaster situations. The ethical part is equally significant in reporting a disaster. In a riot situation or community violence, how to give correct news in a way that it does not hurt sentiments of any section of the society is very important.

Technology in Media:

There are two major types of media that exists – 1. Electronic media and 2. Print media. Radio, (both satellite as well as wireless), and Television (cable, DTH etc) are prominent player in electronic media, whereas newspapers, magazines, journals are part of the print media.

Technology has a crucial role in information acquisition, analysis, forecasting and dissemination. New technological advances in communications offer the prospect of considerable improvement, both in the anticipation of sudden-onset disaster, and in dealing with after-effects once disaster occurs. Communication underlies virtually all elements of the hazard-mitigation process. The capabilities of communications, data-gathering, and data-management technology have leaped forward in parallel with our increasing knowledge about the origins and behaviour of natural hazards and the mitigation of their effects. Indeed, advances in telecommunications and computer sciences are among the major contributors to the recognition that technology can do much to blunt the effects of natural hazards.

In meteorology, the deployment of geosynchronous satellites for telecommunications and for Earth observation, combined with the use of supercomputers to analyse the data gathered from space, has led to highly sophisticated models of tropical storm formation and behaviour, providing earlier and far more reliable information with which to plan evacuations and other hazard-mitigation strategies. Similarly, remote sensing from space can now identify insect infestations by detecting changes in the colour of the Earth's surface. Seismological devices, also linked to supercomputers, are greatly improving our understanding of earthquake propagation. The hope is that this increased knowledge will enable us, in time, to provide reasonably early warnings about earthquakes in the same way as we can increasingly do so for volcanic eruptions, tsunamis, and various meteorological events.

Table-: Linkages between Communication Technology and Management of Various Classes of Hazards

Hazards	**Satellite Sensors**	**Satellite Remote Telemetry**	**Radio and TV**	**Print Media**	**Terrestrial Sensors**
EARTHQUAKE		Linking sensors to the central facility and reverse	Transmitting a warning and protection information/data	Education for protection, including evacuation and building techniques	Strain gauges vibration sensors

LANDSLIDES	Meteorological monitoring of soil wetness	Transmitting data to the central facility and reverse	Transmitting warning and protection information/data	Education for protection, including evacuation and building techniques	Strain gauges wetness sensors
TSUNAMIS	Wave surge detection	Transmitting data to the central facility and reverse	Transmitting warning and protection information/ data	Education for protection, including evacuation and building techniques	Subsea vibration sensors
VALCANOS	Optical and thermal sensors	Transmitting data to the central Facility and reverse	Transmitting a warning and protection information/data	Education for protection, including evacuation and location techniques	Vibration and thermal sensors
FLOODS	Optical Monitoring and Meteorology	Transmitting data to the central facility and reverse	Transmitting warnings and protection data	Education for protection, including evacuation and location techniques	Flow, rain, and river high sensors
CYCLONES	Meteorology	Transmitting data to the central facility and reverse	Transmitting warnings and protection data	Education for protection, including evacuation, and construction location techniques	Meteorological monitoring for storm surge
WILDFIRES	Optical and thermal monitoring	Transmitting data to the central facility and reverse	Transmitting warnings and protection data	Education for protection, including Prevention and resistance construction	An optical and thermal sensor to support visual siting

Where Media Can Contribute:

Since disasters are a significant source of news and capture the attention of populations worldwide, the media provides tremendous visibility for disaster-related issues and, if used properly, can aid the process of disaster management very effectively. Some of the areas where media can contribute include:

1) Aid prioritization of Disaster Risk Issues

The media can influence the government to prioritize disaster risk issues, thereby ensuring that "self-serving" political interests are not emphasized at the expense of the wider population. For example, the media may expose excessive and inefficient expenditure to relocate persons from vulnerable areas just before a general election with a view to secure votes, while little or no attention is given to replenishing the stock of relief supplies in the

national warehouse for distribution in the event of a disaster. This kind of exposure facilitates more prudent and balanced prioritization of disaster risk issues.

2) Facilitate creation of Early Warning Systems:

Owing to the extensive outreach - the media can help disaster mitigation experts create Early Warning Systems by providing information on risks and existing technologies that can aid the development of useful concepts and systems. Emergency Alert System (EAS), which uses radio, TV and cable services across the country in United States for transmitting early warning, has been very effective.

3) Increase international donations:

The media can trigger donations from the international community subsequent to the occurrence of national disasters, as well as push the government to increase budgetary allocations for disaster response programmes.

4) Improve coordination of risk assessment activities:

The media can improve the coordination of risk-assessment activities between policymakers and donor communities. This integration of effort should result in increased availability of resources and improved work programmes geared towards saving lives of affected populations and vulnerable communities.

Impact of Media

The media is a mere tool in the hands of the disaster management professional and can, therefore, yield positive or negative results depending on how it is used.

The media is usually the first to define the event as an official disaster. They inform the public about it and therefore heighten awareness. This resulting awareness influences public opinion about how the disaster is being managed and often determines the level of attention that relief agencies pay to a particular disaster.

Positive Effects of Media

1. The media provides instantaneous information and is considered to be a trusted source, especially at the local level, where the news media have a “vested interest” in the home-town.
2. The network’s continuous and factual coverage of incidents and post-disaster events can aid decision-making and response immediately after a disaster, thereby saving lives and property.
3. The media is an invaluable asset in times of a disaster by disseminating information about public safety, giving useful details on areas such as impassable roadways and downed utility lines, etc.
4. Other important public health concerns are usually addressed by issuing water safety advisories and providing information about sites where medical help is available for the public.
5. In the absence of telephones and other mechanisms for communicating with the world outside an

affected area, the news media provide:

- the affected population with much-needed information and
- the outside world with a glimpse of what the affected community is dealing with.

Negative Effects of Media

1. The media may exaggerate some elements of the disaster and create unnecessary panic.
2. The media's inaccurate portrayal of human behaviour during and after disasters may create a very dramatic and exciting, but only partially truthful story. For instance, it is not uncommon to see footage of people looting after a disaster on all news networks, but most viewers may not realize that all the networks were covering the same store being looted. As a result, people may feel that widespread and uncontrollable looting is taking place in the affected area(s) which may not be true at all.
3. Influential politicians may manipulate the media for personal or political gains. For example, Hurricane Dean significantly affected the island of Jamaica a few weeks before the 2007 general elections. The electronic media consistently showed members of a particular political party issuing relief items to the poor, which sent a subliminal message that the political party in question was more responsive to the needs of the people than the other. Incidentally, the political party (that was portrayed in a positive light by the media) won the elections and now forms the new government of Jamaica.
4. News reporters may provide biased coverage for purposes of sensationalism by capturing horrific devastation on a street, choosing to ignore that on the opposite side of the street, all the houses are intact with minor damage. This kind of "irresponsible journalism" may lead to the deployment of unnecessary and inappropriate resources to moderately affected areas, thereby depriving the more severely affected areas of much-needed aid.
5. Media representatives often converge on a high-profile event, creating tremendous "congestion" in the affected area. This influx of individuals with their own needs into an already burdened area can be overwhelming, which may hinder or compromise search and rescue operations, jeopardize rescuer safety and hamper the provision of care needed by the critically ill and injured.

The advancement in communication technology has added unimaginable value to the mass communication service produced and provided by the media. Mass communications technology has already made a significant impact on how the public learns of and perceives various socio-cultural issues in Indian society. Systematic dissemination of education, awareness and alerts on disaster management CAN be an add-on mass media service at a very low cost.

We see from the above discussion that the media can play a very positive and important role in times of disaster, but can likewise, if not managed properly, hinder the response and

recovery process. With this in mind, it is important to recognize that convergence of the media generally occurs after major disasters and, as such, a plan to effectively manage the media should be part of every disaster management plan and standard operating procedures.

Partnerships with the Media

The media has a role to play in all phases of disasters. During actual hazard events, the media is a crucial response partner in the rapid dissemination of warnings and information to vulnerable communities that would be most impacted. This role would become more important with the establishment of state Emergency Operation Center (State EOC) network and Decision Support System (DSS).

After a disaster has struck, news media can provide effective communication channels and can assist in rapidly providing a picture of how an incident has affected impacted areas, thus helping authorities to more efficiently direct aid and rescue efforts to survivors.

Media's role in disaster preparedness includes - Broadcasting of reliable information for the safety of the public, collection and distribution of information to/from the public, but the information requires the same verification as any other source of information used by journalists to be credible and reliable.

Broadcast media can play a very effective role in educating the public about disasters; warning of hazards; gathering and transmitting information about affected areas; alerting government officials, relief organizations, and the public to specific needs; and facilitating discussions about disaster preparedness and response.

Role of Education in Disaster Management

School Curricula around the World

The number of disasters around the world is increasing year by year. These disasters include natural calamities as well as manmade conflicts like war, terrorist attacks, chemical abuse, etc. As per the Red Cross report, over the last decade, an average of 242 million people per year were killed and affected by disasters and conflicts. Natural catastrophes reportedly cost an estimated US$ 78.7 billion per annum (2000 prices). The costs of disasters are also increasing year by year. Hence, it has become essential that the disaster /risk management skills are imparted to the public in general and to the younger generation all over the world.

help local governments in implementing disaster management skills at an early stage of childhood. In this report, an effort is made to collect information on disaster management education that is being taught formally and informally in different countries. The focus is on the extent of different types of disaster mitigation and survival techniques imparted to students of primary and higher primary schools. The World Wide Web is the main source of information compiled in this report. Several countries have implemented disaster rescue and relief operation skills at the school level, but the detailed information on the curriculum is not available. In such cases, an effort is made to collect the information through mail, phone and published reports.

The analysis of available information is carried out in a standard pre-decided format, to give a clear idea of the extent to of disaster management education is taught in schools all over the world. One of the main points considered for analysis is whether the school curriculum includes basic information to students on Do's and Don'ts during disasters such as earthquakes and flash floods. Many of the countries impart basic disaster management skills informally through posters, seminars and drills without including in the formal curricula. The earthquake drills for primary students play an important role in communicating the necessary measures the kids have to take during emergencies, which can save their lives and prevent fatal injuries. This point is also considered in our analysis review. The report consists of a detailed curriculum for each country where information has been available. An analysis was conducted on available information in terms of the fact sheet at the end of the report.

List of Countries with Hazards Teaching Primary or Secondary School Curriculum (Excluding India)

Algeria, Argentina, Australia, Bangladesh, Bolivia, Brazil, British Virgin Islands, Montserrat, Columbia, Costa Rica, Cuba, Czech Republic, El Salvador, France, Greece, Hungary, Iran, Japan, Kenya, Lithuania, Madagascar, Mauritius, Macedonia, Monaco, Mongolia, Nepal, New Zealand, The Philippines, Portugal, Romania, Russian Federation, Senegal, Sweden, Tonga, Turkey, Uganda, United States of America, Venezuela.

Major Observations

As per the collected information on school curriculum the disaster management is being taught as a formal education in very few countries. Also, many of the countries have different school boards.

Each board follows a different curriculum and there is no compulsory requirement for these school boards to include disaster management in the school curricula (e.g. in Australia, Bangladesh, India, and United Kingdom).

Many of the school boards teach emergency drills informally by seminars and posters. The Dos and Don'ts during emergencies, e.g., during an earthquake, are just given as informal information to students. Very few countries conduct earthquake drills as a national activity in schools. In many of the cases, the disaster management subject is limited to earthquakes and floods only; the other types of disasters are not included at all.

From the analysis, one can see that many countries have just started to implement disaster management subjects in their school boards; this can be seen in the detailed report. In many of the countries, the implementation of disaster-related subjects is mainly because of the initiatives by NGOs and international agencies such as UN/ISDR, ADRC, etc. It is also seen that there is a strong experience context in the implementation of disaster management curricula, and most countries that have implemented them have experienced a major disaster immediately preceding the introduction of these topics.

School Curriculum in India

Background

India experiences a large number of disasters every year. The major disasters that have occurred during recent years include earthquakes, cyclones, tsunamis, floods, droughts, landslides and industrial accidents resulting in the loss of a large number of lives and injuries to countless others. It has been seen that disasters of different types and natures occur at frequent intervals. Following the Bhuj Earthquake of 2001, in which a very large number of schools were destroyed, and students and teachers were affected, the Government of India decided to focus on disaster education in schools to inculcate a culture of safety among the students and teachers.

The school system in India is divided into a number of school boards. Some school boards are operating at national level and have member schools in many parts of the country. Most school boards are state-specific and their member schools are confined to that particular state only. The curricula of the schools are decided by the school boards, and the school completion examinations (after 10 and 12 years of schooling) are also conducted by the board. The largest national school board is known as the Central Board of Secondary Education (CBSE) with around 9,000 schools affiliated with it. The CBSE is an autonomous education board of Government of India and is often considered to be the most important school board in India.

The CBSE has introduced disaster management as a part of Social Sciences course in class VIII, IX and X since 2004 for all students. These courses cover a wide range of hazards, their consequences and mitigation and preparedness measures. Since the courses have been introduced at a relatively senior level, these courses are expected to also reach out to the families of the students. In addition, the CBSE has introduced elements of disaster management as a part of Environmental Studies

course in class V. The CBSE has also introduced disaster management as a unit subject in Geography for class XI students. After class X, the students under CBSE board have the option of choosing major streams of further education (such as science, commerce, etc.) and the subject Geography is available to only those students who chose this subject. In addition, the CBSE has embedded some topics related to disaster management in class V.

The Government of India has also requested other school boards to include disaster management courses in their curriculum at appropriate levels. The Council of Board of School Education (COBSE), a voluntary association of 51 school boards is in the process of taking up the implementation of disaster management education in schools.

One of the other major national boards, the Council for the Indian School Certificate Examinations (ICSE), has also introduced topics of disaster management in class IX. The ICSE board includes over 600 private schools that are mainly located in major urban areas.

Some states have also introduced state-level initiatives for disaster management in their schools. The best-known instances of state-level disaster management education at the school level are in Orissa and Gujarat. Orissa had experienced a major cyclonic storm in 1999, while Gujarat suffered the Bhuj Earthquake in 2001, and the level of public awareness in both these states is relatively high.

This report describes the school education initiatives of the CBSE in details, followed by the salient features of school disaster management education of the ICSE board, and in Orissa and Gujarat.

Central Board of Secondary Education (CBSE)

Disaster Management Curriculum

The disaster management curriculum in Class V introduces the basic concepts of the most commonly occurring disasters in India, viz. earthquake, flood and drought. The main objectives of the Class V curriculum on disaster management (as a part of the Environmental Studies subject) are:

1. Acquaint students with some major disasters that have occurred in India recently, such as earthquakes, floods and drought. The emphasis is on understanding the consequences of these disasters, their mitigation measures and communicating that these are due to naturally occurring physical processes.

2. Introduce the students to the role of governmental, international and local organisations after a natural calamity. In addition, the important role of local people is also emphasised.

The disaster management curriculum in Class VIII introduces the concepts of hazard, vulnerability, risk and disaster management. The disaster cycle is not explicitly discussed in this class. The main objectives of the Class VIII curriculum are:

1. Acquaint students about various disasters that India is vulnerable to, and the hazard maps that enable them to visualize their vulnerabilities. (Emphasis would be on the effects rather than causes, since the geographical reasons for the occurrence of natural hazard dealt with in geography).

2. Introduce a few key concepts in disaster management, in simple terms, to orient them to these words that are used in media, discussions, analysis, etc, when a disaster strikes. The questions at the

end of each lesson would provide a guide to teachers on what the learning expectations are from students, and in setting examination papers.

3. Introduce the concepts of being prepared for disasters through simple do's and don'ts that school children can imbibe and spread to families and community. Introduce also the concept of preparedness leading to reduce vulnerability and possible reduction in impact of the disaster on lives, livelihoods and property.

4. Develop an interest in the subject through interactive activities in the classroom, so that students seek more information on disasters.

The curriculum includes concepts in disaster management, with emphasis on disaster preparedness. Both natural and manmade disasters are included in the curriculum. The concept of community Contingency Plan and importance of mitigation measures are also introduced.

The disaster management curriculum in Class IX is the second level formal introduction to disaster management studies. The main objectives of the Class IX curriculum are to teach about mitigating disasters such that their impact is reduced and the possibility of preventing hazards from becoming disasters. Introduction to community-based disaster management, and disaster management plans for schools are taught.

The curriculum in Class X intends to groom the students to handle disaster management. The curriculum tries to give hands-on experience to students on various survival skills, which would save many precious lives in emergencies. It also discusses various alternative communication systems. It gives an introduction to safe construction practices and strengthening of existing buildings against earthquakes. It also outlines many Government and non-government bodies that play a major role in managing disasters and sharing public responsibilities. Planning for disaster prevention is also included in the syllabus.

The curriculum of Class X appears to have been developed after the Great Indian Ocean tsunami in December 2004. The curriculum, therefore, provides special focus on tsunamis, alternative communication systems and the importance of advanced planning for disaster management.

The disaster management curriculum in Class XI has been introduced as a unit of the geography subject. The curriculum of this course is at a high level, and discusses the technical aspects of various hazards and disaster management concepts. The disaster management cycle is also discussed in detail in this course. The main objectives of the Class XI curriculum are:

- To acquaint students with the concepts of disaster management and the various terminologies used in this field.
- To describe the various natural hazards that occur and their consequences and mitigation measures.

The curriculum discusses the concepts in disaster management in much more detail than in the earlier classes, and includes the technical aspects of the various natural hazards. The curriculum also

describes the occurrence of major natural disasters in India, their consequences and mitigation/preparedness measures.

Disaster Education for Common People

The main objective of this research is to collect information on disaster education of ordinary people at the community level, mainly through internet and publications. Specifically, there were two objectives as:

- Identify various methodologies for disaster education of ordinary people that are applied over the world
- Study in detail what kinds of disaster education are carried out in Nepal as a case study

National Society for Earthquake Technology-Nepal (NSET) conducted the research on Education of Ordinary People at the Community Level in developing countries. A case study on disaster education for common people in Nepal was also carried out.

Internet Search for the Practice of Disaster Education for Common People

Global search engines like www.google.com, www.yahoo.com, local search engines like www.google.com.id as well as USAID's internal search engine www.usaid.gov were used to search for data of disaster community education.

Initially the search for information was very difficult because only such keywords as disaster community education Indonesia or community education disaster were used. But as more information was discovered, such search criteria as disaster community education (with the keyword "community education" must be present in the page). Country names were also added in the search criteria in order to narrow down the search. Local search engines were also used, such as www.google.com.id. Several donor agencies such as USAID (www.usaid.gov) and disaster reduction agencies (www.adrc.org) were searched because such sites provided detailed (in terms of the program period, budget, etc.) information about the implementation programs.

Types of Information Available

When the keyword disaster was included in the search criterion, most of the results were about news of some form of disaster, mostly about how big international institutions like the Red Cross conducted some relief work. But these pages were mostly for general public notices, appeals for donations and support; they did not contain information about disaster community education. If keywords like disaster community education were included in the search criteria, results were about proposals that community education was necessary in case of disasters, or recommendations about disaster community education. Less than 10% of the search results were descriptions of some disaster community education projects. Detailed descriptions of some community education projects were scarce. Some of the programs or projects were of larger scale, with disaster community education being a small part of it which is also discussed in sections below. Much time is needed to look into these available documents to extract the information to fill the database.

Analysis of the Data

All the relevant data was downloaded for different programs/projects/cases. The summary of all the cases is presented in tabular format. For readers who want to learn more on certain programs/projects, websites given at the end of column. The final results in terms of geographical coverage, number, nature and time of the programs/projects, implementing group hazard coverage, funding agencies and methods of education are summarized in the table.

Geographical Coverage and the Number and Nature of Programs

The study identifies 189 relevant case studies from 31 countries in Asia and 1 case from 11 countries in South Pacific regions. On the basis of geographical coverage, two types of projects/programs were identified. One, existing in single country (for example, United Nation Development Programme (UNDP) country programs or Asian Disaster Preparedness Centre (ADPC) training courses, conducted in single country. The other type of programs/projects covers two or more than two countries. The former category includes 162 programs/projects while the latter includes 25 programs/projects. Most of programs especially from UNDP and European Commission Humanitarian Office (ECHO)/Disaster Preparedness ECHO (DIPECHO) contain several projects under each country's program.

Among the identified case studies, highest number of programs/projects that focused on disaster education was found in the Philippines (26 programs) followed by Japan (22 programs), Thailand (19 programs), India (18 programs) and Indonesia (17 programs).

High number of programs in Japan and Thailand are also due to number of regular types of training courses conducted by Asian Disaster Preparedness Centre (ADPC) and Asian Disaster Reduction Centre (ADRC) respectively. It is interesting to note that the highest number of programs could be in Thailand if all of the courses (regional and other training courses etc.) conducted by Asian Disaster Preparedness Centre (ADPC) are included in total identified cases. However, it was not possible to find web pages covering all of such courses. To elaborate more on it, "15th Regional Training Course on Community Based Disaster Risk Management" (Jan 22 - Feb 2, 2007) identified can be understood that this course has occurred for 15th times till Feb 2, 2007. However, this study identified this course as one case instead of 15 courses because of the availability of the particular web pages. There are 6 such courses conducted by Asian Disaster Preparedness Centre (ADPC) and others in the total 187 cases identified.

Similar types of courses are conducted by Asian Disaster Reduction Centre (ADRC) in Japan and all of such courses (7 programs) are identified in this study. Unlike ADPC case, Web Pages on all of these courses were available in the internet. If all of such courses were to be considered then the total number of case study would increase by 75 more cases (i.e. 262 instead of 187 case studies).

Types of Programs/Projects

The identified programs were also further analysed on whether each of the disaster education program are independent or part of the program. Trainings conducted by Asian Disaster Preparedness Centre (ADPC) like "Community Based Disaster Risk Management" or JICA/ADRC's "Seminar on

Disaster Management" which solely are trainings fall on this category. This category also includes all other programs which are developed to provide disaster education only. The other category includes "ASEAN Regional Program on Disaster Management" which has disaster education component as the part of the larger program.

To elaborate further, more than half of programs/ projects (54%) are independent in nature i.e. more than half of the programs are solely developed for providing disaster education only and slightly less (46%) have disaster education activities along with other activities. It was also found that 25% of the identified programs/projects are regular in nature while other programs/projects are based on the life or existence of programs/projects. For example, regular trainings conducted by training institutions, Red Cross Societies and some NGOs. Examples again include ADPC "Community Based Disaster Risk Management" which is conducted on regular fashion, JICA/ADRC's "Seminar on Disaster Management" which is conducted every year, or Friday Free Clinic of National Society for Earthquake Technology described more later in this report.

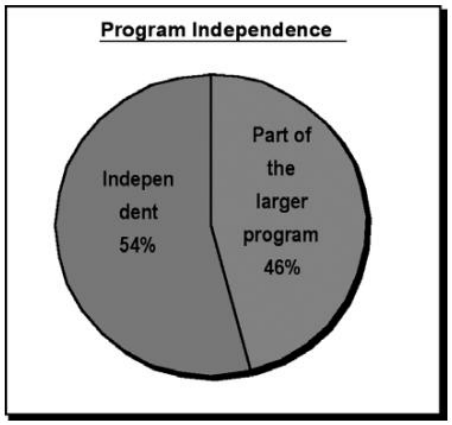


Figure 1 Program Independence

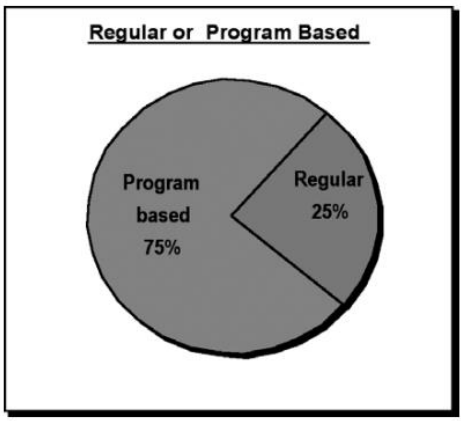


Figure 2 Regular or Program Based

Time of Start of the Program

The starting year of all the programs/projects were observed among the identified. Programs/projects were found to start from 1994. However, this does not conclude the absence of disaster education programs/projects before 1994. Figure 4 below shows that most of the programs/projects started in the year 2002 to 2006. It was found that, 26 programs/projects (highest number) started in the year 2006 followed by 25 programs in 2004, 21 programs/projects in 2003, and 15 programs/projects in the year 2002.

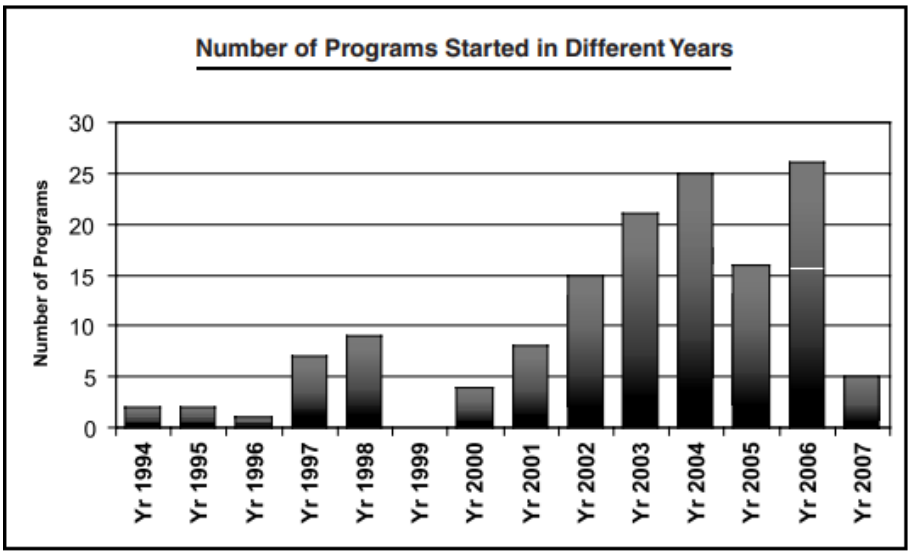


Figure 3: Number of Programs Started in Different Years

Implementing Group

Various implementing groups were observed. It showed International and National Governmental Organisations (NGO/INGO) including Red Cross and Red Crescent Societies have implemented the most programs/projects followed by technical institutes. Technical Institutes include technical centres such as Asian Disaster Preparedness Centre (ADPC), Asian Disaster Reduction Centre (ADRC), and various other technical centres and training institutions. Government includes national and international government agencies, departments etc. UN agencies include agencies under United Nations. Total of 189 case studies collected were further analysed on the basis of hazard covered, target group, objectives of the training, methods of education, duration, and funding agencies. The details of all 189 cases including one case with countries from South Pacific Region are given in the table.

Target Groups

Analysis on the target groups for disaster education showed about 110 programs/projects are targeted straight to the communities. Governments are the second highest target with 93 projects/programs followed by UN, NGO and INGO, 43 programs/projects, School community (schoolchildren and teachers), 40 programs/projects, and technicians (masons, engineers etc.) 34 programs/projects. Almost all of the programs have many targets groups however, all the projects/programs ultimately benefits communities. All these programs/projects are targeted alone or with other groups.

Hazards Covered

Hazards covered by the identified program were analysed. About 70 % of the program considered multiple hazards (two or more hazards). In other word, most of the programs/projects had disaster education components (like trainings, lectures, drills etc.) with the focus on multiple hazards. Furthermore, the multi-hazard cases usually cover those hazards that are specific to the country or

region. For example, China's single "Disaster Management Programme" of UNDP covers hazards like floods, droughts, earthquakes, blizzards and typhoons. Multi-hazard category also includes those program that focuses on general disaster risk management, such as regular types of training, "JICA-ADRC seminar on Disaster Management" of Japan. Furthermore, this category includes any general disaster risk management training, workshops, exhibitions, etc.

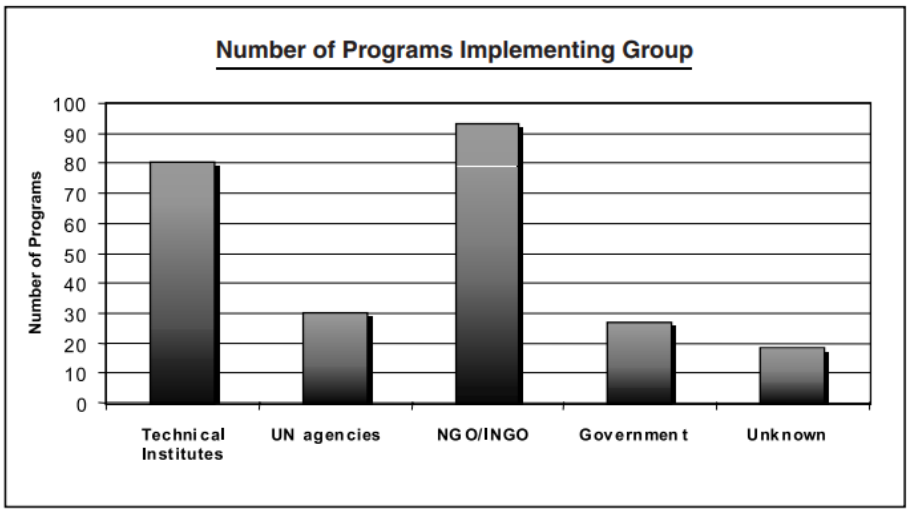


Figure 4 Program Implementing Group

As compared to multi-hazard coverage, very less programs/projects are found to consider specific hazards. Specific hazards include earthquakes, floods, tsunamis, Drought, Typhoons/Cyclones, Landslides and Fire. Respective coverage is shown in Figure 5 below. There are very less (11% or below) programs/projects that consider these specific hazards only. For example, a regional program "Reducing Vulnerability of School Children to Earthquakes" focuses on earthquakes.

Among single hazard, Earthquakes (11%) followed by Flood (9%), Tsunami (5 %) are found to be covered by most of the programs/projects. It was also noted that many program/projects have emerged after particular disasters. One program of this type is American Red Cross Society's "Tsunami Recovery Program - Disaster Management" emerged after the Indian Ocean Tsunami of 2004.

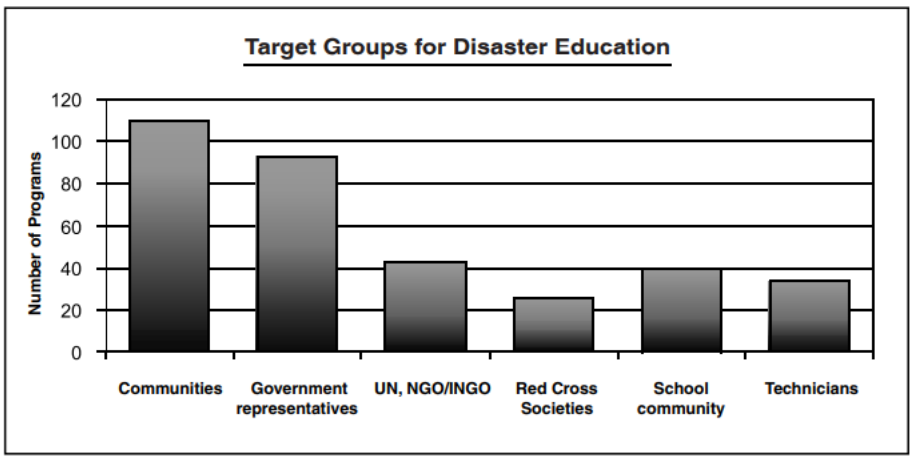


Figure 5 Target Groups for Disaster Education

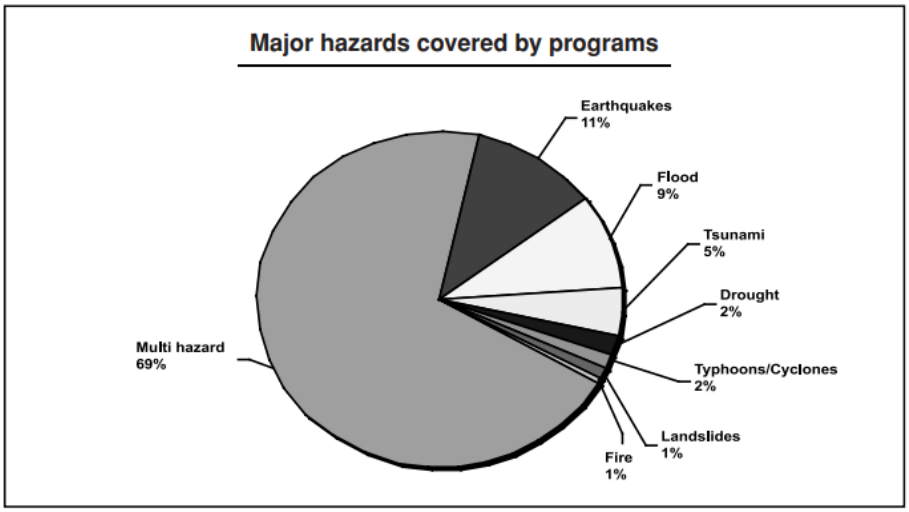


Figure 6 Major Hazards Covered by the Programs

Agencies Funding Community Education

Among the various funding agencies in the region, most of the non-formal disaster education programs identified were funded by USAID/OFDA (33 programs), followed by UNDP (25 programs), JICA (16 programs), ECHO/DIPECHO (15 programs), and Canada Fund/CIDA (8 programs). There were 23 programs whose source of funding was not known, and 23 programs where participants pay themselves for the education. It mostly includes training programs conducted by the Asian Disaster Preparedness Centre (ADPC) and Red Cross Societies in respective countries.

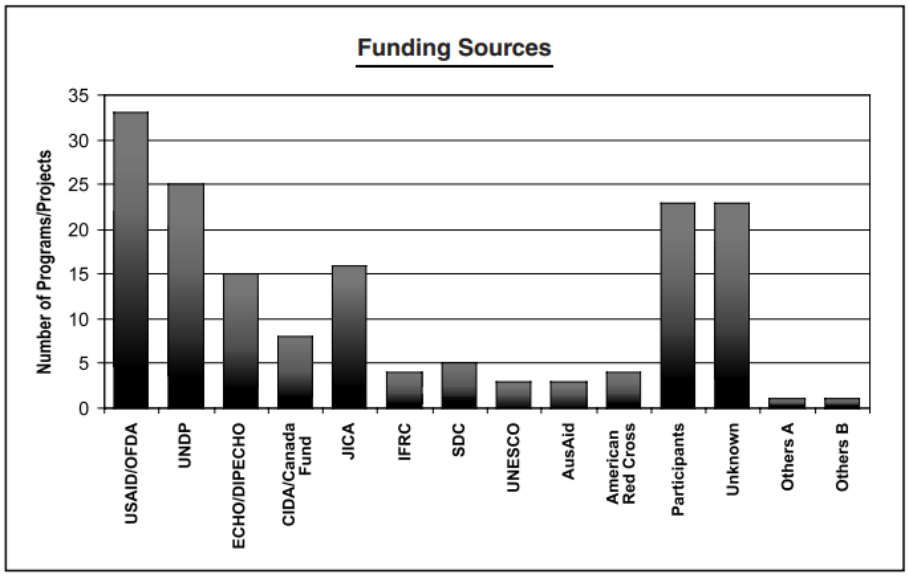


Figure 7: Agencies Funding Community Education

Others A: Includes two programs each by UNCRD, UNISDR, UNICEF, World Bank, GTZ, CARE, DFID, OCHA Kobe, and the Norwegian Government.

Others B: Includes one program each by UNDESA, UNESCAP, UNEP, WFP, Oxfam, UNHABITAT, Japanese Red Cross, Myanmar Red Cross, Vietnam Red Cross, Cambodian Red Cross, Netherlands Government, French Government, New Zealand Government, Bangladesh Government, Indian Government

CARE-Cooperative for Assistance and Relief Everywhere, DFID-Department for International Development, OCHA-Office for the Coordination of Humanitarian Affairs, UNCRD-United Nations Centre for Regional Development, UNDESA-United Nations Division for Sustainable Development, UNEP-United Nations Environment Programme, UNICEF-United Nations Children's Fund, UNISDR-United Nations International Strategy for Disaster Reduction, UNESCAP-United Nations Economic and Social Commission for Asia and the Pacific, OCHA-Office for the Coordination of Humanitarian Affairs, GTZ-German Technical Cooperation, WFP-World Food Programme

Methods of Education

Various methods of non-formal education were observed among the identified cases. As none of the programs/projects had an exact program as "non-formal education", this study tried to consider all the possible means of non-formal education that were provided by the identified projects/programs. To simplify different categories of non-formal education all the identified programs/projects were categorized into 10 broad categories as shown in Figure 8.

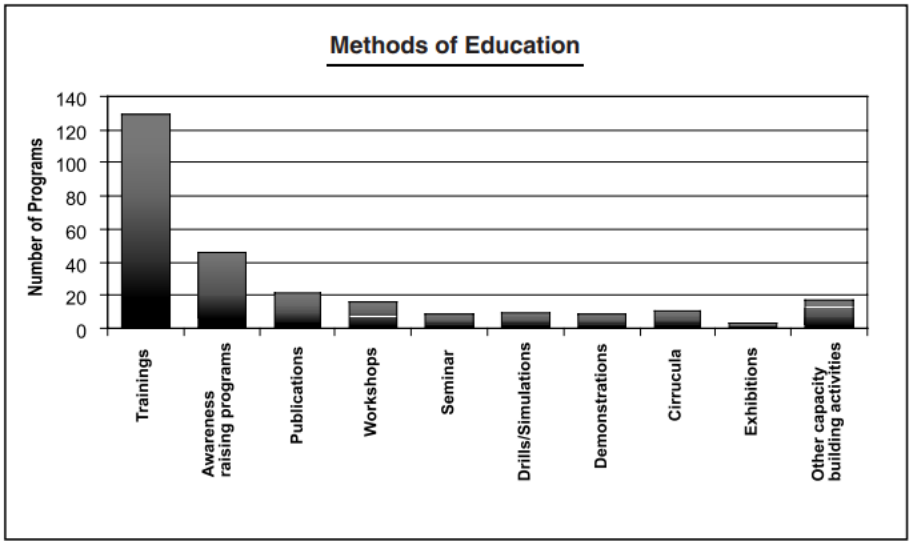


Figure 8 Methods of Education

Training

Training category includes any forms of training activities such as classroom-based, lectures, field exercises, on-the-job etc., mentioned in the programs. It includes training given by Red Cross Societies, Asian Disaster Preparedness Centre (ADPC), Asian Disaster Reduction Centre (ADRC) and other training centres for special training activities in the specific programs. Among the various methods of disaster education, training was the most used method (129 out of 189 cases) for non-formal education among the identified programs/projects.

Awareness Raising Activities

Awareness-raising activities were the second highest observed methods found among the identified programs. This category includes all the programs/projects that had any awareness-raising components in their objectives or activities. It includes public awareness programs/activities/campaigns, community empowerment, education campaigns, public information campaigns and information exchange. Though publications, demonstrations, drills, simulations and exhibitions are awareness activities, to make more detail, they are separated from this broad awareness raising category. Awareness raising activities is covered by 46 programs and ranks second highest means of non-formal education among the identified programs/projects.

Publications

Publications category includes any publications related to disaster education, such as related newsletters, publications, pamphlets, posters, booklets, films, books, guidelines and education materials related to disaster training materials, etc. It covered 21 of the total 189 identified programs/projects. Two significant publications identified were "Natural Disaster Preparedness and Education for Sustainable Development", UNESCO, 2007 and the Tsunami awareness booklet "Inamura-no-hi", ADRC & ADRRN, 2005.

Workshops and Seminars

Workshops and seminars related to disasters are covered by 18 and 9 programs, respectively. Though these activities are covered by only 27 programs, they, in fact, have the potential to be the highest in number for methods in disaster education. There is high chance that all of these activities are not available in the websites.

Demonstrations, Drills, Simulations, and Exhibitions

Demonstrations, drills and simulations, and exhibitions category in this study include all the programs / projects that have been mentioned as it is in the respective programs. They are found in 9, 10 and 3 programs, respectively.

Curricula

Curricula include all the programs/projects that have mentioned curricula in their respective programs/projects. It mainly refers to the development of disaster education curricula in the schools. This category was identified in 11 programs.

Other Capacity Building Activities

Finally, the other capacity building category includes programs/projects that directly or indirectly provide non-formal education. This includes skill development activities, development of disaster management plans, disaster management committees, group formation for disaster management, study tours, participatory learning approaches, technology transfer and other capacity building activities. They are available in 17 programs/projects.

Difficulties in Collecting Information

Followings were the four main difficulties in collecting information from the internet:

The data were not posted on the website. Although many programs were implemented, information about those programs was not posted in the websites. Many programs or institutions that implemented the programs did not have a website. Thus, collecting data was very difficult.

The posted data were mostly incomplete. The posted data in the internet did not give all the required information needed for a better collection of data. The data posted were either incomplete, or were already removed from the website.

Information not specific the websites that contained information about disaster community education were not well structured (as there is no specific format to post the information on the internet). Most of the information available on the websites was so broad that it made the research time-consuming, especially to abstract the required information.

Role of Civil Society in Disaster Management

Civil society plays a crucial role in disaster management by building community awareness, providing immediate relief, and advocating for better policies. They help communities prepare for disasters through training and early warning systems, provide essential supplies and psychological support during emergencies, and ensure vulnerable populations are not overlooked. In the long term, they assist in recovery efforts, build community resilience, and influence government policies to create more inclusive and effective disaster risk reduction strategies.

India is highly vulnerable to a large number of natural hazards such as earthquakes, landslides, floods, droughts, river erosion, cyclones and tsunamis. Many areas are multi-hazard prone. Compounding these disaster risks are factors such as our socio-economic conditions, unplanned urbanization creating increased risk to the built-environment, environmental degradation, and the impact of epidemics and pandemics. All these points to a future where disasters will seriously threaten India’s economy, its population and sustainable development unless swift, effective and persistent measures are taken.

Disaster risks recognize no political boundaries and losses on account of disasters are on the rise with grave consequences for hard-won development gains and the very survival, dignity and livelihood of individuals, particularly the poor. Actions in one region can have an impact on risks in another. There is now international acknowledgement that efforts to reduce disaster risks must be systematically integrated into policies, plans and programmes for sustainable development and poverty reduction, and supported through bilateral, regional and international cooperation, including partnerships.

Though the whole world faces frequent and severe disasters, the developing countries suffer much more significantly the impact thereof. Those living in developing countries are naturally much more adversely affected as compared to those in the developed world, largely on account of their inherent vulnerabilities and the lack of preparedness.

A major concern in recognition of the importance of DM as a national priority, GoI in 2005 enacted the Disaster Management Act, 2005 (53 of 2005). The DM Act 2005 recognizes that hazard risk

and vulnerability in specific geographic areas may induce disasters. The proactive approach in the DM Act 2005, including coordination of the activities of the NGOs at various levels, addresses disaster risk and vulnerability through pre–disaster preparedness and multi–stakeholder participation.

The Act entrusts the State Executive Committees and District Authorities with the responsibility to advice, assist coordinate and encourage the involvement of NGOs and civil society organizations working at grass root level in the districts for disaster management. Sections 38 (2)(a), 22(2)(j) and 30(2)(xix) of the Act mandate every State Government, SEC of SDMA and DDMA respectively for collaboration with stakeholder agencies including NGOs for the purpose of improving the effectiveness of DM. Similarly, the Act mandates NGOs to act in an equitable and non–discriminatory manner for the purpose of assisting or protecting the disaster affected communities or for providing relief to the affected communities or while dealing with any effects of threatening disaster situations and has fixed the responsibility to monitor this on SEC and DDMAs of the State vide sections 24(j) and 34(I) respectively (Source DM Act 2005).

National Policy on Disaster Management (NPDM) 2009

Disaster Management involves a continuous and integrated process of planning, organizing, coordinating and implementing measures, therefore NDMA had adopted a step-by-step procedure, starting with the formulation of National Policy on Disaster Management. This policy has resulted into disaster specific guidelines through a mission-mode approach involving several initiatives with the help of various stakeholders concerned viz, administrative, academic, scientific & technical and NGOs operating at national, state and local levels.

NPDM 2009, with a vision to build a safer and disaster resilient India by developing a holistic, proactive, multi-disaster oriented and technology driven strategy through a culture of prevention, mitigation, preparedness and response, outlines the following provisions for greater involvement of NGOs/Civil Society.

Para 5.3.3: ***Stakeholders' Participation***

The participation of civil society stakeholders will be coordinated by the SDMAs and DDMAs. Civil Defence, NCC, NYKS, NSS and local NGOs will be encouraged to empower the community and generate awareness through their respective institutional mechanisms. Efforts to promote voluntary involvement will be actively encouraged.

Para 7.4.1: ***Role of State, District and Local Authorities***

It is the primary responsibility of the State Governments/SDMAs to monitor and assess any developing situation and keep the NDMA and NEC apprised of the same. They will also be responsible to constantly evaluate their own capabilities to handle that situation and project the anticipated requirements for the Central resources well in time. Inter-state assistance and cooperation will be encouraged. The States/UTs will also be responsible to develop their own response potential progressively and complete the process at the earliest. This will comprise training and equipping of State response forces, community Preparedness, training and creation of response caches at the district

level. District-level preparations will provide the cutting edge to all response activities. Local authorities, PRIs and ULBs will play a significant Role in the entire process, particularly in response and rescue operations, relief and rehabilitation, awareness Generation and disaster preparedness, restoration of livelihood options and coordination with NGOs and Civil society.

Para 9.2.1: ***Owner-Driven Reconstruction***

Reconstruction plans and designing of houses need to be a participatory process involving the government, affected community, NGOs and the corporate sector. After the planning process is over, while owner driven construction is a preferred option, contribution of the NGOs and corporate sector will be encouraged. Reconstruction programme will be within the confines and the qualitative specifications laid down by the government.

Para 10.4.1: ***Training of Communities***

Building the capacity of communities, as they are the first responders to disasters, is a significant part of the capacity development process. It will include awareness, sensitisation, orientation and developing skills of communities and community leaders. Assistance from NGOs and other voluntary organisations such as the Red Cross and self- help groups will be encouraged. The overall responsibility to give impetus to leadership and motivation will rest with local authorities, PRIs and ULBs under the overall guidance of district and state authorities.

(**Source:** National Policy on Disaster Management 2009)

The paradigm shifts in disaster management brought together the representatives of various stakeholders such as Central Ministries/Departments, State Governments, Science and Technology Institutions, Corporate Sector, NGOs, CBOs etc. This ideology emphasizes the fact that we must learn from each other to deal with many emerging concerns that pose challenges, different from what we are used to facing. Phenomena such as glacial melt, sea level rise, global warming and climate change etc are posing new challenges to the mankind. Concerns such as Business Processes Continuity are also beginning to engage attention of governments and the corporate sector all over the world.

It is now well recognized in the new disaster management mechanism that prevention and mitigation are socially and economically more profitable investments than relief and rehabilitation. The success of disaster management efforts lies largely in integrating the various phases such as prevention or response and creating essential forward and backward linkages. No government can cope with the challenges of disaster management all by itself. NGOs and civil society organizations have close links with the communities and have a great advantage in performing tasks which require a participatory approach. Many of them in the past have made sterling contribution to the task of disaster management.

Moreover, in recent times, lessons learnt from past disasters internationally as well as regionally have begun to play a significant part in reducing disaster risk through knowledge sharing. Great care,

however, needs to be taken to ensure that there is complete understanding among the various agencies and complementary pooling and sharing their strengths.

Chapter 14

Regional Issues

Case Study: Cyclone Gaja (2018) – Impacts, Response, Recovery, and Lessons Learned in Tamil Nadu, India

Introduction

Cyclone Gaja was a severe cyclonic storm that formed over the Bay of Bengal and made landfall near Vedaranyam in Tamil Nadu's Nagapattinam district on November 16, 2018, at approximately 1:45 AM. Classified as a "very severe cyclonic storm," it brought sustained wind speeds of 100-165 kmph, heavy rainfall (up to 200 mm in some areas), and a storm surge of 1-2 meters, exacerbating flooding in the fertile Cauvery River Delta region. This event was one of the most devastating cyclones to hit Tamil Nadu since Cyclone Thane in 2011, affecting eight districts: Nagapattinam, Thanjavur, Thiruvarur, Pudukottai, Karaikal, Cuddalore, Trichy, and Ramanathapuram. Gaja's rapid intensification and unusual inland track highlighted vulnerabilities in coastal agriculture-dependent communities, underscoring the need for enhanced disaster risk reduction (DRR) in a state prone to cyclones (with 10 major events since 2008). The cyclone's socioeconomic toll was amplified by its impact on livelihoods, infrastructure, and ecosystems, serving as a critical case study for India's evolving disaster management framework under the National Disaster Management Act, 2005.

Formation and Path

Gaja originated as a depression over the Andaman Sea on November 10, 2018, intensifying into a cyclonic storm by November 13 and reaching "very severe" status by landfall. It traversed the delta districts at 12-15 kmph, weakening to a deep depression over central Tamil Nadu before dissipating near Coimbatore on November 17. Unlike typical Bay of Bengal cyclones, Gaja's path veered westward, affecting inland areas up to 150 km from the coast. Meteorological data from the India Meteorological Department (IMD) indicated peak winds of 165 kmph in Adhirampattinam and 160 kmph in Muthupet, with gusts exceeding 180 kmph. Satellite imagery and GIS analyses later revealed how the cyclone's asymmetric structure stronger winds on the northern side concentrated damage in Nagapattinam and Thiruvarur.

Impacts:

Cyclone Gaja inflicted multifaceted damages, with economic losses estimated at ₹11,000-15,000 crore (approximately $1.5-2 billion USD), primarily in agriculture and

fisheries. The delta's low-lying terrain amplified flooding, displacing over 3.5 lakh people and rendering 1.17 lakh houses partially or fully damaged (including 50,000 thatched huts and tiled roofs). Power outages affected 39,938 electric poles and numerous transformers, disrupting supply for over two days across 1.5 million households. Drinking water contamination and salinity intrusion further compounded health risks.

Impact Category	Key Statistics	Details
Human Toll	89 deaths (official: 45 in Tamil Nadu, 44 in Kerala/Puducherry); 800+ injuries	Mostly from electrocution, drowning, and falling trees; 2.5 lakh evacuated pre-landfall.
Agriculture & Livelihoods	1.7 lakh coconut/banana trees uprooted; 1.5 lakh acres of crops (paddy, sugarcane) destroyed	Loss of 50,000 cattle/goats; 80% of Nagapattinam's aquaculture ponds damaged, affecting 1 lakh fisherfolk. Land use changes: agriculture land decreased from 34% to 30%; water bodies increased from 8% to 21% due to flooding.
Infrastructure	1.17 lakh houses damaged; 5,000 km roads/bridges affected; 1,000 schools closed	Power restoration delayed in remote areas; telecom towers toppled, isolating communities.
Environmental	Mangrove degradation; soil erosion in coastal zones	Increased salinity in groundwater; barren land reduced from 8% to 6%, but scrub/salt pan areas dropped from 21% to 17%.
Economic	₹11,000-15,000 crore total; ₹8,000 crore in Tamil Nadu	70% losses in primary sector; disrupted supply chains for 6 months.

Vulnerable groups, small farmers, fisher folk, and women-headed households-bore the brunt, with psychological trauma reported in 20% of surveyed survivors.

Response Measures

Tamil Nadu's response was proactive, leveraging lessons from prior cyclones like Vardha (2016), resulting in low mortality compared to historical events (e.g., 1999 Odisha super-cyclone: 10,000 deaths). The Tamil Nadu State Disaster Management Authority (TNSDMA) activated the State Emergency Operations Centre (SEOC) on November 12, coordinating with IMD for hyper-local warnings via SMS, FM radio, and village amplifiers. Over 3 lakh people were evacuated to 1,000+ relief camps, with 3,000 accommodated in church-run schools in partnership with NGOs like the United Evangelical Lutheran Church in India (UELCI).

Key actions included:

- **Early Warning and Evacuation:** Door-to-door alerts in 48 hours; fisher folk boats secured offshore.
- **Immediate Relief:** Deployment of 15 National Disaster Response Force (NDRF) teams; airdrops of food packets to remote areas. Tamil Nadu Disaster Response Force (TNDRF) cleared 5,000 km of debris within 72 hours.
- **Health and Sanitation:** Mobile medical units treated 10,000 cases; chlorine tablets distributed to prevent waterborne diseases.
- **Power and Connectivity:** Temporary generators and Jio/Airtel towers restored essentials.

Central government support via NDMA included ₹1,800 crore from the National Disaster Response Fund (NDRF). Community involvement e.g., self-help groups managing shelters enhanced efficiency, though gaps like delayed reach to 20% of remote hamlets persisted.

Recovery Mechanisms

Recovery emphasized "Build Back Better" (BBB), with a focus on resilient infrastructure and livelihoods. The Tamil Nadu government allocated ₹3,000 crore for Phase I (2018-19), supplemented by ₹9,843 crore from the central government. Key efforts:

- **Housing and Infrastructure:** Reconstruction of 50,000 cyclone-resistant homes under PMAY; elevated roads and embankments in delta districts.
- **Livelihood Restoration:** ₹30,000 compensation per lost cattle; ₹3,000 per goat. Subsidized saplings for 1.7 lakh trees; aquaculture ponds desalinated with solar pumps.
- **Economic Instruments:**
  - **Compensation:** Chief Minister's Public Relief Fund (CMPRF) disbursed ₹2 lakh ex-gratia per death and ₹10,000 for injuries via Direct Benefit Transfer (DBT). Tamil Nadu SDRF released ₹800 crore for floods/cyclones, covering 50% of NDRF norms.
  - **Insurance:** Pradhan Mantri Fasal Bima Yojana (PMFBY) claims of ₹2,500 crore for 1.2 crore farmers; parametric pilots for fishers based on wind-speed triggers. Low uptake (25%) highlighted awareness gaps.
  - **Funds and Loans:** ADB's $100 million credit line for coastal resilience; MGNREGA generated 1 lakh jobs for debris clearance and mangrove planting.
- **Ecosystem Restoration:** 13 coastal districts planted 10 lakh mangroves, reducing future surge risks by 30%.

By 2023, 90% of infrastructure was restored, but livelihood recovery lagged, with 40% of farmers reporting income dips.

Lessons Learned and Recommendations:

Gaja exposed gaps in inland preparedness and insurance penetration, informing updates to the Tamil Nadu State Disaster Management Plan (TNS DMP) 2023. Key lessons:

- **Strengths**: Effective evacuations capped deaths; public-private partnerships (e.g., NGOs for shelters) accelerated relief.
- **Challenges**: Communication blackouts in 30% of areas; over-reliance on ex-post compensation delayed BBB.
- **Recommendations**: Scale parametric insurance via national pools; integrate GIS/machine learning for real-time risk mapping (e.g., AHP models for vulnerability zoning). Enhance community drills and eco-DRR (e.g., mangroves as buffers). The 15th Finance Commission advocated 1% of GDP for DRF, emphasizing Gaja-like events for sovereign risk transfer.

Gaja's legacy underscores India's shift toward proactive DRR, reducing potential losses by 30-40% in subsequent cyclones like Michaung (2023). Ongoing research, including ADB pilots, continues to refine these strategies for climate-resilient coastal Tamil Nadu.

Case Study: The Indian Ocean Tsunami of 26 December 2004

(The Great Sumatra-Andaman Earthquake and Tsunami)

Overview

The Indian Ocean Tsunami, triggered by a 9.1–9.3 Mw under-sea megathrust earthquake off the west coast of northern Sumatra, Indonesia, at 00:58 UTC (06:28 IST) on 26 December 2004, remains the deadliest tsunami in recorded history and the most devastating natural disaster in modern India.

- Earthquake epicenter: 3.3°N, 95.8°E, 30 km depth
- Rupture length: ~1,300–1,600 km along the Sunda megathrust
- Tsunami wave heights: 10–30 m on Indonesian coast; 3–12 m along Tamil Nadu, Andhra Pradesh, Kerala, and Andaman & Nicobar Islands
- Countries affected: 14 (Indonesia, Sri Lanka, India, Thailand, Maldives, Somalia, etc.)
- Global death toll: ~2,30,000–2,80,000
- India’s official death toll: 12,405 dead + 3,996 missing (total ~16,400)
- Andaman & Nicobar Islands and coastal Tamil Nadu bore 95% of India’s fatalities

Impact on India

Region	Deaths + Missing	Injured	Displaced / Affected Population	Economic Loss
Tamil Nadu	8,009	2,500+	6.5 lakh	₹10,000–12,000 crore
Andaman & Nicobar Islands	1,672 + 3,955 missing	600+	50,000	₹4,000 crore
Puducherry	599	—	50,000	₹500 crore
Andhra Pradesh	108	—	30,000	₹300 crore
Kerala	177	—	1 lakh	₹200 crore
Total India	~16,400	—	~25 lakh	~₹15,000 crore (2005 prices)

Tamil Nadu (Worst-affected mainland state)

- Worst-hit districts: Nagapattinam (6,065 deaths), Cuddalore, Kanyakumari, Chennai
- Nagapattinam town alone lost ~75% of its fishing population in Velankanni and Akkaraipettai villages
- 1,089 km of coastline affected; 1.5 lakh hectares of agricultural land salinized
- 80,000 fishing boats/craft destroyed; 90% of coir and cashew industries collapsed

Andaman & Nicobar Islands

- Southern Nicobar Islands (Great Nicobar, Car Nicobar, Katchal) experienced 10–15 m waves
- Entire islands like Trinket were split into two; Indira Point (southernmost tip of India) subsided by 4.25 m and was permanently submerged
- 40% of Port Blair's population displaced; Campbell Bay jetty destroyed

Immediate Response (First 72 Hours)

- No tsunami early-warning system existed in the Indian Ocean in 2004 → first waves reached Andaman within 15–20 minutes, Tamil Nadu within 2 hours
- Local response relied on police, fishermen, NGOs, and armed forces
- Indian Navy & Coast Guard launched Operation Sea Waves (Andamans) and Operation Rainbow (mainland)
- Within 48 hours: 25 Indian Navy ships, 25 aircraft, 2,000 personnel deployed

- Air dropping of food and water began on 27 Dec in Car Nicobar and Great Nicobar
- International aid: 60+ countries pledged $14 billion globally; India initially declined foreign aid but later accepted coordinated help

Relief & Rehabilitation (2005–2010)

Agency / Scheme	Key Contributions
Prime Minister's National Relief Fund	₹700 crore immediate relief
Rajiv Gandhi Rehabilitation Package (Tamil Nadu)	₹3,646 crore (2005–10) – largest state package
World Bank + Asian Development Bank	$900 million loan + grant
UNDP, IFRC, Oxfam, CRS, CARE	Cash-for-work, temporary shelters, psycho-social care
Housing	1.35 lakh permanent houses built (mostly elevated, cyclone-resistant designs)
Livelihoods	45,000 new fiberglass boats, 50,000 nets, 1,500 catamarans distributed
Emergency Tsunami Reconstruction Project (ETRP)	Rebuilt 130 coastal bridges, 500 km roads, 150 schools

Notable innovations:

- Owner-driven housing model (people built their own homes with technical support) – highly successful in Tamil Nadu
- Bio-shield programme: 2,000 hectares of mangroves and shelter-belt plantations
- Community-based disaster preparedness groups (Village Task Forces)

Economic Instruments Used

Instrument	Implementation
Compensation	Death: ₹1 lakh (central) + ₹1 lakh (TN state) → later increased to ₹5 lakh for fishermen families Hut damage: ₹2,000–₹4,000 Boat loss: ₹50,000–₹3 lakh depending on type
Insurance	Extremely low penetration (<1% of fishermen insured). Post-tsunami, National Fishermen Insurance Scheme launched (2006). PMFBY later included tsunami as a peril.
Recovery Funds	Central + State + Multilateral loans (soft loans at 1–2% interest, 10-year moratorium)
Debt Relief	All agricultural and fishing loans waived in affected areas

Long-term Legacy and Institutional Reforms

1. Indian National Centre for Ocean Information Services (INCOIS) – Tsunami Early Warning System established 2007 (operational within 10 minutes of earthquake)
2. National Disaster Management Authority (NDMA) – Guidelines on tsunami risk issued 2009
3. Disaster Management Act 2005 – Directly influenced by the tsunami; created NDMA, SDMAs, DDMAs
4. Coastal Regulation Zone (CRZ) Notification 2011 – Stricter setbacks, no-construction zones
5. Mangrove for Futures (MFF) – IUCN-India programme planted >10,000 hectares post-2004
6. Community Early Warning Systems – Sirens, village committees, school drills now standard in 2,000 coastal villages

Key Lessons Learned

- Absence of a regional tsunami warning system cost tens of thousands of lives
- Social vulnerability (fisher folk, women, children) far outweighs physical exposure
- Cash transfers and owner-driven reconstruction are faster and more dignified than contractor-driven models
- Restoring mangroves and bio-shields is cheaper and more effective than concrete seawalls
- India transitioned from being an aid recipient to a provider of tsunami early-warning to 28 Indian Ocean rim countries

The 2004 tsunami remains the defining disaster that transformed India's entire disaster management architecture from relief-centric to risk-reduction and resilience-focused, and gave birth to one of the world's most advanced tsunami warning systems.

Unit 4

Title: Title: Major Natural Disasters in India and Tamil Nadu

Dr. C. Lakhmanan & Dr. R. Jaganathan

Chapter 15

India's Geo-Climatic Profile: Hazards, Risk, and Vulnerability

The Subcontinent of Hazards

India, often described as a "subcontinent of hazards," embodies a remarkable diversity of natural environments, climates, and geological formations. Stretching from the mighty Himalayas in the north to the sunny coasts of the Indian Ocean in the south, the country's geography places it among the most hazard-prone regions in the world. India's vast landmass lies across several physiographic zones—mountains, plateaus, plains, deserts, and coastal regions—each with distinct natural processes and associated risks. The interaction of these landforms with dynamic atmospheric and hydrological systems gives rise to a wide range of disasters, both natural and anthropogenic.

Located between latitudes ***8°4′ N and 37°6′ N*** *and* ***longitudes 68°7′ E and 97°25′ E*****,** the Indian subcontinent occupies a central position at the meeting point of major global climatic and tectonic systems. To its north stands the Himalaya, a young and seismically active mountain range created by the ongoing collision between the Indian and Eurasian plates. To the south, the peninsular plateau forms one of Earth's most ancient and stable landmasses—yet it is not free from risks such as droughts, extreme heat, and occasional seismic activity. The vast Indo-Gangetic plains, crisscrossed by mighty rivers like the Ganga, Brahmaputra, and Indus, experience recurrent floods and riverbank erosion, while the long eastern and western coasts face the twin challenges of cyclones and coastal inundation. The arid west, exemplified by the Thar Desert, undergoes land degradation, wind erosion, and water scarcity, further magnified by changing climatic conditions.

This extraordinary variety in physiography is accompanied by equally complex and varied climatic gradients. India experiences a monsoon-driven climate, with nearly three-fourths of its annual rainfall concentrated between June and September. The spatial and temporal variability of the monsoon introduces both abundance and scarcity as it brings floods in some regions and droughts in others. Beyond the monsoon, India's exposure to tropical cyclones, heatwaves, cold waves, thunderstorms, and landslides underscores how the same climatic systems that support life can also generate devastating impacts. Rapid population growth, unplanned urbanization, and environmental degradation have further amplified the destructive potential of these natural processes.

The cumulative impact of these interacting factors—geologic instability, climatic extremes, and human encroachment—has situated India among the world's most hazard-affected countries. According to the National Disaster Management Authority (NDMA), over 58 percent of India's landmass is vulnerable to earthquakes of moderate to very high intensity, around 12 percent is flood-prone, approximately 68 percent of the cultivable area is susceptible to droughts, and nearly 8,000 kilometres of coastline are exposed to cyclones and storm surges. These figures highlight that disasters in India are not isolated events but recurring expressions of the country's underlying physical and social vulnerabilities.

Hazard vs. Vulnerability

To understand India's geo-climatic risks clearly, it is essential to distinguish between the terms hazard and vulnerability, which often appear interchangeably in everyday use but hold distinct scientific meanings in disaster studies.

A ***hazard*** refers to a potentially damaging physical event, phenomenon, or human activity that may cause injury, loss of life, property damage, or disruption of society and environment. Hazards may be natural, such as earthquakes, floods, and droughts, or anthropogenic, like industrial accidents and pollution. In the Indian context, hazards are deeply tied to geography—earthquakes result from plate tectonics, floods from riverine and monsoonal systems, and landslides from steep mountainous terrains.

Vulnerability, in contrast, defines the degree to which a community or system is likely to be affected by a hazard. It reflects the social, economic, infrastructural, and institutional conditions that make people more or less capable of coping with or recovering from disasters. For instance, two regions may experience the same flood, yet the one with poor drainage, weaker housing, and limited relief systems will suffer greater losses. In India, vulnerability is closely linked to factors such as poverty, population density, gender inequality, and inadequate governance.

Therefore, hazard describes the potential threat, while vulnerability explains the human and environmental susceptibility to that threat. Together, they shape risk, which can be understood through a simple relationship:

$$\textbf{Risk} = \textbf{Hazard} \times \textbf{Vulnerability}$$

This relationship helps geographers and disaster managers assess not only where hazards are likely to occur but also who is most at risk and why.

Vulnerability

It is typically divided into four main categories: physical, economic, social, and attitudinal. These help understand why some areas or groups face bigger risks and need targeted protection.

Physical Vulnerability

This focuses on perceptible elements like location and built environment. Areas near fault lines, floodplains, or coasts face higher exposure due to geographic proximity, while poor construction quality—such as substandard materials or non-seismic designs—amplifies structural failure risks, as seen in events like the 2001 Gujarat earthquake. Infrastructure age, urban density in slums, and limited access to roads or hospitals further compound these issues, turning hazards into disasters

Social Vulnerability

Rooted in human and societal structures, this involves weak family networks, leadership gaps, discrimination based on caste, gender, or ethnicity, and unequal access to information or services. Marginalized groups like indigenous communities or the elderly often lack early warnings due to language barriers or illiteracy, reducing coping capacity. Cultural norms and political exclusion exacerbate isolation during crises, highlighting how social fabrics determine resilience.

Economic Vulnerability

This arises from financial fragility, including poverty, dependence on single livelihoods like agriculture in hazard-prone areas, and absence of insurance or savings. Communities reliant on informal sectors struggle with recovery, as disasters disrupt income without fallback mechanisms. Limited diversification and control over resources like farmland intensify losses, making economic structures a key vulnerability driver.

Attitudinal and Environmental Dimensions

Attitudinal vulnerability stems from risk denial, low awareness, or complacency, fostering dependency and poor preparedness behaviours. Environmental factors, such as ecosystem degradation or resource depletion, intersect all categories by eroding natural buffers like wetlands. These multi-dimensional aspects demand integrated assessments using GIS or participatory methods for targeted risk reduction.

India’s Geo-Climatic Profile

India’s geo-climatic diversity presents both opportunities and challenges. Being in tectonic youth stage makes it a dynamic landscape for geomorphic study, while its seasonal rhythms sustain one of the world’s largest populations. Yet this very dynamism exposes millions to recurrent hazards. Understanding India’s hazard landscape requires viewing it as an interplay of natural processes and human systems—a perspective crucial for sustainable development and disaster risk reduction.

Disaster Profile by Physiographic Region in India

Physiographic Region	Major Disaster Types	Key Vulnerable States/Areas
Himalayan Region	Earthquakes, Landslides, Floods	Uttarakhand, Himachal Pradesh, J&K, Sikkim
Indo-Gangetic Plain	Riverine Floods, Urban Floods, Heatwaves	Uttar Pradesh, Bihar, West Bengal, Punjab
Peninsular Plateau	Droughts, Heatwaves, Moderate Earthquakes	Maharashtra, Karnataka, Andhra Pradesh
Coastal Plains	Cyclones, Coastal Flooding, Tsunamis	Odisha, Andhra Pradesh, Tamil Nadu, West Bengal
Thar Desert	Drought	Rajasthan
Islands	Cyclones, Earthquakes, Tsunamis	Andaman & Nicobar, Lakshadweep

Area Under Risk

Given India's high vulnerability to a wide array of natural and anthropogenic hazards, quantifying the extent of affected areas provides critical insight into the true scale of disaster impacts faced by the country. The following table contextualizes the magnitude of land and human exposure to disasters, thereby facilitating a comprehensive understanding of risk and informing targeted disaster risk reduction and management strategies.

Hazard Type	Percentage / Extent	Notes
Earthquake vulnerability	57-59% of landmass	Moderate to very high intensity earthquakes; includes active Himalayan and peninsular zones

Flood and river erosion vulnerability	Around 12% of land (40+ million hectares)	Flood-prone plains and river basins
Drought vulnerability	28-68% of agricultural land	Variation depending on regional climatic and soil contexts
Cyclone vulnerability	8-12% of land, mainly coastal states	Coastal areas with ~5700 km coastline prone to cyclones and tsunamis
Landslides and avalanches	Hilly areas (Western Ghats, Himalayas)	High risk due to slope instability, earthquakes, and heavy rainfall
Other hazards	Urban flooding, chemical, biological, radiological, nuclear emergencies	Emerging hazards in urban and industrial areas
Socio-economic vulnerability factors	Population growth, unplanned urbanization, poverty, migration, cultural aspects	Influence exposure and adaptive capacities
Hazard and vulnerability mapping	Use of GIS and multi-hazard risk mapping	Critical for identifying high-risk zones and guiding disaster preparedness

As we go further, we will see the Hazard Maps created by BMTPC, the agency behind the release of the Vulnerability Atlas India.

THE VULNERABILITY ATLAS

The Vulnerability Atlas of India is like a national “risk map book” that shows which parts of the country are more likely to be damaged by major natural hazards, especially in terms of buildings and houses. It is prepared by the Building Materials and Technology Promotion Council (BMTPC) under the Ministry of Housing and Urban Affairs.

Why it was created?

India loses a large number of resources every year to floods, cyclones, earthquakes, and other hazards, which led the government to shift from only giving relief after disasters to preparing and planning in advance. The Atlas was first published in 1997 and later updated in 2006 and 2019 using new census data, better hazard information, and digital mapping tools.

Its main purpose is to give a single, reliable reference for planners, engineers, and local authorities so they can understand which areas and which types of buildings are at higher risk and need safer construction or retrofitting.

What is it?

The Vulnerability Atlas is a set of maps, tables, and brief explanations that show hazard zones and how vulnerable the housing stock is in every district of India. The latest (3rd) edition presents state-

and union territory-wise maps for earthquakes, winds/cyclones, floods, and also includes information on landslides and thunderstorms.

For each district, the Atlas links the intensity of hazards (for example, how strong an earthquake or cyclone can be) with the types of buildings and materials used there. This helps to estimate how much damage houses might suffer during different disasters. Let us have the table tell us more about the functions the Vulnerability atlas serves.

Functional area	Specific function
Hazard mapping	Provides national, State/UT, and district-level maps of earthquake, cyclone/wind, and flood hazard zones, with additional mapping for landslides and other events in later editions.
Spatial risk profiling	Shows how hazard intensities vary spatially, allowing identification of higher-risk districts and regions at a glance.
Housing risk assessment	Includes district-wise “housing risk tables” that link hazard intensity with Census-based wall and roof types to estimate likely damage to housing stock.
Macro-level vulnerability analysis	Enables macro-level evaluation of vulnerability of the built environment, especially residential buildings, without needing detailed site-specific studies.
Support to land-use planning	Guides selection of safer locations for settlements, infrastructure, and public facilities by indicating zones of higher and lower hazard.
Input to building design	Informs engineers and architects about expected hazard forces so they can design or retrofit buildings to appropriate safety standards and codes.
Regulatory support	Acts as a reference document for incorporating hazard considerations into building bye-laws, town planning schemes, and approval processes.
Prioritization of mitigation	Helps authorities prioritize retrofitting, strengthening, and mitigation measures in districts where vulnerable housing coincides with high hazard zones.
Disaster preparedness planning	Supports preparation of disaster management plans by identifying likely damage scenarios and critical risk hotspots.
Resource allocation	Assists governments in targeting resources, schemes, and support (e.g., housing programs) to areas where risk to housing is highest.
Capacity building & training	Used as a teaching tool in e-courses and trainings for engineers, planners, and officials to build capacity in hazard-safe construction.
Public awareness	Provides a simple way for citizens and local bodies to see the hazard status of their district, promoting awareness and safer construction choices.
Monitoring and updating risk	Through periodic revisions (1997, 2006, 2019), reflects updated hazard zonation and housing data, helping track changes in risk patterns over time.
Support to national schemes	Serves as a technical input for housing and urban development schemes (e.g., PMAY-Urban) to mainstream disaster resilience in program design.

Considering that the Maps serve in creating informed decisions and plans in a multitude of functional areas, what information is presented and how becomes the question.

The What, How and Whom

The atlas provides detailed information about vulnerability related to major hazards such as Earthquakes, Floods and river erosion, Cyclones, Droughts, Landslides
Additionally, it references other hazards like urban flooding, windstorms, and more.

- Data Presentation- The atlas uses maps, charts, and tables to show:
  - The geographic extent of hazard-prone areas
  - The degree of vulnerability by state and district
  - Critical information on populations and infrastructure at risk

- Stakeholder Use - The atlas is designed for use by multiple stakeholders including:
  - Government agencies for planning and resource allocation
  - Academic institutions for disaster risk research and training
  - Emergency response teams for preparedness and mitigation strategies

The Vulnerability Atlas of India 2019 is a vital tool for visualizing and understanding India's exposure to natural hazards. It supports informed decision-making and disaster risk governance by combining scientific data with practical planning needs. For freshers in disaster management, it offers a clear, practical introduction to the science of hazard vulnerability and the importance of risk-informed development.

Let us Understand the Hazard Maps.

Activity

Find out the various organizations and statutory bodies in India that publish maps on hazards and vulnerability. See what map or hazard each organization specifically studies or maps.

Discuss

Do we really need as many organizations to study &monitor these events? Back your arguments up with reasons…

MAJOR HAZARDS MAPS

BMTPC Hazard Maps

BMTPC stands for the Building Materials and Technology Promotion Council, a statutory body established in 1990 under the Ministry of Housing and Urban Affairs. This organization concentrates on the development, promotion, and practical application of innovative, cost-effective, and eco-friendly building materials alongside construction technologies aimed at transforming the housing sector across India.

Core Directives
The council serves as a necessary bridge between laboratory research and on-site construction practices, systematically identifying, evaluating, and scaling technologies derived from indigenous or waste resources such as fly ash, bamboo, and agricultural by-products. Emphasis falls on sustainable

methodologies, workforce skill enhancement, and quality assurance via mechanisms like the Performance Appraisal Certification Scheme (PACS).

Key Role in Disaster Management
In the realm of disaster management, BMTPC occupies a pivotal position through its specialization in disaster-resistant construction technologies calibrated to India's diverse hazard landscape—including earthquakes, cyclones, and floods. Responsibility extends to the creation and ongoing maintenance of the Vulnerability Atlas of India (editions: 1997, 2006, 2019), which delineates district-level housing vulnerabilities and informs resilient design protocols. Following events like the 2001 Gujarat earthquake, contributions included advisory inputs on revised building regulations, prototype housing demonstrations, and retrofitting protocols.

Practical Contributions

- Functions as a technical collaborator in flagship initiatives such as PMAY-Urban (Pradhan Mantri Awas Yojana), conducting appraisals for high-seismic-risk (Zone IV/V) projects to ensure compliance with safety norms.
- Operates training facilities, e-learning modules, and demonstration projects to equip engineers, artisans, and administrators with expertise in hazard-mitigating techniques.
- Influences national policy frameworks by shaping building codes, urban development strategies, and competitions like the Global Housing Technology Challenge.

Such applied expertise underscores BMTPC's essential function in advancing India's transition from reactive disaster relief to forward-looking risk mitigation.

India: Geological Hazard Map

Aspect	Interpretation of India Earthquake Hazard Map
Highest hazard (Zone V)	Himalayan arc, parts of northeast states, Andaman–Nicobar Islands – very high damage risk (MSK IX or more); dense faults and earthquake epicentres.
High hazard (Zone IV)	Foothills of Himalayas, parts of Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Delhi region, Bihar, parts of Gujarat and Northeast – frequent strong earthquakes.
Moderate hazard (Zone III)	Large parts of Indo-Gangetic Plain, central India, sections of western and southern states – moderate but significant risk, requiring earthquake-resistant design.
Low hazard (Zone II)	Much of southern and interior peninsular India and Lakshadweep – relatively lower expected shaking, yet occasional moderate events possible.
Overall message	No region is “earthquake free”; risk is highest in plate boundary and faulted regions, but safe construction is necessary throughout the country.

The table above depicts how the map categorizes India into four primary seismic zones:

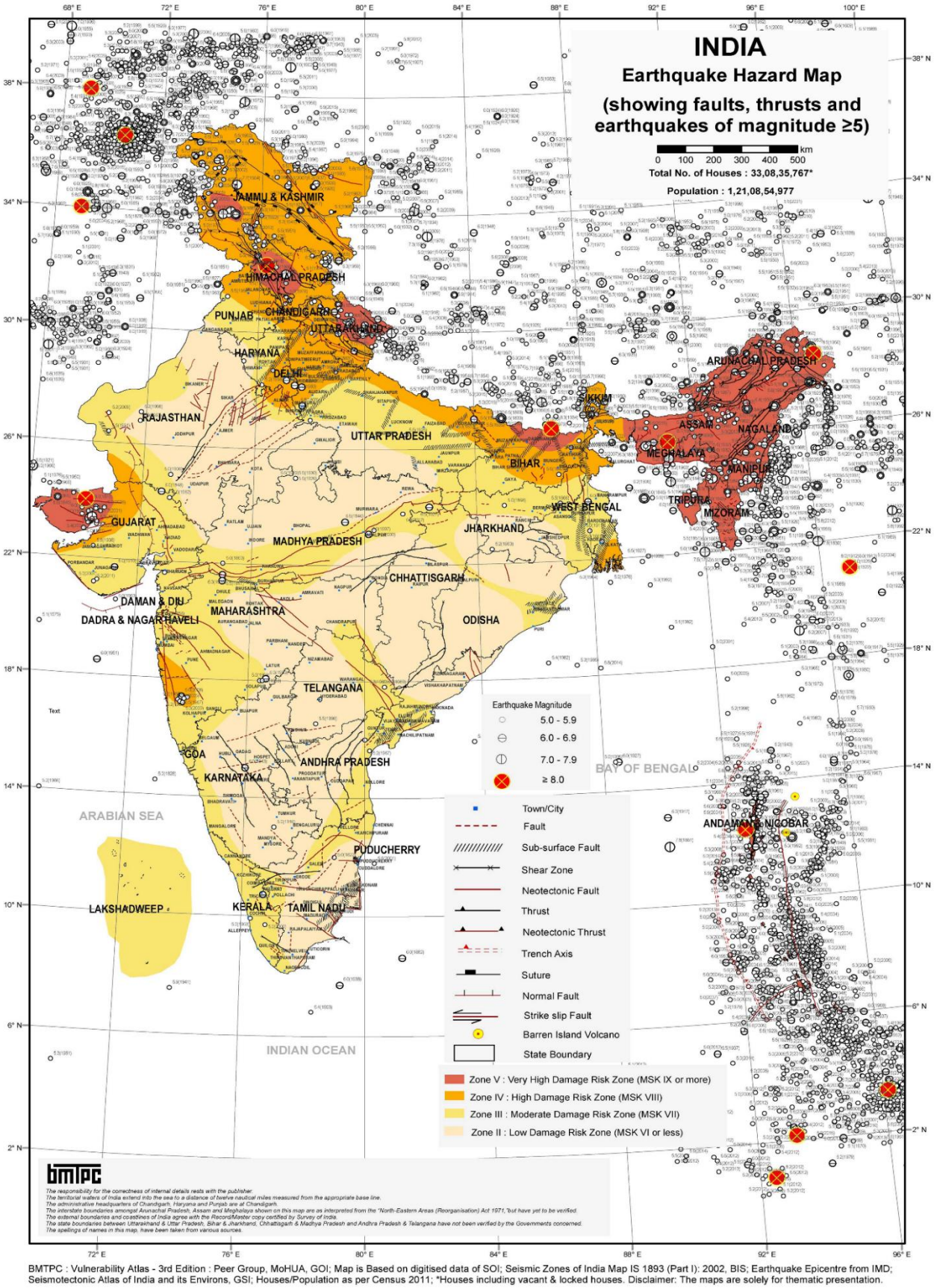


Fig. 1 India Earthquake Hazard Map (BMTPC)

Epicentres and Faults: The map uses black circles to represent historical earthquake epicentres (magnitude ≥ 5). High concentrations in the Himalayan north, North-East, and Andaman & Nicobar indicate intense seismic activity. The map also details various fault lines—thrusts, shear zones, normal faults, neotectonics zones—which underlie the physical cause of earthquakes.

Major cities and towns are marked for spatial reference, highlighting high population exposure in cities like Delhi, Guwahati, and Srinagar which lie near significant faults or epicentres.

Population and Built Environment: The legend notes a population count of approximately 1.21 billion and a housing stock of over 330 million, emphasizing the risk to both life and infrastructure across regions. Denser population and infrastructure in high-risk zones translate into higher potential losses from seismic events.

Disaster Risk Management Implications

- Integrated Planning: The hazard map aids policymakers, urban planners, and emergency services in identifying high-risk zones, prioritizing risk reduction, and enforcing building codes.
- Community Awareness: Areas in Zones IV and V should promote earthquake preparedness, resilient construction, and public education to reduce disaster impacts.
- Targeted Mitigation: Mapping faults and epicentres enables authorities to focus on retrofitting, emergency response planning, and rapid deployment of aid post-disaster.

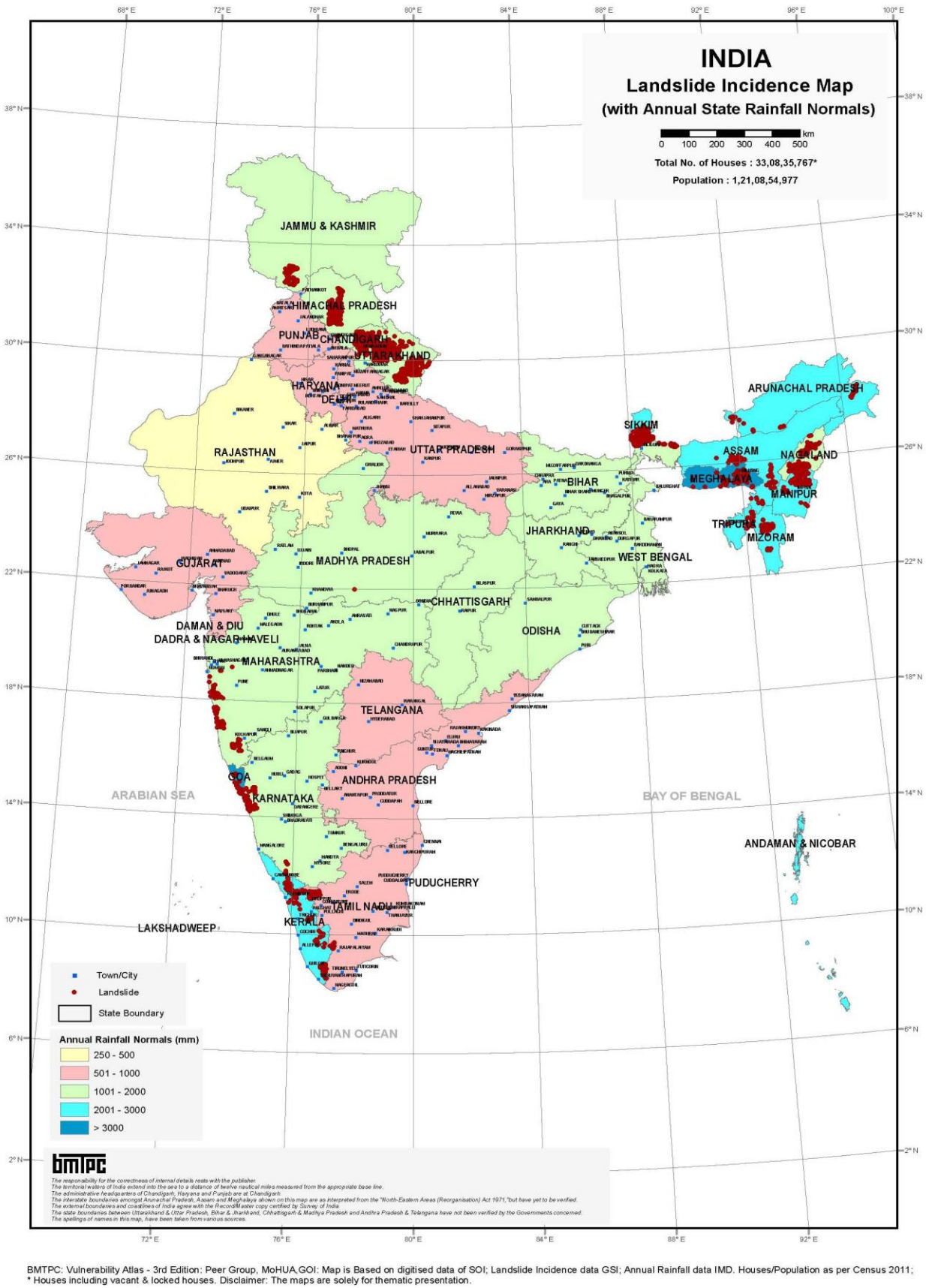
India- Landslide Incidence Map

Risk Factors and Implications

- Topographic and Climatic Drivers:
  Landslide patterns on this map reflect a combination of geomorphology (steep slopes, tectonic activity), land use (deforestation, infrastructure), and meteorology (intense or prolonged rainfall).
  Hazard is geographically uneven—hill states and the Western and Eastern Ghats are considerably more exposed than the arid or flat regions of India.
- Human Exposure and Planning Needs:
  Urban centres and villages located near major landslide clumps face significant risks to housing, infrastructure, and lives—necessitating robust preparedness and mitigation strategies such as slope stabilization, afforestation, and resilient construction.

Educational and Policy Relevance

- For disaster management students, this map offers a clear illustration of multi-hazard environments: landslide risk is rarely isolated, but often occurs where high rainfall, tectonic zones, and population density intersect.
- For planners, it guides the prioritization of risk reduction investments, emergency planning, and resilient design in landslide and rainfall hotspots.



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.2 India- Landslide Incidence Map

India - Hydro-Meteorological Hazards (Water & Climate)

India – Flood Hazard Map

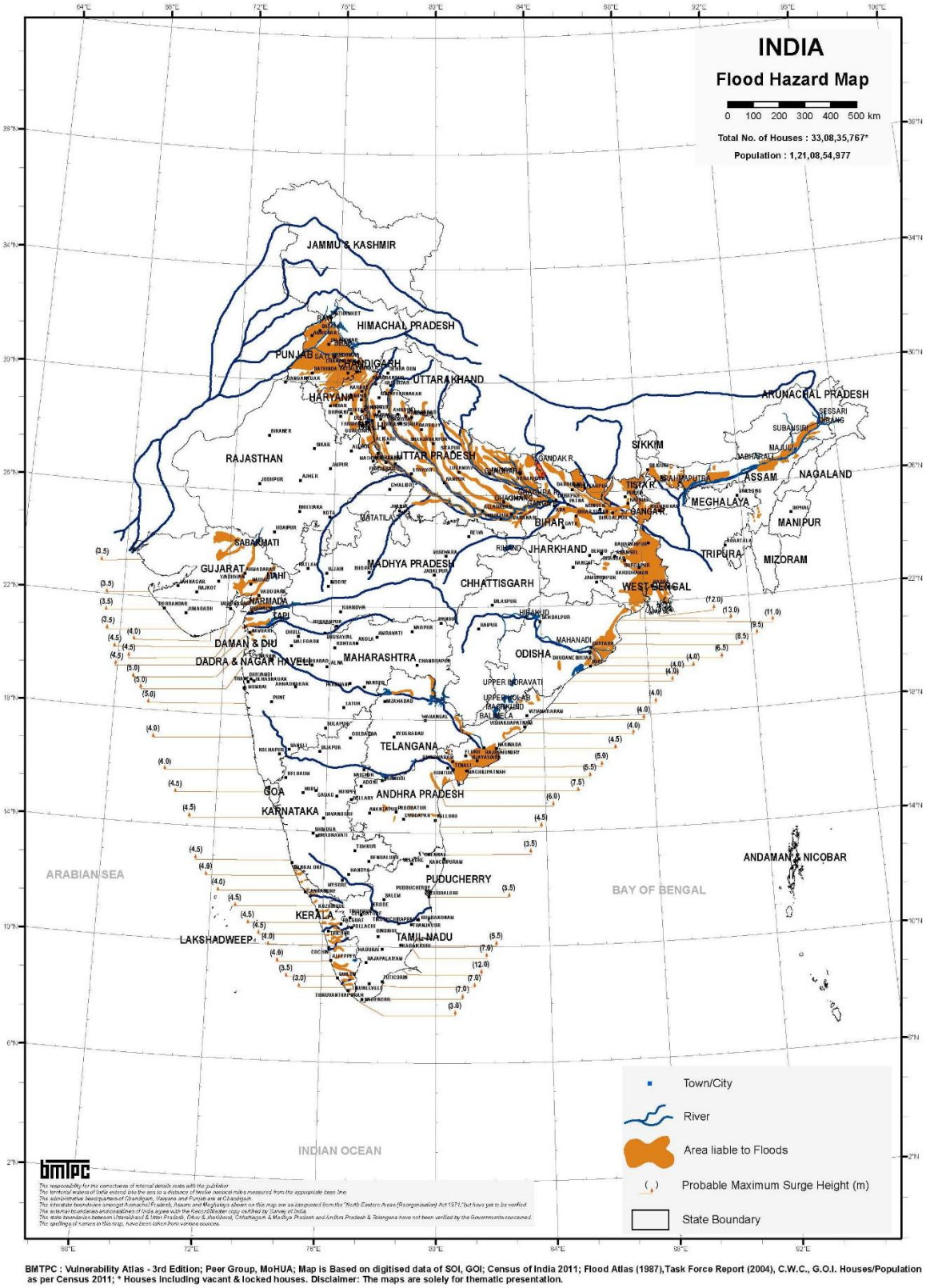


Fig.3 India- Flood Hazard Map

Geographic Distribution of Flood-Prone Areas

- **Areas Liable to Floods:**
  The map uses orange shading to denote regions vulnerable to flooding. The most prominent flood-prone zones align with major river valleys—including the Ganga, Brahmaputra, and their tributaries—covering substantial parts of Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal, and Assam. These alluvial plains are naturally susceptible to seasonal riverine flooding due to monsoon rainfall, upstream discharge, and drainage congestion.
  Coastal flood risk zones are also present along the eastern coastline (Odisha, Andhra Pradesh, West Bengal, Tamil Nadu), reflecting vulnerability not just to river floods but to storm surges and cyclonic-induced flooding.
- **River Systems:**
  Major rivers are marked in blue, emphasizing their central role in shaping India's flood risk geography. Exhibit regions downstream of high-volume catchments, such as the Brahmaputra and Ganga, are acutely exposed to recurring floods.
- **Maximum Surge Heights:**
  Thin brown contour lines along the coasts represent probable maximum surge heights in meters, indicating potential inundation from cyclones or extreme weather events. East Coast states (Odisha, Andhra Pradesh, Tamil Nadu) and parts of Gujarat are notably marked, underscoring their risk for coastal flooding.

Urban and Settlement Exposure

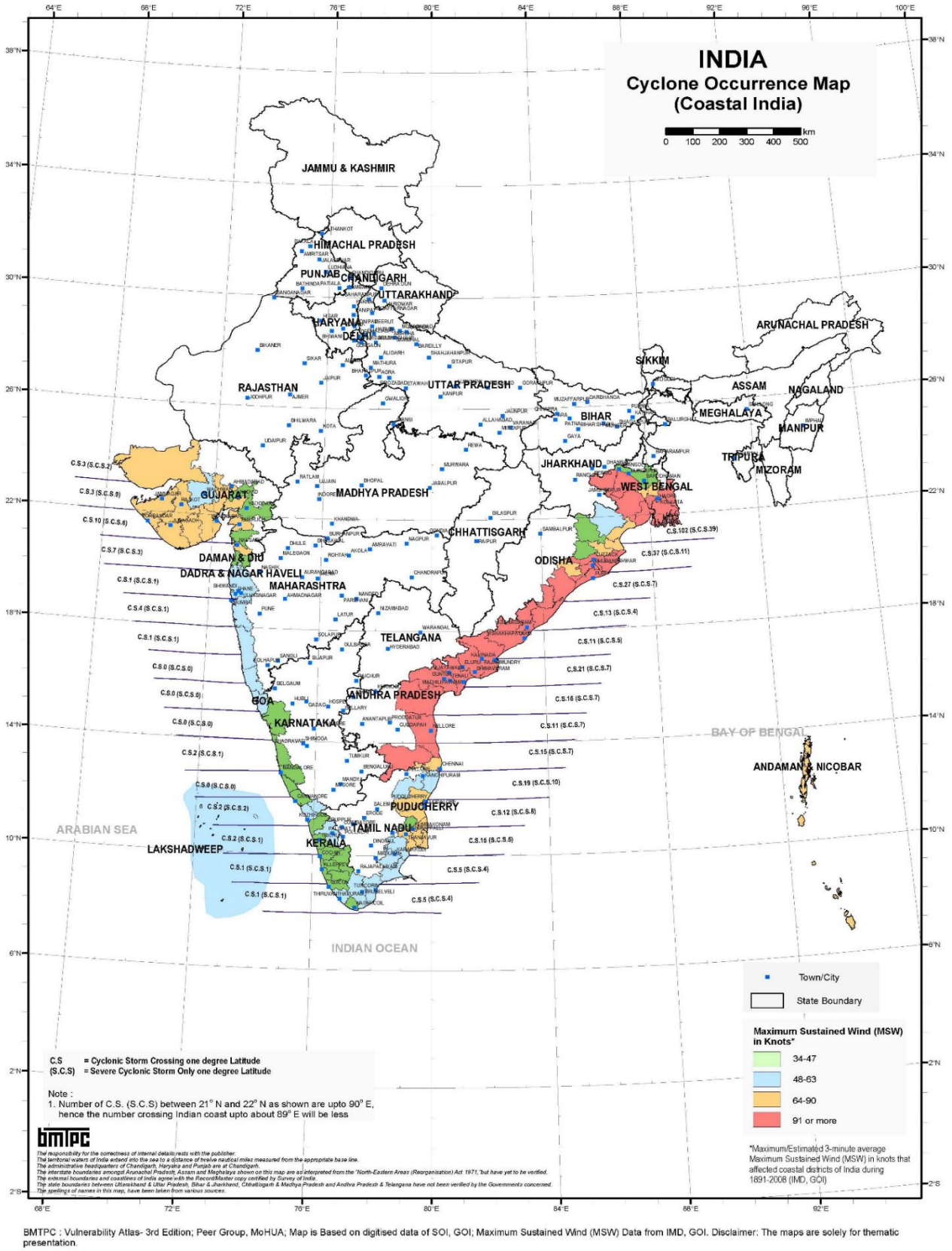
Significant urban centres and towns referenced on the map overlap with flood-liable regions—a critical observation for planners, as high population densities and built assets in these areas heighten disaster impacts.

The map's accompanying data box lists India's total population and housing stock, pointing to the massive exposure of lives and property to flood hazards.

Implications for Disaster Management

- Risk-Based Planning:
  This map is invaluable for pinpointing priority zones for flood risk assessment, infrastructure resilience planning, and emergency response deployment.
- Policy and Preparedness:
  The spatial detail assists authorities in setting flood management policies, designing drainage networks, implementing flood protection embankments, zoning regulations, and community preparedness programs.
- Awareness and Education:
  For students and community stakeholders, the visualization underscores the scale and complexity of India's flood challenge—ranging from riverine and urban floods to coastal storm surges.

India – India- Cyclone Occurrence Map



BMTPC : Vulnerability Atlas- 3rd Edition; Peer Group, MoHUA; Map is Based on digitised data of SOI, GOI; Maximum Sustained Wind (MSW) Data from IMD, GOI. Disclaimer: The maps are solely for thematic presentation.

Fig.4 India- Cyclone Occurrence Map

Distribution and Intensity of Cyclone Risk

- Colour Codes for Wind Intensity:
    - Green (34–47 knots): Represents coastal districts subjected to moderate cyclonic winds.
    - Yellow (48–63 knots): Marks areas facing higher intensity winds and more frequent cyclonic activity.
    - Orange (64–90 knots): Denotes districts highly exposed to strong cyclones with severe potential damage.
    - Red (91 knots or more): Highlights critical districts along the Odisha, Andhra Pradesh, and West Bengal coasts, which are at the highest risk from extremely strong cyclones.
- Regional Patterns:
    - The east coast, particularly the stretch from West Bengal through Odisha, Andhra Pradesh, and northern Tamil Nadu, emerges as the most cyclone-prone, with recurring exposure to the most intense storms. The MSW in this corridor frequently exceeds 91 knots, as indicated by the red shading.
    - Parts of the west coast, like Gujarat, western Maharashtra, Goa, and southern Kerala, are marked in yellow and orange—signifying moderate to high cyclonic risk, though generally less severe than the east coast.
    - Union Territories, like Lakshadweep and Daman & Diu, also appear in the moderate risk categories.
- Cyclonic Storm Tracks:
  Numbers and acronyms such as C.S. (Cyclonic Storm) and S.C.S. (Severe Cyclonic Storm) represent the frequency of cyclonic systems crossing each degree of latitude along the coast, derived from historical IMD data (1891–2008). The East Coast's higher numbers illustrate its greater exposure due to the Bay of Bengal's warm waters and prevailing wind patterns.

Urban and Settlement Exposure

The overlay of town/city markers with risk colours emphasizes the human dimension of cyclone hazards—major metropolitan and densely populated coastal districts are positioned within high-risk zones. This correlation underscores the urgent need for robust urban planning, resilient building codes, and emergency shelters in these areas.

Disaster Management Implications

- Risk-Informed Planning:
  The map guides infrastructure development, ensuring critical facilities (hospitals, schools, power utilities) in high MSW zones meet stringent wind safety standards.
- Preparedness and Response:
  It enables authorities to anticipate cyclone impacts, pre-position relief, conduct community awareness campaigns, and maintain updated evacuation procedures.
- Insurance and Adaptation:
  Cyclone mapping supports risk-based insurance schemes and climate adaptation planning for vulnerable coastal populations.

India – Thunderstorm Incidence Map

BMTPC: Vulnerability Atlas - 3rd Edition: Peer Group, MoHUA, GOI; Map is Based on digitised data of SOI;Thunderstorm data from IMD. Disclaimer: The maps are solely for thematic presentation.

Fig.5 India- Thunderstorm Incidence Map

The image provides a spatial visualization of the frequency of thunderstorms at various meteorological stations across the country for the period 1981–2010.

Geographic Distribution and Intensity of Thunderstorms

- **Thunderstorm Frequency:**
    - The map displays data in five size categories, ranging from 1 to 89 thunderstorms per location over the observed period.
    - The highest category (76–89 thunderstorms) is marked by the largest brown dots, showing significant clustering in the eastern states of West Bengal and Assam, the Andaman & Nicobar Islands, parts of northeast India, and isolated pockets in southern states such as Kerala and Tamil Nadu.
    - Moderate to high frequencies (31–75) are common throughout the Indo-Gangetic plains, parts of central India, western coastal states, and the Himalayan foothills.
    - Western regions, such as Gujarat and Rajasthan, and arid/semi-arid central states, register fewer thunderstorms, as do portions of peninsular India away from the coast.

- **Meteorological Influences:**
    - Areas with frequent thunderstorms usually coincide with zones of high humidity, active monsoon currents, orographic uplift (mountain-induced rainfall), and proximity to large water bodies such as the Bay of Bengal and Arabian Sea.
    - The east and northeast get affected by the summer and pre-monsoon thunderstorms ("Kalboishakhi" in Bengal, "Bordoisila" in Assam), contributing to higher incidence in these regions.

Urban and Settlement Exposure

- Urban centres and major cities, especially in high-frequency zones like Kolkata, Guwahati, and Chennai, face increased risk of thunderstorm impacts, including lightning strikes, strong winds, short-duration heavy rainfall, and localized flooding.
- High population density and concentrations of built infrastructure mean that thunderstorms can disrupt normal life, damage properties and utilities, and pose health/safety risks.

Disaster Risk Management Implications

- **Preparedness and Response:**
    - Awareness about thunderstorm frequency is crucial for disaster risk reduction, informing early warning systems, preparedness drills, and public advisories to reduce casualties from lightning and wind-related incidents.
- Infrastructure Planning:
    - The spatial distribution guides planners in designing resilient electrical grids, communication towers, and emergency shelters, ensuring they withstand abrupt weather events.
- Agricultural and Rural Impact:
    - Thunderstorms can damage standing crops, livestock, and rural infrastructure, making risk mapping vital for agricultural extension services and insurance policies.

The chapter discusses and opens a window to the world of vulnerability assessment and mapping how it plays out in the bigger picture of the disaster management scenario. Ow that we have had a basic overview of the major hazards and vulnerability patterns; it is time to take a regional approach. The following chapters will get more detailed providing better access and information on how vulnerability affect with more relatable regional level examples and real-life scenarios.

Chapter 16

Regional Vulnerability Patterns Across Tamil Nadu’s Coastal Plain and Highland Zones

Introduction

Tamil Nadu, spanning India's southern peninsula, is a landscape of striking geographic, climatic, and socio-economic diversity. This chapter explores the multifaceted vulnerability patterns that structure risk and resilience across three primary physiographic domains: the coastal plains, central interior plains, and western highlands. Integrating spatial, socio-economic, agricultural, and geo-pedological data, this synthesis elucidates the intertwined roles of natural processes and human activity in shaping vulnerability and guiding adaptation priorities for sustainable development. Tamil Nadu’s diverse landscapes—from the coastal plains to the western highlands exhibit pronounced spatial variability in soil erosion vulnerability, shaped by the complex interplay of geological, geomorphological, and pedological factors. This chapter synthesizes recent research to present a process-based understanding of landscape vulnerability, highlighting how underlying geo-pedological controls govern erosion patterns, resilience indicators, and management priorities across the state’s distinct zones.

The geological diversity of Tamil Nadu, ranging from Peninsular Gneiss and Charnockite formations to Quaternary alluvial and marine deposits, establishes the initial conditions for soil development and landscape vulnerability. Crystalline formations such as Peninsular Gneiss dominate the northern and central regions, creating complex mineral assemblages that influence soil genesis, texture, and hydrological behaviour. In contrast, the eastern coastal belt is underlain by younger, unconsolidated Quaternary deposits, which are highly susceptible to fluvial and aeolian erosion due to their loose, sandy, and silty nature. Acid Intrusive formations in the western highlands further alter soil geochemistry, lowering pH and increasing heavy metal mobility, while Marine-Paleo-Tidal Flat Deposits along the southeastern coast create saline, poorly structured soils vulnerable to both water and wind erosion. These lithological differences create distinct pedogenic pathways, with soil properties such as texture, coarse fragment content, bulk density, and pH varying systematically across the landscape. For example, the western highlands exhibit finer-textured soils with lower bulk density and higher organic matter, while the eastern plains are dominated by coarser, more compacted soils with elevated pH and salinity. These geochemical and physical contrasts directly influence landscape resilience, with high-carbon soils in the deltaic plains demonstrating greater stability and resistance to erosion compared to the low-carbon, highly erodible soils of the western highlands.

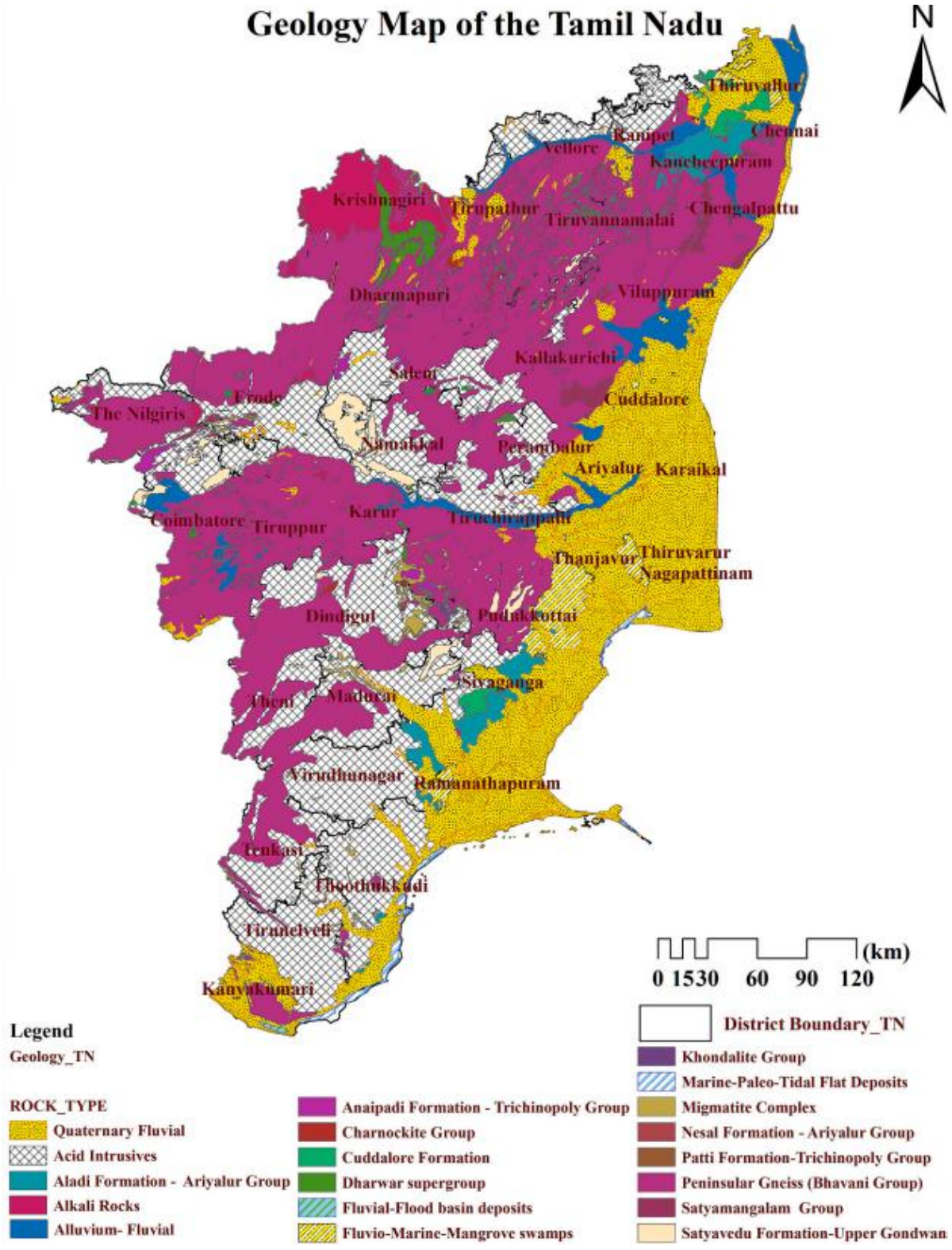


Figure 1: Spatial distribution of lithological units and pedogenic parent materials (*Source: Manikanda Bharath et al., 2026*)

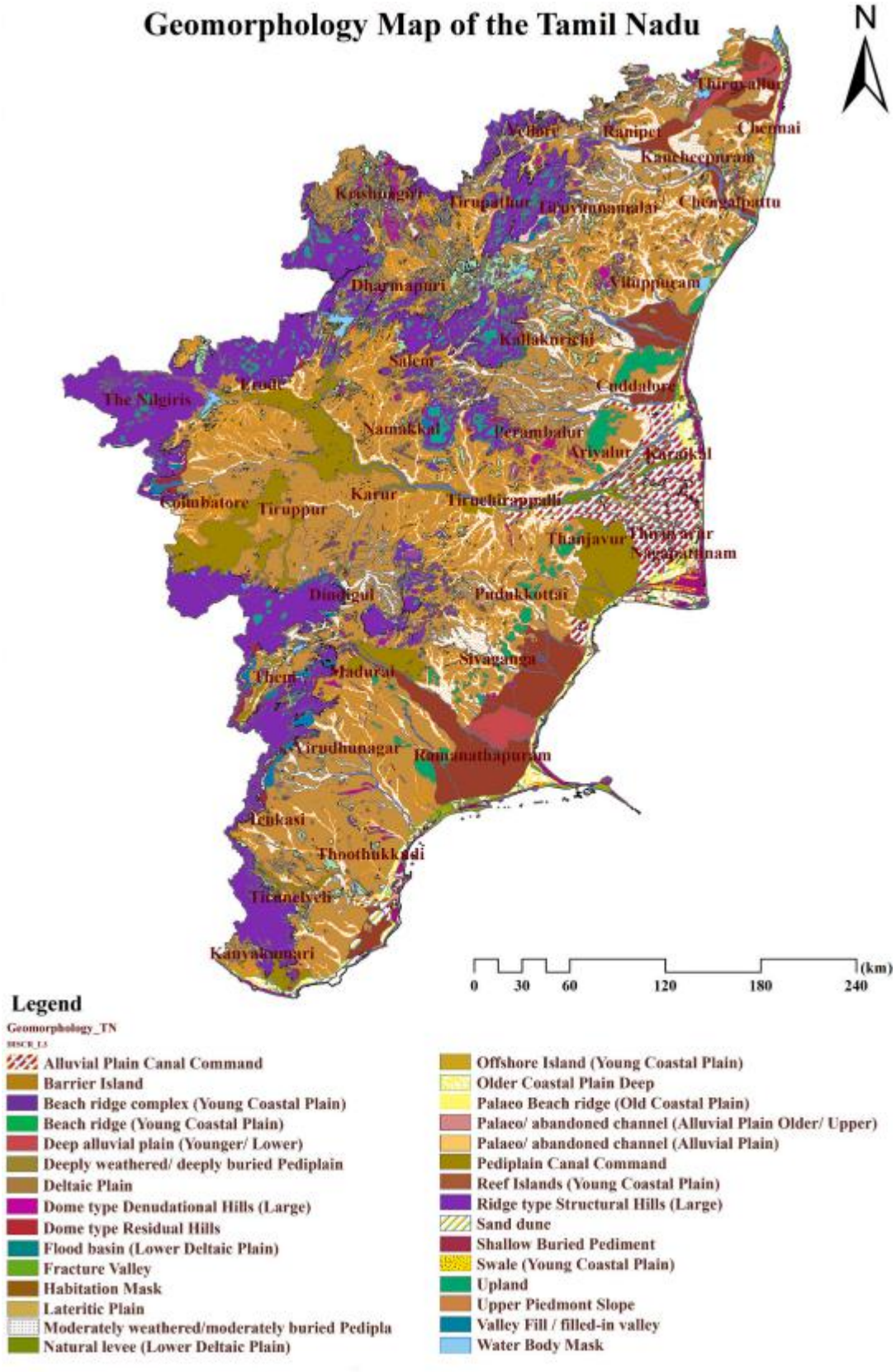


Figure 2: Geomorphological units and landform evolution patterns (*Source: Manikanda Bharath et al., 2026*).

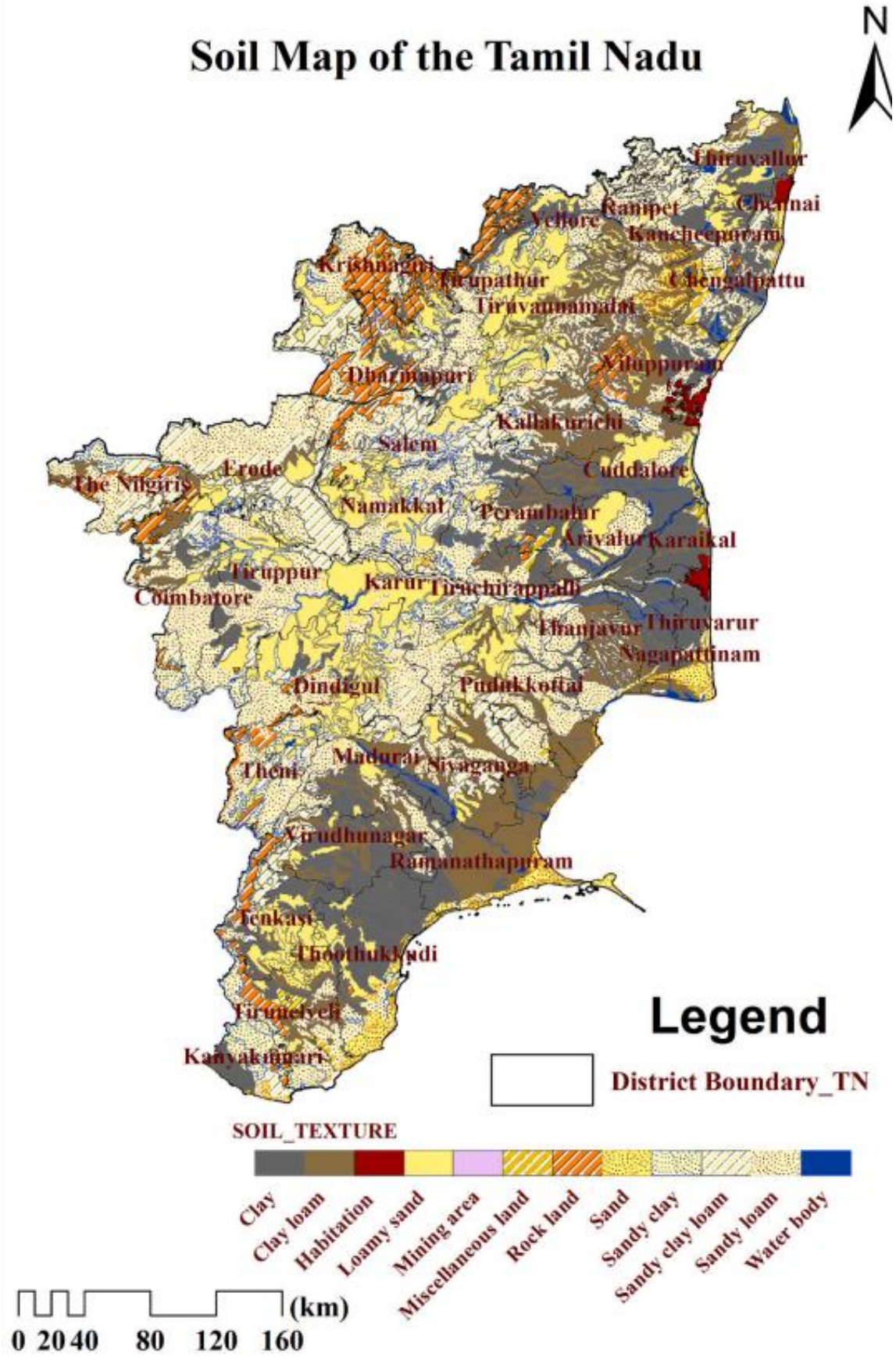


Figure 3: Soil textural distribution and hydrological functional domains (*Source: Manikanda Bharath et al., 2026*).

Vulnerability, as a scientific concept, has evolved into a central theme within environmental studies, climate science, and disaster risk research. It broadly refers to the degree to which a system—human or environmental—is susceptible to harm from external stresses. These stresses may arise from natural processes such as extreme rainfall, erosion, sea-level rise, or from socio-economic pressures including urbanization, livelihood fragility, and demographic change. Over the past few decades, researchers across multiple disciplines have refined definitions and frameworks to capture the multifaceted nature of vulnerability, emphasizing that it extends beyond simple exposure to hazards. Instead, vulnerability represents a combination of inherent sensitivity, external pressures, and the adaptive capacity of a system to withstand or recover from adverse impacts.

Tamil Nadu provides an exemplary setting for examining vulnerability in an integrated manner due to its striking physiographic diversity—from the wave-dominated coastlines of the Bay of Bengal and the Gulf of Mannar to the fertile interior plains and the rugged highlands of the Western and Eastern Ghats. Each of these zones hosts distinct environmental processes, geological foundations, land-use practices, and socio-economic conditions, creating unique patterns of risk and resilience across the state. The dynamic interplay between natural systems and human activities intensifies this complexity. Coastal districts, for instance, experience recurrent storm surges, shoreline erosion, and flooding, while the interior plains grapple with groundwater depletion, drought variability, and land degradation. Meanwhile, the highlands face challenges linked to steep slopes, soil erosion, and ecological sensitivity. Understanding these interlinked processes is essential for interpreting vulnerability as a spatially and temporally variable phenomenon.

Historically, vulnerability assessment emerged from disaster studies, where the focus was to understand why certain communities suffered disproportionately during hazard events. As the scope expanded, the concept began to integrate ecological processes, socio-economic characteristics, institutional capacity, and climate-induced stressors. This interdisciplinary evolution paved the way for frameworks that consider exposure, sensitivity, and adaptive capacity as the core components of vulnerability. Exposure refers to the presence of people, infrastructure, or ecosystems in harm-prone areas. Sensitivity captures how strongly these entities are affected by stress, which may depend on factors such as soil type, landform, livelihood patterns, or demographic structure. Adaptive capacity reflects the ability of systems to anticipate, cope with, and recover from impacts. Together, these components help explain why regions with similar hazards may exhibit vastly different vulnerability outcomes.

Tamil Nadu's vulnerability landscape is shaped not only by natural and climatic forces but also by developmental pressures. Dense coastal settlements, expanding agricultural activities, industrial corridors, and rapid urbanization alter land-use patterns and amplify stress on natural systems. While the coastal belt houses critical economic zones and fishing communities, the interior plains support extensive agriculture that is highly sensitive to climate variability. The uplands, recognized for their ecological richness, are equally fragile due to soil erosion, hydrological instability, and land cover change. These conditions highlight the need for region-specific vulnerability assessments that recognize the heterogeneity of natural and socio-economic drivers across the state.

In recent years, advancements in geospatial technologies, remote sensing, and multi-criteria evaluation have transformed vulnerability studies. Tools such as satellite measurements, digital

elevation models, soil information systems, and hazard modelling frameworks allow researchers to capture spatial patterns with greater precision. Concurrently, socio-economic datasets, public perception surveys, and community-based assessments contribute essential insights into human dimensions of vulnerability. These methodological developments enhance our ability to identify hotspots, anticipate emerging risks, and support decision-makers in designing targeted interventions.

Vulnerability Frameworks and Key Assessment Approaches

The region's vulnerability assessments draw on multi-indicator frameworks that combine physical exposure (to hazards such as cyclones, floods, sea-level rise, drought, and erosion), socio-economic sensitivity (demography, occupation, infrastructure), and adaptive capacity (education, diversification, and disaster management infrastructure). Recent work increasingly incorporates high-resolution spatial data, field surveys, and geospatial modelling to identify micro-level patterns and process domains within and between regions as follows:

a) Coastal Zone Vulnerability
b) Central and Inland Plain Zone Vulnerability
c) Highland Zone Vulnerability

Physiography and Environmental Setting of Tamil Nadu

Tamil Nadu occupies a unique geographical position in the southernmost part of the Indian peninsula, bounded by the Bay of Bengal to the east, the Indian Ocean to the south, and flanked by the Western and Eastern Ghats. This diverse physical setting contributes significantly to the spatial variations in environmental processes, climatic regimes, and landscape responses, all of which have critical implications for regional vulnerability. The physiographic layout of the state is not merely a backdrop; it is a dynamic framework that shapes exposure to hazards, influences ecological stability, and governs the distribution of natural resources.

The state can be broadly divided into three major physiographic regions—coastal zones, interior plains, and highlands—each characterized by distinct geological formations, geomorphic patterns, hydrological systems, and ecological conditions. The coastal belt stretches for more than 1,000 km along the eastern margin, forming one of India's longest and most densely inhabited coastlines. This region exhibits a wide array of landforms including sandy beaches, barrier dunes, tidal flats, estuaries, mangrove ecosystems, and deltaic plains formed by major rivers such as the Cauvery, Palar, and Vaigai. The morphology of the coast is heavily influenced by monsoonal winds, wave climate, nearshore currents, and sediment transport dynamics. As a result, issues such as shoreline erosion, saltwater intrusion, cyclonic storm surges, and tidal flooding are widespread, making the coastal environment inherently vulnerable.

Moving inland, the central plains represent one of the most agriculturally productive regions of the state. These plains are formed by alluvial and colluvial deposits derived from the surrounding hill systems and fluvial activity. The region's soils range from deep black cotton soils to red loamy and alluvial types, creating varied agricultural potential across districts. The plains also house major river basins, tanks, and reservoirs that support extensive irrigation networks. However, the same physiographic advantages also contribute to vulnerability in the form of groundwater depletion, recurring droughts, sedimentation of water bodies, and land degradation driven by intensive cultivation and land-use changes. Human pressures, including

urban expansion, industrial corridors, and infrastructure development, further reshape the natural landscape and increase sensitivity to climatic extremes.

In contrast, the highland regions associated with the Western and Eastern Ghats represent an ecologically sensitive and geologically complex terrain. These uplands are characterized by steep slopes, rugged ridgelines, deep valleys, and forested tracts that host rich biodiversity. The Western Ghats, recognized as a global biodiversity hotspot, influence regional climate by intercepting monsoonal winds and generating orographic rainfall. The resulting hydrological systems feed major rivers and sustain downstream ecosystems. However, the combination of steep gradients, fragile lithology, and intense rainfall renders the highlands prone to soil erosion, landslides, slope instability, and localized flooding. Land-use modifications—such as plantation agriculture, quarrying, and road construction—further disturb slope stability and hydrological balance, amplifying vulnerability.

The geological framework of Tamil Nadu also plays a significant role in shaping its environmental setting. The state rests on a complex assemblage of Archaean crystalline rocks, Proterozoic sedimentary formations, and Quaternary coastal deposits. This mosaic of lithological units determines soil characteristics, groundwater potential, mineral resources, and susceptibility to erosion. For example, crystalline basement terrains in the highlands give rise to shallow, coarse-textured soils that are easily eroded, while the sedimentary tracts of the plains support deeper soils but are more sensitive to land-use pressure and hydrological deficits. Meanwhile, the unconsolidated coastal deposits are highly dynamic, responding rapidly to marine and atmospheric conditions.

Climatically, Tamil Nadu is strongly influenced by the dual monsoon system—the Southwest Monsoon (June to September) and the Northeast Monsoon (October to December). Unlike most Indian states, Tamil Nadu receives a substantial portion of its annual rainfall from the Northeast Monsoon, making it particularly sensitive to variations in that season. Irregularities in monsoonal behaviour, such as delayed onset or concentrated high-intensity rainfall, directly impact agriculture, water availability, and hazard occurrence. The highlands enjoy relatively cooler temperatures and higher rainfall, while the coastal regions experience humid tropical conditions with strong maritime influences. Temperature gradients, rainfall variability, and wind regimes create region-specific environmental pressures that shape vulnerability differently across the state's physiographic zones.

Hydrologically, Tamil Nadu is defined by a network of river basins, tanks, reservoirs, wetlands, and aquifers. While the plains depend substantially on surface water stored in tanks and reservoirs, many coastal districts rely heavily on groundwater. Over-extraction, coupled with declining recharge and saline intrusion, has led to water stress in several regions. The highlands serve as important recharge zones, but increasing anthropogenic disturbance affects the natural hydrological functioning. Seasonal rivers and ephemeral streams in the highlands respond rapidly to rainfall, often triggering flash floods and erosion processes, whereas the plains experience prolonged water scarcity during drought years.

Ecologically, the state encompasses a mosaic of forests, agricultural fields, wetlands, mangroves, grasslands, and coastal ecosystems. Each ecological zone supports distinct flora and fauna and provides essential ecosystem services such as carbon storage, flood regulation, nutrient cycling, and habitat support. However, ecological fragility varies across regions. Highland forests are sensitive to fragmentation and invasive species, plains ecosystems are

susceptible to agricultural intensification and pollution, and coastal environments face threats from land conversion, aquaculture expansion, and climate-induced hazards.

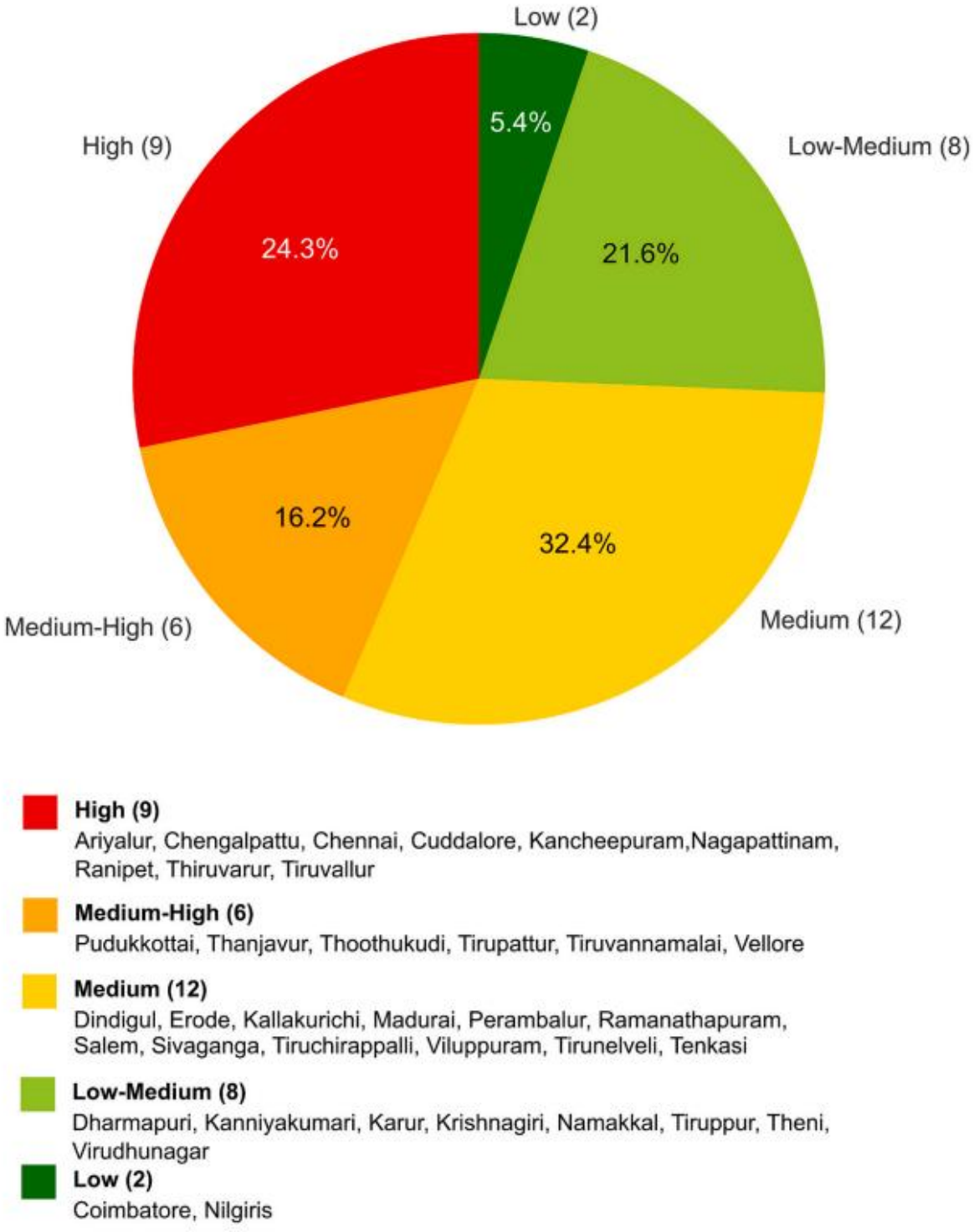


Figure 4: Carbon storage capacity classes and landscape resilience indicators (*Source: Manikanda Bharath et al., 2026*).

Taken together, Tamil Nadu's physiographic and environmental attributes form a complex, interconnected system where natural and anthropogenic factors interact to determine the degree of vulnerability. Understanding this setting is crucial because it provides the physical and

ecological foundation upon which regional risks emerge. Whether assessing erosion in the highlands, drought in the plains, or storm surges along the coast, the state's environmental diversity shapes both the nature of hazards and the capacity of landscapes to withstand them.

Chapter 17

Methods and Approaches in Vulnerability Assessment

The study of vulnerability has expanded significantly over recent decades, evolving from a hazard-centric perspective to a multifaceted, interdisciplinary field that integrates environmental dynamics, socio-economic characteristics, and technological advancements. As vulnerability research matured, the need for robust analytical frameworks and scientifically grounded methodologies became evident. Tamil Nadu's diverse landscapes—coastal systems prone to cyclones, plains affected by drought and land degradation, and highlands susceptible to erosion—demand approaches that are sensitive to spatial variation and capable of capturing localized complexities. This chapter outlines the principal methods and analytical approaches that underpin contemporary vulnerability assessments, highlighting their relevance to regional-scale studies.

Early vulnerability assessments relied heavily on hazard frequency, historical events, and descriptive evaluations; however, these methods provided only partial insight because they focused primarily on the physical exposure of regions to specific hazards. As researchers recognized that vulnerability is influenced not just by exposure but also by internal sensitivity and the capacity to respond, new frameworks emerged that incorporated multiple environmental and socio-economic dimensions. This shift resulted in the development of composite vulnerability indices—an approach that remains central today. These indices combine diverse indicators representing exposure, sensitivity, and adaptive capacity, enabling researchers to quantify vulnerability and classify regions into categories ranging from low to very high.

A widely used technique in constructing such indices is Multi-Criteria Evaluation (MCE). In this approach, each factor contributing to vulnerability is assigned a relative importance based on expert knowledge, literature evidence, or statistical reasoning. One of the most common decision-support techniques within MCE is the Analytical Hierarchy Process (AHP), which structures complex problems into hierarchical levels and assigns weights through pairwise comparisons. This technique is particularly useful in integrating environmental layers such as slope, land cover, lithology, geomorphology, rainfall, and soil properties with socio-economic indicators like population density, literacy rates, agricultural dependency, and livelihood characteristics. AHP-based models are especially advantageous in the context of Tamil Nadu, where physiographic diversity demands a regionally calibrated weighting system.

Another important methodological strand involves index-based models developed for specific hazards. For example, coastal studies frequently employ the Coastal Vulnerability Index (CVI), which incorporates variables such as shoreline change rate, coastal slope, tidal range, wave height, and geomorphic type. CVI offers a concise yet comprehensive means of highlighting zones that are at risk from sea-level rise, storm surges, and erosion. In highland and upland regions, erosion assessments often rely on models such as the Revised Universal Soil Loss Equation (RUSLE), which quantifies soil loss by integrating factors including rainfall erosivity, soil erodibility, slope length, slope steepness, land cover, and conservation practices. These models help identify areas where terrain and land-use combinations produce heightened erosion sensitivity.

The increasing availability of satellite imagery and geospatial tools has revolutionized vulnerability assessment. Remote sensing provides valuable information on land use/land cover changes, vegetation health, soil moisture variability, shoreline shifts, and flood extents, enabling the detection of long-term trends and abrupt changes. High-resolution Digital Elevation Models (DEMs) derived from sensors such as SRTM, ASTER, and more recently LiDAR, allow detailed terrain analysis that is crucial for modelling slope instability, water flow accumulation, and geomorphic susceptibility. Geographic Information Systems (GIS) serve as the central platform where these datasets converge, allowing integration, reclassification, overlay analysis, and spatial visualization of vulnerability components.

Socio-economic vulnerability assessment has also advanced with the growing availability of census data, household surveys, and community-level indicators. Contemporary approaches increasingly incorporate qualitative data—such as perceptions of risk, preparedness levels, and coping capacity—collected through interviews and surveys. These insights help capture dimensions of vulnerability that cannot be fully represented through spatial or numerical datasets alone. Particularly in rural and coastal communities, perceptions often reflect historical memory of hazards, livelihood constraints, and trust in local governance—factors that significantly affect adaptive capacity. Hybrid approaches that combine environmental, climatic, and socio-economic indicators have become increasingly common in regional vulnerability assessments. In Tamil Nadu, this integration is essential because vulnerability arises from a mixture of physical and human pressures. For example, coastal erosion may be driven by wave climate but magnified by settlement expansion; agricultural sensitivity may originate from rainfall variability but be intensified by groundwater depletion; and landslide risk in the highlands may be triggered by intense rainfall but worsened by land conversion. Only integrated frameworks can capture these interconnected drivers.

Recent developments in machine learning, geospatial modelling, and statistical analysis have further enhanced vulnerability assessment. Techniques such as random forests, logistic regression, neural networks, and spatial clustering help identify complex relationships among variables and improve predictive accuracy. While these methods require detailed data and computational resources, they hold significant promise for forecasting emerging hotspots and supporting proactive planning. Their applicability is growing in Tamil Nadu due to improved data availability and increasing institutional interest in predictive environmental analytics. Field validation remains a crucial component of any vulnerability assessment, as model outputs must be grounded in on-the-ground observations. Site visits allow verification of erosion features, shoreline positions, groundwater conditions, and socio-economic realities that may not be fully captured by remote sensing or secondary datasets. Validation enhances the reliability of vulnerability maps and ensures that decision-making is based on credible evidence.

In summary, vulnerability assessment has moved from descriptive to computational, from single-hazard to multi-dimensional, and from broad regional scales to fine-grained spatial analysis. This methodological evolution reflects not only scientific advancement but also the pressing need to understand vulnerability as a dynamic and layered phenomenon. Tamil Nadu's varied landscapes demand flexible, integrative, and context-sensitive approaches capable of capturing the differential pressures experienced across coastal, plain, and highland zones. The methods outlined in this chapter form the foundation for the analyses presented in the

subsequent chapters, which explore how these frameworks reveal spatial patterns of vulnerability across the state.

CHAPTER 18

Coastal Zone Vulnerabilities

Tamil Nadu's coastline forms one of the most dynamic and ecologically significant margins of the Indian peninsula. Stretching over a thousand kilometres, it interfaces directly with the Bay of Bengal, the Palk Strait, and the Gulf of Mannar, each embodying unique oceanographic and geomorphic behaviours. The coastal environment plays a vital role in sustaining livelihoods, fisheries, ports, agriculture, and tourism, while simultaneously functioning as a buffer against oceanic processes. Despite its productive potential, the coastline remains highly vulnerable due to the convergence of natural forces, climatic perturbations, and mounting human pressures. Understanding coastal vulnerability therefore requires an integrated view of geomorphology, shoreline dynamics, hazard climatology, and socio-economic exposure.

The coastline of Tamil Nadu is shaped by a combination of sedimentary plains, deltas, beaches, dunes, estuaries, and lagoonal systems. These landforms respond continuously to the interaction of waves, tides, currents, and sediment transport. Even small shifts in these processes can trigger major morphological adjustments, particularly in the Coromandel Coast where monsoonal winds and seasonal wave reversals exert strong control on shoreline mobility. The natural dynamism of the coast becomes problematic when human settlements, infrastructure, and economic activities occupy zones that were once free to adjust. The combination of rigid infrastructure, reduced sediment supply, and hydroclimatic variability intensifies vulnerability.

A central component of coastal vulnerability is shoreline change, an issue highlighted extensively for Tamil Nadu's coast. Historical records and modern satellite-based assessments have revealed alternating phases of erosion and accretion, with several stretches exhibiting persistent retreat. These erosional hotspots align closely with regions exposed to high wave energy, sediment deficits, and human alterations such as harbours and groynes. The installation of coastal engineering structures, though intended to protect specific segments, often disrupts longshore sediment movement, resulting in downdrift erosion. Such patterns underscore the need to evaluate human interventions as part of the broader vulnerability mosaic rather than isolated local solutions.

Cyclonic storms constitute another major driver of vulnerability along Tamil Nadu's coastline. The state is recurrently affected by tropical cyclones originating in the Bay of Bengal, which bring destructive winds, storm surges, and intense rainfall. Coastal districts such as Nagapattinam, Cuddalore, Chennai, and Kanyakumari have experienced severe events marked by extensive flooding, saline water intrusion, and large-scale infrastructure damage. The compound effects of high tides and storm surges amplify inundation, particularly in low-lying coastal plains and deltaic tracts. When combined with sea-level rise projections, these hazards point to an increasing risk landscape for the coming decades.

Assessments based on coastal vulnerability indices have provided important insights into the spatial distribution of risk. Parameters such as coastal slope, geomorphic type, shoreline change rate, mean significant wave height, tidal range, and sea-level rise contribute collectively to the vulnerability profile of each coastal segment. Areas with low beach width, gentle slopes, and unconsolidated sediments are more susceptible to landward transgression, while estuarine and

deltaic systems face enhanced risks due to their naturally sediment-rich but structurally fragile nature. The retrieved coastal vulnerability assessment for the Tamil Nadu coast highlights the variability among coastal stretches, demonstrating that even within the same district, shoreline behaviour and hazard intensity can differ markedly depending on geomorphic context.

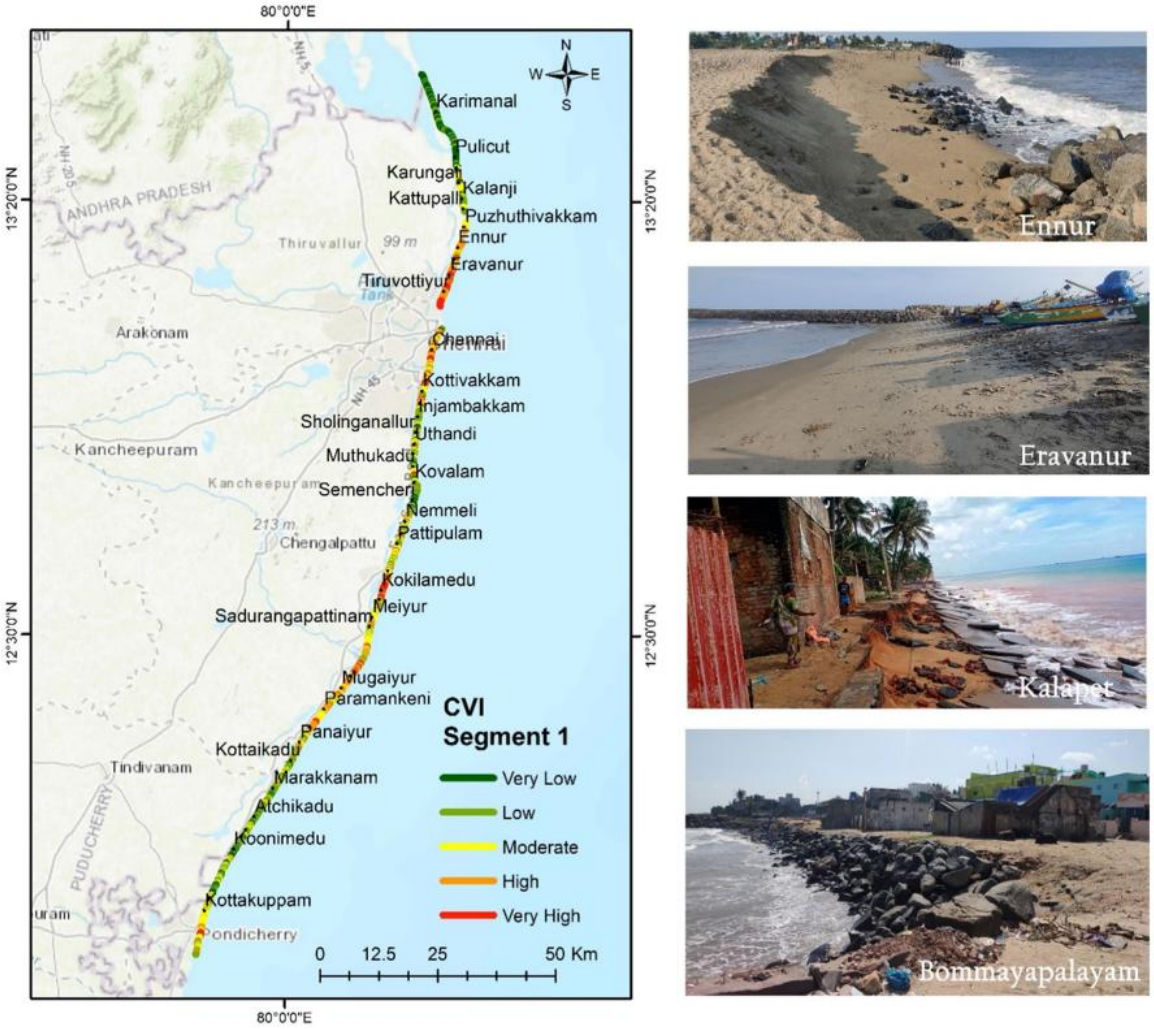


Figure: CVI map of Segment 1 (*Source: Devanantham Abijith et al., 2023*)

Figure: CVI map of Segment 2 (*Source: Devanantham Abijith et al., 2023*)

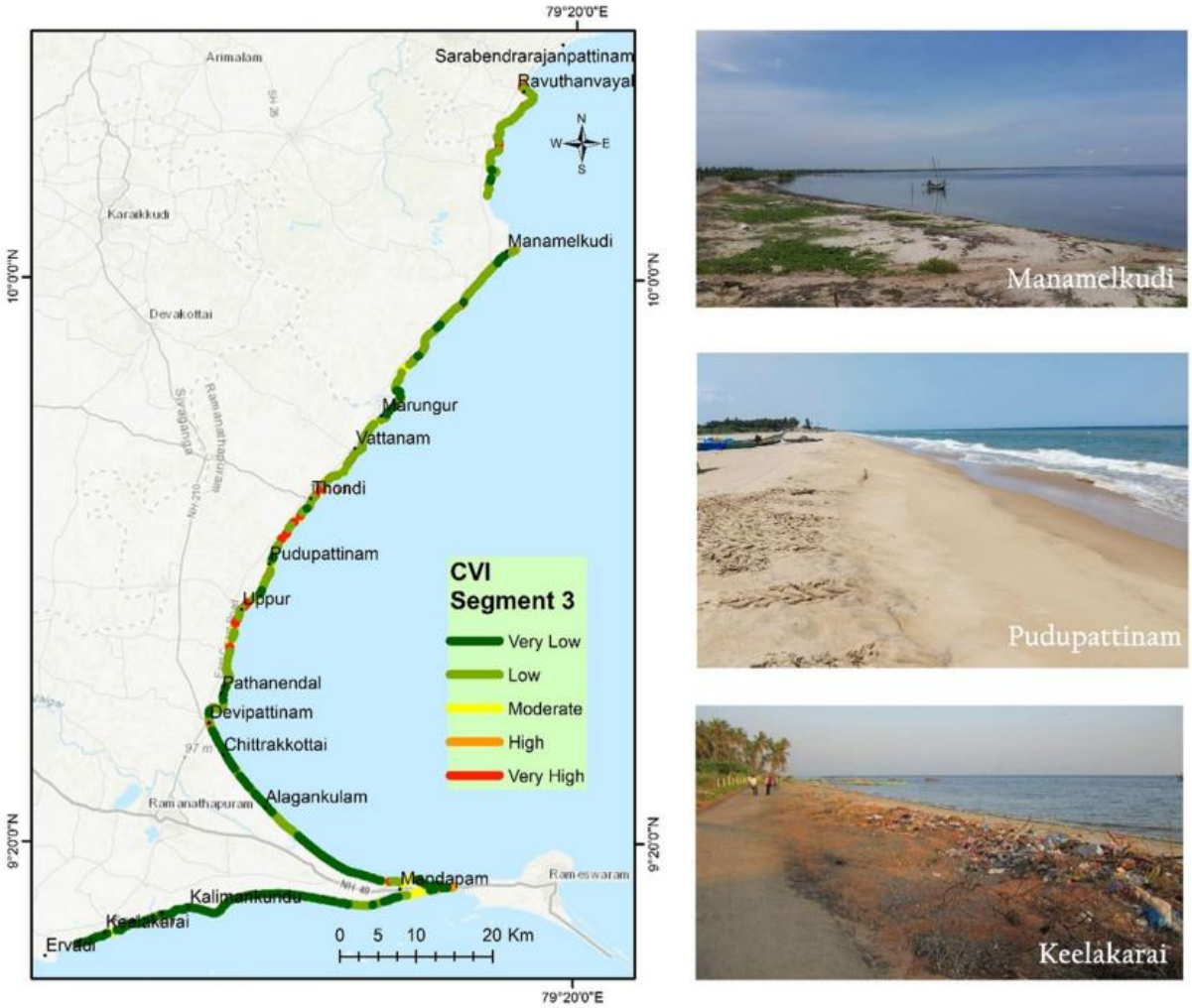


Figure: CVI map of Segment 3 (*Source: Devanantham Abijith et al., 2023*)

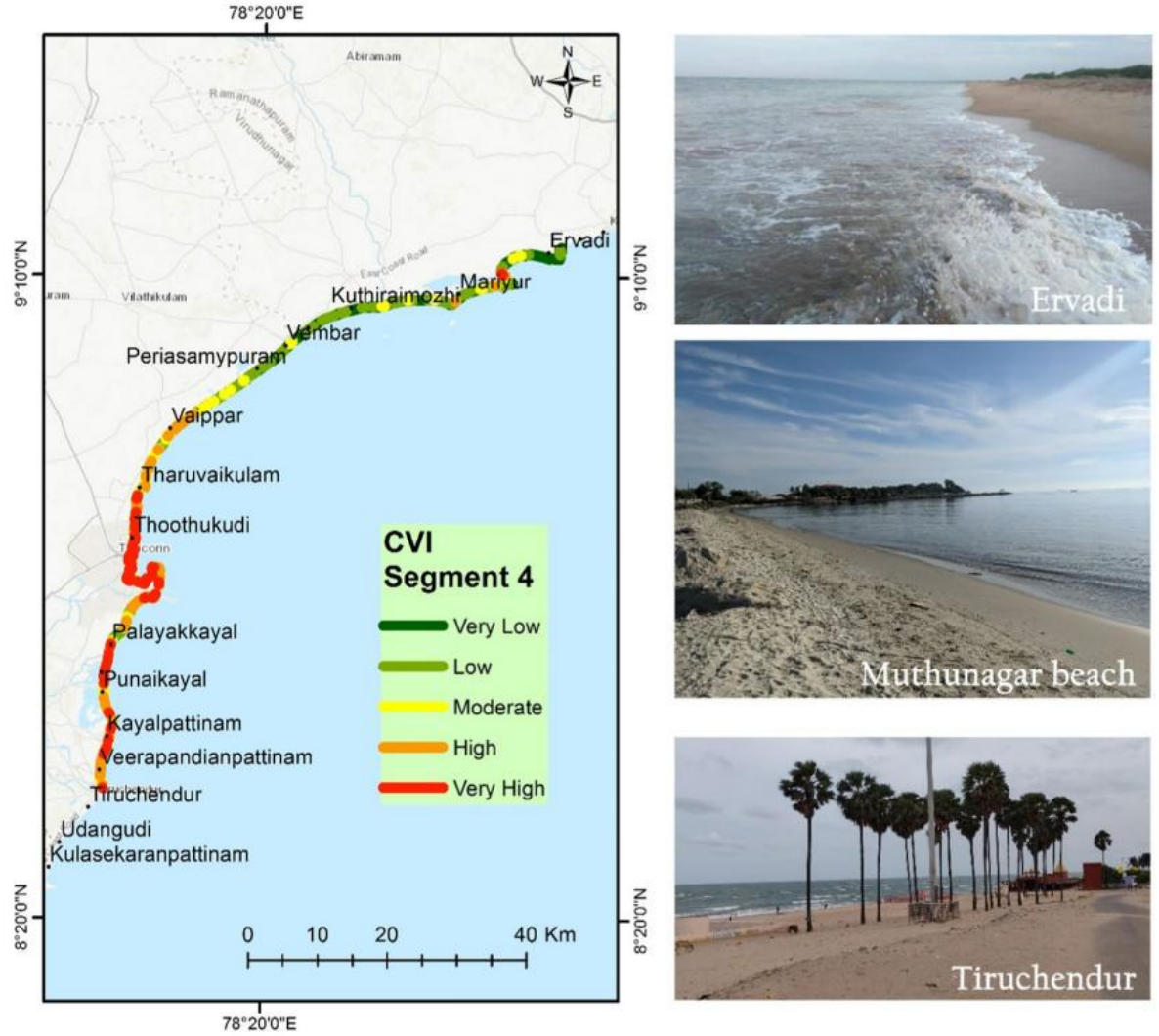


Figure: CVI map of Segment 4 (*Source: Devanantham Abijith et al., 2023*)

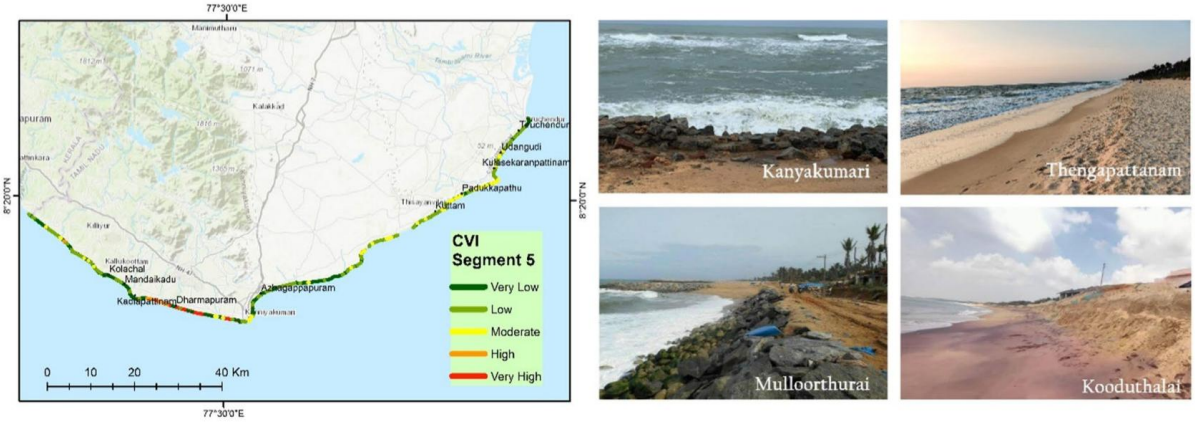


Figure: CVI map of Segment 5 (*Source: Devanantham Abijith et al., 2023*)

Table: Segment-wise Coastal Vulnerability in Tamil Nadu

Segment	Very Low (%)	Low (%)	Moderate (%)	High (%)	Very High (%)	Dominant Influencing Factors
1	14.8	29.6	27.5	19.4	8.7	Urban settlements (Chennai-Pondicherry), low elevation, heavy erosion, dense population
2	2.04	18.04	31.19	31.68	17.05	Deltaic terrain, high vegetation and settlement, significant erosion (Cuddalore-Nagapattinam)
3	13.72	21.68	2.61	36.17	25.82	Heavy wave action, tidal creeks, moderate elevation, exposed headlands (Rameswaram-Ramanathapuram)
4	32.05	22.25	20.41	13.38	11.91	Accretion zones, sandy beaches, anthropogenic activity (Tuticorin zone), sediment discharge from Thamirabarani River
5	5.56	31.99	40.63	19.91	1.91	Cliffs, rocky promontories, low-lying coast, some flood-prone areas (Kanyakumari-Kulasekarapattinam)

Human dimensions further complicate the coastal vulnerability pattern. Many coastal communities depend heavily on fishing, salt production, agriculture, and tourism—activities that are highly sensitive to environmental disturbances. The concentration of population near the shoreline exposes more people to hazard-prone environments, while limited adaptive infrastructure, inadequate evacuation planning, and livelihood dependence intensify socio-economic sensitivity. Ports, industrial corridors, and thermal power plants add layers of infrastructural exposure, creating potential cascading impacts during extreme events.

The interplay between geomorphic characteristics and human occupation becomes particularly evident in areas where settlements have expanded onto dunes, beach ridges, and tidal flats,

compromising the natural capacity of these features to absorb wave energy. Wetland loss, mangrove degradation, and conversion of coastal lowlands reduce ecosystem-based resilience. Conversely, regions with well-preserved dunes, mangroves, and coastal vegetation exhibit comparatively lower vulnerability because natural systems provide frictional resistance against hydrodynamic forces.

Climate change acts as a compounding driver. Sea-level rise threatens to accelerate shoreline recession, inundate low-lying areas, and alter salinity regimes in estuaries and groundwater systems. Increasing sea-surface temperatures potentially influence cyclone intensity, while changing rainfall patterns affect sediment supply from rivers. These climatic influences, layered upon existing geomorphic instability and socio-economic stress, enhance the overall vulnerability of Tamil Nadu's coast.

Despite these challenges, coastal vulnerability assessment offers pathways for informed management. Spatial vulnerability maps allow identification of hotspots where interventions such as dune restoration, mangrove afforestation, controlled development, and hazard-resilient infrastructure can reduce risks. The adoption of integrated coastal zone management approaches—emphasizing natural buffers, sustainable sediment budgets, and community engagement—supports long-term resilience. Equally important is recognizing that vulnerability is not static; ongoing monitoring through satellite imagery, wave and tide observations, and coastal surveys is vital to detect changes and refine adaptation strategies.

Overall, the coastal zone of Tamil Nadu embodies a dynamic interplay of natural processes and human influences, resulting in a complex vulnerability landscape. The combination of geomorphic fragility, hydrodynamic forces, climatic hazards, and socio-economic exposure underscores the need for holistic, scientifically informed, and locally grounded approaches to coastal management. By understanding the drivers of vulnerability in a spatially nuanced manner, coastal planners and policymakers can develop targeted strategies that balance protection, development, and ecosystem conservation. The insights presented here set a foundation for examining vulnerability in the plains and highlands, where different sets of processes shape the risk profile but remain interconnected through the broader environmental fabric of Tamil Nadu.

Chapter 19

Environmental and Socio-economic Vulnerability in the Coastal Plains

The coastal plains of Tamil Nadu form one of the most densely inhabited and economically active regions of the state. Extending along the eastern shoreline, these plains accommodate fishing hamlets, agricultural settlements, transport corridors, industrial nodes, and rapidly expanding peri-urban clusters. Their physical setting—low elevation, extensive alluvial deposits, proximity to the sea, and dense human occupation—creates a unique vulnerability landscape shaped by both environmental processes and socio-economic pressures. Understanding vulnerability in these coastal plains requires an analysis that goes beyond geomorphology, acknowledging the decisive role played by human systems, livelihood structures, and community resilience capacities.

The environmental sensitivity of the coastal plains is intrinsically linked to their geological and geomorphic character. These regions comprise deltaic tracts, beach–dune systems, tidal flats, and back-swamps, all of which are naturally dynamic and periodically influenced by marine and fluvial processes. Flooding, saline intrusion, shoreline oscillations, and high-intensity rainfall are recurrent features, making the plains inherently exposed to multiple hazards. Yet, environmental exposure alone does not fully explain the region's vulnerability. Instead, it is the intersection of these hazards with dense populations, fragile livelihoods, and limited adaptive infrastructure that transforms risk into a persistent socio-economic challenge.

Table: Major coastal disaster events in the coastal plains of Tamil Nadu during the last two decades (2000–2020)

Major Disaster	Month/Year	Geographical extent and Impact	Reference
Cyclone	November 2000	Graded as an extremely severe cyclonic storm with a wind speed of around 180 kmph. Ten lives were lost due to this cyclone. The other major losses were crop damage and uprooting of trees. Major affected areas were Cuddalore, Nagapattinam and Puducherry	IMD http://www.rsmcnewdelhi.imd.gov.in/
Fire Accident	July 2004	A fire at a government-aided school in Kumbakonam killed 93 children. It happened due to school's narrow stairway, poor lighting, thatched roof and kitchen in the proximity of the school building	Walia & Satapathy, 2007
Tsunami	December 2004	The tsunami from the 2004 M = 9.1 Sumatra-Andaman earthquake was primarily caused by vertical displacement of the seafloor in response to slip on the inter-plate thrust fault. The run-up height was 3 to 10 m and inundated 300 to 3000 m inland. In the coastal Tamil Nadu, 7,965 people lost their lives. Most of the fatalities were recorded in Nagapattinam (6,051), Chennai and Kanyakumari (206). The total damage is about one million USD.	EM-DAT 2020; Gopinath et al. 2014; Anandan & Sasidhar, 2011
Flood	December 2005	Two weeks of continuous rainfall caused flash floods in the low-lying areas of Tiruvarur, Nagapattinam, Cuddalore, Pudukottai, Ramanathapuram, Chennai and Karaikal. The death toll is about 490	DMMD 2005
Cyclone Nisha and Flood	November 2008	Heavy rainfall and gusty winds accompanied the cyclonic storm that gusted around 80 kmph. The highest rainfall was recorded at Vedaranyam (333 mm). In addition to more than 100 lives, 0.8 million acres of paddy were lost in Cuddalore, Nagapattinam, Karaikal, Thanjavur and Tiruvarur districts	IMD http://www.rsmcnewdelhi.imd.gov.in/
Cyclone Thane	December 2011	Thane was a very severe cyclonic storm with a wind speed of 140 kmph. It mainly affected the agricultural areas of Cuddalore, Puducherry, Thiruvarur, Nagapattinam, and Thanjavur districts	IMD http://www.rsmcnewdelhi.imd.gov.in/ ; Punithavathi et al., 2012
Building Collapse	June 2014	An eleven-story under-construction building at Moulivakkam in the suburb of Chennai collapsed, killing 61 construction workers	Radhakrishnan, 2017
Flood	December 2015	The unprecedented rains in the first week of December 2015, the worst in 100 years, battered Chennai, Tiruvallur, Kanchipuram and Cuddalore districts. Chennai recorded over 33 cm of rain in 24 hours from December 1-2, resulting in widespread economic damage	Rajan, 2016
Cyclone Vardah	December 2016	Vardah is a very severe cyclonic storm with a windspeed of 130 kmph. It severely affected the Chennai region. Tweny four lives were lost. The state government estimated the infrastructure damage to be ~3 billion USD.	IMD http://www.rsmcnewdelhi.imd.gov.in/
Drought	2017		https://tnsdma.tn.gov.in

Table: Major coastal disaster events in the coastal plains of Tamil Nadu during the last two decades (2000–2020)

Major Disaster	Month/Year	Geographical extent and Impact	Reference
		Low rainfall coupled with irregular/erratic monsoons in the state lead to severe drought. Agricultural and drinking water sectors were adversely affected	
Ennore Oil spill	January 2017	Two ships viz; MV BW Maple and MV MT Dawn collided. A major portion of the spilt oil was trapped in the Ernavur groin fields and subsequently, it drifted southwards spreading along the shore. Most of the oil slick was confined to the north of Royapuram Fishing harbour of Chennai	ICMAM 2017
Cyclone Ockhi	November 2017	Ockhi was graded a very severe cyclonic storm (windspeed was around 85 kmph). Due to Ockhi, 199 Fishermen missing, 6,868 houses were damaged, 8,000 acres of rubber plantation were damaged, 25,000 coconut trees were uprooted, and 12,000 acres of banana plantations were damaged in Kanyakumari district. Inland flooding and inundation were experienced due to heavy to extremely heavy rainfall	IMD http://www.rsmcnewdelhi.imd.gov.in/
Cyclone Gaja	November 2018	Gaja was a very severe cyclonic storm with a wind speed of 120 kmph. Major affected areas were Nagapattinam, Thiruvarur and Thanjavur districts. Of the 26,089 households affected, 10,512 houses were destroyed. Being a hub for perennial crops, 80% of the tree cover over 20 years old have been uprooted in the Cauvery delta region	IMD http://www.rsmcnewdelhi.imd.gov.in/; Nivedita et al., 2019
Industrial Accident	July 2020	The boiler at Unit-5 in stage 2 of the Neyveli Thermal Plant (Cuddalore District) exploded early in the morning when workers were about to resume operations resulting in six killed and 17 injured	https://www.downtoearth.org.in/
Cyclone Nivar / Flood	November 2020	Nivar is a severe cyclonic storm with a wind speed of 90 kmph. Chennai, Puducherry, Villupuram and Cuddalore, districts were affected both by wind gusts and extreme rainfall	IMD http://www.rsmcnewdelhi.imd.gov.in/
Cyclone Burevi / Flood	December 2020	Burevi is a cyclonic storm with a wind speed of 70-80 kmph. Southern and central coastal districts received very heavy rainfall and low-lying regions were inundated	IMD http://www.rsmcnewdelhi.imd.gov.in/

Socio-economic vulnerability assessments from the coastal districts highlight that communities living in these plains possess varying levels of sensitivity and coping capacity. Many households depend heavily on climate-sensitive livelihoods such as fishing, agriculture, salt-pan work, and small-scale trading. These occupations, while deeply embedded in local culture and tradition, offer limited income security and are highly susceptible to disruptions caused by cyclones, floods, and storm surges. The destruction of boats, nets, agricultural fields, and salt pans during extreme events often leads to prolonged livelihood instability, pushing households into cycles of debt and asset depletion.

Population characteristics further intensify vulnerability. High population densities in settlements close to the shore, combined with limited access to durable housing, piped water, sanitation, and healthcare, magnify the impacts of environmental hazards. Many settlements

exhibit mixed housing patterns, with temporary or semi-permanent structures that cannot withstand cyclonic winds or coastal inundation. Age structure, literacy levels, and occupational diversity also shape sensitivity. Vulnerability profiles derived from multi-criteria socio-economic assessments reveal that areas with low literacy, high dependency ratios, and narrow livelihood options consistently emerge as hotspots. These communities have fewer resources to prepare for hazards, limited access to early warning systems, and reduced capacity to recover from losses.

Infrastructure availability plays an equally prominent role. In several coastal plains, evacuation shelters, all-weather roads, storm-resistant public buildings, and resilient power distribution systems remain inadequate or unevenly distributed. During coastal floods or cyclones, the lack of safe shelters forces families to remain in exposed locations. Similarly, the absence of secure storage facilities means that fishing gear, agricultural inputs, and household assets cannot be protected from damage. These infrastructural deficiencies, when layered upon environmental exposure, heighten the severity of disaster impacts.

Table: District-wise number of villages/wards under different classes of composite socio-economic vulnerability

Vulnerability Class / District	Very low	Low	Moderate	High	Very high
Ariyalur	–	–	3	22	10
Chennai	3	16	128	8	–
Cuddalore	–	2	54	261	219
Kancheepuram	5	13	159	362	98
Kanniyakumari	5	26	90	12	1
Karaikal	1	1	26	2	–
Nagappattinam	1	–	34	308	158
Puducherry	–	–	44	24	–
Pudukkottai	2	3	76	129	31
Ramanathapuram	3	16	172	160	8
Sivagangai	–	3	47	68	2
Thanjavur	1	3	78	351	163
Thiruvallur	1	4	76	232	122
Thiruvarur	–	2	59	351	138
Thoothukkudi	–	13	124	150	14
Tirunelveli	1		21	22	4
Viluppuram		1	33	170	89
Viruthunagar	–	–	4	4	1
Total villages	23	103	1228	2636	1058

Multi-hazard assessments conducted in coastal plains underscore the overlapping nature of risk. Communities do not face hazards in isolation; instead, they encounter a combination of cyclonic winds, storm surges, heavy rainfall, and tidal flooding—often within short intervals. The socio-economic assessment reveals that households frequently prioritize some risks over others based on experience and immediate livelihood threats. For instance, fishing communities may perceive storm surges as more dangerous due to previous loss of boats, while farmers may fear saline intrusion more than wind damage because it directly affects crop productivity. Such perception-based variations highlight the necessity of localized, community-specific adaptation strategies.

Another critical dimension of vulnerability in the coastal plains is the degradation of protective ecosystems. Mangroves, coastal wetlands, and backwater systems historically served as natural buffers, absorbing storm energy and reducing flooding intensity. However, expansion of

aquaculture, conversion of wetlands, and encroachment for settlements have diminished these protective features. Loss of mangroves and dune systems not only heightens physical exposure but also disrupts local livelihoods that depend on these ecosystems. Environmental degradation therefore acts as both a driver and a consequence of socio-economic vulnerability.

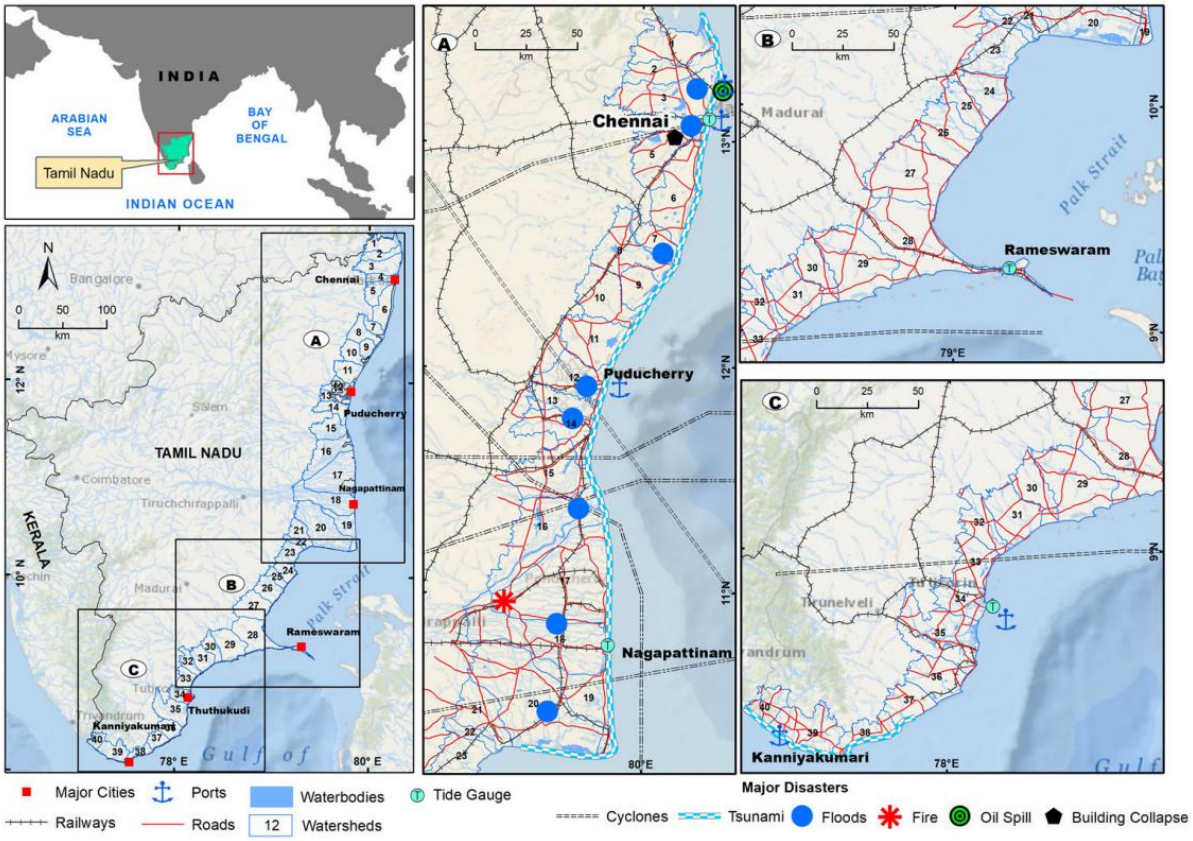


Figure: Location of the southeast coastal region of India - Tamil Nadu coast plains (A: Coromandel Coast, B: Palk Strait and C: Gulf of Mannar). The base map shows the delineated coastal watersheds of Tamil Nadu along with the locations of major hazards during the past two decades (2000-2020). The background map represents the topography of land and sea.

Despite these challenges, coastal communities exhibit significant adaptive knowledge accumulated through generations of living in dynamic environments. Traditional fishing calendars, indigenous weather forecasting practices, and locally developed coping strategies provide valuable insights into community-based resilience. However, these informal systems alone are insufficient in the face of increasingly erratic climatic patterns and intensifying cyclonic events. Modern adaptation strategies—such as early warning dissemination, hazard-resistant housing designs, livelihood diversification, financial insurance schemes, and ecosystem restoration must complement local knowledge to build sustainable resilience.

The socio-economic vulnerability patterns identified across Tamil Nadu's coastal plains point to the need for region-specific interventions. Strengthening livelihood security, improving basic services, enhancing disaster preparedness, and restoring protective ecosystems must form the core of future strategies. At the same time, participatory planning approaches are essential for ensuring that interventions account for local needs, cultural practices, and community priorities. The integration of environmental and socio-economic indicators thus provides a

holistic understanding of vulnerability, enabling more targeted and equitable risk-reduction measures.

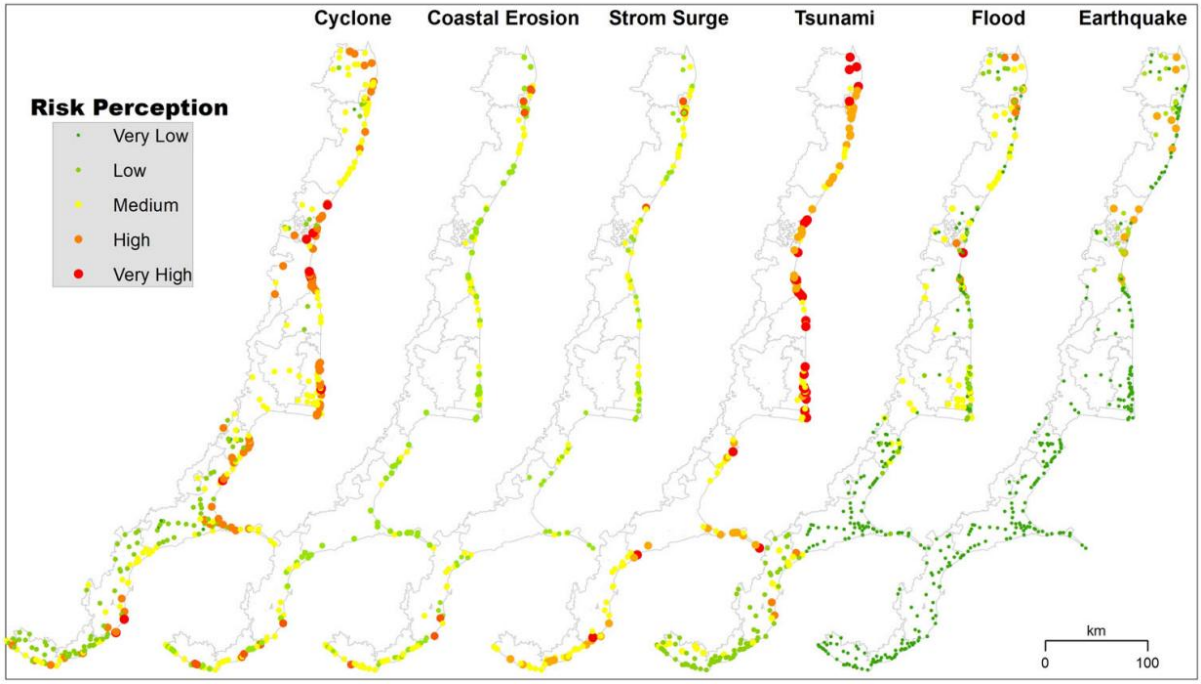


Figure: Spatial distribution of natural hazard risk level in the coastal Tamil Nadu assessed through the public perception survey on a) cyclone b) coastal erosion c) storm surge d) tsunami e) flood and f) earthquake.

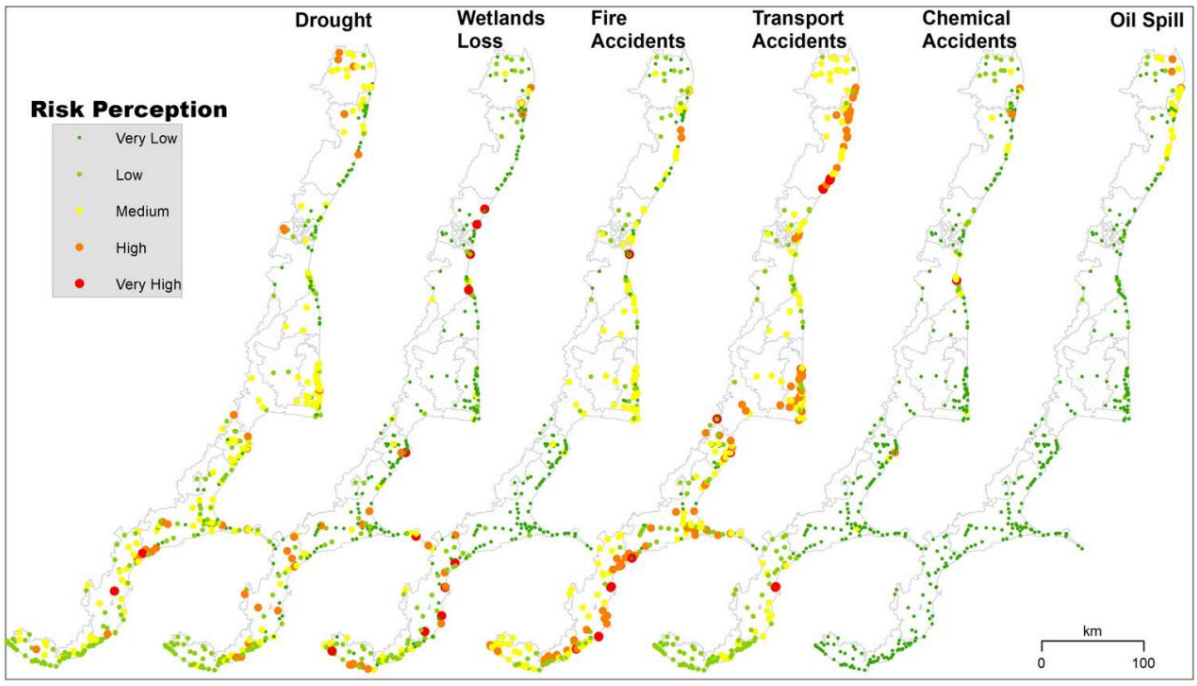


Figure: Spatial distribution of human-induced risk level in the coastal Tamil Nadu assessed through the public perception survey on a) drought b) wetland loss c) fire accident d) transport accident e) chemical f) oil spill.

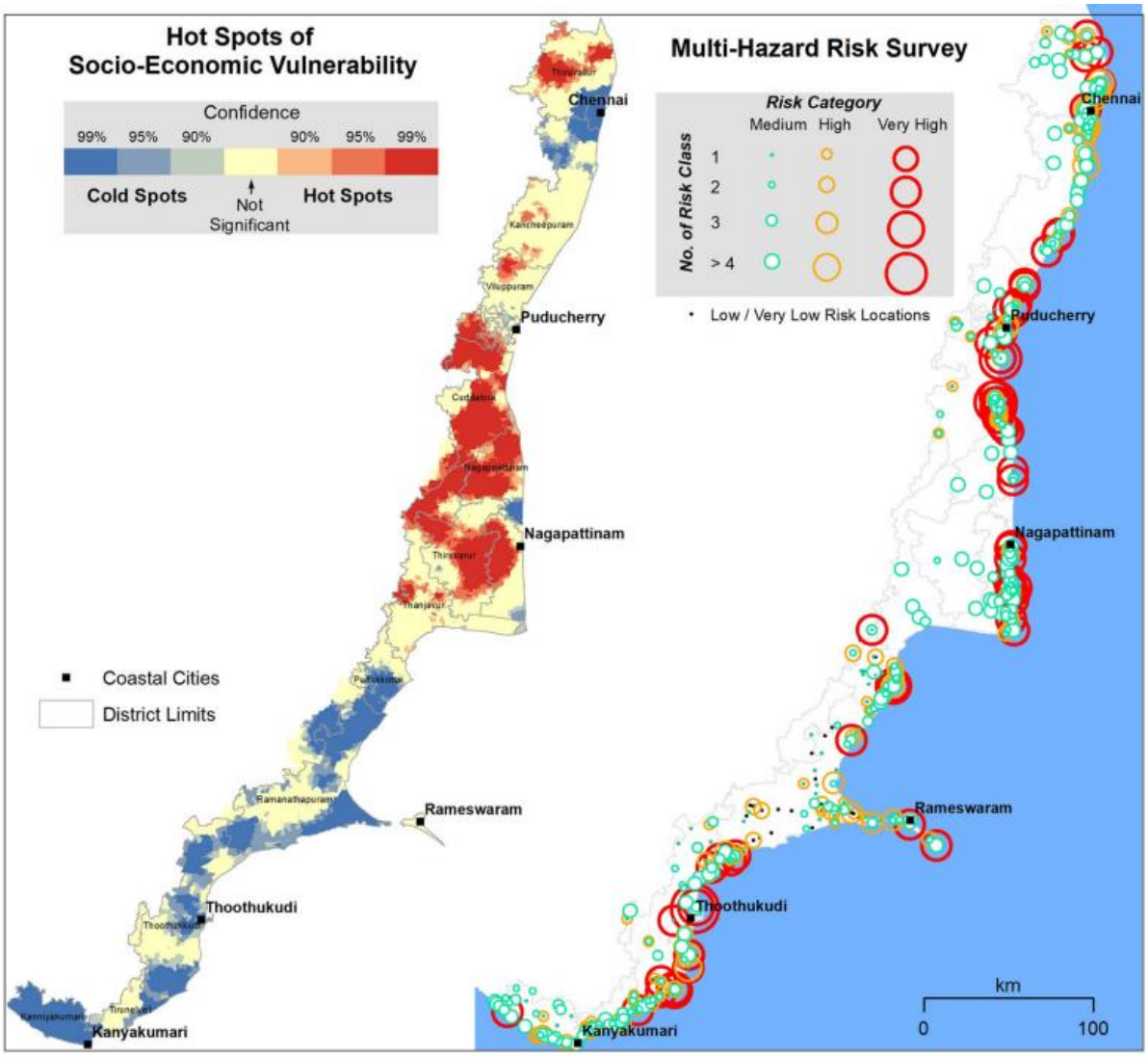


Figure: Hot spots of socio-economic vulnerability (left) and spatial distribution of multi-hazard risks (right) in coastal plains of Tamil Nadu. Left: The hot (red shades) and cold (blue shades) spots of socio-economic vulnerability are represented with different levels of confidence intervals. The villages that not formed either under hot or cold spots are depicted with yellow colour. Right: The different colour of the circle designates medium (green), high (yellow) and very high (red) risk categories. The size of the circle denotes the number of risk classes with different risk categories. For instance, the largest red circle denotes more than four different risks (natural and/or human induced) observed with very high-risk category.

The Coastal Hazard Wheel (CHW): It is a universal coastal classification and management framework designed to support resilience and adaptation of coastal areas worldwide under changing climate conditions. It enables combined multi-hazard assessment for key coastal risks such as ecosystem disruption, gradual inundation, saltwater intrusion, erosion, and flooding. CHW functions as a coastal language and decision-support tool by classifying specific coastal environments, determining their hazard profiles, identifying relevant hazard management options, and facilitating communication among scientists, policymakers, and stakeholders. The framework is especially relevant for climate change adaptation and disaster risk reduction, providing guidance at local, regional, and national levels even in areas with limited data or institutional capacity.

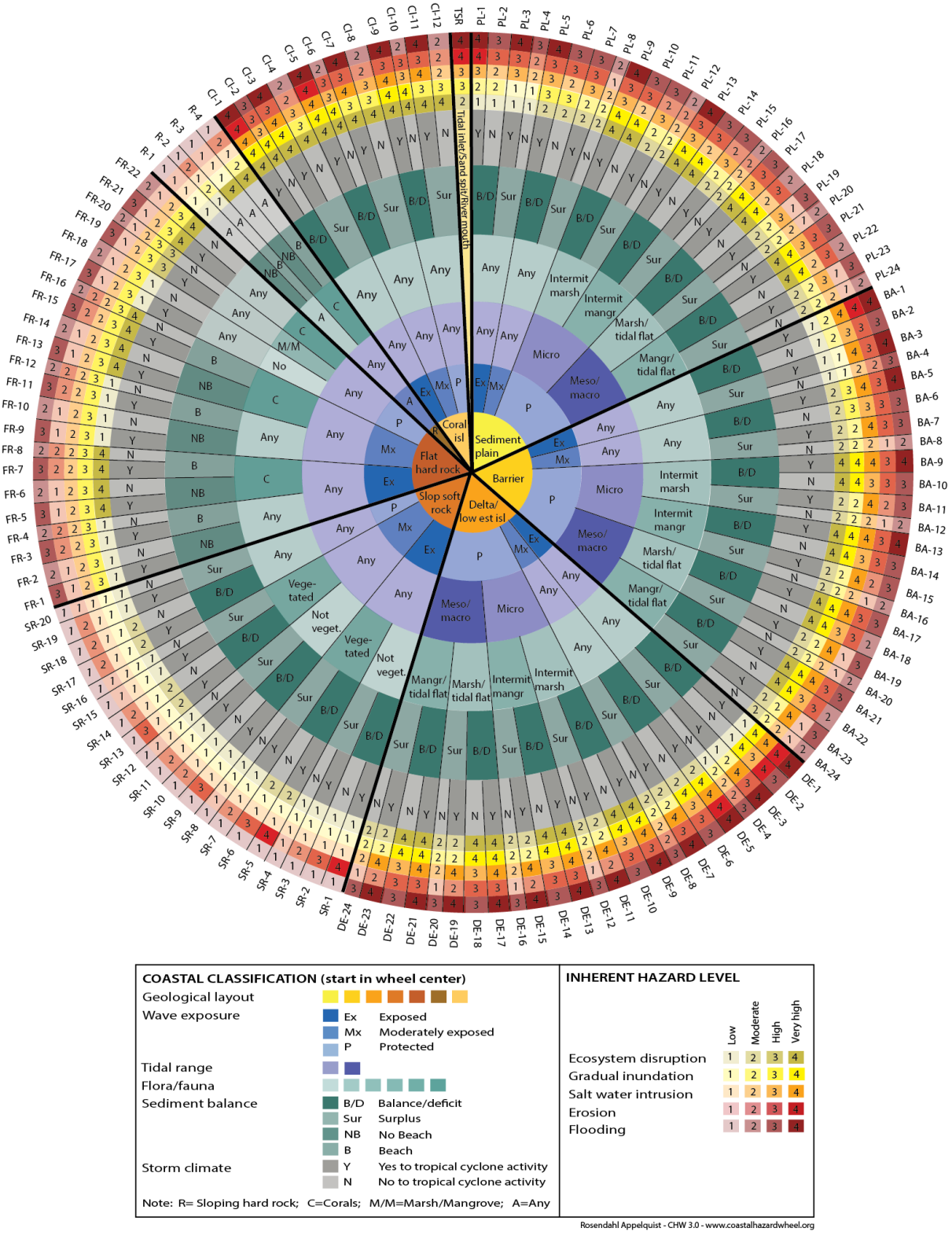


Figure: The Coastal Hazard Wheel 2.0 *(Palpanabhan Kasthuri Bavinaya et al., 2024)*

Table The most common coastal types in Tamilnadu

Coastal Type	Length (Km)	Percentage (%)
Sediment Plain (PL5)	310.50	28
Sediment Plain (PL12)	224.40	20
Sediment Plain (PL8)	89.96	8
Tidal inlet/Sand spit/River mouth (TSR)	88.31	8
Flat Hard Rock (FR3)	75.718	7
Barrier (BA5)	67.428	6
Barrier (BA8)	48.324	4
Flat Hard Rock (FR1)	42.078	4
Sediment Plain (PL16)	40.295	3.5
Delta (DE16)	29.674	2.5

The significant outcome of the study on coastal vulnerability assessment for the southeast coast of India, specifically Tamil Nadu, is that flooding emerges as the most prevalent and severe hazard, with 62% of the coastline facing high or very high vulnerability to flooding. Other major hazards identified include gradual inundation affecting 56%, erosion affecting 55%, and saltwater intrusion affecting 46% of the coastline at high or very high vulnerability levels. Ecosystem disruption, primarily impacting mangrove and salt marsh habitats, is the least severe hazard but still critical in localized areas. The study utilizes the Coastal Hazard Wheel (CHW) framework integrating geomorphology, wave exposure, tidal range, flora/fauna, sediment balance, and climate to spatially map and categorize vulnerabilities. The findings highlight the need for localized management interventions such as mangrove restoration, groundwater management to limit saltwater intrusion, coastal protection structures for erosion control, and flood mitigation measures including seawalls and flood shelters to safeguard people, biodiversity, and coastal resources sustainably.

Table Summarizing the hazard vulnerability results by percentage of Tamil Nadu's coastline length

Coastal Hazard	Low Vulnerability (%)	Moderate Vulnerability (%)	High Vulnerability (%)	Very High Vulnerability (%)	Total High+Very High (%)
Ecosystem Disruption	37	58	4	1	5
Gradual Inundation	0	44	54	2	56
Saltwater Intrusion	0	54	36	10	46
Erosion	18	27	43	12	55

Coastal Hazard	Low Vulnerability (%)	Moderate Vulnerability (%)	High Vulnerability (%)	Very High Vulnerability (%)	Total High+Very High (%)
Flooding	0	38	16	46	62

The coastal plains represent a landscape where natural dynamism meets human dependence, creating a complex vulnerability structure that demands both scientific insight and policy sensitivity. As coastal populations continue to grow and climatic pressures intensify, sustainable management of these plains becomes indispensable. The following chapters will examine similar processes shaping vulnerability in the interior plains and highland regions, revealing how physical geography, land-use practices, and human systems interact across Tamil Nadu's diverse physiographic zones.

Coastal vulnerability index model

The comprehensive study modelled coastal hazards along Tamil Nadu's 1076 km coastline. It developed coastal hazard wheels and mapped vulnerabilities such as sea-level rise, tropical cyclones, and saline intrusion. The coastal vulnerability index showed very high vulnerability in major coastal districts like Pulicat and Nagapattinam. Sea-level rise impacts on land-use categories were quantitatively modelled showing increasing inundation with higher sea-level scenarios.

Table Sea Level Rise Impact Table (sq.km for different Sea Level Rise levels):

Land use Class	**1m SLR (sq.km)**	**3m SLR (sq.km)**	**5m SLR (sq.km)**
Aquaculture	85.25	150.27	167.60
Built-up Land	13.17	52.44	155.96
Crop Land	3.18	39.10	84.89
Fallow Land	108.35	487.37	898.91
Mangrove Forest	11.10	19.68	25.60

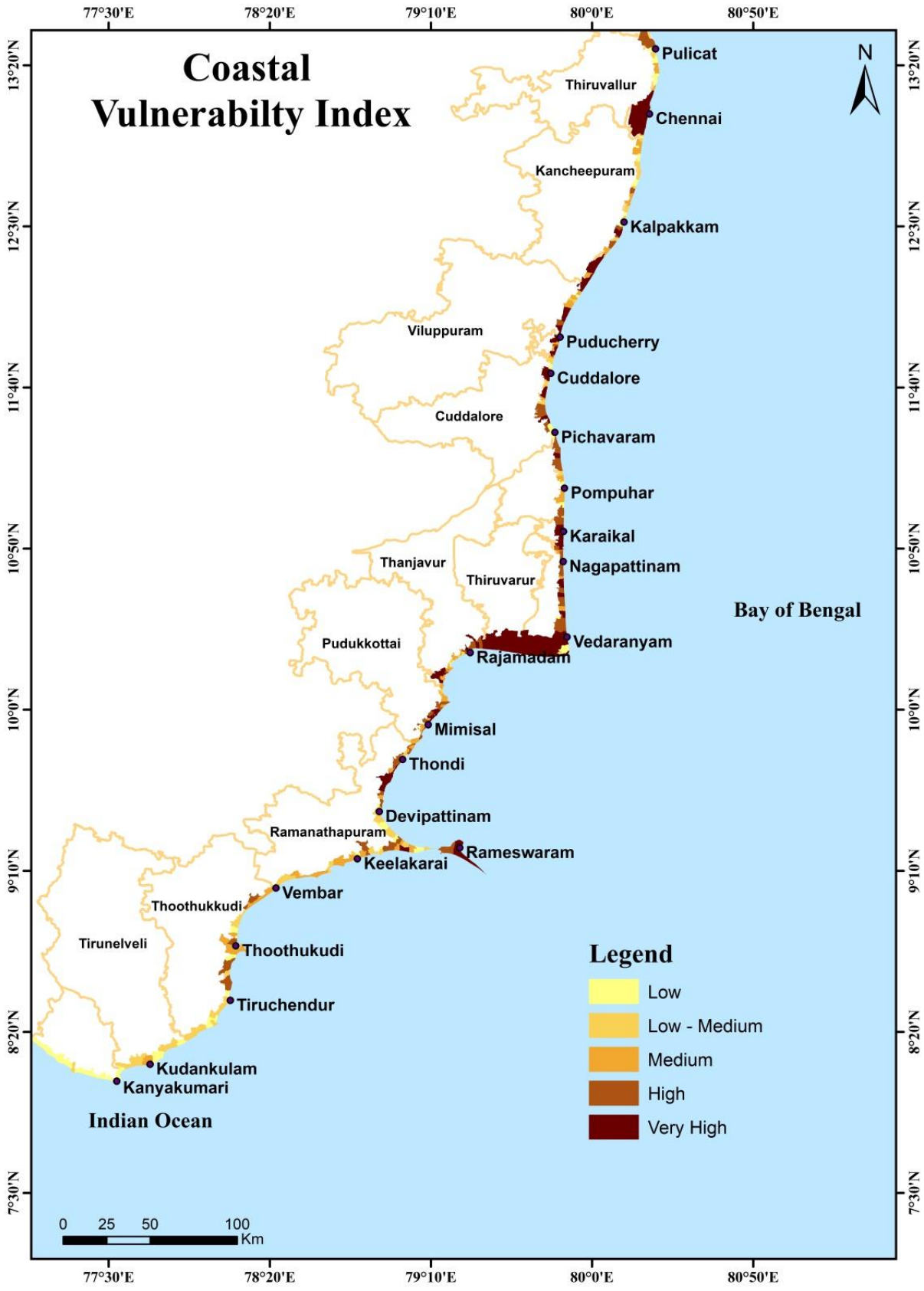


Figure Coastal vulnerability index model for Tamil Nadu

Table Coastal vulnerability index model

Class	Area in Sq.km	Vulnerable Areas
Very High	826.34	Pulicat, Chennai, Puducherry, Cuddalore, Karaikal, Nagapattinam, Vedaranyam, Mimisal, Thondi and Rameshwaram
High	608.53	
Medium	885.89	Kalpakkam, Pompuhar and Thoothukudi
Low-Medium	542.35	Parts of Kancheepuram and Ramanathapuram
Low	748.85	Kanyakumari and Parts of Tirunelveli and Thoothukudi

Multi Hazard Risk Assessment for Nagapattinam Coastal Zone:

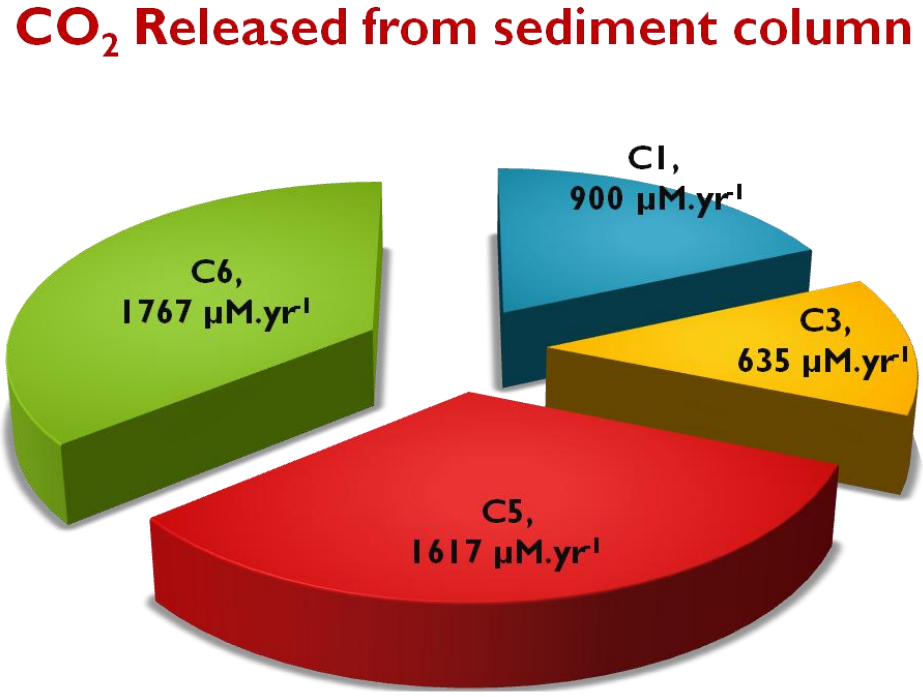
Various hazards affecting the Nagapattinam coastal belt and a coastal vulnerability index using GIS and image processing tools. The study delineated hazard zones and proposed risk management strategies. Coastal aquifers in specific locations were found highly vulnerable. Multi-hazard vulnerable zonation covered 1819 sq.km. Mangrove cover changes were tracked with fluctuations in Pichavaram and Muthupet areas over decades.

Table Mangrove Cover Change (sq.km):

Year	Pichavaram	Muthupet
1970	6.46 sq.km	23.27 sq.km
1977	5.67 sq.km	-
1999	6.34 sq.km	8.58 sq.km
2007	7.50 sq.km	15.48 sq.km

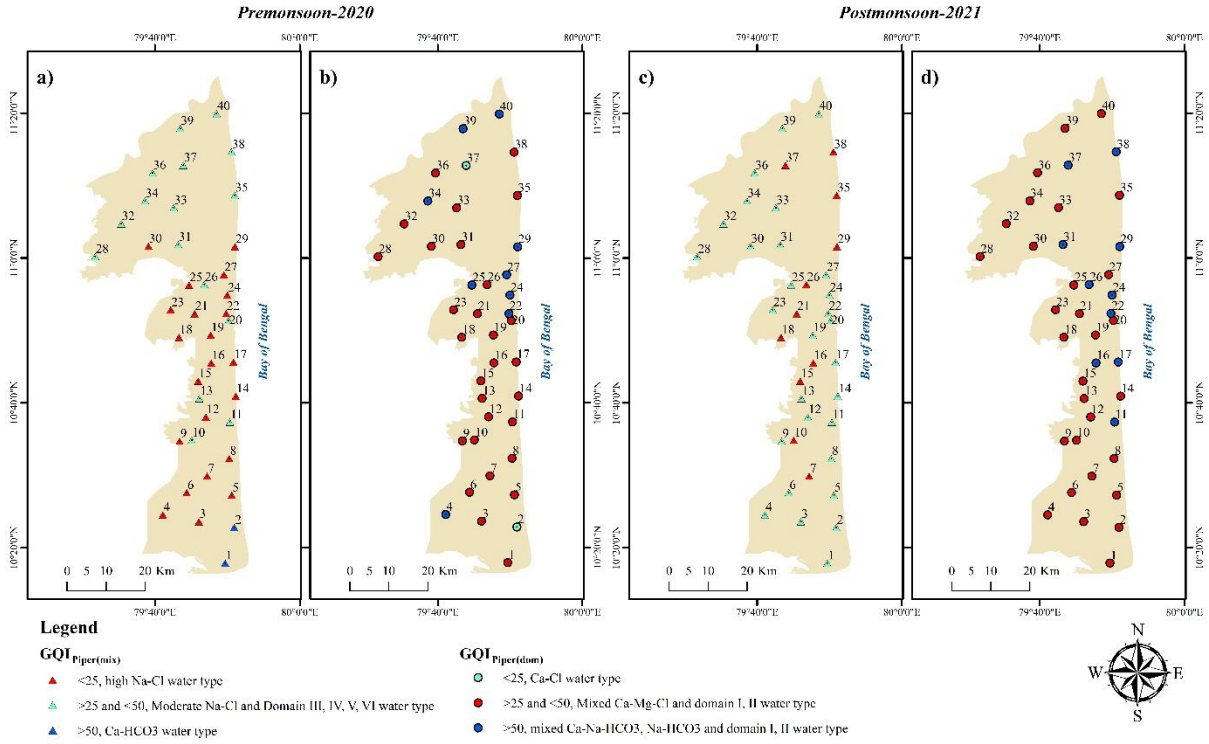
Carbon Sequestration in Vedaranyam Wetlands:

Organic carbon in different mangrove species was estimated with *Aegiceras corniculatum* showing the highest content despite Avicennia marina covering most area. Total above-ground biomass was calculated with carbon sequestration potential in the wetlands quantified in teragrams, highlighting ecological carbon storage significance.



Seawater interaction with coastal aquifers of Nagapattinam district

Hydro-chemical analysis showed seawater intrusion affecting groundwater quality in Nagapattinam, Karaikal, and Mayiladuthurai districts. Water types were dominated by Na-Cl and mixed Ca-Mg-Cl facies. Various groundwater quality indices and seawater fraction indexes were used for pre- and post-monsoon samples indicating salinization processes.



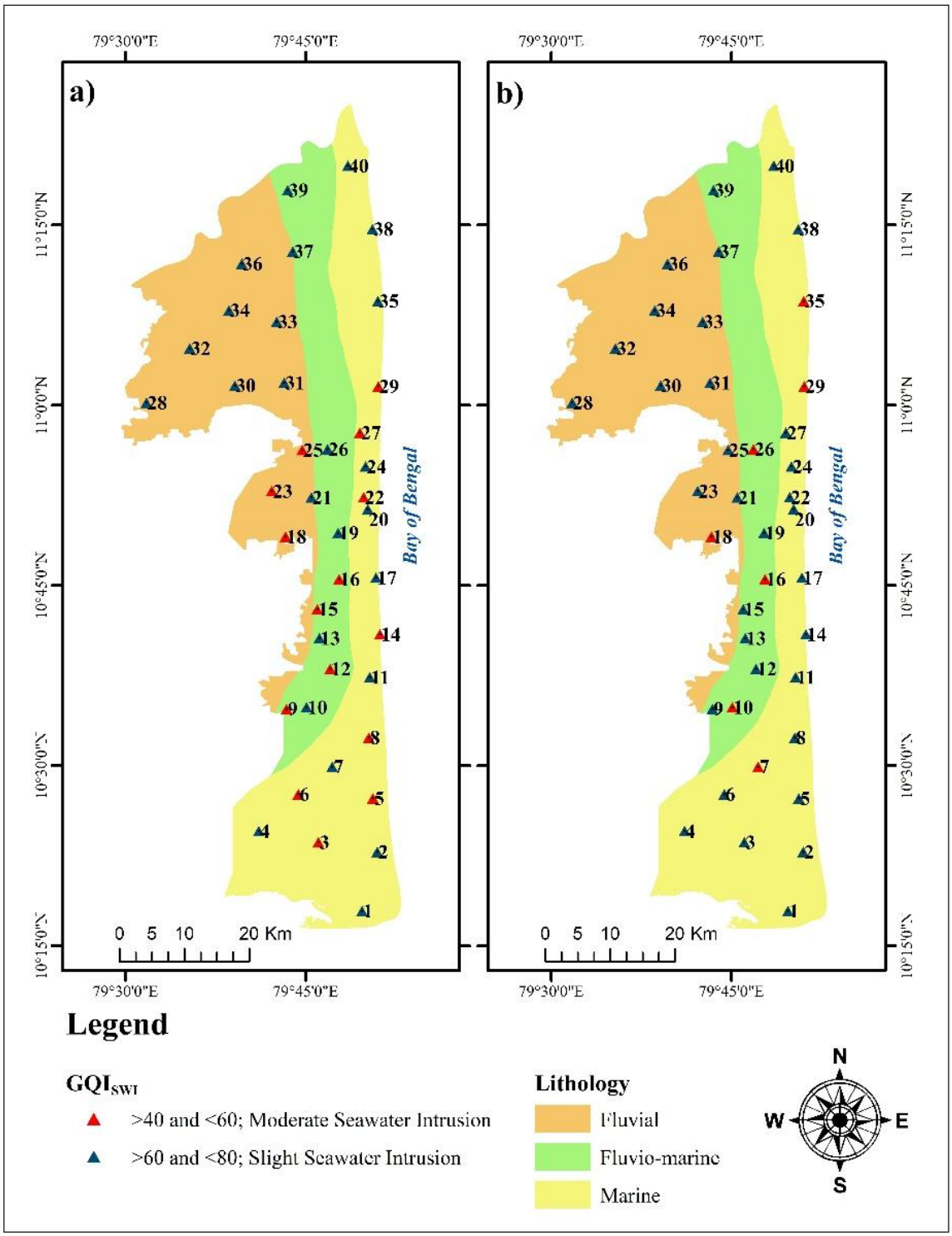


Figure: GQI_{SWI} of pre-monsoon (PRM-2020) (a) and post-monsoon (POM-2021) (b) groundwater samples from Nagapattinam, Karaikal, and Mayiladuthurai districts of Tamil Nadu in the coastal southeast India.

The assessment of groundwater quality in the coastal aquifers of Mayiladuthurai, Karaikal, and Nagapattinam districts in southeast India involved the examination of hydrochemical facies and ion-exchange processes, focusing on the impact of seawater intrusion. The evaluation of freshwater (groundwater) salinization resulting from the intrusion of saltwater (seawater) was

conducted using various methods, including the Piper plot (GQIPiper(mix) and GQIPiper(dom)), Seawater fraction index (GQIfsea), and the Groundwater Quality Index (GQISWI) based on seawater intrusion. Many groundwater samples from the southeastern section of the study area exhibited water types dominated by Na-Cl and mixed Ca-Mg-Cl, consistent across both seasons. This observation can be attributed to the hydraulic conductivity of marine sediments, which facilitates the movement of Na-Cl-bearing seawater into the groundwater system.

Flood Susceptibility Analysis in Chennai Corporation Using Frequency Ratio Model

The study analysed flood susceptibility zones in the Chennai Municipal Corporation using the Frequency Ratio (FR) model with ten independent parameters, including landforms, land use/land cover, slope, elevation, soil texture, soil drainage, lithology, Topographic Wetness Index (TWI), distance from the river, and surface runoff. A total of 123 flooded locations were identified from news reports and satellite data; 100 sites were utilized for building the FR model, while 23 locations served for validation. Flood susceptibility zones were categorized into four classes: very high, high, medium, and low vulnerability. Notably, the high and very high-risk classes encompassed 38.93% and 10.48% of the area, respectively, indicating significant flood vulnerability. The FR model demonstrated impressive performance, achieving a success rate of 96% and a prediction accuracy of 95.6%, proving its suitability for flood susceptibility prediction and offering valuable guidance for future flood management decisions.

Spatial distribution of flood susceptibility class in the study area

S.No	Flood susceptibility class	Range of FR value	Area in Sq.km	% area
1	Very high	More than 12.5	62.51	10.48
2	High	10.0–12.5	232.17	38.93
3	Medium	7.5–10.0	223.36	37.45
4	Low	5.0–7.5	78.23	13.11

Agricultural Vulnerability to Climate Change in Tamil Nadu

Agriculture in Tamil Nadu occupies a central position in the state's economy, livelihood structure, and food security framework. Yet, it remains one of the most climate-sensitive sectors, exposed to frequent rainfall variability, recurring droughts, and progressive land degradation. As monsoon-dependent cropping systems confront growing climatic instability, understanding the spatial patterns of agricultural vulnerability becomes essential for designing targeted adaptation strategies. This chapter synthesizes advanced methodological insights and district-level vulnerability patterns derived from recent assessments, particularly the dynamic vulnerability framework applied to Tamil Nadu's 13 pre-restructured districts. The analysis highlights how exposure, sensitivity, and adaptive capacity jointly shape each region's climate risk profile, revealing a complex mosaic of agricultural fragility across the state.

Table: Climate change exposure level across districts of Tamil Nadu

Rank	District	% Growth in SWM rainfall	% Growth in NEM rainfall	% Instability in SWM rainfall	% Instability in NEM rainfall
1	Chengalpattu	-0.91	0.05	7.78	12.49
2	Coimbatore	1.25	1.00	37.70	14.89
3	Salem	-1.17	1.29	7.10	16.68
4	Thanjavur	-1.32	1.44	12.30	14.40
5	North Arcot	-0.64	0.45	9.51	12.48
6	Tiruchirapalli	-1.19	1.43	10.07	14.35
7	Erode	-1.38	1.41	10.93	13.03
8	Madurai	-0.77	1.01	8.64	13.90
9	Ramanathapuram	-1.12	0.82	8.25	11.78
10	South Arcot	-1.21	0.79	13.19	6.94
11	Tirunelveli	0.78	0.70	13.25	11.54
12	Dharmapuri	-0.01	2.13	6.59	16.55
13	Pudukottai	-0.51	1.80	10.64	11.77

Note: SWM indicates South West Monsoon, NEM indicates North East Monsoon.

Tamil Nadu experiences a tropical climate marked by high dependence on monsoonal rainfall, with nearly half of the annual precipitation derived from the northeast monsoon alone. This climatic pattern makes agriculture inherently fragile, as even moderate deviations in either monsoon often trigger widespread impacts on crop yields, water availability, and farm incomes. Rising temperatures, erratic rainfall, extended dry spells, and frequent extreme weather events—already documented in recent decades—intensify pressures on agricultural systems, particularly in districts with limited irrigation infrastructure or high reliance on rainfed cultivation. These pressures operate within a landscape characterized by marginal landholdings, tenancy insecurity, traditional production practices, and low diversification, amplifying climate risks for smallholder farmers.

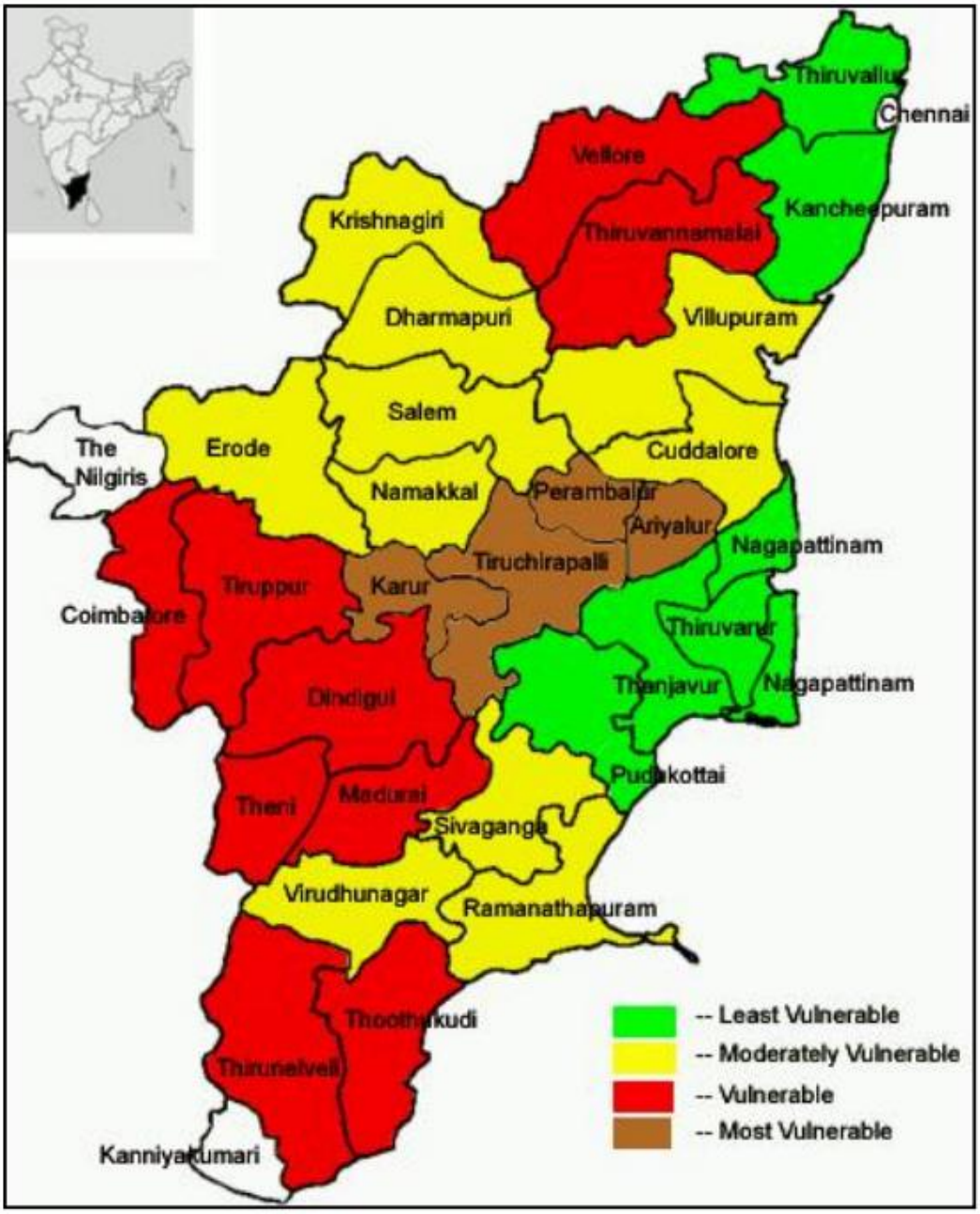


Figure Agricultural vulnerability mapping of Tamil Nadu to climate change (*Source: Jayakumara Varadan and Pramod Kumar, 2015*)

The agricultural vulnerability assessment for Tamil Nadu represents a significant methodological shift from earlier demographic-heavy approaches. Instead of relying on static socio-economic indicators, the framework emphasizes dynamic performance indicators, especially growth and instability in rainfall, cropped area, and yields. These indicators better capture evolving climate stresses and agricultural responses over time, aligning vulnerability measurement with real-time system behaviour.

Three principal components structure the assessment:

a) Exposure
b) Sensitivity

c) Adaptive Capacity

a) Exposure: Exposure refers to the degree to which districts experience climate variability. The analysis includes both growth and instability in southwest and northeast monsoon rainfall. Declines in southwest monsoon precipitation and erratic northeast monsoon cycles significantly elevate exposure levels in several districts. This dual-metric approach allows differentiation between regions facing gradual changes and those experiencing high volatility (e.g., Coimbatore's sharp rainfall inconsistency despite positive growth trends).

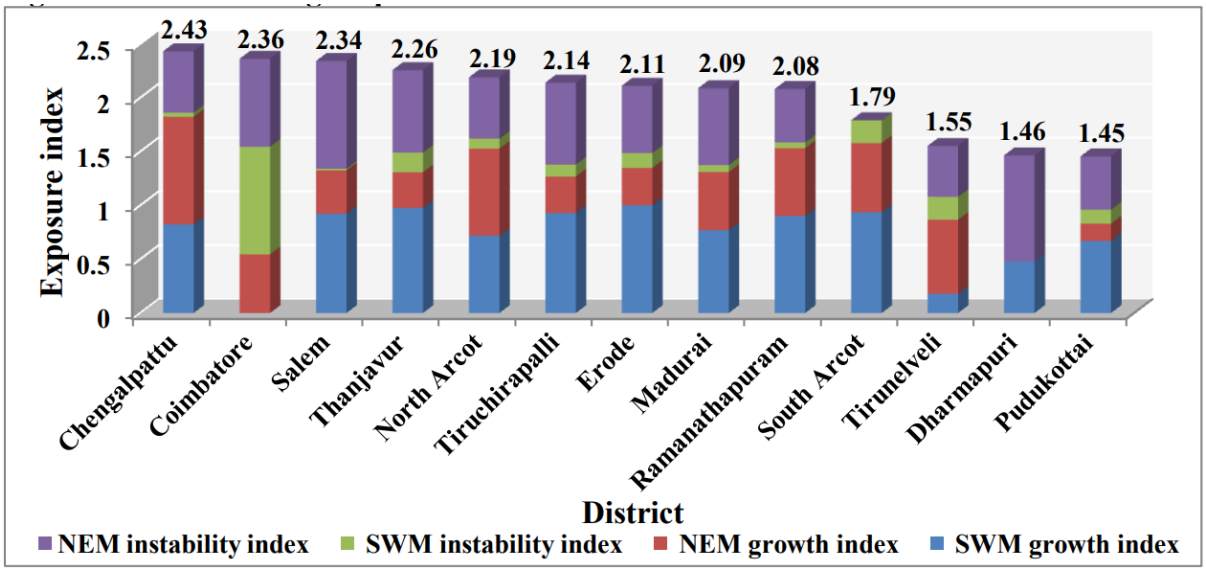


Figure: Climate change exposure index across districts of Tamil Nadu (*Source: Jayakumara Varadan and Pramod Kumar, 2015*).

b) Sensitivity: Sensitivity captures the susceptibility of agricultural systems to climatic disruptions. The framework focuses on instability in area and yield of major crops, weighted by each district's cropping pattern. This provides a more accurate picture of risk because districts with more diversified crop portfolios tend to experience higher sensitivity due to their exposure to multiple climate-responsive commodities. Tiruchirapalli's high sensitivity reflects this pattern, with instability recorded across maize, cotton, and sunflower cultivation.

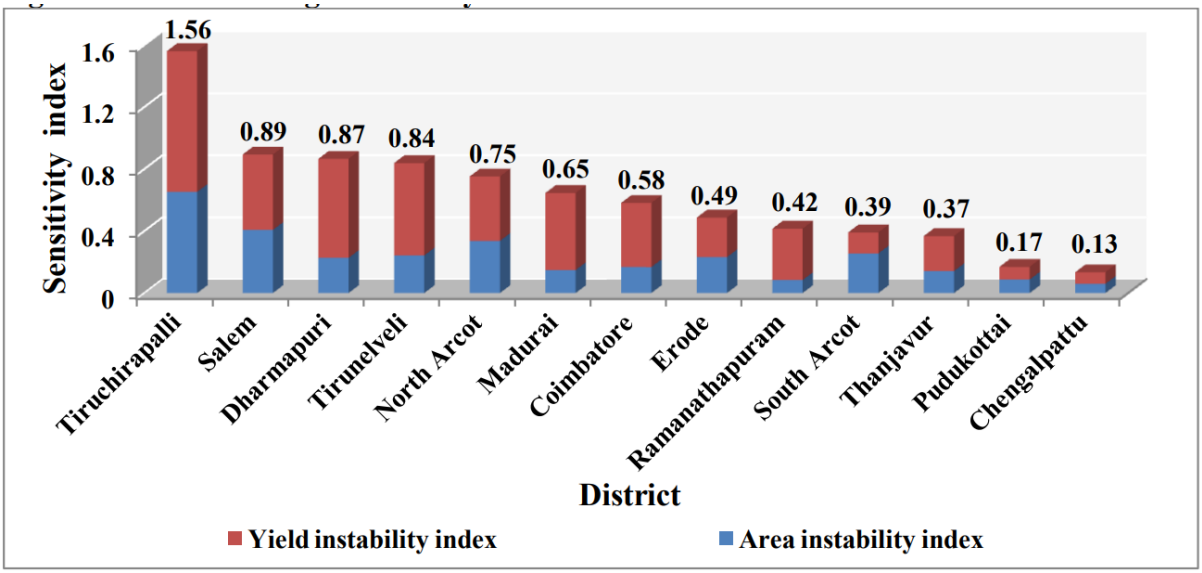


Figure Climate change sensitivity index across districts of Tamil Nadu (*Source: Jayakumara Varadan and Pramod Kumar, 2015*).

c) Adaptive capacity: Adaptive capacity represents the ability of districts to cope with climate impacts. Only bio-physical indicators—growth rates in crop diversification, net cultivated area, cropping intensity, crop yields, and area under major crops—are used to track changes over time. This avoids reliance on static socio-economic metrics and better reflects agricultural system resilience. Districts such as Chengalpattu and Thanjavur show strong adaptive capacity through consistent improvements in diversification and productivity metrics.

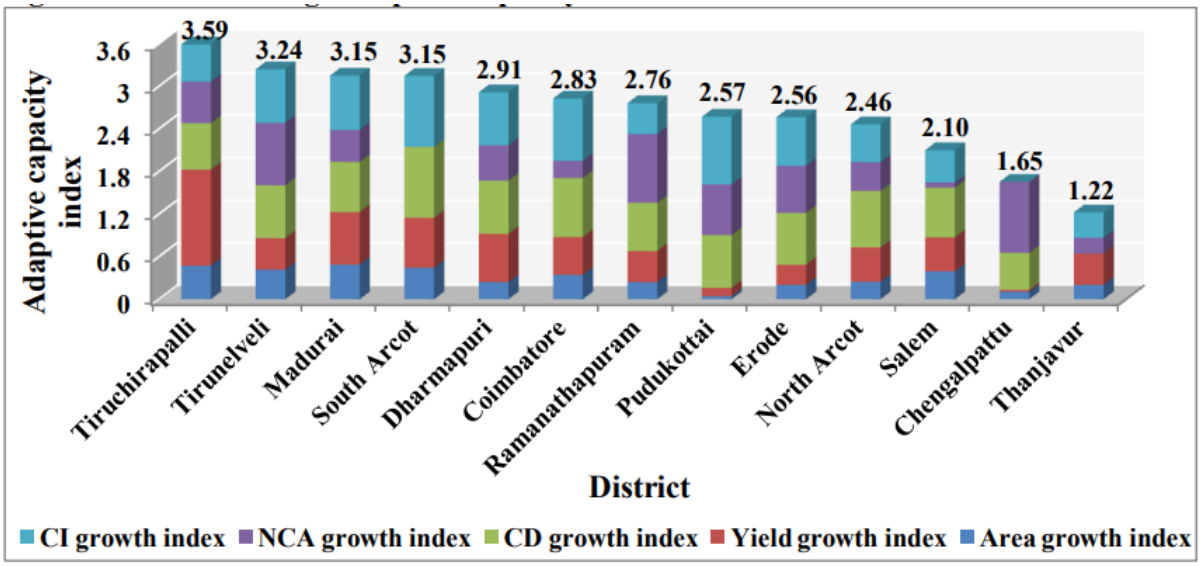


Figure Climate change adaptive capacity index across districts of Tamil Nadu (*Source: Jayakumara Varadan and Pramod Kumar, 2015*).

The three components are normalized, weighted logically according to the proportional importance of each district's major crops, and aggregated into a single Agricultural Vulnerability Index (AVI). A beta distribution–based fractile classification then groups districts into five vulnerability categories—least, moderate, vulnerable, highly vulnerable, and most vulnerable—allowing more meaningful interpretation beyond simple ranking.

Spatial Patterns of Agricultural Vulnerability

The combined exposure, sensitivity, and adaptive capacity scores reveal diverse vulnerability patterns across Tamil Nadu:

Category	Districts	Reason
Most Vulnerable District	Tiruchirapalli	Characterized by high exposure, extreme sensitivity due to diversified crop portfolios, and low adaptive capacity. It emerges as the most vulnerable district, requiring urgent and integrated climate adaptation interventions
Vulnerable Districts	Madurai, Coimbatore, Tirunelveli, North Arcot	These districts experience either high exposure or limited adaptive capacity, despite moderate sensitivity levels. Climatic inconsistency, especially in monsoon rainfall, places further stress on agricultural productivity in these areas
Moderately Vulnerable Districts	Salem, South Arcot, Ramanathapuram, Dharmapuri, Erode	These districts show balanced yet concerning levels across indicators. Their vulnerability stems from either moderate rainfall instability, moderate sensitivity, or partial limitations in adaptive capacity
Least Vulnerable Districts	Chengalpattu, Thanjavur, Pudukottai	Despite high exposure in certain cases (e.g., Chengalpattu), these districts benefit from strong adaptive capacity or low sensitivity. Thanjavur's stable cropping intensity and cultivation area growth contribute significantly to its resilience

Key Drivers of Vulnerability

Several thematic insights emerge from the district-level vulnerability assessment:

Rainfall Instability as a Primary Driver	Declines in southwest monsoon rainfall, combined with erratic northeast monsoon behaviour, disproportionately elevate exposure in districts such as Chengalpattu, Thanjavur, Salem, and Tiruchirappalli.
Crop Diversification Can Increase Sensitivity	Contrary to conventional expectations, diversification amplifies climate exposure by spreading risk across multiple climate-sensitive crops. Tiruchirappalli and Salem offer clear examples of this pattern.
Adaptive Capacity Varies Widely Across Districts	Districts with growing cropping intensity, diversified cultivation, and positive yield trends demonstrate higher resilience. Conversely, districts with stagnating cultivation area and low yield improvements exhibit reduced adaptive capacity.
Agro-climatic Zones Do Not Determine Vulnerability	Districts within the same zone often fall into different vulnerability categories, reinforcing that local cropping patterns, rainfall dynamics, and bio-physical capacities play a more influential role than regional classifications.

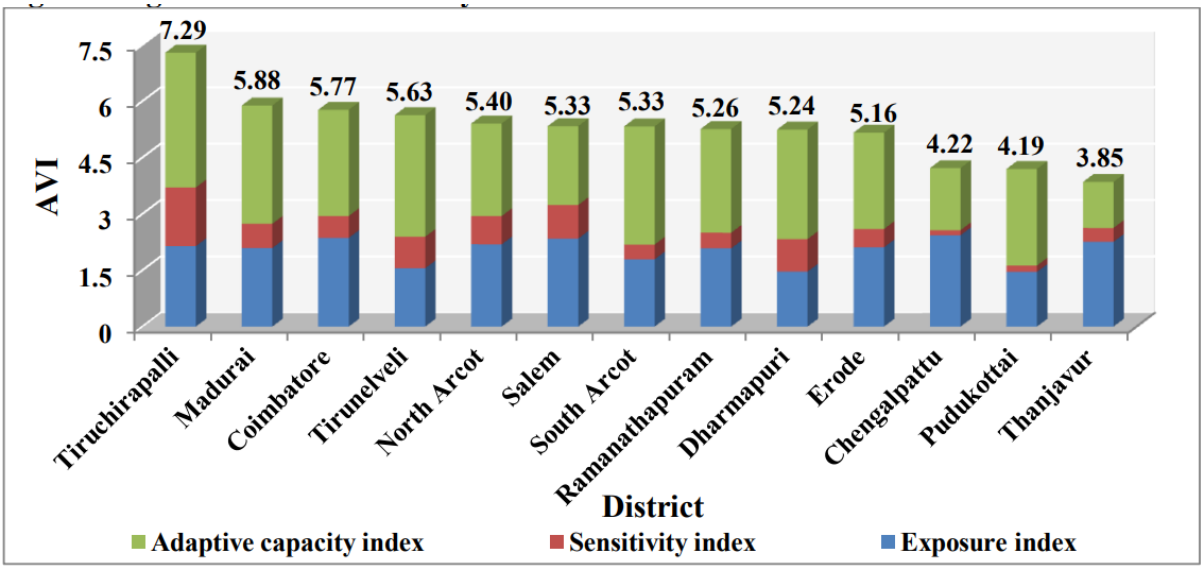


Figure: Agricultural vulnerability index across districts of Tamil Nadu (*Source: Jayakumara Varadan and Pramod Kumar, 2015*).

In summary, agricultural vulnerability to climate change in Tamil Nadu is shaped by a complex interaction of monsoon behaviour, cropping instability, and adaptive capacity. The dynamic vulnerability assessment framework provides a nuanced, district-specific understanding of these risks. The identification of Tiruchirapalli as the most vulnerable district, alongside varying vulnerability levels across the state, highlights the need for tailored interventions that integrate climatic realities with local cropping patterns and resource conditions. As climate variability intensifies, strengthening adaptive capacity through targeted investments in irrigation, crop improvement, land management, and farmer-centric resilience planning will be critical for safeguarding Tamil Nadu's agricultural future.

Plain-land System Vulnerabilities and Land Use Dynamics

The interior plains of Tamil Nadu constitute one of the most economically significant and ecologically sensitive regions of the state. These plains, stretching between the coastal belt and the bordering highland systems, support major agricultural zones, dense settlements, industrial corridors, and intricate networks of tanks, reservoirs, and irrigation channels. Their physiographic stability often creates an impression of resilience; however, beneath this apparent steadiness lies a complex vulnerability structure shaped by land degradation, water scarcity, climatic variability, and intensive land-use pressures. The vulnerabilities of the plain-land systems are not isolated phenomena but arise from slow, cumulative processes that have been reshaping the region over several decades.

One of the defining features of the plains is their dependence on monsoonal rainfall and surface water storage. While the alluvial soils and gentle slopes facilitate agriculture, the plains suffer recurrent droughts when the northeast monsoon fails or arrives erratically. The high dependence on seasonal rainfall amplifies agricultural uncertainty, as seen in several districts exhibiting high exposure and cropping instability. Declining rainfall trends, coupled with prolonged dry spells, cause tanks to desiccate prematurely, groundwater tables to plummet, and irrigation cycles to shorten. Agricultural landscapes dominated by paddy, sugarcane, and millet

systems have become increasingly sensitive to these hydrological disruptions, leading to fluctuating productivity, crop abandonment, and heightened farmer vulnerability.

Groundwater depletion represents another critical dimension of plain-land vulnerability. In many districts, groundwater extraction exceeds natural recharge due to increased irrigation demand, urban expansion, and declining tank systems. The conversion of traditional water bodies into urban layouts, institutional complexes, or agricultural fields disrupts hydrological recharge patterns. Enlarged well depths, progressive reliance on borewells, and energy-intensive pumping further stress aquifers. As aquifer levels fall, water quality deteriorates, with elevated salinity and hardness posing additional agricultural challenges. These conditions create a feedback loop where declining resources force farmers to shift cropping patterns or reduce cultivation, thereby weakening local agricultural resilience.

Land degradation is a widespread yet often under-recognized issue in the plains. Soil fertility depletion, nutrient mining, erosion on gentle slopes, and sedimentation in tanks collectively reduce agricultural potential. Continuous cropping without adequate fallow periods, excessive fertilizer use, and the replacement of mixed cropping with monocropping weaken soil structure over time. Sedimentation in tanks and reservoirs reduces storage capacity, contributing to water scarcity during dry spells and increasing flood risk during heavy rainfall. These issues reflect the intricate relationship between land use, soil quality, and hydrological stability in the plains.

Land-use dynamics have also undergone significant transformation. Rapid urbanization around major cities and tier-II towns has led to fragmentation of agricultural lands, conversion of fertile tracts into residential colonies, industrial estates, and transport infrastructure. The expansion of built-up areas encroaches upon agricultural fields, wetlands, and drainage pathways, altering the natural flow of water during monsoon events. Urban sprawl creates heat-island effects, modifies microclimates, and heightens the demand for groundwater. In peri-urban belts, shifting livelihoods from agriculture to service-sector occupations has created a zone of transition where land-use decisions are increasingly driven by market forces rather than agro-ecological suitability.

Industrial activities in the plains add another layer of vulnerability. Industrial corridors generate employment and economic growth but also contribute to pollution of soil and water resources. Effluents discharged into rivers, tanks, or farmlands degrade soil productivity and affect potable water supplies. In regions where agriculture and industry coexist, such as the western plains, conflicts over water allocation intensify during drought periods. Industrial expansion also inflates land prices, incentivizing farmers to sell their land, which accelerates agricultural decline and transforms rural socio-economic structures.

Climatic variability interacts with these pressures to produce complex vulnerability patterns. Rising temperatures increase evapotranspiration rates, expanding irrigation water requirements at a time when sources are diminishing. High-intensity rainfall events, now more frequent, overwhelm drainage systems and produce localized flooding, particularly in urban and peri-urban areas where natural drainage paths are obstructed. These events accelerate soil erosion even on gentle slopes and lead to rapid runoff that limits groundwater recharge. The combined effects of temperature rise, rainfall irregularities, and land degradation create conditions that undermine long-term agricultural stability.

Social vulnerability intertwines with environmental stress in the plains. Farmers with small and marginal landholdings face disproportionate impacts due to limited adaptive capacity. The absence of irrigation insurance, rising input costs, and fluctuating market prices exacerbate economic fragility. Crop failures can push families into debt cycles, leading some to shift out of agriculture entirely. Regions with diversified cropping patterns may manage risk more effectively, but as the agricultural vulnerability analysis reveals, diversification sometimes increases sensitivity when multiple climate-dependent crops incur simultaneous losses. The agricultural plains thus exhibit a delicate balance between production potential and climatic fragility.

Despite these challenges, the plains have significant adaptive opportunities. Adoption of micro-irrigation, revival of tank systems, crop diversification aligned with agro-climatic suitability, and integration of climate-resilient varieties offer considerable promise. Strengthening local water governance, restoring drainage networks, and reducing encroachment on wetlands can enhance hydrological resilience. Innovative land-use planning those balances urban growth with agricultural preservation is essential to prevent unchecked conversion of productive lands. At the farm level, adoption of conservation agriculture, soil-health management practices, and community-based resource sharing can mitigate vulnerability.

The vulnerability of Tamil Nadu's plain-land systems is thus a product of cumulative hydrological stress, land degradation, inconsistent rainfall, and rapid transitions in land use. These processes interact across scales, shaping the socio-ecological resilience of the region. As climate variability intensifies, the plains require sustained policy attention, guided by scientific assessments and grounded in community realities. The next chapter extends this discussion to the highland and upland regions, where steep terrain, soil erosion, and ecological fragility produce distinct patterns of vulnerability interconnected with the processes unfolding in the plains.

Chapter 20

Highland Geomorphology and Erosion Vulnerability

The highlands of Tamil Nadu—comprising the Western Ghats, Eastern Ghats, and a series of interconnected uplands—represent some of the most geomorphologically complex and environmentally fragile landscapes in southern India. Characterized by steep slopes, deeply weathered profiles, structurally controlled ridges, and intensively dissected terrain, these regions play a crucial role in maintaining hydrological balance, biodiversity, and climatic stability. Yet, the very features that make the highlands ecologically significant also render them highly susceptible to soil erosion, landslides, and landscape degradation. As land pressures increase and climate patterns shift, the vulnerability of these highland systems becomes increasingly apparent.

The geomorphic structure of the highlands is shaped by tectonic uplift, differential weathering, and long-term fluvial incision. Steep gradients accelerate runoff, while thin, poorly developed soils limit agricultural suitability. In many upland pockets, land conversion for plantations, road construction, and settlement expansion further amplifies the instability of slopes. These anthropogenic alterations modify natural erosion processes by reducing vegetation cover, exposing weak soil horizons, and redirecting surface flow paths. As a result, erosion risks extend beyond natural geodynamics, forming a hybrid vulnerability regime shaped jointly by environmental forces and land-use decisions.

Soil erosion vulnerability in highland regions is influenced by the interplay of terrain characteristics, soil properties, lithology, land cover, and rainfall intensity. The recent geo-pedological assessment conducted in a southern Indian highland terrain demonstrates how high-resolution geo-big data and deep learning approaches can effectively identify erosion hotspots and understand the underlying drivers of vulnerability. The study highlights that terrain gradient—particularly slope angle—is one of the strongest predictors of erosion in mountainous landscapes. Steep slopes encourage rapid runoff and reduce the time for infiltration, mobilizing both surface soil and subsurface material. When combined with high-intensity rainfall typical of monsoon-driven hill regions, these conditions produce significant erosive forces.

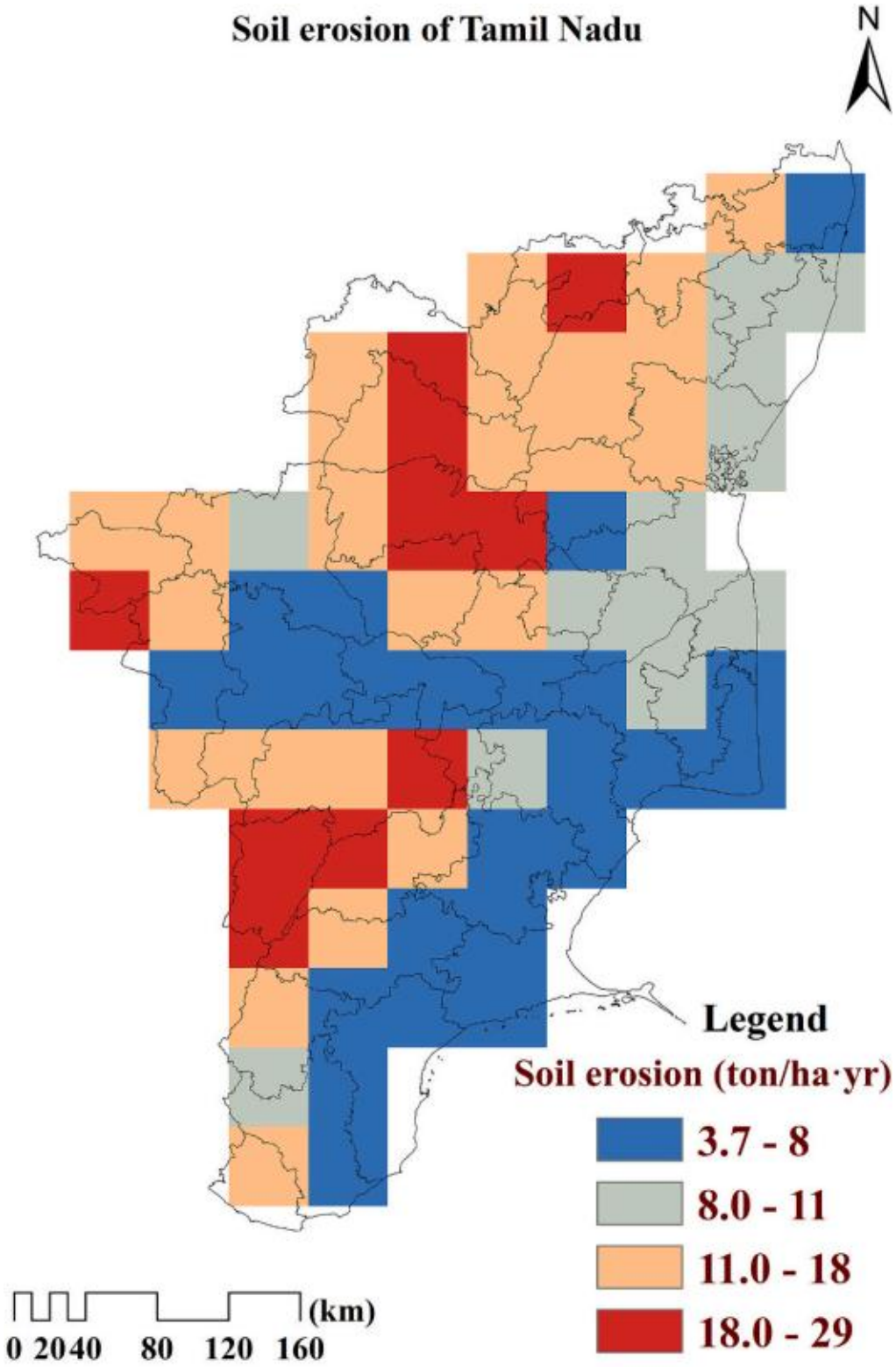


Figure: Soil erosion process domains and landscape vulnerability patterns (*Source: Manikanda Bharath et al., 2026*).

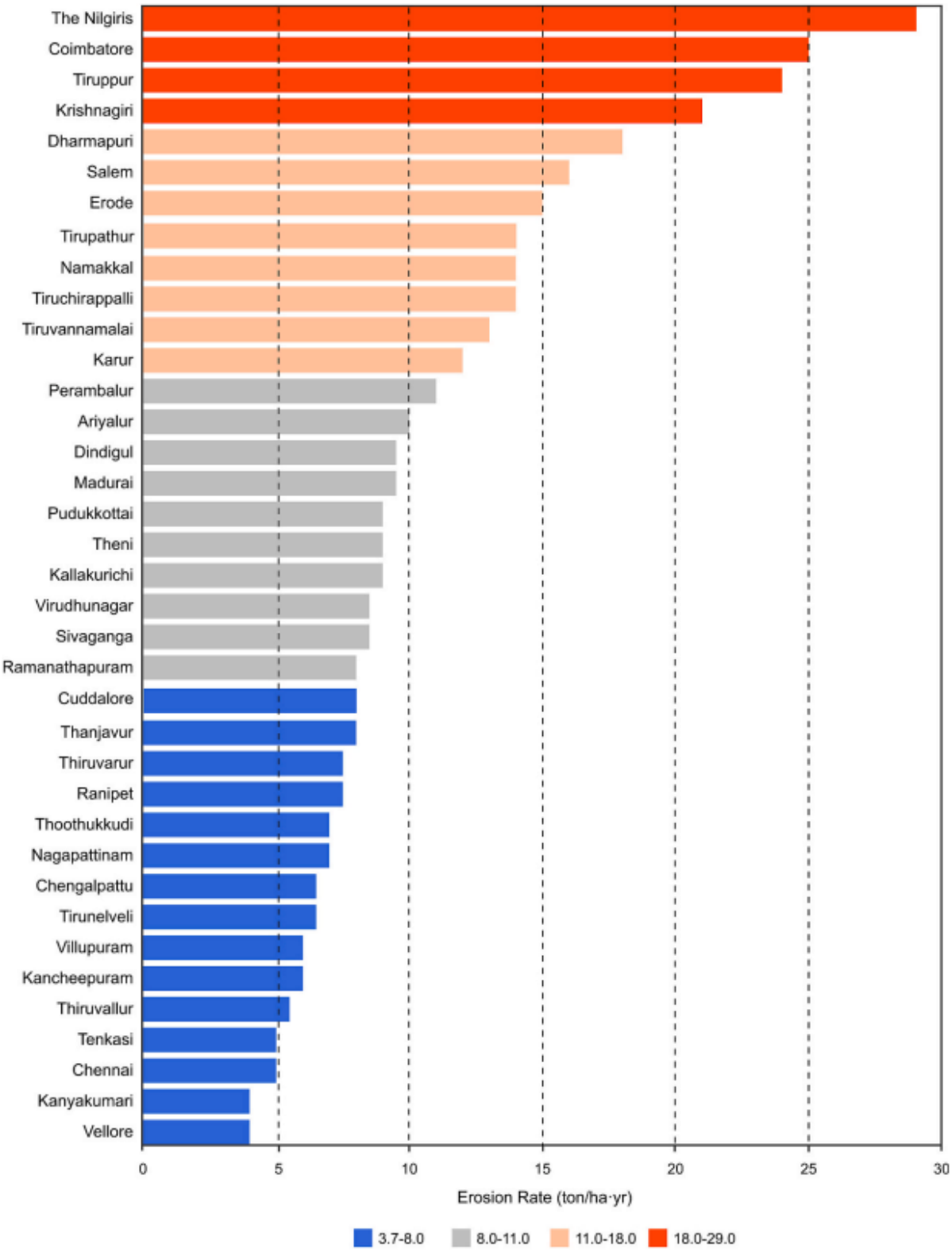


Figure: District-level erosion intensity and management priority zones (*Source: Manikanda Bharath et al., 2026*).

Lithology exerts equally critical control over erosion susceptibility. Hard crystalline rocks of the Ghats weather into shallow, coarse soils that are structurally weak and easily detached during heavy rainfall events. In contrast, areas under charnockites and gneisses exhibit variable

resistance depending on mineral composition and weathering depth. The geo-pedological analysis documents distinct erosion responses across lithological categories, with highly weathered zones showing greater instability. Soil texture and mineralogy further influence erodibility; for example, sandy loam soils, common in certain upland tracts, exhibit higher detachment rates than clay-rich profiles.

Vegetation cover plays a central protective role in highland stability. Natural forests of the Western Ghats historically suppressed erosion through dense root networks and canopy interception. However, conversion of native forests to plantations—such as tea, coffee, pepper, and eucalyptus—has reduced this protective function. Plantation crops often leave soil bare during pruning cycles and harvesting practices. Roads built along steep hill cuts expose raw soil, initiate gully formation, and channelize runoff downslope. These human-induced alterations contribute significantly to the spatial variability observed in erosion models.

One of the most striking insights from recent assessments lies in the role of hydrological pathways. The deep-learning–based analysis shows that flow accumulation and drainage density strongly influence erosion patterns, indicating that erosion risk often concentrates in areas where surface runoff converges. In highland settings, these zones become focal points for rill and gully formation. Unpaved roads, terraced fields, and abandoned slopes frequently act as unintended conduits that accelerate sediment transport. Over time, such concentrated erosion undermines agricultural viability, threatens infrastructure, and contributes to sedimentation downstream.

Climatic variability intensifies these vulnerabilities. The highlands receive some of the state's highest rainfall totals, especially along the windward slopes of the Western Ghats. When rainfall arrives in short, high-intensity bursts—a trend increasingly observed under changing climate conditions—erosion processes accelerate dramatically. Saturated soils lose cohesion, slope failures become frequent, and mass movement events contribute to large sediment pulses. These episodic but powerful events shape the long-term erosion regime and can override the effects of gradual geomorphic change.

Beyond physical drivers, socio-economic factors indirectly influence erosion dynamics. Highland communities often depend on plantation-based employment or hill agriculture. In marginal areas, farmers cultivate steep slopes without adequate conservation measures due to limited land availability. Terraces may be poorly maintained, drainage channels clogged, or protective bunds damaged, increasing the vulnerability of cultivated land. Expanding tourism also places pressure on fragile slopes, as demand for infrastructure leads to hill cutting, deforestation, and unregulated construction.

The cumulative effects of geomorphic processes, land-use pressures, and climatic variability necessitate advanced modelling approaches to understand and predict erosion vulnerability. The use of geo-big data, high-resolution digital elevation models, and deep-learning architectures in the referenced study demonstrates a significant methodological advance. These techniques identify nonlinear relationships among multiple erosion drivers, providing high spatial accuracy in predicting vulnerable zones. Such models offer crucial decision-support tools for planning soil conservation, identifying restoration priorities, and designing slope-stabilization measures.

Despite these vulnerabilities, the highlands possess considerable ecological resilience. Forest restoration, sustainable plantation management, slope re-vegetation, and maintenance of natural drainage channels can significantly reduce erosion intensity. Indigenous soil- and water-conservation techniques, such as contour bunding, vegetative barriers, and stone trenches, remain effective when implemented consistently. Integrated watershed management, which links hilltop conservation with downstream water security, provides an essential framework for enhancing resilience.

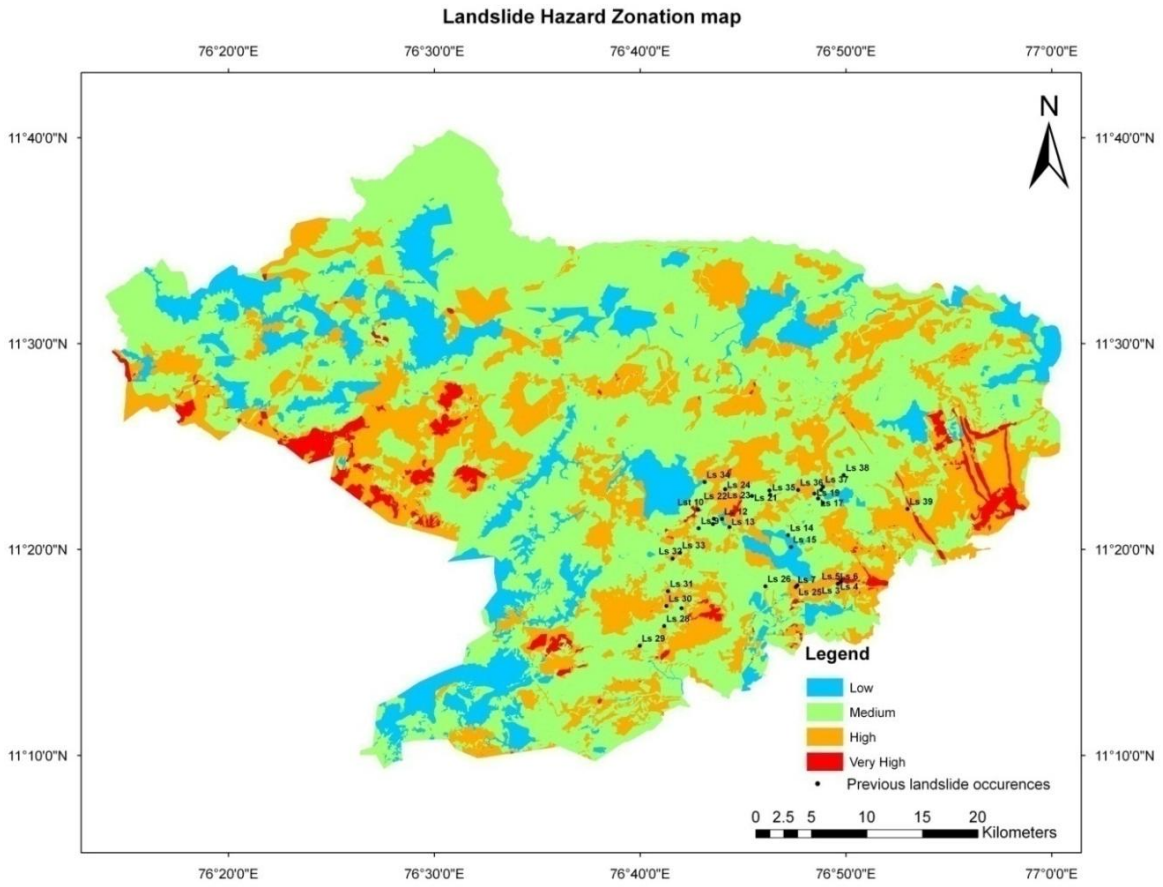
In conclusion, Tamil Nadu's highland regions exhibit a multifaceted vulnerability pattern shaped by steep terrain, sensitive soils, variable lithology, land-use alterations, and climatic extremes. The evolving landscape of erosion risk underscores the need for scientifically informed and community-responsive strategies that restore ecological balance while supporting local livelihoods. As pressures intensify, the highlands will require sustained attention, monitoring, and adaptive management to safeguard their environmental and socio-economic functions. The insights gained from geo-pedological and deep-learning–based assessments form a strong foundation for developing targeted interventions that can preserve these critical landscapes for future generations.

Landslide Stability Analysis for Nilgiris District

Using remote sensing and GIS, active landslide-prone areas were identified. A slope stability index was developed from DEM data classifying zones from very low to extremely high susceptibility. A disaster management information system was created for real-time monitoring and early warning to aid mitigation and rescue during landslide events.

Table Slope Stability Index Classification

Classification	SI Values	Susceptibility
Stable	>1.5	Very Low
Moderately Stable	1.25-1.5	Low
Quasi Stable	1.0-1.25	Moderate
Lower Threshold	0.5-1.0	High
Upper Threshold	0.5-1.0	Very High
Defended slope zone	<0.0	Extremely High



Socio-economic Dimensions of Highland Vulnerability

The highlands of Tamil Nadu—stretching across the Western Ghats, Eastern Ghats, and scattered upland blocks—present a socio-economic landscape that is as diverse as the terrain itself. While these regions are often celebrated for their ecological richness, cool climate, and plantation-based economies, they also exhibit distinctive socio-economic vulnerabilities shaped by geographic isolation, fragile livelihoods, limited access to services, and exposure to climatic and geomorphic hazards. These vulnerabilities are deeply intertwined with the environmental conditions explored in the preceding chapter, forming a coupled human–environment system that requires holistic understanding.

Highland communities are largely structured around plantation economies, small-scale hill agriculture, forestry activities, and increasingly, tourism. Plantation crops such as tea, coffee, cardamom, pepper, and banana dominate the economic landscape of regions like the Nilgiris, Kodaikanal, Valparai, and Yercaud. While plantations provide employment for thousands of workers, they also create patterns of socio-economic dependency. Plantation labourers—often migrants or descendants of migrant families—live in settlements that are spatially concentrated but economically constrained. Wages are modest, opportunities for income diversification are limited, and access to health, water, and sanitation facilities often depends on estate management. These conditions elevate socio-economic sensitivity, making households more vulnerable to disruptions caused by landslides, heavy rainfall, or market fluctuations.

Smallholder farmers in the highlands operate under a different set of constraints. Landholdings are generally small and fragmented, and cultivation often takes place on terraced slopes or narrow valley bottoms. Such farms rely heavily on monsoon rainfall and are sensitive to both climatic variability and soil erosion. Inputs such as fertilizers and labour are more expensive in hill regions due to transportation constraints, increasing production costs relative to plains agriculture. When extreme events damage terraces, irrigation channels, or access roads, smallholder farmers experience immediate livelihood impacts with minimal buffer capacity. Economic vulnerability is therefore closely tied to both exposure and limited adaptive resources.

Accessibility emerges as a significant socio-economic determinant of highland vulnerability. Many hill settlements are connected through winding roads that are prone to damage during heavy rainfall or landslides. Road closures isolate communities, disrupt access to education, delay medical assistance, and halt the movement of goods. For households dependent on daily wage labour, even short-term disruptions in mobility translate into income loss. Schools, hospitals, and markets located in valley towns become difficult to reach during extreme events, widening social inequalities and undermining long-term well-being.

Health vulnerabilities in the highlands are shaped by both environmental and socio-economic factors. Certain regions experience higher prevalence of respiratory issues due to cold, damp conditions and reliance on firewood for cooking. Access to quality healthcare remains uneven, with primary health centres often operating with limited staff and supplies. During extreme climatic events, such as intense monsoon rains, pregnant women, elderly populations, and individuals with chronic illnesses face heightened risks due to delays in emergency evacuation and limited access to secondary medical facilities. These factors contribute to a layered vulnerability structure where geographic isolation amplifies health impacts.

Tourism, though an important driver of highland economies, introduces another dimension of socio-economic fragility. The seasonal nature of tourism results in fluctuating incomes for households involved in hotel services, transport, food stalls, and handicrafts. An increase in extreme events or environmental degradation can deter tourists, leading to sudden income loss. Furthermore, expansion of tourism infrastructure—guest houses, homestays, roads, and recreational centers—often occurs on vulnerable slopes, increasing the risk of landslides and degrading protective vegetation. The resulting environmental stress indirectly increases socio-economic risk for both residents and businesses.

Demographic characteristics of highland communities also influence vulnerability. Many highland settlements include aging populations, as younger generations migrate to urban centres in search of education and employment. This demographic shift reduces the labour force available for agricultural and conservation activities, resulting in poorly maintained terraces, abandoned settlements, and reduced social support networks. Elderly populations face greater challenges during evacuation or recovery after disasters, creating disproportionate vulnerability in remote hill villages.

Education and institutional support play pivotal roles in shaping adaptive capacity. While literacy rates in certain hill districts are relatively high, access to technical training, climate information, and modern agricultural guidance remains limited. Farmers may lack knowledge

of soil conservation, contour farming, or crop diversification strategies suited to highland micro-climates. Community institutions, such as cooperatives or watershed committees, are unevenly distributed, and their effectiveness varies across regions. Limited institutional reach slows the dissemination of early warning information, delays relief efforts, and restricts long-term climate adaptation planning. Market access further contributes to socio-economic vulnerability. Many highland products—tea, spices, vegetables, and fruits—depend on external markets located in the plains. When landslides or heavy rains block transportation routes, perishable goods cannot be transported, resulting in economic losses. Market volatility also affects plantation-based incomes, leaving workers and small farmers exposed to global price fluctuations beyond their control.

Despite these vulnerabilities, highland communities exhibit resilience grounded in local knowledge, community bonding, and adaptive cultural practices. Traditional soil-conservation techniques, use of native crops adapted to hill conditions, and community-based water management reflect long-term adaptation to environmental variability. However, these systems are under increasing pressure from land-use changes, climate variability, and socio-economic transformations.

In summary, the socio-economic vulnerability of Tamil Nadu's highlands arises from a complex interplay of livelihood dependency, geographic isolation, limited access to services, and demographic shifts. These vulnerabilities are closely linked with the geomorphic and climatic risks described in earlier chapters, creating interconnected systems that impact both households and wider regional development. Addressing highland vulnerability therefore requires integrated interventions that strengthen livelihoods, improve accessibility, enhance public services, and promote environmentally sustainable land-use practices. The following chapters will explore pathways for building resilience across Tamil Nadu's diverse physiographic zones.

Cross-Zonal Comparative Vulnerability Analysis

Tamil Nadu's diverse physiographic zones—coastal margins, coastal plains, interior plains, and highland systems—exhibit distinct vulnerability characteristics shaped by their environmental processes, land-use transformations, and socio-economic structures. While each zone faces unique pressures rooted in its natural setting, a comparative analysis reveals overlapping drivers, shared structural weaknesses, and interconnected risk pathways. This chapter synthesizes cross-zonal vulnerability patterns to illustrate how exposure, sensitivity, and adaptive capacity vary across the state and how these variations influence overall regional resilience. The coastal zone represents the frontline of climatic and oceanographic hazards. Exposure here is dominated by shoreline change, cyclonic storms, storm surges, sea-level rise, and the near-constant reshaping of geomorphic landforms. Sensitivity increases due to dense settlements, ports, industrial facilities, and ecologically fragile features such as dunes and wetlands. Adaptive capacity, however, varies widely: districts with strong infrastructure and early-warning systems fare better than those with limited preparedness. The coastal zone thus exemplifies high exposure and moderate-to-high sensitivity, moderated by uneven adaptive resources.

Moving inland, the coastal plains display a more intricate socio-ecological vulnerability structure. While physical exposure decreases compared to the immediate coast, socio-economic sensitivity increases due to livelihood dependence on fishing, agriculture, and salt industries. These sectors are acutely climate-sensitive, magnifying vulnerability even under moderate environmental hazards. Infrastructure gaps—such as limited safe shelters, poor drainage, and inadequate protective systems—further heighten risk. The coastal plains represent a zone where socio-economic factors outweigh environmental exposure in driving vulnerability patterns.

Table Major vulnerable districts for each zone, aligned to the categories and vulnerability dimensions

Attribute	Coastal Plains	Central Plains & Inland	Western Highlands	Major Vulnerable Districts
Dominant hazards	Cyclone, flood, tsunami, erosion	Drought, flood, climate variability, residual coastal impacts	Erosion, landslide, surface runoff	Coastal: Chennai, Cuddalore, Nagapattinam, Puducherry, Thanjavur
				Inland: Tiruchirapalli, Madurai, Salem, Coimbatore
				Highlands: Dharmapuri, Nilgiris, Coimbatore
Socio-economic exposure	Very high	Moderate-High	Low-Moderate	Coastal: Chennai, Nagapattinam, Cuddalore, Puducherry
				Inland: Tiruchirapalli, Madurai, Salem
				Highlands: Dharmapuri, Nilgiris
Physical exposure	Highest (multi-hazard)	Moderate	Moderate-High	Coastal: Northern and central coastal districts (Chennai to Nagapattinam)
				Inland: Central and southern plains districts
				Highlands: Western Ghats districts
Soil vulnerability				Coastal: Nagapattinam, Thiruvarur, Tanjavur

Attribute	Coastal Plains	Central Plains & Inland	Western Highlands	Major Vulnerable Districts
	Erosion, salinity, waterlogging	Moderate soil erosion, water stress	Severe erosion, soil acidity	Inland: Tiruchirapalli, Madurai
				Highlands: Dharmapuri, Nilgiris, Coimbatore
Adaptive capacity	Improving but uneven	Variable, dependent on district investments and diversification	Moderately high if forested; low if deforested	Coastal: Chennai (varied), Puducherry (moderate)
				Inland: Higher in Chengalpattu, lower in Tiruchirapalli
				Highlands: Dependent on forest cover
Recent change direction	Intensifying due to urbanization, sea-level rise, infrastructure expansion	Modest adaptation, persistent instability	Land degradation; resilience varies with management	Coastal urban corridors: Chennai, Puducherry, Cuddalore
				Inland: Mixed progress, some agriculture adaptation in Chengalpattu
				Highlands: Continued deforestation impacts

The interior plains offer a sharply different landscape of vulnerability. Here, hazards arise primarily from rainfall variability, groundwater depletion, land degradation, and recurrent droughts. Exposure is influenced less by sudden disasters and more by slow-onset climatic stresses that affect agriculture, water security, and rural economies. Sensitivity is shaped by the dominance of smallholder farming, high dependence on monsoonal rainfall, and gradual deterioration of soil quality. Adaptive capacity varies significantly, with districts possessing resilient cropping systems, tank networks, or irrigation infrastructure exhibiting lower vulnerability than those with declining resource bases. In many interior plain districts, variability in monsoon performance is the single largest driver of agricultural and socio-economic stress.

In contrast, the highlands face vulnerabilities rooted in geomorphology and ecological fragility. Exposure is driven by steep slopes, shallow soils, erosive rainfall, and the potential for landslides and mass movement. Sensitivity is amplified by land-use change—particularly the expansion of plantations, tourism infrastructure, and road networks that destabilize slopes and reduce vegetative cover. Highland communities, often isolated and dependent on plantation economies or slope agriculture, face socio-economic vulnerabilities linked to limited accessibility, fluctuating markets, and restricted livelihood diversification. Adaptive capacity is constrained in many settlements due to geographic isolation, weak institutional reach, and dependence on fragile ecosystems.

Comparing the zones reveals important thematic distinctions. The coastal regions face high exposure to extreme events, whereas the plains—both coastal and interior—experience chronic, slow-onset stresses such as drought, groundwater decline, and land degradation. Highland regions face episodic but high-impact hazards, with erosion and landslides shaping their vulnerability landscape. These differences highlight the need for tailored adaptation strategies that reflect the dominant hazard regime of each zone.

Despite these distinctions, commonalities emerge across all zones. Land-use change plays a pivotal role in magnifying vulnerability. Conversion of wetlands in coastal plains, expansion of urban layouts in interior plains, and clearing of native forests in highlands all weaken the natural buffers that historically mitigated environmental hazards. Socio-economic fragility is another shared factor. Marginalized households—whether fishers on the coast, farmers in the plains, or plantation workers in the highlands—experience disproportionate impacts due to limited resources, restricted mobility, and weak institutional support. Climatic variability acts as a cross-cutting stressor, affecting water availability, crop yields, soil stability, and livelihood security across all zones.

Another important theme is the spatial connectivity of vulnerabilities. Erosion in the highlands contributes to sedimentation in the plains, affecting tank systems and irrigation networks. Groundwater depletion in interior plains influences freshwater availability along the coast, increasing saline intrusion. Shoreline instability affects fishing livelihoods, driving migration inland and altering socio-economic structures in the plains. These interlinkages highlight that vulnerability in one zone can cascade into others, producing broader regional effects.

Adaptive capacity also varies along a gradient from coast to highlands. Coastal zones benefit from stronger institutional presence, early warning systems, and long-term disaster-management investments, while highland regions often rely on community-based adaptation and traditional knowledge. The plains occupy an intermediate position, where agricultural adaptation strategies exist but require modernization and scaling. This gradient suggests that resilience-building must be viewed as a multi-scalar process that addresses local needs while strengthening inter-zonal linkages.

In summary, cross-zonal analysis reveals a complex but interpretable vulnerability mosaic across Tamil Nadu. The dominance of rapid-onset hazards along the coast, slow-onset climatic stress in the plains, and geomorphic instability in the highlands underscores the need for region-specific strategies. Yet, shared challenges—land-use transformation, socio-economic marginalization, and climate variability—provide opportunities for unified, state-wide resilience frameworks. Understanding these cross-zonal patterns forms a foundation for policy interventions that integrate ecological restoration, sustainable land management, diversified livelihoods, and climate-informed planning. The following chapters will build on these insights to propose comprehensive adaptation pathways tailored to Tamil Nadu's physiographic and socio-economic diversity.

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Chapter 21

Preparation of a Hazard Calendar for India and Tamil Nadu

A Hazard Calendar is an essential tool for understanding the seasonal and temporal patterns of disasters, enabling better planning, preparedness, and early warning. In India, where a wide range of natural hazards occur—such as cyclones, floods, droughts, heat waves, landslides, forest fires, and thunderstorms—preparing a hazard calendar helps identify the months or seasons when each hazard is most likely to occur. This calendar is developed using long-term meteorological records, historical disaster data from agencies like IMD, NDMA, NIDM, and state disaster management authorities, along with satellite-based observations of hydrological and climatic patterns.

In the Indian context, the hazard calendar reflects strong climatic seasonality driven by the southwest and northeast monsoons. Cyclones typically peak during May–June and October–November in the Bay of Bengal, affecting the east coast including Tamil Nadu. Floods are most intense during the southwest monsoon months (June–September) in northern, northeastern, and central India, while the northeast monsoon (October–December) brings heavy rainfall to Tamil Nadu and parts of Andhra Pradesh. Heat waves dominate the pre-monsoon season (March–June) across north, central, and parts of peninsular India. Drought conditions emerge after monsoon failure and peak during January–May in several states. This seasonal mapping allows agencies to anticipate risks and mobilize resources effectively.

While creating a hazard calendar, regional variations must be considered, as different states experience hazards differently. For example, Himalayan states face landslide and avalanche risks during the monsoon and winter respectively, whereas western states face higher drought probability due to arid climates. Similarly, forest fire seasons differ: in central and southern India, fires peak during February–May when vegetation dries up, whereas in the northeastern region, shifting cultivation cycles also influence fire occurrence. By incorporating such spatial and temporal variations, the hazard calendar becomes a powerful, location-specific planning instrument.

For Tamil Nadu, the hazard calendar is distinct because the state is strongly influenced by the northeast monsoon (October–December). Cyclones from the Bay of Bengal frequently strike during this season, making Tamil Nadu one of India’s most cyclone-prone states. The state also experiences heavy rainfall and flooding during November–December, especially in coastal districts like Chennai, Cuddalore, Nagapattinam, and Kanyakumari. Heat waves occur

from April to June, while droughts develop if the monsoon rains fail. Forest fires are common in the Western and Eastern Ghats—especially in the Nilgiris, Dindigul, Erode, and Krishnagiri—mostly during January–April when dry conditions prevail. This Tamil Nadu-specific hazard calendar helps in micro-level planning and district-wise preparedness.

Developing a hazard calendar ultimately supports early warning, community awareness, pre-positioning of emergency supplies, and targeted risk reduction strategies. It enables governments, disaster management authorities, and communities to anticipate hazardous periods and take preventive measures such as reservoir management, emergency drills, health advisories, and forest fire control actions. Thus, the hazard calendar becomes a vital component of multi-hazard disaster risk management for both India and Tamil Nadu.

Climate: Six major climatic subtypes, ranging from desert in the west, to alpine tundra and glaciers in the north, to humid tropical regions supporting rainforests in the southwest and the island territories. Terrain: mountains in the north, vast Indo-Gangetic plain with desert area in the west. Parallel ranges run from the Arabian sea coast, to their south, the remaining peninsular landmass, the deccan plateau, is flanked on the left and right by the coastal ranges. Northern India prone to cold waves, mainly in January and February while Odisha often experiences heat waves between April and May.

Latest Floods Events with Affected Areas

June: 2007 - flooding and storm-related damage in the southern Indian states of Andhra Pradesh, Kerala and Karnataka; 2002.

July: 2009 - Orissa state; Bihar and Uttar Pradesh; 2006 - flooding and inundation in low-lying areas affecting Gujarat, Madhya Pradesh and Rajasthan in west part and Orissa in east part; 2005 Assam and Arunachal Pradesh; 2004 - hardest hit Assam and Bihar.

August: 2009 - River Ghagra and other streams in Bahraich district of Uttar Pradesh; Bihar State; 2007 - Assam, Bihar, Orissa and West Bengal.

September: 2009 - landslide in Mumbai; Ropar district of India's northern Punjab state; Assam and New Delhi; 2008 - Bihar, 2 million affected caused by the overflowing Kosi River.

October: 2009 - State of Karnataka Bijapur, State of Andhra Pradesh; 2008 - Tamil Nadu state; 2005 - heavy rains and floods due to a depression developed over southwestern Bay of Bengal

and intensified into a TD affected southern States of Tamil Nadu, Karnataka, West Bengal and Orissa.

Tropical Storm and Affected Areas

May: 2009 - Storm Aila hit eastern areas - West Bengal; Kolkata; 2008 - severe storm started from the western state of Rajasthan and hit the national capital, Delhi and Uttar Pradesh

June: 2007 - TS in southern Andhra Pradesh state

November: 2008 - TC hit Tamil Nadu and Puducherry; 1996

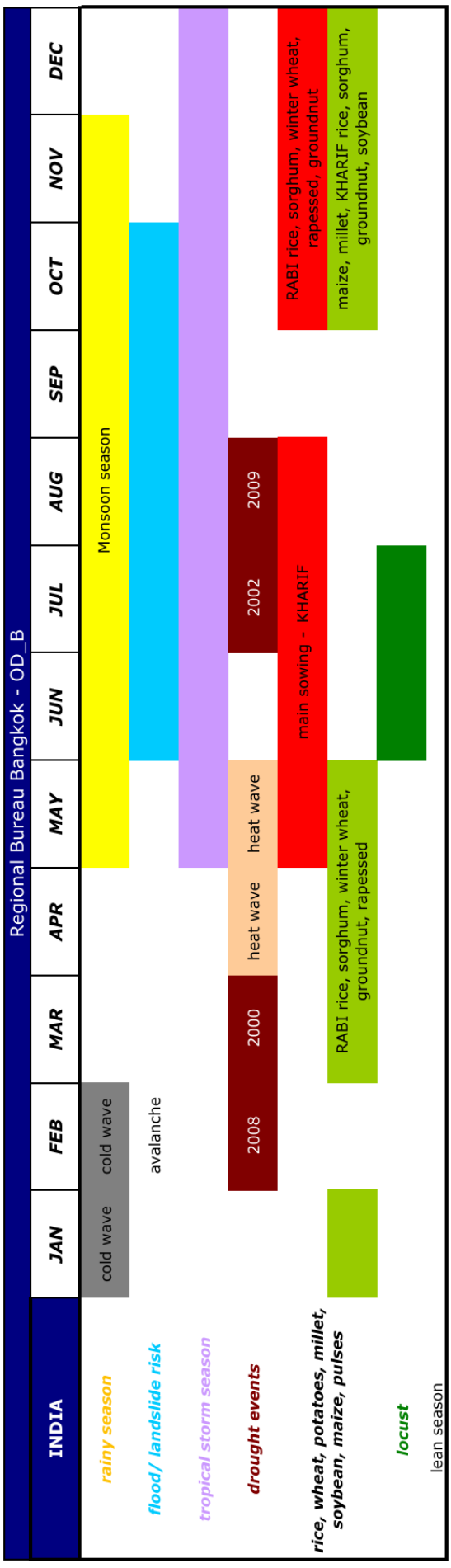
December: 2003 - TC on the eastern coasts; 2000 - late Dec

Drought Events with Affected Areas:

Worst droughts recorded in **1943** and **1965**-more than 1 million people killed. **2009** - 44% deficient monsoon in the region that includes Punjab, Haryana and west Uttar Pradesh; some districts of eastern Jharkhand and North eastern Manipur declared drought-hit; more than half of Assam state declared drought hit; total number of drought-hit districts in Uttar Pradesh has risen to 47; Andhra Pradesh also affected; **2008** - Bundelkhand region declared drought-affected; **2002**; **2000**

Locust Events with Affected Areas:

Locust infestation prone states are Rajasthan, Gujarat, Punjab, Haryana, Andhra Pradesh, Karnataka and Maharashtra; substantial damage caused during the period **1926 to 1940, 1941 to 1946, 1949 to 1955 and 1955 to 1962**. In recent years India experienced large-scale locust invasion in **1978**. Again, during July **1993**, the country experienced unprecedented level of locust invasion. 2007-warming issued for summer breeding areas in the west and small locusts present in the Kutch region of Gujarat; **2005** - Sindh and Indo-Pakistan border at risk; **2002** - invasion of locusts across the border into the desert state of Rajasthan


Regional Bureau Bangkok - OD_B
INDIA
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
rainy season
cold wave
cold wave
Monsoon season
flood/ landslide risk
avalanche
tropical storm season
drought events
2008
2000
heat wave
heat wave
2002
2009
main sowing - KHARIF
RABI rice, sorghum, winter wheat, rapessed, groundnut
maize, millet, KHARIF rice, sorghum, groundnut, soybean
rice, wheat, potatoes, millet, soybean, maize, pulses
RABI rice, sorghum, winter wheat, groundnut, rapessed
locust
lean season