

DISASTER RISK, RESILIENCE AND RECOVERY REPORT - 2024



**Integrated Centre for Adaptation, Disaster Risk Resilience
and Sustainability (ICARS)**

ICARS - IIT Roorkee – Greater Noida Campus (NCR), India

DISASTER RISK, RESILIENCE AND RECOVERY REPORT - 2024

ICARS-IIT Roorkee – Greater Noida Campus(NCR), India



DISASTER RISK, RESILIENCE AND RECOVERY REPORT – 2024

ISBN No: 978-81-991519-6-3

Copyright © 2025, ICARS-IIT Roorkee – Greater Noida
Campus(NCR), India

Edition: 2025

Authors :

Anil K Gupta, Fatima Amin, Vishnu P, Nupur Tyagi, Mishel
Mohan

Published by :

ICARS-Indian Institute of Technology Roorkee, Gr. Noida
Campus

Citation :

Gupta, A. K., Amin, F., Vishnu, P., Tyagi, N., & Mohan, M.
(2025) Integrated Centre for Adaptation, Disaster Risk
Resilience and Sustainability-Indian Institute of Technology
Roorkee, Greater Noida, Pages 83

Disclaimer :

The Disaster Risk, Resilience, and Recovery Report 2024 is a knowledge-focused publication intended to support evidence-based understanding of disaster risks, resilience initiatives, and recovery processes in India. It aligns with national and international disaster risk reduction frameworks and reflects deliberations of the National Platform for Disaster Risk Reduction (NPDRR), without constituting official policy positions. The views expressed are those of the authors and contributors, and the report is intended to inform dialogue, learning, and decision-making.



Dr. Anita Gupta
Advisor (DST) &
Head, Climate, Energy and Sustainable
Technology (CEST) Division



Department of Science and Technology (DST)
Government of India
Technology Bhavan, New Mehrauli Road,
New Delhi - 110016



Message

India, owing to its diverse geography, climate variability, and socio-economic complexities, remains highly vulnerable to a wide spectrum of natural and human-induced disasters. From floods and cyclones to earthquakes and emerging climate risks, these hazards threaten lives, livelihoods, and developmental gains. Continuous scientific assessment of risks and capacities is therefore essential to inform evidence-based policies and strengthen disaster resilience.

The Department of Science & Technology (DST) has played a key role in advancing disaster risk management through multi-hazard risk assessments, climate modeling, earthquake microzonation, and advanced early warning systems. The integration of geospatial technologies, data science, and artificial intelligence has further strengthened risk analysis and decision-making processes.

In the 3rd Meeting of the National Platform for Disaster Risk Reduction (NPDRR), chaired by the Hon'ble Prime Minister of India, DST was entrusted with strengthening the science and technology dimensions of disaster risk governance. The Department has been assigned to enhance research-driven risk assessment, promote technological innovation in early warning and forecasting systems, and foster collaboration among scientific institutions to support resilient and risk-informed development planning.

I am pleased to present the Disaster Risk, Resilience and Recovery Report 2024, Which is an annual feature developed by ICARS (a Centre of Excellence of DST at IIT Roorkee – Greater Noida Campus). This Report reflects our collective commitment to science-driven resilience and sustainable development. I commend the ICARS team for their dedicated efforts and trust that this Report will serve as a valuable resource in building a safer and more resilient India.

Anita Gupta



Preface

Disaster risk and resilience represent one of the most pressing challenges for India, with impacts cutting across ecological, economic, and social systems. India, being one of the most disaster-prone countries in South Asia, continues to face recurrent risks from floods, cyclones, earthquakes, landslides, droughts, and heatwaves that vary across regions and sectors. These risks underscore the urgent need to mainstream disaster risk reduction into all dimensions of development. This vision directly resonates with Point 1 of the Hon'ble Prime Minister's 10 Point Agenda on disaster risk reduction: "All development sectors must imbibe the principles of disaster risk management."

National policies and programmes such as the National Disaster Management Plan, the multi-hazard early warning systems, the National Cyclone Risk Mitigation Project, and initiatives on landslide and earthquake risk microzonation have reflected India's commitment to proactive disaster risk management. At the same time, institutions, research organizations, and community networks are playing an equally critical role in enhancing resilience capacities, reducing vulnerabilities, and enabling science-based planning and preparedness. The deliberations of the National Platform for Disaster Risk Reduction (NPDRR) have further emphasized innovation, collaborative research, and systemic approaches to manage the multi-dimensional nature of risks.

The Annual Disaster Risk, Resilience and Recovery Report 2024 is a collective attempt to record and analyze the evolving landscape of disaster risks, resilience strategies, and recovery frameworks in the country. It represents an integrative effort to bring together scientific research, field-level evidence, and policy perspectives into one consolidated resource. This report is designed as a knowledge reference for policymakers, planners, researchers, and community stakeholders in advancing resilience-building and ensuring that disaster risk reduction remains integral to sustainable development.

As the Principal Investigator at the Integrated Centre for Adaptation, DRR & Sustainability (ICARS), Indian Institute of Technology Roorkee, Greater Noida Extension Center, I feel privileged to introduce this volume, which truly reflects the collaborative spirit of multiple institutions, researchers, and practitioners. It is my firm hope that this report will serve as both an archive of present capacities and a guiding framework for shaping a safer, resilient, and inclusive future for India.

Prof Anil K Gupta



"Consultation Session on Disaster Risk Resilience and Recovery" under the aegis of RESSummit 2025.

Acknowledgements

The preparation of the Disaster Risk, Resilience and Recovery Report 2024 has been a truly collaborative endeavor, made possible through the invaluable contributions of diverse ministries, departments, scientific institutions, and academic partners.

We are thankful to Prof. Abhay Karandikar (Secretary, DST-Gol) for entrusting IIT Roorkee with the opportunity to undertake and work on the ICARS-CoE. A special note of thanks to Dr. Anita Gupta (Advisor & Head, CEST, DST-Gol), Dr. Vandana Singh (Scientist-F, CEST, DST-Gol) and Dr. Swati Jain (Scientist-D, CEST, DST-Gol) for the constant encouragement and support extended to ICARS.

The project team is thankful to Prof. K.K.Pant (Director, IIT Roorkee), Dr. Akhilesh Gupta (Distinguished Professor, CDMM, IIT Roorkee), and Dr. Thanga Raj Chelliah (HoD, WRD&M, IIT Roorkee) for their constant support and encouragement for undertaking the various strategic endeavours and ensuring the smooth functioning of ICARS. We also acknowledge the guidance and support of Padma Shri Prof. Anil Gupta (founder of Honey Bee Network and visiting professor at IIM Ahmedabad, Gujarat) on various endeavours of ICARS.

Our sincere thanks are extended to the various line Ministries and Government Departments whose active engagement and valuable inputs enriched the scope of this document. Their efforts reflect the nation's collective resolve to advance disaster risk reduction and resilience.

From the ICARS team, a special thanks to the Co-PIs (Prof. Ashish Pandey, Prof. Akshay Dvivedi, Dr. Komal Tripathi), and expert collaborators (Dr. Mohit Mohanty, Prof. Manish Goyal, IIT Indore and Dr. Rajarshi Dasgupta, IIT Delhi) for their collaborative efforts and valuable contributions to ICARS. Further, I acknowledge Ms. Fatima Amin (Project Scientist-I) for leading and coordinating the Disaster. Special thanks to the drafting team of the Annual Disaster Risk, Resilience and Recovery Report 2024 from Sphere India- Mr. Vikrant Mahajan (CEO, Sphere India), Ms. Nupur Tyagi (Programs Manager, Sphere India), Mr. Vishnu P (Program Coordinator Inter-Agency Coordination), Ms. Mishel Mohan (Manager - Program Implementation) for their hard work. We also acknowledge the support extended by HCL Foundation in this process. Thanks are also due to the team at ICARS including the scientists Ms. Richa Srivastava, Ms. Pritha Acharya and Dr. Ravi Katiyar, Research Assistant (Adapt-DMIR), Ms Jyoti Saini and Junior Research Fellow, Mr. Deepak Pandey and Ms. Alpna for their contributions to the endeavours of the project. Further we acknowledge the support of all the members from ministries, organizations and other stakeholders who were involved and consulted during meetings for finalizing the Annual Disaster Risk , Resilience and Recovery Report 2024. We deeply appreciate the contributions of our Co-PIs Prof. Ashish Pandey, Prof. Manish Kumar Goyal, Dr Mohit Prakash Mohanty and Dr Komal Tripathi for their research inputs, data support, and technical reviews, which significantly enhanced the depth and quality of the report. Special recognition is due to the other Faculty of Water Resources Development and Management (WRD&M), Indian Institute of Technology Roorkee, for their intellectual guidance and academic contributions in advancing research on disaster risk, water-related hazards, and resilience strategies.

We would like to extend our heartfelt appreciation to all the members of the Advisory Committee and the respective Working Groups (annexure I) for their invaluable contributions, insightful review comments, and inputs, for our various strategic outcomes.

Prof. Anil K. Gupta
Principal Investigator

ICARS – IIT Roorkee, Greater Noida Extension Center



Workshop on “Disaster Management and Resilient Infrastructure in Changing Climate and Environmental Risks” jointly and for NDMA, MOEFCC and DST-Govt. of India, at ICARS, IIT-R Greater Noida Campus (NCR) on 10-11 Feb 2025.

About the Publication

The Disaster Risk, Resilience, and Recovery Report 2024 is a pioneering initiative aimed at providing a comprehensive and systematic understanding of disaster risks, resilience initiatives, and recovery processes across India. This report is not just a document but a part of a continuous process that aligns with national and international frameworks, including the Sendai Framework for Disaster Risk Reduction (SFDRR), Sustainable Development Goals (SDGs), and the Paris Agreement.

This report is directly aligned with the National Platform for Disaster Risk Reduction (NPDRR), specifically reflecting the deliberations of the 2nd and 3rd NPDRR meetings. The 2nd NPDRR meeting emphasized the need for enhancing planning, leveraging technology, and documenting best practices (Points 9 and 5). The 3rd NPDRR meeting further underscored the importance of building capacities, promoting transparency, and integrating innovative approaches (Points 11 and 15). The report serves as a national knowledge repository, tracking disaster risks, innovative resilience practices, and recovery outcomes.

India faces complex and evolving disaster risks due to factors such as climate change, urbanization, ecological degradation, and socio-economic vulnerabilities. This report designed to bridge the knowledge gap by providing an evidence-based, structured assessment of disaster risks, response capacities, and recovery outcomes, promoting accountability, innovation, and evidence-based decision-making.

Globally, organizations like UNESCAP, through their Asia-Pacific Disaster Reports, have highlighted the importance of understanding cascading risks and emerging threats in the region, providing a broader regional perspective. The International Recovery Platform (IRP) has consistently focused on the “Build Back Better” approach in recovery, offering frameworks that emphasize resilience in post-disaster recovery. In South Asia, the All India Disaster Mitigation Institute (AIDMI) has documented disaster impacts and recovery initiatives, providing valuable insights into community-based resilience. Meanwhile, the Nepal Disaster Reports have offered a detailed understanding of disaster risks and recovery in mountainous regions, underscoring the importance of localized, context-specific interventions.

However, while these reports provide valuable lessons, the report stands apart by offering an India-centric, multi-stakeholder perspective. It is developed with the active involvement of government agencies, NGOs, private sector entities, and community organizations, ensuring a comprehensive understanding of resilience and recovery within India’s diverse disaster landscape. This report not only documents disaster impacts but also highlights innovative resilience initiatives, tracks recovery progress, and provides actionable recommendations.

Purpose of Study

With climate change exacerbating weather patterns, India is increasingly vulnerable to a variety of extreme events. Each year presents new and unanticipated challenges, which are met with the sheer grit and resilience of its systems and people. However, with the intensification of climate extremes, India can no longer afford to rely solely on reactive measures. Anticipatory action has become a critical necessity.

While India's disaster management systems are well-equipped to handle the aftermath of predictable events, such as cyclones, relying on reactive measures alone is insufficient. Anticipating future climate-induced challenges and building the capacity to cope and adapt to these changes is essential for fostering resilience. This requires a proactive approach to reviewing new disasters encountered annually, reflecting on lessons learned, and enhancing capacities to withstand future calamities.

Currently, there is limited research on the challenges faced by the disaster management sector across India each year. This study aims to fill that gap by capturing the evolving landscape of risks, documenting innovative strategies for resilience employed by various stakeholders, and reflecting on lessons learned. It focuses on three key aspects of disaster management:

1. The Changing Risk Landscape
2. Initiatives for Resilience
3. Audit of Recovery Processes

The study also seeks to analyse major disasters from the year, derive lessons, identify best practices, and propose actionable recommendations for the future. It will be an annual exercise initiated by the Integrated Centre for Adaptation, Risk, and Resilience (ICARS) and Sphere India.

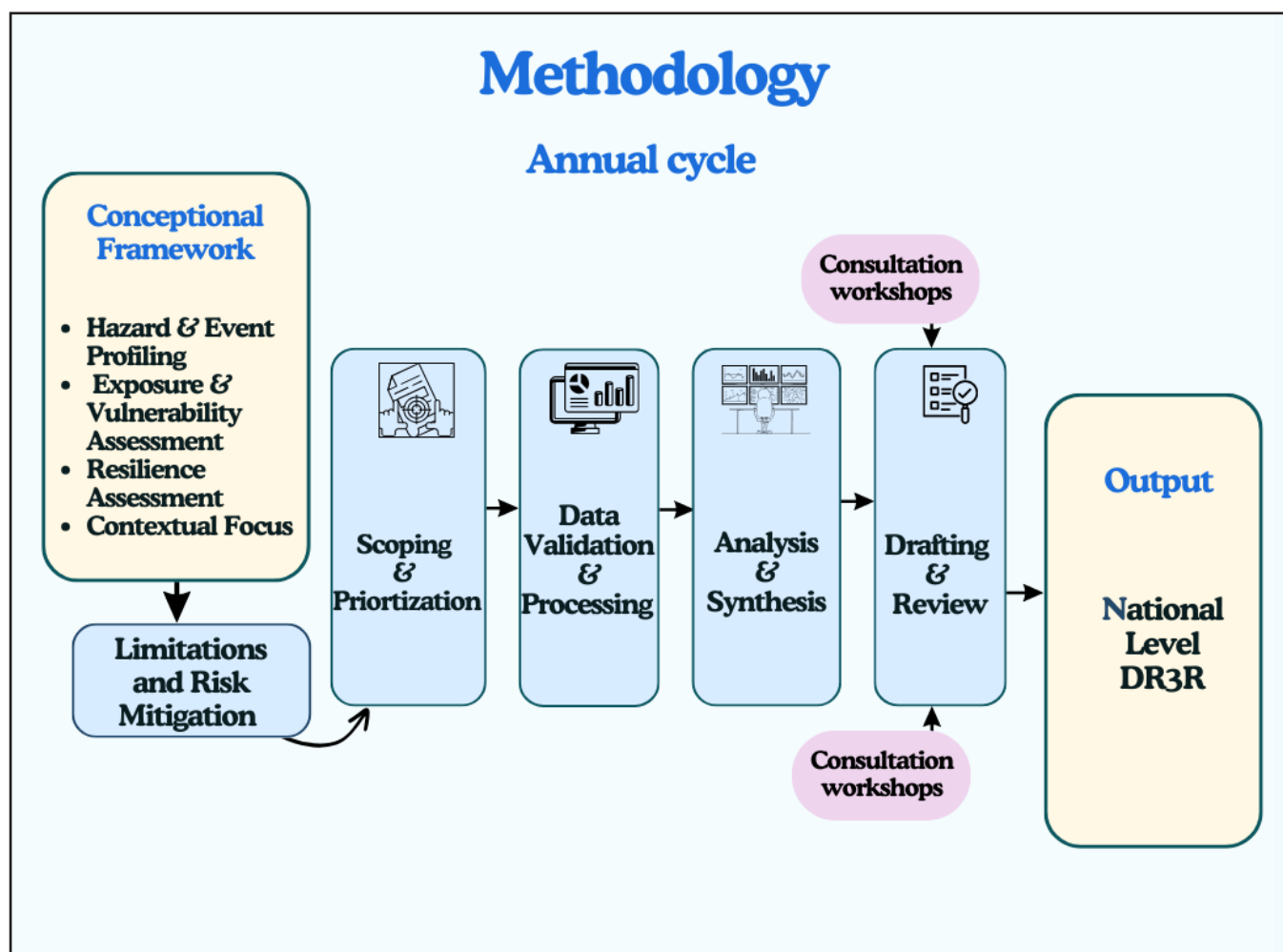
Objectives of the Study

1. Review of Annual Disasters: Capture the changing risk landscape of the year, including emerging dimensions of risk and vulnerability.
2. Documentation of Innovations and Resilience Initiatives: Highlight progress made in resilience-building, including new government initiatives at the central and state levels, contributions by the private sector (e.g., CSR efforts), and innovative practices introduced by international agencies (e.g., CDRI health infrastructure toolkit).
3. Audit of Recovery Processes:
 - o Conduct recovery audits to analyse activities undertaken after Post-Disaster Needs Assessments (PDNAs), to evaluate recovery gaps.
 - o Summarize key findings and assess whether new approaches to recovery were implemented by governments or other stakeholders.
 - o Provide actionable recommendations where gaps exist to initiate discussions on enhancing recovery processes.

Methodology

To understand and learn from past disasters as well as pave the way for future events, a multifaceted approach is required to capture the complexities of annual extreme events. The study employs a three-step methodology to cover the extensive array of disasters in India. First, the study includes literature review focusing on news articles, situation reports, needs assessments, academic research to build the background for emerging risks in India. Second, in-depth case studies are developed that attempt to highlight and break down the factors contributing to

specific disasters in the year. Following this, an Annual Learning and Planning workshop is organised that dissects these disasters and integrate lessons learnt, gaps and challenges and recommendations for adaptive strategies from diverse stakeholders including disaster management practitioners, private sector actors, academia, government stakeholders, community leaders, etc. These inputs are further condensed to provide targeted recommendations for specific stakeholder groups. This structured approach aims to foster a deeper understanding of the dynamic risk landscape, promote resilience-building, and encourage collaborative action for effective disaster management.



1. **Literature Review:** To establish a foundational understanding of emerging risks in India
2. **In-depth Case Studies:** To examine the factors contributing to specific disasters during the year.

Annual Learning and Planning Workshop: To analyze disasters, distill lessons learned, identify gaps and challenges, and formulate adaptive strategies.



The 2024 Wayanad landslide Kerala, India

Contents

About the Publication	vii
Purpose of Study	vii
Objectives of the Study	viii
Methodology	viii
 Chapter 1: Introduction	 1
1.1 India's Disaster Profile	1
1.2 Major Disasters in India (2024) and Their Impact	2
1.2.1 Floods and Landslides	2
1.2.2 Cyclones or Cyclonic Storms	12
1.2.3 Geological and Climate-Induced Events (GLOF, Riverbank Erosion, Land subsidence etc)	15
1.2.4 Other extreme weather events (heatwave, coldwave, lightning, lack of winter precipitation in northern states etc)	16
1.3 Matrix of Impact (Quantitative)	21
 Chapter 2: Changing Landscape of Risk	 23
2.1 Wayanad Landslide	23
2.2 Tripura Flood	26
2.3 Joshimath Land Subsidence	27
2.4 River bank Erosion - West Bengal	29
2.5 Assam Flood	30
2.6 Heatwave in India	33
2.7 Glacial Lake Outburst Floods (GLOFs) in the Himalayas	35
2.8 Rising Threat of Lightning in India	37
2.9. Synthesis and Key Insights: Changing Landscape of Risk	39
 Chapter 3: Initiatives for Resilience	 41
3.1 Government-Led Initiatives	41
3.1.1 Major Initiatives by the Central Government	41

3.1.2	Policy and Legislative Measures	43
3.1.3	Enhancing Disaster Preparedness through NDMA Initiatives	44
3.2	Private Sector and CSR Contributions	44
3.2.1.	Innovation and Technology in Disaster Resilience	45
3.2.2	Corporate Social Responsibility (CSR) Initiatives in Disaster Resilience	45
3.3	Humanitarian and Community-Led Resilience Initiatives	46
	Stories from the field	47
3.3.4	The Path to Long-Term Resilience	48
3.4	Key Learnings and Future Directions	48
Chapter 4: Progress in Recovery		51
4.1.	Post-Disaster Needs Assessments (PDNAs) and Recovery Frameworks	52
4.2.	Gaps and Challenges	63
4.3.	Innovations in Recovery	65
4.4.	Recommendations for Strengthening Recovery	66
Chapter 5: Lessons and Recommendations		69
5.1.	Policy	70
5.2.	Research	73
5.3.	Capacity building	75
5.4.	Stakeholder engagement	77
References		81
Annexure I		85

List of Figures and Tables

Figure 1:	Major Disasters in India covered by Sphere India	1
Figure 2:	Flooded Vijayawada city in Andhra Pradesh Source: DtE_05/09/2024 (Media)	3
Figure 3:	Villagers repaying the embankment breach caused due to flood in Assam Source : The Hindu_21/07/2024 (Media)	3
Figure 4:	Flood affected area in Gaya Source: abp News_17-0-2024 (Media)	4
Figure 5:	Waterlogging in Delhi after rainfall Source: The Hindu_01/08/2024 (Media)	5
Figure 6:	Flooded area after heavy rainfall in Vadodara Source: Hindustan Times_29/08/2024 (Media)	5
Figure 7:	Cloud burst at Shamej in Rampur, in Shimla Source:The Hindu_01/08/2024 (Media)	6
Figure 8:	Landslide affected area in Uttara Kannada Source: The India Express_25/12/2024 (Media)	6
Figure 9:	Sea waves crash against the stalls at Shivaji park chowpatty Source : The Hindu_25/07/2024 (Media)	7
Figure 10:	Flood affected Areas in Katni district Source: The India Express_25/207/2024 (Media)	8
Figure 11:	Landslide Area in Sikkim Source: CNN World_25/06/2024 (Media)	8
Figure 12:	Areal view of flood affected area in Gomati Source: ANI_27/08/2024 (Media)	9
Figure 13:	Floodwater submerged area, in Gorakhpur Source: The India Express _ 20/07/2024 (Media)	9
Figure 14:	Road Blocked in Chamoli district Source: The Indian Express _ 11-08-2024 (Media)	10
Figure 15:	Landslide affected area in Chooralmala, Wayanad Source: Down to Earth _ 06-09-2024 (Media)	11
Figure 16:	Buildings submerged due to floods in West Benga Source: Wire _ 26/09/2024 (Media)	12
Figure 17:	Heavy rains accompanied by a hailstorm Source: The Hindu _ 06/05/2024 (Media)	13

Figure 18: Flooded Street followed by Cyclone Remal in Imphal Source: Hindustan Times _ 24/12/2024 (Media)	14
Figure 19: NDRF personnel clear a tree that fell after cyclone Dana made landfall, in Anantpur village, Balasore district Source: Reuters _ 25/10/2024 (Media)	14
Figure 20: Roads submerged in floodwaters after cyclonic storm triggered heavy rainfall in Puducherry Souce: Mint _ 01/12/2024 (media)	14
Figure 21: Houses damaged in Ramban Source: Mint _ 26/04/2024 (Media)	15
Figure 22: Damaged House in Murshidabad Source: Frontline _ 18/08/2024 (media)	16
Figure 23: Farm labourers, with their faces covered for protection from heat, Karnal, Haryana Source: Reuters _19/06/2024 (Media)	17
Figure 24: People sit around a bonfire to warm themselves during a cold winter, in New Delhi Source: Financial Express _ 18/12/2024 (Media)	18
Figure 25: Representational Image of Lightning	19
Figure 26: Gulmarg’s resorts slopes, which are usually covered in snow at this time of the year, carry a green look Source : Hindustan Times _ 23/01/2024 (Media)	19
Figure 27: Forest Fire in Uttarakhand Source: Hindustan Times_ 20/06/2024 (Media)	20
Figure 28: Changing Disaster Risk: 2023-24	23
Figure 29: Wayanad Landslide: Before and After Source: NRSC	24
Figure 30: landslide location map Source: KSDMA	24
Figure 31: Flood inundated Area Source: Media_27-08-2024	26
Figure 32: Joshimath Land Sinking Areas Source: Media_13-01-2023	27
Figure 33: Eroded banks of the Ganga at Shibpur village in Murshidabad Source: Media	29
Figure 34: Flood affected people in Darrang District Source: Media_11-07-2024	31
Figure 35: News Clipping of Assam Flood	32
Figure 36: IMDs Seasonal outlook for hot weather season_2024 Source: Ministry of earth science- Press release	33
Figure 37: News Article on heatwave situation in India in 2024 Source: Media	34
Figure 38: Army officials recover a vehicle after the incident Source: Media	35
Figure 39: News Article on GLOF	36

Figure 40: News article on Lightning	37
Figure 41: Presentation from NDMA at APMCDRR 2024	44
Figure 42: Anti river bank erosion Schemes	59
Table : Matrix of Impact (Quantitative)	21
Heat related Causalities in India Source: Down to Earth_13-09-2024	33



Disaster-Risk Resilience, Response & Recovery Annual Learning and Planning Workshop: 2024

Introduction

Chapter

1

This chapter explores the major disasters that impacted India in 2024, highlighting their scale, severity, and the challenges they posed to communities and response systems. It examines the widespread floods, cyclones, landslides, droughts, heatwaves, lightning strikes, and forest fires, emphasizing their increasing frequency and intensity. The chapter also delves into the broader implications of these disasters, including displacement, infrastructure damage, economic losses, and environmental degradation. By analyzing these events, this chapter aims to provide a comprehensive understanding of India's disaster landscape, emphasizing the urgent need for strengthened preparedness, resilience-building, and sustainable risk reduction measures.

1.1 India's Disaster Profile

India remains one of the most disaster-prone countries in the world, facing a wide range of natural hazards, including floods, cyclones, landslides, droughts, heatwaves, lightning strikes, forest fires, and extreme weather anomalies. In 2024, disasters affected millions of people, causing significant loss of life, destruction of infrastructure, economic setbacks, and long-term displacement. Floods and landslides were the most frequent disasters, impacting over 30 million people, with Assam, Bihar, Uttar Pradesh, Maharashtra, and West Bengal among the worst-hit states. Cyclones like Remal, Dana, and Fengal devastated coastal regions, displacing lakhs and damaging thousands of homes and hectares of farmland. Heatwaves intensified, with temperatures hitting 49°C in Delhi, killing over 600 people, while lightning emerged as India's deadliest weather hazard, claiming 1,374 lives. Drought conditions in Maharashtra and Karnataka wiped out 48 lakh hectares of crops, worsening water shortages and agricultural distress. The Uttarakhand Forest fires set new records, destroying 1,747 hectares of land and killing 11 people. Additionally, weakened winter precipitation in the Himalayas signaled potential long-term water scarcity issues. With climate change driving more extreme and unpredictable weather events, India's disaster risks are escalating, demanding urgent investment in climate resilience, early warning systems, sustainable infrastructure, and disaster preparedness strategies to mitigate future losses.

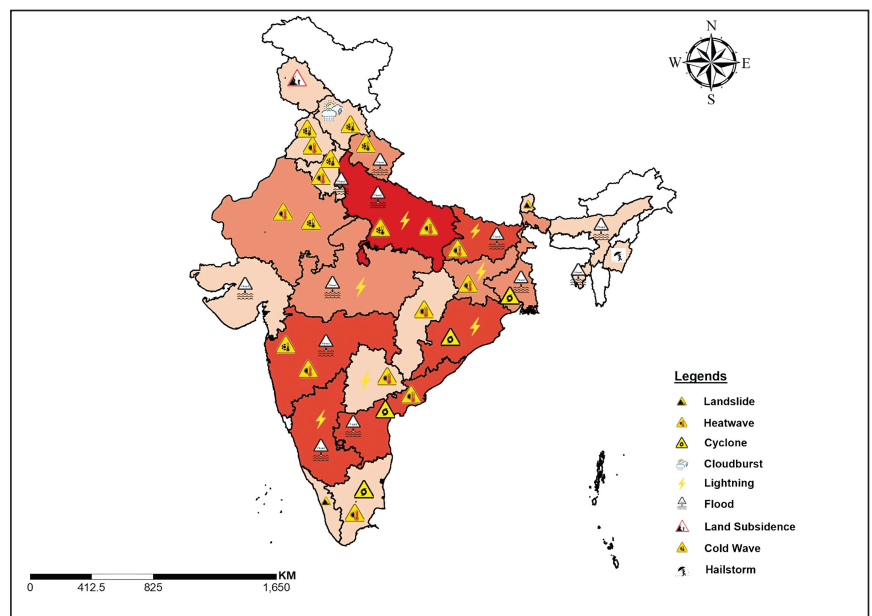


Figure 1: Major Disasters in India covered by Sphere India

1.2 Major Disasters in India (2024) and Their Impact

In 2024, India faced widespread devastation due to floods, landslides, cyclones, heatwaves, lightning strikes, droughts, and forest fires, impacting millions of people and causing significant loss of life, displacement, and economic damage. Floods and landslides were the most destructive disasters, affecting over 30 million people across Assam, Bihar, Uttar Pradesh, Gujarat, Maharashtra, Karnataka, Andhra Pradesh, West Bengal, Delhi, Himachal Pradesh, Uttarakhand, Tripura, Madhya Pradesh, and Kerala. Assam suffered the worst floods, with 3.3 million people affected, 113 deaths, and over 68,000 hectares of crops destroyed. Bihar (1.2 million affected) and Uttar Pradesh (1.8 million affected, 54 deaths) also faced severe flooding, leading to large-scale displacement. Landslides in Sikkim, Wayanad, and Himachal Pradesh caused massive destruction, with Wayanad reporting 231 deaths and 119 missing persons. Cyclones Remal, Dana, and Fengal caused widespread devastation, with Cyclone Fengal alone impacting 1.5 crore people, damaging over 10,000 homes, and leading to large-scale agricultural losses.

Beyond hydrometeorological disasters, extreme weather events caused unprecedented human and economic losses. India's worst heatwave in years led to over 700 deaths, with Delhi recording 49°C and severe water shortages affecting millions. Lightning became the deadliest weather hazard, killing 1,374 people, with Bihar, Odisha, and Madhya Pradesh among the worst-affected states. Droughts in Maharashtra and Karnataka destroyed 48 lakh hectares of crops, worsening food insecurity and rural distress. Forest fires in Uttarakhand reached a record high, with 21,033 fire incidents destroying 1,747 hectares of land and killing 11 people. Additionally, weak winter precipitation in the Himalayas heightened concerns over water shortages and agricultural sustainability.

1.2.1 Floods and Landslides

In 2024, India witnessed widespread and devastating floods and landslides across multiple states, primarily due to intense monsoon rainfall, cyclonic activity, and extreme weather patterns. States such as Assam, Bihar, Uttar Pradesh, Gujarat, Himachal Pradesh, Uttarakhand, Karnataka, Maharashtra, Andhra Pradesh, Madhya Pradesh and Tripura faced severe flooding, displacing millions of people, causing hundreds of fatalities, and leading to massive agricultural and infrastructure losses. Assam recorded over 113 deaths, with 3.3 million people affected, while Bihar and Uttar Pradesh suffered major casualties and displacement due to riverine flooding. Urban areas like Delhi and Mumbai saw extreme waterlogging, disrupting transport and daily life, while coastal and hilly regions like West Bengal, Kerala, and Himachal Pradesh experienced embankment breaches and flash floods. Gujarat and Andhra Pradesh were also heavily impacted, with thousands of hectares of farmland submerged, leading to economic distress among farmers.

Simultaneously, landslides triggered by heavy rainfall wreaked havoc in Sikkim, Himachal Pradesh, Uttarakhand, and Kerala, with Wayanad witnessing one of the deadliest landslides that claimed over 231 lives. The Himalayan states of Sikkim and Uttarakhand, prone to cloudbursts and landslides, saw major destruction of roads, homes, and power infrastructure, while Tripura faced a combination of landslides and floods that displaced over 1.5 lakh people. The increasing frequency and intensity of these disasters underscored the urgent need for better flood management, embankment reinforcement, early warning systems, and sustainable urban planning to mitigate future risks.

1.2.1.1 Andhra Pradesh Flood

Andhra Pradesh faced two major flood events in July and September 2024, causing widespread devastation across multiple districts. The first flood occurred in late July due to heavy rains and the rising waters of the Godavari River, affecting the districts of East Godavari, West Godavari, Alluri Sitarama Raju (ASR), Eluru, and Konaseema.

Over 43 villages in West Godavari were submerged, damaging 37,000 hectares of paddy fields and cutting off 54 villages in ASR district. In Konaseema, 186 villages were affected, with 7,013 acres of farmland submerged. Authorities set up 149 relief camps in ASR district, deploying 44 boats for evacuations. The floods caused severe damage to infrastructure, submerging roads and disrupting essential services. Government agencies and disaster response forces, including the NDRF and SDRF, were actively involved in rescue operations, relocating thousands of people to safety.

A second wave of catastrophic flooding struck in early September, this time affecting Vijayawada and the surrounding districts of NTR, Krishna, Guntur, and Bapatla. A cloudburst overwhelmed the Budameru

Vagu and Krishna River, causing some of the worst flooding recorded in the region. Over 644,000 people in Andhra Pradesh were impacted, with 45 fatalities reported. The floods submerged 181,538 hectares of agricultural land, caused significant power disruptions, and left 411 villages underwater. In response, the government deployed drones to deliver food and essential supplies, while humanitarian organizations provided direct relief to affected communities. The Ministry of Home Affairs (MHA) formed an expert team to assess flood management and dam safety, while NGOs, in partnership with the state government, provided food for over one million flood victims.



Figure 2 : Flooded Vijayawada city in Andhra Pradesh/
Source: DtE_05/09/2024 (Media)

1.2.1.2 Assam Flood

The 2024 Assam floods were one of the most devastating in recent history, with continuous flooding from late June to mid-July. The worst impact was recorded on July 9, 2024, when 30,83,830 people were affected across 27 districts, including Dhubri, Barpeta, and Cachar. By July 18, 2024, the flood had caused 113 deaths, including fatalities from drowning, landslides, and electrocution. Over 3,337,981 people were affected in 16 districts, and 823 villages remained submerged. The floodwaters submerged 68,768 hectares of crops on July 7, marking the highest agricultural loss during the disaster. By July 18th, 24,501 houses were reported damaged, of which 3,306 were completely destroyed.

The flood had a severe impact on Assam's infrastructure and environment. On July 7, Kaziranga National Park lost 114 animals, including six rhinos, 100 hog deer, and two sambar deer, due to drowning. Over 1.5 million livestock were affected throughout the state, and 214 animals were washed away in a single day. Roads, bridges, embankments, and railway tracks were heavily damaged in Bajali, Goalpara, Kokrajhar, and Dhubri, disrupting transportation. Power supply was also disrupted in multiple districts, leaving thousands without electricity for days. By mid-July, 543 relief camps were sheltering 3.45 lakh



Figure 3: Villagers repaying the embankment breach caused due to flood in Assam| Source : The Hindu_21/07/2024 (Media)

displaced people, while more than 1,170 boats were deployed for rescue operations. Despite extensive relief efforts by the government, NDRF, SDRF, and humanitarian organizations, continuous rainfall, rising water levels, and embankment breaches prolonged the crisis. The large-scale displacement, agricultural losses, and destruction of homes highlighted the urgent need for improved flood control and mitigation strategies in Assam.

1.2.1.3 Bihar Flood

In September 2024, Bihar faced severe flooding in two phases, affecting millions across multiple districts. The first phase, which began around mid-September, resulted from rising water levels in the Ganges and its tributaries. The most affected districts included Buxar, Bhojpur, Patna, Saran, Vaishali, Munger, Khagaria, Samastipur, Begusarai, Lakhisarai, Bhagalpur, and Katihar, impacting over 1.2 million people. The floods caused major transportation disruptions, including the suspension of railway services between Sultanganj and Ratanpur. By September 23, eight fatalities had been reported, and over 36,000 people were evacuated. The second wave of flooding, beginning on September 26, was triggered by heavy rainfall in Nepal and the release of approximately 600,000 cusecs of water from the Birpur and Valmiki Nagar barrages into the Kosi,

Gandak, and Bagmati rivers. This phase was more severe, affecting 16 districts, including East Champaran, Araria, and Sitamarhi, and displacing over 6.96 lakh people. Embankment breaches in Sitamarhi and West Champaran led to widespread devastation, including the flooding of the Valmiki Tiger Reserve. The overall toll of the disaster reached 52 deaths, with 37 drowning cases occurring on September 24 alone.



Figure 4 : Flood affected area in Gaya | Source: abp News_17-0-2024 (Media)

The Bihar government and humanitarian organizations launched extensive relief operations. By late September, 85 relief camps were operational, housing over 47,000 displaced people, while 222 community kitchens served meals to approximately 175,600 individuals daily. More than 1,170 boats, including 13 boat ambulances, were deployed for rescue efforts. The state government distributed 279,450 polythene sheets and 108,200 dry ration packets, while mobile medical teams provided healthcare services. The Bihar Inter Agency Group (B-IAG), in collaboration with UNICEF and Sphere India, coordinated response efforts, conducting emergency meetings and planning a Joint Rapid Needs Assessment. Local organizations provided medical aid and food distribution.

1.2.1.4 Delhi Flood

In August 2024, Delhi and the National Capital Region (NCR) experienced severe flooding due to heavy rainfall, resulting in widespread waterlogging and infrastructure damage. The torrential downpour led to seven fatalities, including electrocution incidents near Gurgaon's IFFCO Chowk metro station and in Bindapur, as well as drowning cases in Mayur Vihar Phase 3. The city's drainage system was overwhelmed, causing major traffic disruptions at key points such as ITO, Minto Bridge, Pul Prahladpur Railway Underpass, and Dhaula Kuan. Waterlogging forced the closure of all government and private schools, while flights were diverted from Delhi airport due to adverse weather conditions. Structural damage was reported, including a house collapse in North Delhi's Sabzi Mandi area, where one person was injured.

In response, the Delhi government and disaster management authorities launched immediate relief measures. The Delhi Police issued traffic advisories to guide commuters away from severely waterlogged areas, while the Delhi Disaster Management Authority (DDMA) circulated public safety guidelines on flood preparedness. Citizens were advised to stay indoors, secure their homes, and avoid unnecessary travel. Emergency services, including fire brigades and municipal workers, were deployed to clear waterlogged streets and assist stranded residents. Despite these efforts, the severity of the flooding highlighted the urgent need for improved urban drainage infrastructure and long-term flood mitigation planning in Delhi.

1.2.1.5 Gujarat Flood

In July and August 2024, Gujarat experienced two waves of severe flooding, causing significant damage across multiple districts. The first major incident occurred around July 22, when heavy rainfall ranging from 7 to 29 cm lashed 13 districts, including Surat, Bharuch, Valsad, and Jamnagar. A total of 55 houses were damaged, and 898 people had to be evacuated to safer areas. One of the most tragic incidents was the collapse of a three-story building in Devbhoomi Dwarka's Jam Khambhalia town, which resulted in three fatalities and required an extensive six-hour-long rescue operation. Several districts, including Porbandar and Surat, experienced severe waterlogging, disrupting daily life.

A second wave of flooding struck Gujarat in late August, further intensifying the crisis. A deep depression, which originated over Madhya Pradesh, moved into Gujarat, leading to torrential rainfall in 12 districts, with Navsari recording 356 mm of rain. The floods affected 143 villages, causing four deaths, nine missing persons, and injuries to eight others. Approximately 20,000 individuals had evacuated, and extensive damage was reported, including the destruction of 62 houses and the loss of 232 livestock. In response, the Gujarat government deployed 14 NDRF and 22 SDRF teams for rescue and relief operations. The Chief Minister convened a high-level meeting to oversee the situation and visited the State Emergency Operations Centre to coordinate efforts. Humanitarian organizations, played a crucial role by providing food, shelter, and rescue support. Despite the large-scale response, infrastructure damage, including the closure of 523 roads, posed significant challenges to relief operations.

1.2.1.6 Himachal Pradesh Cloudburst

Himachal Pradesh was severely impacted by two major cloudburst incidents in July and August 2024, leading to devastating flash floods, landslides, and infrastructure collapse. The first cloudburst struck Manali on July 25, causing



Figure 5 : Waterlogging in Delhi after rainfall |
Source: The Hindu_01/08/2024 (Media)



Figure 6 : flooded area after heavy rainfall in Vadodara |
Source: Hindustan Times_29/08/2024 (Media)

flash floods from Dhundi to Palchan and submerging parts of the Kullu-Manali National Highway. Three houses were washed away, and residents of Palchan village were forced to evacuate in the middle of the night. The rising Beas River flooded nearby areas, damaging roads and bridges, while landslides blocked key transport routes. The cloudburst also affected power projects and Mahila Mandal office buildings, displacing 13 individuals. Emergency response teams, including the Border Roads Organisation (BRO) and the district administration, worked to restore connectivity and provide relief to displaced families.

A second wave of extreme weather struck on August 1, triggering multiple cloudbursts across Shimla, Kullu, and Mandi districts. These incidents caused widespread destruction, killing 14 people and leaving 45 others missing. The disaster destroyed 95 houses, 14 bridges, and 10 shops, while landslides rendered 85 roads impassable, including two national highways. The worst-hit areas included Rampur in Shimla, where 33 people went missing, and Padhar in Mandi, where nine lives were lost. In Kullu, the Kurpan canal overflowed, destroying 61 houses and multiple cattle sheds. The government deployed NDRF, SDRF, ITBP, and Home Guard teams for rescue operations, supported by Red Cross, and other humanitarian agencies. Relief efforts focused on providing shelter, hygiene kits, and essential supplies, but the economic loss was estimated at ₹748 crore, highlighting the scale of devastation.

1.2.1.7 Karnataka flood

In August 2024, Karnataka experienced floods due to above-normal monsoon rainfall, resulting in widespread destruction across 13 districts. The northern interior region, which usually receives 260 mm of rainfall, saw an increase to 322 mm, while the state's overall rainfall exceeded its average of 553 mm, reaching 699 mm by August 12. The floods caused 58 deaths and significant agricultural losses, with 80,000 hectares of farmland submerged. Infrastructure suffered heavily, with 8,000 houses impacted—1,126 completely collapsed, 1,176 severely damaged, and 2,338 partially damaged. Additionally, livestock losses included 151 large cattle and 137 small cattle. The worst-affected areas included Belagavi, Gokak, Kagwad, and Chikkodi, where roads, bridges, and homes were severely damaged, leaving many residents displaced.

The Karnataka government responded with relief measures, including financial aid and rehabilitation efforts. The Chief Minister visited affected villages, inspecting damage and meeting with displaced families in relief centers. The government announced compensation of ₹1,20,000 and new houses for those whose homes were completely destroyed, with ₹9.21 crore disbursed for these efforts. Additionally, ₹1.40 crore was allocated to repair minor damages



Figure 7 : cloud burst at Shamej in Rampur, in Shimla /
Source: The Hindu_01/08/2024 (Media)



Figure 8 : Landslide affected area in Uttara Kannada /
Source: The India Express_25/12/2024 (Media)

and compensate for lost household items. Plans for the relocation of vulnerable villages were also discussed. Humanitarian organizations, conducted assessments across 12 districts and coordinated relief efforts through meetings on August 6 and 21.

1.2.1.8 Maharashtra Flood

In July 2024, Maharashtra experienced severe flooding due to continuous heavy rainfall, particularly affecting Pune, Kolhapur, Mumbai, Palghar, and Gadchiroli districts. Pune city and its surrounding areas were hit the hardest, with low-lying areas submerged and major bridges, such as Mundhwa and Holkar Bridge, underwater. The relentless downpours led to the release of 35,000 cusecs of water from Khadakvasla Dam, exacerbating the flooding. In Pune, four people lost their lives—three due to electrocution and one in a landslide in Maval tehsil. Over 500 families were displaced and relocated to temporary shelters. Kolhapur faced severe flooding as the Panchganga River rose to 41 feet, prompting road closures, while Mumbai witnessed waterlogging in several neighborhoods, disrupting transport and daily life.

In Gadchiroli, 12 houses collapsed due to continuous rain, and multiple villages in Dhanora block were affected.



Figure 9 : Sea waves crash against the stalls at Shivaji park chowpatty/
Source : The Hindu_25/07/2024 (Media)

Between May 15 and July 25, 2024, at least 94 people lost their lives across Maharashtra due to monsoon-related calamities, including lightning strikes, landslides, tree falls, floods, and structural collapses. Additionally, four people were reported missing, and 145 people sustained injuries. A total of 241 individuals were evacuated, while at least 306 animals perished, and eight animals were injured.

In response, Maharashtra government, along with disaster response teams, launched extensive relief efforts. The NDRF and fire brigade were deployed to assist residents in flooded areas, and local authorities issued warnings to people in riverside villages and landslide-prone regions. Schools in Pune and Mumbai were closed, and in Mumbai, the Disaster Management Authority coordinated with the Brihanmumbai Municipal Corporation (BMC) to manage urban flooding. Various NGOs worked alongside district authorities to provide relief materials, assist displaced families, and monitor the evolving situation. Emergency helplines were activated, and transportation advisories were issued to prevent further casualties.

1.2.1.9 Madhya Pradesh Flood

In 2024, Madhya Pradesh was the worst-hit state in India in terms of extreme weather events, experiencing 185 extreme weather days, the highest in the country. The state suffered significant losses due to floods, heatwaves, severe storms, and other hydro-meteorological disasters, with 353 reported fatalities. The floods caused widespread destruction, submerging villages, washing away roads, and damaging essential infrastructure. Over 7,278 houses were destroyed, leaving thousands homeless, while 25,170 hectares of agricultural land were severely impacted, leading to economic distress among farmers. Additionally, 61 livestock were lost, further affecting rural livelihoods. The central region, including Madhya Pradesh and Maharashtra, bore the brunt of these climate disasters, making them some of the most affected states in 2024.

In response, the Madhya Pradesh government, along with the National Disaster Response Force (NDRF) and State Disaster Response Force (SDRF), launched extensive relief efforts. Over 42,083 people were evacuated, and 37,050 individuals were rescued, including 53 who were airlifted from high-risk zones. The government provided financial assistance to 169,000 affected individuals, while 50,111 families received essential household supplies. Municipal authorities allocated emergency funds to restore roads and public infrastructure, ensuring connectivity in flood-hit areas. The agriculture department worked on compensation schemes for affected farmers, while disaster response teams cleared debris and restored power lines. Despite these efforts, the rising frequency of extreme weather events in Madhya Pradesh highlights the urgent need for enhanced early warning systems, improved drainage infrastructure, and long-term climate adaptation strategies.



Figure 10 : Flood affected Areas in Katni district |
Source: The India Express_25/07/2024 (Media)

1.2.1.10 Sikkim Landslide

In June 2024, Sikkim experienced devastating landslides triggered by excessive rainfall, leading to significant loss of life and destruction. The worst-affected region was Mangan district in North Sikkim, where heavy rains caused massive landslides, resulting in the deaths of nine people and injuring two others. The state received 250mm of rain in just 13 days, 54% above normal levels, leading to widespread flooding and infrastructure damage. Around 50 houses were destroyed in Mangan, and the overflowing Teesta River submerged Melli Stadium in South Sikkim, leaving several people homeless. A newly constructed bridge near Sangkalang, built after an earlier glacial lake outburst, was completely washed away, cutting off key locations such as Chungthang, Lachung, and Lachen. Additionally, National Highway 10, a vital link to West Bengal, was blocked by landslides, leaving North Sikkim isolated and stranding approximately 2,000 tourists. The disaster also led to power outages, with electricity poles swept away, and mobile network disruptions, making communication difficult.

In the aftermath of the disaster, the Sikkim government and humanitarian organizations launched relief and recovery efforts. A relief camp was set up at Pakshep for displaced families, and the district administration, led by Mangan District Magistrate, coordinated emergency response measures. Humanitarian groups provided medical support and monitored the evolving situation. However, connectivity issues hampered communication, making it difficult for responders to coordinate effectively.



Figure 11 : Landslide Area in Sikkim |
Source: CNN World_25/06/2024 (Media)

1.2.1.11 Tripura flood

In August 2024, Tripura faced one of its most devastating disaster, triggered by relentless monsoon rainfall that led to massive flooding and landslides across multiple districts. The worst impact was recorded between August 19 and August 28, 2024, when 31 people lost their lives, three were injured, and one person was reported missing. The disaster affected over 17 lakh people across all eight districts, forcing 1,49,087 individuals (38,971 families) into 822 relief camps. The flooding caused widespread infrastructure damage, including 2,588 landslides, which blocked major highways and rural roads. Over 1,618 homes were completely destroyed, while 1,796 homes were severely damaged, and 17,471 were partially affected. The power supply suffered extensive damage, with 1,603 electric poles, 501 transformers, and 642 km of conductors destroyed. The floods also devastated agriculture, submerging 1.60 lakh hectares of farmland, including 1.20 lakh hectares of paddy fields. The economic losses were staggering, with an estimated ₹15,000 crore in total damage.



Figure 12 : Areal view of flood affected area in Gomati | Source: ANI_27/08/2024 (Media)

The government and humanitarian organizations launched large-scale relief operations to manage the crisis. The state government, with support from the NDRF and SDRF, deployed 11 NDRF teams and multiple Quick Response Teams, evacuating over 1,831 people. The Madhya Pradesh and Uttar Pradesh governments contributed ₹30 crore for relief efforts, while the Chief Minister allocated ₹2 crore from the CM Relief Fund. Authorities established 822 relief camps, where affected families received food, drinking water, and medical aid. Despite these efforts, telecommunications were severely disrupted, with mobile networks failing in some areas, prompting the Department of Telecommunications to activate intra-circle roaming facilities. NGOs provided essential supplies like food, hygiene kits, and shelter materials.

1.2.1.12 Uttar Pradesh Flood

In July 2024, Uttar Pradesh faced flooding in two waves, leading to widespread devastation across multiple districts. The first wave, occurring around July 12, affected 16 districts, including Gonda, Balrampur, Kushinagar, and Lakhimpur Kheri. Over 1.8 million people were impacted, with 54 deaths reported, many due to lightning strikes and drowning. Nearly 250,000 residents were displaced, and agricultural losses were extensive, with 191,515 hectares of farmland submerged. Key rivers, including the Sharda, Ghaghra, and Rapti, flowed above danger levels, worsening the situation. By July 26, the flooding had expanded, impacting 26 districts and 1,809 villages. The total affected population exceeded 1.6 million,



Figure 13 : Floodwater submerged area, in Gorakhpur | Source: The India Express_20/07/2024 (Media)

and economic losses from crop damage alone amounted to ₹94,277 lakhs. Infrastructure damage was severe, with 2,138 houses destroyed, and erosion in Lakhimpur Kheri put several villages at risk.

In response, the Uttar Pradesh government, along with disaster response teams, launched extensive relief operations. The National and State Disaster Response Forces (NDRF & SDRF) evacuated nearly 11,000 people to safety. Over 108 relief camps were set up, and thousands of food packets, hygiene kits, and drinking water supplies were distributed. Humanitarian Organizations provided solar lamps and dignity kits, and supported affected communities with essential supplies. To prevent further erosion, authorities carried out flood prevention work in vulnerable areas. Additionally, 1,674 animal relief camps were set up, treating and vaccinating thousands of livestock. Despite ongoing efforts, continued rainfall warnings and damaged infrastructure posed challenges to long-term recovery.

1.2.1.13 Uttarakhand Flood

Uttarakhand faced two major flood disasters in July and August 2024, triggered by heavy rainfall, cloudbursts. The first wave of flooding in early July affected eight districts, including Almora, Bageshwar, Chamoli, and Uttarkashi, with rising river levels causing significant damage. Champawat and Udham Singh Nagar were particularly hard hit, with Banbasa, Tanakpur, and Sitarganj experiencing severe waterlogging. Landslides blocked 1,198 roads across the state, including three national highways, while power outages and disrupted water supply further worsened conditions. Eleven people lost their lives, and over 2,000 were displaced. In response, the government deployed NDRF, SDRF, and the Army for rescue operations, evacuating 981 stranded individuals and setting up relief camps for those affected.



Figure 14 : Road Blocked in Chamoli district |
Source: The Indian Express _ 11-08-2024 (Media)

A second and more severe flood event struck in early August due to cloudbursts and extreme rainfall, leading to flash floods and landslides. The worst-affected areas included Tehri Garhwal, Rudraprayag, and parts of Pithoragarh. Seventeen people lost their lives, and 25 were injured as houses collapsed, roads washed away, and bridges on the Kedarnath route were destroyed, forcing the suspension of the pilgrimage. Over 10,000 pilgrims were airlifted from stranded locations. The Uttarakhand government, with support from the Indian Air Force, launched large-scale rescue missions using helicopters and ground forces. Relief efforts included setting up emergency shelters, providing food and medical aid.

1.2.1.14 Wayanad Landslide

On July 30, 2024, a catastrophic landslide struck Mundakki, Chooralmala, in Vellarimala Village, Meppadi Panchayat, Wayanad District, Kerala. Triggered by incessant heavy rainfall, the landslide buried nearly 700 houses under debris, and damaged 1165 houses. The disaster resulted in massive casualties, with 231 bodies and 212 body parts recovered, while 630 individuals sustained injuries. Over 214 people were rescued alive, but approximately 128 remained missing. The landslide caused extensive infrastructure damage, displacing thousands of residents. Initially, 2,556 people took shelter in relief camps, but by August 24, all camps were successfully closed, with affected families relocated to rented homes, government quarters, or relatives' houses. The landslide

also devastated local roads, bridges, and power supply systems, compounding the region's suffering.

The response to the disaster was swift and multi-faceted, involving government agencies, humanitarian organizations, and local volunteers. Over 1,200 personnel from the NDRF, Army, Air Force, Navy, and state agencies carried out search and rescue operations, supported by drones, radars, sniffer dogs, and heavy machinery. Helicopters conducted multiple sorties, delivering relief materials and evacuating stranded residents. The Kerala government provided financial assistance, including ₹6,000 for rent and ₹300 per day to unemployed members of affected families. District IAG and NGOs, played a crucial role in relief coordination, ensuring efficient resource mobilization.

A Post-Disaster Needs Assessment (PDNA) was initiated to guide long-term recovery, emphasizing housing, livelihood restoration, and mental health support for survivors.

1.2.1.15 West Bengal Flood

In September 2024, West Bengal faced severe flooding due to a deep depression over Bangladesh and Gangetic West Bengal, which brought heavy rainfall and led to the discharge of excess water from Damodar Valley Corporation (DVC) reservoirs. The floods affected over 2.5 lakh residents across six districts, with Birbhum, Bankura, Howrah, Hooghly, North and South 24 Parganas, East and West Medinipur, and Paschim Bardhaman among the worst hit. Ghatal in West Medinipur and Udaynarayanpur in Howrah suffered the most damage, as rising river levels, including the breaching of the Dwarakeswar River, forced many residents to flee. The flooding also submerged key infrastructure, including Panskura railway station and the adjoining bus stand in East Medinipur, rendering them inaccessible. Crops were severely damaged, further worsening the economic impact on affected communities. The disaster resulted in three confirmed deaths and forced the evacuation of 25,000 people to safer locations.

The West Bengal government and disaster response agencies took immediate action to mitigate the crisis. Approximately 180 temporary shelters were set up to accommodate around 1 lakh displaced residents. The Chief Minister directed officials to commence road repairs as soon as floodwaters receded and instructed better management of water releases from DVC dams to prevent further flooding. The National Disaster Response Force (NDRF) deployed two teams across West Bengal, conducting rescue operations in West Medinipur, Howrah, Hooghly, and East Medinipur. They successfully rescued 33 people and evacuated 892 individuals, along with



Figure 15 : Landslide affected area in Chooralmala, Wayanad/
Source: Down to Earth _ 06-09-2024 (Media)



Figure 16 : Buildings submerged due to floods in West Bengal/
Source: Wire _ 26/09/2024 (Media)

saving 12 livestock. Junior doctors and healthcare workers set up free medical clinics, while NGOs provided dry food, shelter materials, and essential hygiene supplies.

1.2.2 Cyclones or Cyclonic Storms

In 2024, India faced multiple cyclones and cyclonic storms, bringing widespread destruction, loss of life, and economic hardship across several states. The most devastating storms included Cyclone Remal, Cyclone Dana, and Cyclone Fengal, which severely impacted West Bengal, Odisha, Tamil Nadu, Andhra Pradesh, Puducherry, and Kerala. These storms led to high casualties, large-scale evacuations, and massive infrastructure damage, with thousands of houses destroyed and millions affected. Cyclone Remal, which struck in May 2024, caused 75+ deaths, affected over 5 lakh people, and resulted in severe flooding and embankment breaches in West Bengal, Assam, and Mizoram. Cyclone Dana, making landfall in Odisha in October, forced the evacuation of 2.4 lakh people, damaging over 29,500 houses and submerging large tracts of farmland. Cyclone Fengal, the most severe in terms of financial damage, affected 1.5 crore people, destroying over 10,000 houses and causing ₹944.8 crore in losses in Tamil Nadu alone. Additionally, a severe hailstorm in Manipur in May damaged 28,423 houses across 16 districts, leaving thousands displaced and requiring emergency relief efforts.

These extreme weather events underscored India's growing vulnerability to cyclonic storms driven by climate change and warming ocean temperatures. The government, along with NDRF, SDRF, Indian Coast Guard, and local disaster management authorities, undertook large-scale evacuation and relief operations, saving thousands of lives. Despite these efforts, the repeated impact of cyclones in coastal states highlighted the urgent need for stronger embankments, improved cyclone-resistant housing, and enhanced early warning systems to minimize future losses. The increasing frequency and intensity of cyclones indicate that India must invest in climate-resilient infrastructure and adaptive strategies to protect vulnerable communities from the devastating effects of cyclonic storms in the years to come.

1.2.2.1 Hailstorm in Manipur

On May 5, 2024, a severe hailstorm accompanied by heavy rainfall struck Manipur, causing widespread destruction across 16 districts. The worst-hit areas included Imphal West, Imphal East, Bishnupur, Thoubal, Kakching, Tengnoupal, Kangpokpi, Noney, and Churachandpur. The storm damaged 28,423 houses, with 6,055 houses affected in Imphal West, 5,600 in Imphal East, and 1,179 in Bishnupur. The powerful winds and hailstones uprooted trees, shattered vehicle windshields, and blew away tin roofs, leaving many homes exposed to further damage. Imphal International Airport also suffered structural damage, and electricity supply was disrupted across multiple districts. Farmlands were severely impacted, with significant crop losses, worsening the economic burden on local farmers. In addition, existing relief

camps set up due to ethnic violence were also damaged, leaving vulnerable populations even more at risk. The disaster resulted in one fatality and three injuries, while debris blocked major roads, disrupting transportation.



Figure 17: Heavy rains accompanied by a hailstorm |
Source: The Hindu _ 06/05/2024 (Media)

In response, the Manipur government sanctioned ₹6.09 crore for immediate relief efforts, distributing ₹50 lakh to each of the five valley districts and ₹40 lakh to each of the eleven hill districts. 43 relief camps were established to shelter displaced families. Deputy commissioners were tasked with assessing damage reports, and residents were urged to submit photographs of damaged homes for repair assistance. NGOs provided financial aid, essential supplies, and shelter materials to affected households.

1.2.2.2 Cyclone Remal

Cyclone Remal, the first storm of the 2024 North Indian Ocean cyclone season, made landfall on May 26, 2024, between Sagar Island (West Bengal) and Khepupara (Bangladesh), bringing winds of 110-120 kmph and intense rainfall that caused widespread destruction across West Bengal, Mizoram, Assam, Manipur, Meghalaya, Nagaland, and Tripura. The cyclone resulted in at least 75 deaths, with dozens of people missing and over 5 lakh people affected. Mizoram was the worst hit, with 30 fatalities caused by landslides and a quarry collapse in Aizawl, while Assam reported 34 deaths and 2.5 lakh people affected across eight districts, including Nagaon, Cachar, and Hojai. In West Bengal, 2,500 houses were destroyed, and 27,000 were partially damaged, while flooding and embankment breaches in North & South 24 Parganas

caused severe disruptions. Manipur suffered five deaths and 16,364 damaged houses, with 1.88 lakh people affected due to flooding and landslides, while Meghalaya, Nagaland, and Tripura also reported casualties, infrastructure losses, and displacement. Heavy rainfall led to 292 landslides, submerging 8,143 hectares of crops and affecting 32,200 livestock, particularly in Assam. Transport networks were heavily disrupted, with blocked highways, damaged bridges, and halted railway services, while thousands of electric poles and transformers were knocked down, leading to widespread power outages.

The response to Cyclone Remal involved coordinated efforts by state governments, the Indian Army, Assam Rifles, and the NDRF, with over 1,400 relief camps set up across the affected states. West Bengal evacuated over 2 lakh people, while Mizoram relocated 30 families due to landslides. In Assam, 112 relief camps sheltered 22,373 people, and the government provided ex-gratia payments of ₹2 lakh to families of the deceased. Manipur authorities established 56 relief camps and deployed emergency teams to clear roads and restore power, while Nagaland and Meghalaya conducted search and rescue operations with the help of local volunteers. In Tripura, emergency teams restored power infrastructure, repairing 600 damaged electric poles and 82 transformers. The Prime Minister announced financial assistance for affected families, and humanitarian organizations distributed food, hygiene kits, and temporary shelter materials.

1.2.2.3 Cyclone Dana

Cyclone Dana made landfall between Dhamra and Bhitarkanika in Odisha on October 25, 2024, bringing winds of 100-120 kmph and torrential rainfall that caused severe flooding, infrastructure damage, and agricultural losses across Odisha and West Bengal. Odisha evacuated over 6 lakh people to 6,008 cyclone shelters, with Bhadrak, Kendrapara, Balasore, Mayurbhanj, and Jajpur among the worst-affected districts. Although there were no casualties in Odisha, tidal surges flooded several villages and farmlands. In West Bengal, one person died, and heavy flooding



Figure 18 : Flooded Street followed by Cyclone Remal in Imphal/
Source: Hindustan Times _ 24/12/2024 (Media)

was reported in Kolkata, where SSKM Hospital and the Kolkata Municipal Corporation headquarters were inundated. The coastal Sundarbans areas, including Namkhana, Sagar Island, and Patharpratima, suffered extensive damage, with tridents and electric poles destroyed. Significant crop losses were reported, particularly in paddy and potato fields. Transport was also disrupted, with flights halted at Kolkata Airport, trains canceled, and ferry services suspended.

The Odisha and West Bengal governments, along with humanitarian agencies, launched extensive relief efforts. 19 NDRF teams, 51 ODRAF teams, and fire service personnel were deployed in Odisha to assist with evacuations and clear debris. In West Bengal, over 2.4 lakh people were moved to shelters, and NGOs assisted with emergency relief.

The Indian Coast Guard mobilized 11 ships, 5 aircraft, and 14 disaster relief teams for search and rescue operations. The Odisha government focused on providing food, drinking water, and medical aid, while district administrations worked to restore roads and power infrastructure. In West Bengal, IAG members coordinated crop loss assessments and advocated for insurance and compensation for affected farmers.

1.2.2.4 Cyclone Fengal

Cyclone Fengal made landfall between Karaikal and Mahabalipuram near Puducherry on November 30, 2024, bringing winds of 100-120 kmph and torrential rainfall, which caused widespread destruction across Tamil Nadu, Andhra Pradesh, Puducherry, and Kerala. Tamil Nadu was the worst affected, with 14 districts and 1,501 villages impacted, affecting 1.5 crore people. The cyclone resulted in 30 deaths in Tamil Nadu due to floods, landslides, wall collapses, and electrocution. Mailam village in Villupuram received 510 mm of rainfall in 24 hours, leading to severe flooding. Over 6,486 houses were damaged, and 1.69 lakh livestock were lost. Infrastructure damage included 403 km of roads, 135 electricity poles, 2,351 fallen trees, 220 streetlights, and one bridge collapse. In Andhra Pradesh, five districts and 435 villages were impacted, with three deaths and 6,825 hectares of crops damaged. Puducherry reported four deaths, with 4,322 houses destroyed and 32,000 people evacuated to 208 relief camps. Kerala saw moderate impacts, with six districts affected, two houses destroyed, and 22 people displaced. The total agricultural loss across all states exceeded 30,000 hectares, and transport and electricity services were severely disrupted.

The response to Cyclone Fengal was swift, with 15 NDRF teams deployed across Tamil Nadu (9), Andhra Pradesh (4), and Puducherry (2). The Tamil Nadu government mobilized extensive resources, restoring



Figure 19 : NDRF personnel clear a tree that fell after cyclone Dana made landfall, in Anantpur village, Balasore district | Source: Reuters _ 25/10/2024 (Media)



Figure 20 : Roads submerged in floodwaters after cyclonic storm triggered heavy rainfall in Puducherry | Souce: Mint _ 01/12/2024 (media)

drinking water, roads, and electricity while compensating affected families. The Central Government approved ₹944.8 crore in disaster relief for Tamil Nadu. School Education Department began distributing replacement textbooks and uniforms for students in affected areas, starting with Cuddalore. In Andhra Pradesh, the government focused on repairing roads and electricity infrastructure, while Puducherry set up large-scale relief operations, accommodating 8,000 displaced individuals in relief camps. Fishermen received assistance for damaged boats and nets, and special compensation was announced for agricultural losses.

1.2.3 Geological and Climate-Induced Events (GLOF, Riverbank Erosion, Land subsidence etc)

In 2024, India faced severe land subsidence and riverbank erosion, causing widespread displacement and infrastructure damage. In Jammu and Kashmir's Ramban district, land subsidence destroyed 58 houses and a power station, displacing over 500 people and cutting off key road links. Meanwhile, in West Bengal's Murshidabad district, riverbank erosion along the Ganga River displaced 1,500 people and washed away 85 houses, including religious structures. These events highlight the growing impact of climate change and unregulated land use on fragile landscapes.

While state governments and disaster response teams provided emergency relief and compensation, long-term solutions such as stronger embankments, improved drainage, and stricter land-use policies are essential.

1.2.3.1 Land Subsidents in Jammu Kashmir

In April 2024, a land sinking incident occurred in Pernote village, Ramban district, Jammu & Kashmir, leading to the complete destruction of 58 houses and displacing over 500 people. The sinking land also caused the collapse of four electricity transmission towers, a power receiving station, and severe damage to a 3-kilometer stretch of road, cutting off connectivity between the Gool sub-division and Ramban headquarters. The land subsidence worsened due to continuous rainfall, further endangering remaining houses and agricultural lands. Hundreds of acres of farmland were impacted, raising concerns over livelihood losses. The Geological Survey of India launched an investigation into the root causes of the land subsidence, as the threat of further sinking remained active.



Figure 21 : Houses damaged in Ramban/
Source: Mint _ 26/04/2024 (Media)

The response to the crisis was immediate, with the Ramban district administration setting up a 24x7 control room under the supervision of the Block Development Officer to coordinate relief efforts. Affected families were relocated to a community hall in Maitra, where a health camp was established to address medical needs. A community kitchen was set up to provide hygienic meals, and the administration prioritized sanitation and hygiene maintenance at the relief site. A 30-member National Disaster Response Force (NDRF) team, alongside State Disaster Response Force (SDRF) personnel and local volunteers, assisted in evacuations and damage assessments. Meanwhile, authorities activated an alternate road to reconnect Gool sub-division to Ramban headquarters, ensuring the transportation of relief supplies. The State Disaster Response Fund (SDRF) was mobilized to facilitate the speedy release of compensation for affected families.

1.2.3.2 West Bengal River Erosion

In September and October 2024, riverbank erosion along the Ganga River in Murshidabad district, West Bengal, displaced over 1,500 people and caused widespread destruction across Samserganj and Lalgola blocks. This large scale erosion began on September 23, when three houses, a mosque, and part of a graveyard were washed away in Loharpur village, displacing 150 people. Over the following weeks, Pratapganj, Sikdarpur, and Uttar Chanda villages experienced rapid erosion, destroying 85 houses in total—60 in Samserganj and 25 in Lalgola. On October 6 and 7, the most severe erosion occurred in Uttar Chanda village, forcing 1,200 residents to evacuate after dismantling their homes. In total, 900 people were directly affected in one month, with the erosion also impacting public infrastructure, including roads

and embankments. Historical data showed that 500 houses were eroded in 2021-22, and 250 houses were lost in 2023, indicating a worsening trend. The Murshidabad District Disaster Management Plan had already identified 65,000 households as vulnerable to erosion, yet the crisis continues to escalate.

In response, the district administration and local government initiated relief efforts, providing tarpaulins, dry food, rice, lentils, and vegetables to displaced families. Temporary shelters were set up in government primary schools in Uttar Chachanda and New Shivpur to house affected individuals. The Irrigation Department began surveying embankment breaches to plan repair work, but only short-term solutions like sandbags and bamboo reinforcements were being used. The West Bengal government allocated ₹100 crore for erosion prevention, yet land scarcity remains a major challenge for relocating displaced families.



Figure 22 : Damaged House in Murshidabad |
Source: Frontline _ 18/08/2024 (media)

1.2.4 Other extreme weather events (heatwave, coldwave, lightning, lack of winter precipitation in northern states etc)

In 2024, India faced severe droughts, intense heatwaves, deadly lightning strikes, devastating forest fires, and abnormal winter conditions, highlighting the growing impact of climate change. The heatwave saw temperatures reach 49°C in Delhi, causing over 00 deaths, while droughts in Maharashtra and Karnataka damaged 48 lakh hectares of crops. Lightning became the deadliest weather hazard, killing 1,374 people, with Bihar, Odisha, and Madhya Pradesh worst affected. Uttarakhand recorded its worst forest fire season, with 21,033 fires destroying 1,747 hectares and causing 11 deaths. Additionally, weak winter precipitation in the Himalayas raised concerns over water shortages and agriculture. These events underscore the urgent need for better climate resilience, early warning systems, and sustainable policies to mitigate future risks.

1.2.4.1 Drought

In 2024, India experienced a severe drought crisis, with 26% of the country's land area affected, more than double the previous year's figure. 9% of the country faced extreme drought conditions, with Karnataka and Maharashtra being the worst-hit states. In Karnataka, 223 out of 236 taluks were declared drought-affected, leading to massive crop failures across 48 lakh hectares and an estimated economic loss of ₹35,162 crore. Water scarcity was critical, particularly in Bengaluru, where 6,900 out of 13,900 borewells had dried up, forcing reliance on deep borewells drilled up to 1,500 feet. In Maharashtra, 66% of the state was officially declared drought-affected, with 1,532 out

of 2,292 revenue circles facing severe water shortages due to below-average monsoon rainfall. Kerala also braced for drought, with early warnings issued, while Uttar Pradesh identified 100 tehsils across Sonbhadra, Mirzapur, and Bundelkhand as high-risk zones, prompting the installation of Telemetric Weather Stations (TWS) for real-time monitoring.

The government's response involved financial aid, relief measures, and policy interventions. In Karnataka, ₹2,000 was distributed to 33.44 lakh farmers, totaling ₹650 crore in direct aid, along with ₹450 crore for fodder and ₹870 crore for drinking water provisions. The state also sought ₹18,171.44 crore from the National Disaster Response Fund (NDRF). Maharashtra intensified its drought relief efforts, ensuring drinking water access and financial assistance for farmers. Kerala's Center for Water Resources Development and Management (CWRDM) advised farmers on drought-resilient agricultural practices, and Uttar Pradesh installed weather stations to improve early warning systems and climate adaptation strategies. Despite these efforts, the looming Super El Niño raised concerns over continued dry spells and erratic weather patterns, highlighting the urgent need for sustainable water management and long-term drought mitigation strategies.

1.2.4.2 Heat wave

India experienced an extreme and prolonged heatwave in 2024, with temperatures soaring above 45°C across multiple states, resulting in over 700 reported deaths and thousands of heat-related hospitalizations. The highest recorded temperature was 49°C in Delhi on May 29, causing severe water shortages affecting 75,000 homes. Rajasthan saw the most extreme impact, with 44 reported deaths and severe electricity and water shortages across 40 districts. Bihar reported over 89 confirmed deaths and over 300 hospitalizations, while Jharkhand recorded 40+ suspected deaths and 1,326 hospitalizations, particularly in Palamu and Garhwa districts, where temperatures exceeded 47°C. Odisha confirmed five heatstroke deaths, with 41 more suspected cases, and Jharsuguda recorded 47°C on May 30. Uttar Pradesh reported 400+ suspected heatwave deaths, while Tamil Nadu, Andhra Pradesh, and



Figure 23 : Farm labourers, with their faces covered for protection from heat, Karnal, Haryana
Source: Reuters _19/06/2024 (Media)

Telangana faced severe heat stress with temperatures above 43°C. Severe agricultural losses were reported, particularly in Tamil Nadu's Cauvery region, where banana farmers suffered heavy losses due to drought and heat.

The government response included widespread emergency measures to mitigate the crisis. The Union Health Ministry issued heatstroke guidelines, while state governments adjusted school hours, declared holidays, and set up cooling centers. The Delhi Municipal Corporation established temporary air-conditioned shelters, while Jharkhand, Bihar, and Uttar Pradesh governments coordinated with hospitals to allocate special heatstroke wards. In Rajasthan and Madhya Pradesh, water distribution points were set up, and dust storm warnings were issued to lower temperatures. The Odisha Special Relief Commissioner dispatched senior medical teams to assess the situation, and Maharashtra governments implemented early summer breaks for schools, and Tamil Nadu provided compensation for affected farmers.

1.2.4.3 Cold Wave

In 2024, India experienced unpredictable cold wave patterns, affecting public health, agriculture, and daily life across multiple states. While the India Meteorological Department (IMD) had predicted a warmer-than-usual winter, several regions still faced severe cold waves, particularly in northern and central India. Delhi, Punjab, Haryana, Rajasthan, and Uttar Pradesh recorded sharp temperature drops, with Faridkot (Punjab) reaching 1°C and Hisar (Haryana) dropping to 1.7°C in mid-December. In Maharashtra, unexpected cold conditions in November led to an unusual health crisis in Pune, Nashik, and Ahilyanagar, where infants suffered from hypothermia, a rare occurrence in the state. Hospitals reported multiple cases of newborns with dangerously low body temperatures, leading to severe health complications and fatalities. In Uttar Pradesh and Bihar, the extreme cold affected daily-wage laborers, the elderly, and homeless populations, with several deaths and numerous hospitalizations due to hypothermia and respiratory illnesses. The cold wave also paralyzed transport networks, with dense fog disrupting flights, train schedules, and road traffic across Delhi, Punjab, and Uttar Pradesh. The deviation from usual winter patterns also threatened agriculture, with wheat, rapeseed, and chickpea farmers in northern and central India fearing reduced yields due to fluctuating temperature response to the crisis, state governments and health authorities implemented emergency measures.



Figure 24 : People sit around a bonfire to warm themselves during a cold winter, in New Delhi |
Source: Financial Express _ 18/12/2024 (Media)

Hospitals in Maharashtra and northern states were put on high alert, ensuring adequate heating and medical support for infants, the elderly, and vulnerable groups. The National Disaster Management Authority (NDMA) issued public health advisories, urging people to wear warm clothing, avoid prolonged exposure, and seek immediate medical attention for cold-related illnesses. The IMD provided real-time cold wave alerts, allowing state administrations to prepare relief efforts in the worst-affected areas. In agriculture, the Ministry of Agriculture advised farmers to adjust sowing schedules and use protective irrigation techniques to counter the effects of fluctuating temperatures on crops. The Uttar Pradesh and Bihar governments mobilized temporary shelters, provided bonfires in public spaces, and distributed blankets to homeless individuals.

1.2.4.4 Lightning

Lightning emerged as India's deadliest weather phenomenon in 2024, causing 1,374 deaths out of the 3,200 fatalities attributed to extreme weather events. The frequency and intensity of lightning strikes surged by 53% over the past four years, with over 20 million strikes recorded in 2023-24 compared to 13.8 million in 2019-20. The most affected states included Bihar, Uttar Pradesh, Madhya Pradesh, Odisha, Karnataka, Andhra Pradesh, Telangana, and Maharashtra, where rural and agricultural communities bore the brunt of the disaster. In August 2024, Bihar reported 14 deaths in a single day, while Odisha recorded 15 fatalities in just two days in September, prompting the state government to announce ₹4 lakh compensation per victim. Karnataka, which ranked ninth in lightning-related mortality, reported 920 deaths between 2014 and 2024. The majority of casualties were farmers, construction workers, and outdoor laborers who lacked access to early warning systems. Apart from human fatalities, lightning caused widespread infrastructure damage, disrupting power lines, communication networks, and damaging homes, particularly in rural areas.

Recognizing the increasing frequency of lightning strikes, experts and policymakers have called for its classification as a national disaster, which would enable dedicated funds and policy interventions. The Climate Resilient Observing Promotion Council (CROPC), India Meteorological Department (IMD), and Ministry of Earth Sciences have emphasized the need for enhanced early warning systems, such as the Damini app, to issue real-time alerts. The Lightning Resilient India Campaign proposed strengthening detection infrastructure, developing a cadre of lightning experts, and implementing season-based resilience strategies. Scientists noted that for every 1°C rise in temperature, lightning density increases by 12%, making climate change a major factor behind the escalating crisis. To mitigate future risks, building codes must incorporate advanced lightning protection systems, and awareness campaigns should educate communities on safety measures during thunderstorms.



Figure 25 : Representational Image of Lightning

1.2.4.5 Lack of Winter Precipitation in Northern states

In 2024, India experienced significant climatic anomalies that profoundly affected various sectors, particularly in Jammu and Kashmir. The region recorded its driest year in five decades, with a 29% deficit in annual rainfall, receiving only 870.9 mm against the average 1,232.3 mm. This marked the fifth consecutive year of below-normal precipitation, severely impacting water resources, agriculture, and daily life. The prolonged dry spell led to diminished river flows, depleted reservoirs, and stressed groundwater levels, raising concerns about water scarcity. Agricultural activities, heavily reliant on consistent rainfall, faced challenges, threatening crop yields and food security. The water shortage also affected hydropower generation, leading to potential energy deficits. The Gulmarg ski resort, a renowned tourist destination, experienced insufficient snowfall, leading to the postponement of national winter games scheduled for February 22-25, 2025. Approximately 300 athletes were set to compete in four snow sports, but the lack of snow on key ski slopes necessitated the delay. The Himalayan region of Kashmir grappled with a water crisis exacerbated by extreme dry weather and climate change. For the first time in living memory, an ancient spring in southern Kashmir dried up, highlighting the region's vulnerability. Several rivers and springs, including those feeding into the Jhelum River, experienced reduced water flow, leading to concerns about the long-term sustainability of water resources.



Figure 26 : Gulmarg's resorts slopes, which are usually covered in snow at this time of the year, carry a green look|
Source : Hindustan Times _ 23/01/2024 (Media)

The India Meteorological Department (IMD) predicted above-average maximum temperatures for February 2025,

following a warmer January. This trend posed risks to winter crops such as wheat, rapeseed, and chickpeas, which require cooler weather for optimal growth. Below-normal rainfall was also anticipated, potentially leading to lower wheat production, price increases, and depletion of state reserves. Reduced rapeseed output could necessitate increased imports of cooking oils, impacting India's imports of palm oil, soyoil, and sunflower oil from countries including Indonesia, Malaysia, Thailand, Argentina, Brazil, Russia, and Ukraine. These climatic irregularities underscored the urgency for adaptive strategies in water management, agricultural practices, and disaster preparedness to mitigate the adverse effects of climate change.

1.2.4.6 Uttarakhand Forest Fire

Uttarakhand experienced an unprecedented surge in forest fires in 2024, with 21,033 fire incidents detected, a fourfold increase from the previous year. The fires ravaged 1,747 hectares of forest land, making Uttarakhand the worst-affected state in India. The Garhwal region lost 719 hectares, Kumaon 886 hectares, and 142 hectares were damaged in protected wildlife areas. The fires caused 11 fatalities and injured nine people, including four forest personnel, making them the deadliest since 2021. The worst-affected districts included Nainital, Almora, Tehri Garhwal, and Uttarkashi, where each district recorded over 3,000 incidents. Satellite data confirmed a massive increase in fire alerts, with nearly 20,000 forest fire alerts issued in Uttarakhand, compared to 4,862 the previous year. The fires not only destroyed vast forest areas but also severely impacted air quality, wildlife habitats, and local livelihoods. Thick smoke reduced visibility, disrupted transportation, and led to severe respiratory issues among residents. In neighboring Himachal Pradesh, over 10,136 fire counts were detected, an alarming rise from 704 the previous year, with Shimla among the worst-hit districts.



Figure 27 : Forest Fire in Uttarakhand |
Source: Hindustan Times_ 20/06/2024 (Media)

The response to the forest fires was severely inadequate, as authorities were unprepared for the intensity and scale of the crisis. The lack of preventive measures, such as clearing dry pine needles and creating firebreaks, worsened the situation. Forest personnel, lacking firefighting equipment, were seen using tree branches to control fires, raising concerns about safety. In extreme cases, the Indian Air Force and Army helicopters were deployed to prevent fires from spreading to residential areas. The state declared a fire emergency, mobilizing forest officials, disaster response teams, and local volunteers to contain the flames. However, environmentalists criticized the lack of community training and poor coordination, which delayed containment efforts. Experts stressed the need for enhanced early warning systems, improved firefighting infrastructure, and community-based fire prevention strategies.

1.3 Matrix of Impact (Quantitative)

Disaster	Affected Districts	Affected Population	Displaced Population	Casualties	Injured	Missing	Crops Damaged (Ha.)	Livestock Affected	Houses Damaged
Sikkim Landslides	1	-	-	9	2	-	-	-	50
Uttar Pradesh Flood	26	1.8 million	250,000	54	-	-	191,515	-	2,138
Gujarat Flood	12	-	20,898	7	8	9	-	232	117
Andhra Pradesh Flood	9	644,000	-	45	-	-	218,538	-	-
Maharashtra Flood	5	-	500 families	4	-	-	-	-	12
Himachal Pradesh Cloudburst	4	-	13 people displaced	14	25	-	-	-	98
Uttarakhand Flood	6	-	10,000	28	25	-	-	-	-
Wayanad Landslide	1	-	2,556 (initially)	254	630	128	-	-	1165
Delhi Flood	1	-	-	7	-	-	-	-	1
Karnataka Flood	4	-	-	58	-	-	80,000	-	8,000 (1,126 collapsed)
Bihar Flood	16	1.2 million	47,000	52	-	-	-	-	-
West Bengal Flood	6	2.5 lakh	25,000	3	-	-	-	-	-
Assam Flood	27	3.3 million	3.45 lakh	113	-	-	68,768	1.5 million	24,501 (3,306 collapsed)
Tripura Flood	8	17 lakh	1,49,087	31	3	-	1.60 lakh	38 livestock	20,885 (1,618 fully collapsed)
Cyclone Remal	7	5 lakh+	Over 5 lakh	75+	Thousands	-	8,143	32,200+	46,000+
Cyclone Dana	2	-	2.4 lakh	1	-	-	-	-	2,500 destroyed, 27,000 damaged
Cyclone Fengal	4	1.5 crore	8,000 in Puducherry	37	Thousands	-	30,000+	1.69 lakh	6,486 in TN, 4,322 in Puducherry
J&K Land Sinking	1	500+ displaced	500+ relocated	-	-	-	-	-	58
Heatwave in India	Multiple states	-	-	600+	Thousands	-	-	-	-
Lightning Strikes	Multiple states	-	-	1,374 deaths	-	-	-	-	-
Forest Fires in Uttarakhand	5	-	-	11 deaths	9	-	-	-	-



Annual lessons learn workshop

Changing

chapter

2

Landscape of Risk

The risk landscape in India is rapidly evolving due to a complex interplay of climate change, unplanned urbanization, environmental degradation, and socio-economic vulnerabilities. The disasters of 2023-2024—ranging from devastating landslides in Wayanad to unprecedented floods in Assam and Tripura, land subsidence in Joshimath, and intensifying lightning strikes, and heat wave—underscore the shifting nature of hazards. New and emerging risks, including extreme weather patterns, glacial lake outburst floods (GLOFs), and riverbank erosion, are challenging traditional disaster management approaches. The increasing role of humanitarian agencies, corporate social responsibility (CSR) initiatives, and government interventions at national, state, and district levels highlights the growing recognition of multi-stakeholder collaboration in disaster resilience. This chapter explores the factors contributing to heightened disaster risks, examines emerging trends, and emphasizes the need for adaptive strategies to build resilience against the uncertainties of a changing world.

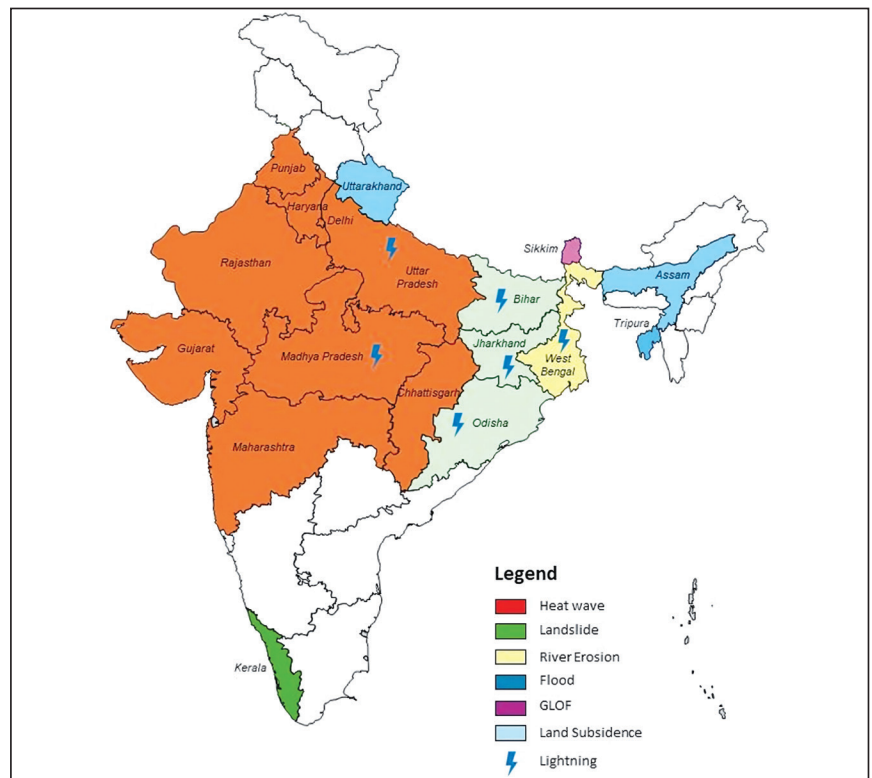


Figure 28: Changing Disaster Risk: 2023-24

2.1 Wayanad Landslide

In the early hours of July 30, 2024, the serene landscapes of Wayanad, known for their rolling hills and tranquil greenery, were shattered by a devastating landslide in Vellarimala village. Triggered by days of relentless rainfall, the disaster unfolded with alarming ferocity, leaving behind a grim trail of destruction. As rescue teams scrambled to respond, a new category of emergencies emerged – ones deeply rooted in climate change and human activity, presenting unique challenges that defy traditional disaster preparedness paradigms.

The landslides, caused by a combination of geological vulnerability and prolonged monsoon downpours, swept through homes, roads, and farmlands, claiming over 231 lives and leaving 119 missing. The sudden collapse of land resulted in the recovery of 212 body parts, underscoring the sheer violence of the event. More than 3,000 individuals sought refuge in emergency camps due to this landslide, where local authorities and NGOs coordinated efforts to provide shelter and safety.

This catastrophic event was not merely a result of nature's wrath. The underlying causes reveal a tapestry of human-induced vulnerabilities and climatic shifts that set the stage for this unparalleled emergency.

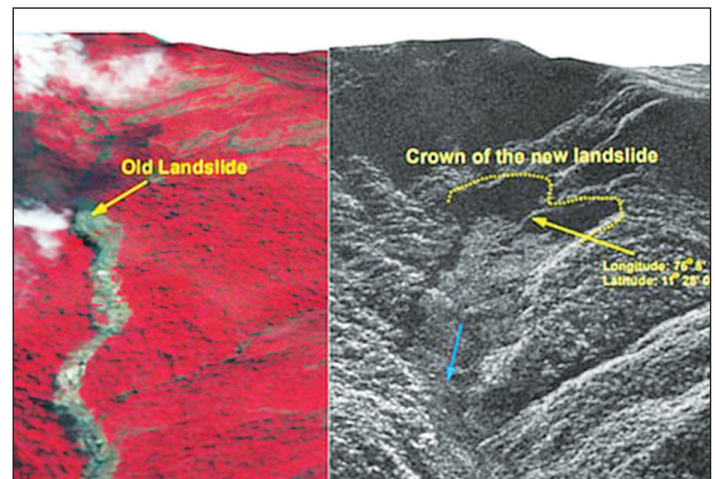


Figure 29 : Wayanad Landslide: Before and After |
Source: NRSC

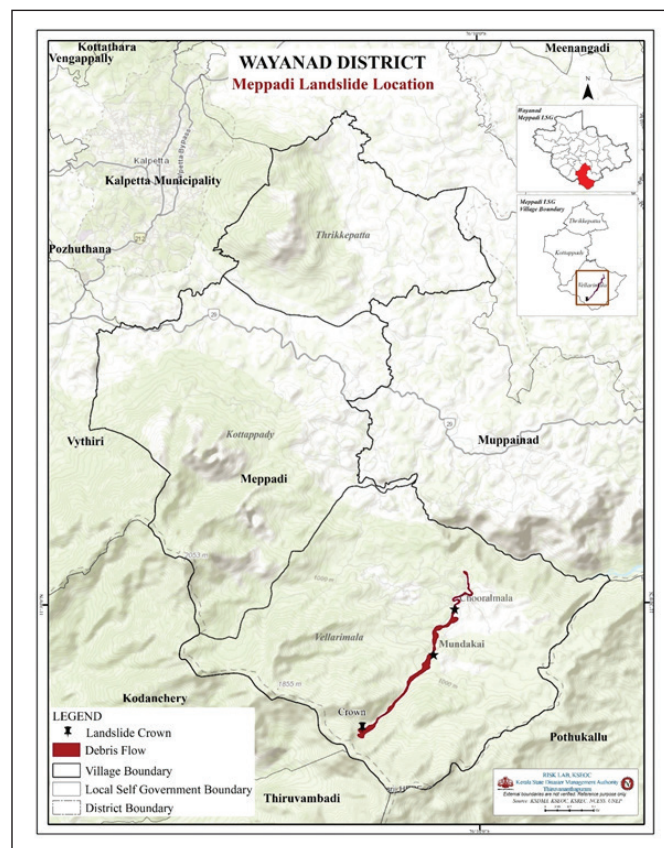


Figure 30 : landslide location map |
Source: KSDMA

A Crisis Unlike Others

The Wayanad landslide differs from conventional disasters in its multi-dimensional impact and the layers of unanticipated challenges it brought to the forefront. The hilly terrain made rescue operations exceptionally arduous especially in remote areas. Roads were obliterated, cutting off access to affected areas and delaying the deployment of aid. Not all areas impacted by the landslide were initially considered vulnerable. While the top Mundakkai area was under landslide threat, Chooralmala was not. Unprecedented debris flow caused debris from the incident to travel an extraordinary 08 kilometers from the epicenter, reaching populated areas in Chooralmala and significantly increasing the disaster's intensity. Unlike floods or earthquakes that affect broader areas in uniform ways, landslides create isolated pockets of devastation, complicating coordination and resource allocation and fragmenting the disaster impact. Moreover, the recovery of fragmented human remains left deep psychological scars on survivors and responders alike, necessitating robust psychosocial support.

While Kerala has a history of landslides, the magnitude and frequency of recent incidents have taken even experts by surprise. There were numerous factors contributing to the lack of anticipation. This includes impacts exacerbated by climate change. Particularly, the Western Ghats, a UNESCO World Heritage Site, have witnessed an increase in extreme rainfall events, attributed to global warming¹ over the past few years. However, predictive models failed to fully capture the scale of this year's rainfall. Reliance on historical weather patterns led to underestimation of the disaster's potential. The rains were dismissed as part of the seasonal monsoon, overlooking early warnings of irregular intensity.

Moreover, intensive land use patterns including unregulated construction, deforestation, and urbanisation have destabilized the fragile ecosystems of western Ghats, exacerbating the risk of landslides².

The consequences of the landslide extend beyond immediate loss of life and property. Farmers lost livelihoods as plantations and working fields were buried under mud, compounding the challenges of a region already grappling with agrarian distress. The prolonged rehabilitation process due to the disaster impact has placed additional financial strain on the affected population. While the state government is currently providing rental support and financial assistance to the victims, and plans are underway to develop a permanent township for the affected community in Kalpetta and Vaduvanchal, the delay in achieving permanent rehabilitation has shifted the burden of rent onto the affected families. Despite government commitments, assessments reveal a gap in financial support, leaving the community struggling to arrange cash for their immediate needs. Additionally, Wayanad being a popular tourist destination, experienced a drop in visitors following the disaster, further straining the local economy. The tragedy caused psychological trauma among survivors, especially children and vulnerable groups.

Lessons

The Wayanad Landslides underscores the need for a paradigm shift in disaster management and planning. Localized risk assessments enabled through tools like micro-level mapping of landslide-prone areas must be integrated into local governance to anticipate and mitigate such disasters. Sustainable development practices such as regulating construction and quarrying in ecologically sensitive areas is critical to prevent further destabilization of the landscape. Building community resilience by equipping local communities with disaster preparedness training and resources can enhance immediate response capabilities. Climate adaptive strategies incorporating climate projections into disaster planning is no longer optional. Investments in predictive models must align with observed changes to build robust anticipatory systems.

¹ Down To Earth - Without global warming, rainfall would have been 11% less intense, finds attribution study

² A Study On Landslide Events In The Western Ghats

The Road Ahead

The Wayanad landslide is a poignant reminder of the evolving nature of emergencies in a changing world. As climate change intensifies and human pressures mount, such disasters will become more frequent and unpredictable. By learning from these tragedies and embracing adaptive strategies, we can hope to build resilience against the emergencies of tomorrow.

In the end, the story of Wayanad is not just one of loss but also of the resilience of its people and the collaborative efforts of organizations that stepped forward in the face of adversity. It is a call to action for all stakeholders to acknowledge and address the complex interplay of climate, ecology, and human activity in shaping the future of disaster management.

2.2 Tripura Flood

The incessant rains began on August 18, 2024, cascading over the verdant hills and low-lying plains of Tripura. For days, the downpour showed no signs of relenting, transforming tranquil rivers into raging torrents and triggering landslides that buried pathways and severed communities from the outside world. By August 20, the full fury of nature was unleashed, leaving vast swathes of the state submerged, and countless lives turned upside down.

Unlike other floods that stem from predictable monsoon patterns, this disaster bore the unmistakable imprint of intensifying climate change. Experts pointed out the erratic intensity of rainfall as a classic hallmark—overwhelming Tripura’s aging infrastructure and unprepared communities³. Over 1.6 lakh hectares of fertile farmland vanished underwater, while landslides at over 2,500 locations blocked critical roads, complicating the already Herculean task of relief operations. The scale was devastating: 32 lives lost, over 38,000 families displaced, and damages exceeding ₹15,000 crore.⁴

The interplay of natural and human factors made this disaster particularly cruel. The sudden bursts of rainfall overwhelmed traditional weather prediction models, while unplanned urbanization and inadequate drainage systems amplified the destruction. Communities nestled in vulnerable areas bore the brunt, with temporary homes reduced to rubble and agricultural livelihoods decimated.

The impact was nothing short of a humanitarian crisis. Nearly 1.5 lakh people sought refuge in relief camps—spaces that were overcrowded and often unequipped to meet even the most basic needs. Food supplies dwindled, with many households unable to cook due to a lack of utensils or functional stoves. Water sources were contaminated, exposing thousands to the risk of waterborne diseases. Schools turned into shelters, halting education for children already grappling with the trauma of displacement.

The scars of the disaster extended beyond the physical. The women and children in relief camps faced heightened vulnerabilities, with concerns over safety and dignity compounding their struggles. Farmers, who had tilled the fertile lands of Tripura for generations, now stood on barren plots, their livelihoods washed away.



Figure 31 : Flood inundated Area |
Source: Media_27-08-2024

³ Tripura's floods 'classic example' of climate change intensifying extreme weather events

⁴ JRNA_Tripura Flood

Yet, amidst the wreckage, stories of resilience emerged. Local NGOs, aided by state and national agencies, rallied to coordinate relief efforts. Relief camps were set up, food and medical aid distributed, and efforts to restore connectivity began. The damage, however, underscored a stark reality: building back better required more than temporary fixes. Tripura needed resilient infrastructure and a robust response to future climate threats.

As the floodwaters receded, they left behind a powerful lesson—a reminder of the urgency to address climate change and invest in disaster preparedness. The tragedy of Tripura's floods was not just in its impact but in its preventability, calling for a collective resolve to safeguard vulnerable communities against the uncertainties of an altered climate.

2.3 Joshimath Land Subsidence

Nestled in the majestic Garhwal Himalayas, the town of Joshimath stood as a gateway to sacred shrines, pristine trekking trails, and breathtaking landscapes. Pilgrims and adventurers alike passed through its winding roads, oblivious to the silent warning signs beneath their feet. For decades, the land whispered its distress—cracks in the earth, shifting walls, and roads that buckled ever so slightly. But the people, eager to build, expand, and modernize, ignored the murmurs. Until, one day, the ground began to give way.

It wasn't sudden, like an earthquake or a flood. It was slow, insidious—an unfolding tragedy that had been decades in the making. The first official alarm had been sounded way back in 1976, when the Mishra Committee Report warned that Joshimath was built on an ancient landslide deposit, a foundation of loose boulders and soft sediment⁵. The report urged caution, recommending that large-scale construction be avoided in the area. But as time passed, the warnings faded into the background. The town continued to grow, multi-story hotels and homes rose, roads widened, and tunnels were carved into the fragile mountains. The people celebrated progress, unaware that with every new structure, they were pushing Joshimath closer to the brink.

Then, in January 2023, the inevitable happened. It started with small cracks in walls—at first barely noticeable, but soon deepening, widening, spreading across homes, roads, and temples. Residents awoke to find their floors tilting beneath them, their ceilings splitting apart. Panic spread as news broke: Joshimath was sinking. Scientists rushed in, their findings grim—by January 11, significant portions of the town were subsiding continuously, and within weeks, over 863 houses bore deep fractures, with 181 declared unsafe⁶. Cracks began to appear on roads, homes, and temples, unsettling the lives of its 20,000 residents⁷. Studies reveal that over 50% of the town is categorized as a high-risk area⁸.



Figure 32 : Joshimath Land Sinking Areas/
Source: Media_13-01-2023

⁵ Mishra Committee report

⁶ Sinking and sleeping of Himalayan city - Joshimath

⁷ PDNA_ Joshimath Sinking

⁸ Over 50% of Joshimath High-Risk Area, Finds IIT-Roorkee

The Anatomy of a Disaster

Joshimath's woes are a tragic interplay of natural and anthropogenic factors. Built on an ancient landslide deposit, the town's foundation is inherently unstable. Layers of loose debris from past landslides form the very ground that supports its infrastructure, rendering it precarious under modern developmental pressures.

The Himalayan region's tectonic activity exacerbates the problem. Frequent seismic tremors destabilize the fragile terrain. But nature alone cannot bear the brunt of blame. Rapid urbanization and unregulated construction have significantly contributed to the crisis. From road-widening projects to hydropower tunneling and blasting activities, human interventions have deepened the fissures in Joshimath's fragile ecosystem⁹.

Why Joshimath Stands Out

Unlike sudden-onset disasters like earthquakes or floods, Joshimath's sinking is a slow-motion calamity. This gradual deterioration makes it uniquely challenging. Unlike the abrupt shock of a landslide or avalanche, the prolonged sinking leaves room for prolonged human suffering and delayed action.

Moreover, the incident isn't confined to Joshimath alone. It holds a mirror to similar vulnerabilities across the Himalayan belt. As a crucial transit point to the revered Badrinath and Hemkund Sahib pilgrimages and the ski slopes of Auli, the sinking of Joshimath has broader implications for tourism, faith, and livelihoods.

Unanticipated, But Avoidable

The sinking of Joshimath could have been mitigated through proactive planning and adherence to geological assessments. Reports from the Geological Survey of India (GSI) has highlighted the risks associated with unregulated development in ecologically sensitive zones. Implementing recommendations from these studies, including controlled construction, improved drainage systems, and sustainable land-use planning, might have helped reduce the extent of land subsidence in the area..¹⁰

A comprehensive report by IIT Roorkee underscores how poor drainage systems aggravated the subsidence. Water seepage, a result of improper urban planning, has compounded the instability of the already fragile terrain.¹¹ Additionally, the absence of robust policies to regulate construction and mitigate environmental impacts has rendered the region increasingly vulnerable.

The Impact on Lives and Landscapes

For the people of Joshimath, this is not just a geological tragedy; it's a humanitarian crisis. Over 800 families have been displaced, forced to abandon their homes and memories. Tourism, a lifeline for the local economy, has taken a significant hit as visitors steer clear of the endangered town. Social structures are crumbling as communities grapple with fear and uncertainty.¹²

Environmentally, the sinking of Joshimath threatens to trigger a domino effect. The Alaknanda River, flowing perilously close to the town, is at risk of being blocked by landslides, potentially causing flash floods downstream. The fragile ecosystems surrounding Joshimath could face irreversible damage, disrupting flora and fauna that have thrived for millennia.

⁹ Analyzing Joshimath's Sinking: Causes, Consequences, and Future Prospects with Remote Sensing Techniques

¹⁰ GSI Report

¹¹ IITR Report

¹² Joshimath: What's the Future of India's Sinking Himalayan Town

Lessons to Learn

Joshimath is more than a cautionary tale; it's a clarion call. The incident highlights the critical need for scientific urban planning and stringent environmental policies. It underscores the urgency of investing in disaster risk reduction measures and community awareness programs.

This tragedy reminds us of the delicate balance between development and nature. As Joshimath continues to sink, the time to act is now—not just for the beleaguered town but for all regions teetering on the brink of similar disasters. Joshimath's story must inspire a paradigm shift towards sustainable development, proving that foresight and preparation can prevent future tragedies from being etched into the landscape of our collective memory.

2.4 River bank Erosion - West Bengal

River bank erosion, is the wearing away of bank materials of a river. This is a common and unavoidable phenomenon of rivers, and it is characterized as a dynamic natural process that involves the removal of riverbank materials.¹³

A Silent Disaster Unfolds

In the heart of West Bengal, nestled along the serpentine course of the Ganga and Padma rivers, lies the district of Murshidabad. Known for its historical significance, the region has recently been thrust into the limelight for a different reason: the devastating phenomenon of riverbank erosion. Unlike sudden calamities like cyclones or earthquakes, this disaster creeps silently, consuming fertile lands, homes, and livelihoods year after year. In the last few years, this erosion has intensified, particularly in blocks like Bhagawangola-II, Samserganj, and Lalgola, turning lives upside down.



Figure 33 : Eroded banks of the Ganga at Shibpur village in Murshidabad |
Source: Media

The erosion of riverbanks is not new to Murshidabad. It's a natural process where the mighty river carves new paths, eroding its banks in the process. However, the situation in Murshidabad has escalated dramatically in recent years. Between September and October 2024, villages like Loharpur, Pratapganj, and Sikdarpur witnessed their lands crumbling into the river—entire homes, mosques, and graveyards were swept away. Over 1,500 people became homeless in just two weeks. The erosion isn't limited to a single event; it's a persistent reality, with areas like Akheriganj, Tiklichar, and Char Krishnapur completely engulfed over decades.

The Unseen Causes

Several factors contribute to this disaster. The construction of the Farakka Barrage upstream has altered sediment deposition patterns, aggravating the erosion downstream. Additionally, the natural sediment load of the Ganga, combined with human activities like sand mining and unregulated embankments, has worsened the situation. The river's dynamic nature—shifting its course and eating away at its banks—is further influenced by climatic changes, including heavier monsoons and erratic rainfall.

¹³ river bank erosion and human displacement – a case study of three decades of bhagawangola-ii block of murshidabad district, west bengal

Why Was This Not Anticipated?

Erosion in a riverine delta is a well-documented phenomenon, yet its impacts can still pose significant challenges for authorities and communities. Historically, erosion has often been regarded as a natural process rather than a hazard requiring targeted intervention. This perspective has influenced the pace of proactive measures and long-term planning. In regions like Murshidabad, where population density is high, relocation and rehabilitation efforts require careful coordination and resource planning.

The Human Cost

Riverbank erosion has significant social and economic consequences. Families often need to relocate, sometimes moving to temporary shelters such as government schools or relief camps. The loss of fertile agricultural land can disrupt livelihoods, leading to financial hardship and prompting some to seek alternative means of income, including migratory labor. In border areas, limited employment opportunities may contribute to engagement in informal or high-risk economic activities. Those displaced by erosion often face challenges in integrating into new communities, highlighting the need for long-term support and sustainable rehabilitation efforts.

A Disaster Unlike Others

What makes riverbank erosion different from other disasters is its slow, relentless nature. Unlike a cyclone that strikes and leaves, erosion is an ongoing process that offers no respite. Its victims are not counted in immediate casualties but in the gradual erosion of their dignity, stability, and future. Moreover, the invisible boundaries of this disaster—where it affects human lives but often escapes the categorization of “natural disaster”—mean that it seldom garners the same urgency in response efforts.

Efforts to Combat the Tide

While local and state governments have taken measures like distributing tarpaulins, food, and essentials, and fortifying banks with sandbags and bamboo structures, these are stopgap solutions. The establishment of a joint committee to devise an integrated erosion management plan is a step forward, but challenges like land scarcity and population pressure persist.

A Call to Action

The story of riverbank erosion in Murshidabad is a cautionary tale of the underestimated power of nature and the resilience of those who live at its mercy. Comprehensive policies, sustainable river management practices, and community involvement are the need of the hour. The river will not stop its course, but with foresight and unity, its wrath can be mitigated. The sands of time may shift, but the spirit of the people of Murshidabad remains steadfast.

2.5 Assam Flood

The year 2024 was marked by an unprecedented escalation in flood events across India, amplifying the vulnerability of states prone to natural disasters. Almost 85% of India’s highest flood-risk districts were concentrated in six states and one union territory, as highlighted by recent climate risk assessments¹⁴. The intensity, frequency, and unpredictability of these floods underscored the severe impacts of climate change. Among the states, Assam bore the brunt of these catastrophes, with the floods in 2024 standing out for their scale and devastation.

In 2024, Assam experienced one of the most severe and prolonged floods in its history. Nearly 14 lakh people across multiple districts were affected, with massive displacement and destruction of infrastructure¹⁵. The

¹⁴ District-Level Climate Risk Assessment for India

¹⁵ The Hindu_12-7-2024

flood's timing, intensity, and patterns made it a “changing disaster,” challenging conventional disaster response mechanisms. Unlike previous years, the floodwaters persisted longer, inundating areas that had rarely witnessed flooding before.

How It Happened

The 2024 Assam floods were driven by a combination of climatic, hydrological, and anthropogenic factors, leading to widespread devastation across multiple districts.

One of the primary contributors was the changing rainfall patterns during the monsoon season. Several districts recorded unprecedented rainfall intensity, with some experiencing their highest-ever precipitation levels in decades. Sudden cloudbursts and concentrated heavy rainfall overwhelmed river systems and reservoirs, leaving little time for water to be effectively managed.

Another significant factor was the accelerated melting of Himalayan glaciers. Rising temperatures led to increased glacial melt, which, in turn, contributed to higher river discharge in the Brahmaputra and its tributaries. This additional water flow further intensified flooding in the region



Figure 34 : Flood affected people in Darrang District |
Source: Media_11-07-2024

Human-induced land-use changes also played a critical role in worsening the disaster. Rapid urbanization, deforestation, and unregulated construction in floodplains disrupted natural drainage systems. Additionally, the encroachment of wetlands and water bodies reduced the land's capacity to absorb excess water, making the region more vulnerable to flooding.¹⁷

Despite the presence of flood control measures, many embankments and levees failed to contain the rising waters. Several were breached, leading to severe inundation of adjacent areas and exacerbating the crisis. Furthermore, global climate anomalies contributed to the intensity of the floods. The El Niño effect, combined with localized climatic variations, altered precipitation patterns and led to extreme weather conditions. Climate models have indicated a rising trend in such extreme events, with the Assam floods serving as a stark reminder of this broader phenomenon.¹⁸

These interconnected factors underscore the need for a more integrated approach to flood management, incorporating climate resilience, sustainable land use, and robust infrastructure planning to mitigate future disasters.

The Floods That Changed Assam

For generations, the people of Assam had learned to live with the floods. Every monsoon, the mighty Brahmaputra and its tributaries swelled, spilling over their banks and leaving behind both destruction and renewal. But in 2024, something was different.

¹⁶ Down to Earth_-04-07-2024

¹⁷ JRNA_IAG Assam

¹⁸ News 18-14-12-2024

The rains came as expected in June, but instead of easing by September, they persisted. October arrived, and yet the skies remained heavy with dark clouds. In villages along the riverbanks, families who had already rebuilt their homes after the initial floods found themselves tearing them down again, seeking higher ground for the second or even third time. Relief workers who thought they had seen the worst were caught off guard as new waves of flooding submerged entire districts.

What made this flood so devastating wasn't just the timing—it was where the water went. Areas that had never faced serious flooding before, including parts of bustling urban centers, were suddenly under water. In Guwahati, roads turned into rivers, and cars lay abandoned in waist-deep water. Schools and hospitals struggled to stay operational, their hallways crowded with stranded families and patients seeking help. The city, unprepared for such prolonged inundation, saw its drainage systems fail spectacularly, leaving neighborhoods waterlogged for weeks. In the countryside, the losses were even more severe.

Farmers watched helplessly as their fields, rich with crops almost ready for harvest, disappeared beneath the floodwaters. Livestock, unable to find dry land, perished in the rising tide. The river, relentless in its course, carved away entire stretches of land, eroding not just the soil but also the hopes of those who depended on it for their livelihoods.

Relief camps swelled with displaced families, but resources were stretched thin. With overcrowding came new dangers—outbreaks of waterborne diseases spread rapidly, adding another layer of crisis to an already dire situation. Aid workers did their best, but the sheer scale of the disaster made it clear that Assam was facing something unprecedented.

As the floodwaters finally began to recede, the real challenge emerged: rebuilding lives. The Assam floods of 2024 had left behind a changed landscape, both physically and socially. The lessons were clear—traditional flood management was no longer enough. There was an urgent need to rethink how water was managed, to restore lost wetlands, to strengthen embankments, and to build communities that could withstand the changing climate. Most importantly, people needed to be prepared. Early warning systems had to improve, local communities needed more training, and cities had to build with resilience in mind. The flood had shown that disasters were no longer predictable, and the only way forward was to adapt.

For those who had lost their homes and livelihoods, recovery would take years. But as Assam slowly emerged from the crisis, there was hope that this disaster would serve as a turning point—a wake-up call that would drive real change, ensuring that the next time the waters rose, the state would be ready.

Conclusion

The 2024 Assam floods exemplify how climate change is reshaping the nature and impact of disasters. This changing disaster demands a shift in approach—from reactive relief to proactive risk reduction and resilience building. Assam's experience is a clarion call for the nation to adopt sustainable and inclusive strategies to combat the escalating challenges of climate-induced disasters.

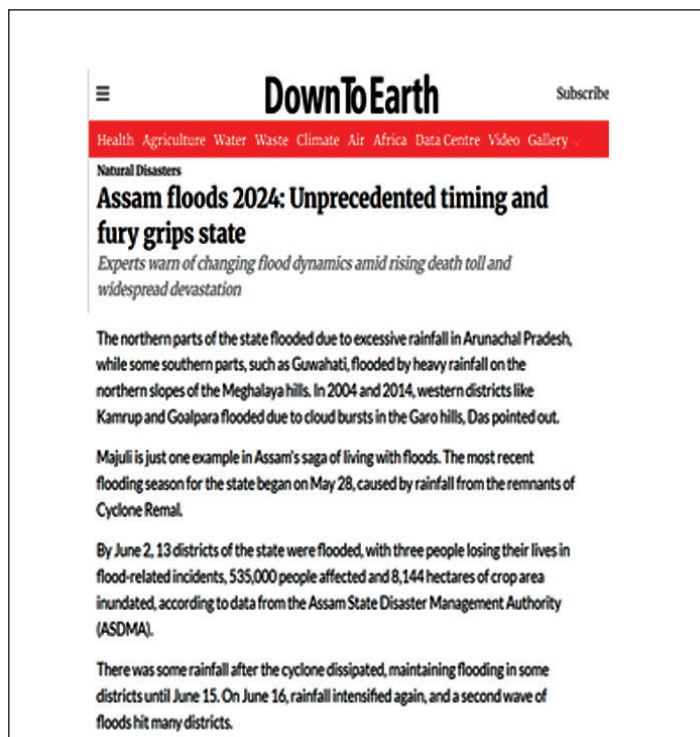


Figure 35 : News Clipping of Assam Flood

2.6 Heatwave in India

In 2024, India faced an unprecedented heatwave that tested the nation's resilience and adaptability. From March to June, vast regions experienced prolonged and extreme heat, pushing the limits of human endurance and infrastructure capacity. This event not only shattered historical temperature records but also underscored the escalating challenges posed by climate change.

The Scale of the Heatwave

Between March 1 and June 18, 2024, India recorded more than 40,000 suspected heat stroke cases, with at least 110 confirmed deaths. The prolonged heatwave led to temperatures soaring to almost 50°C in northern India, marking one of the longest heatwave spells recorded in the country.¹⁹

In Delhi, the heatwave was particularly severe, with temperatures reaching up to 49.1°C in May 2024. The city also experienced unrelenting night-time temperatures, with some parts recording minimum temperatures of 35.2°C, offering little respite from the daytime heat.

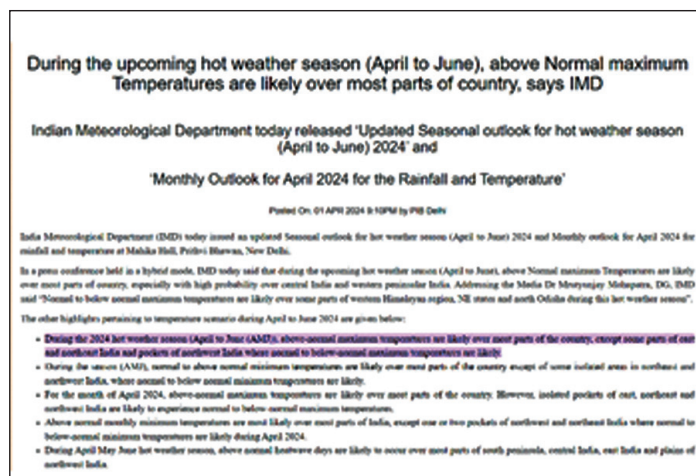


Figure 36 : IMDs Seasonal outlook for hot weather season_2024 /
Source: Ministry of earth science- Press release

State	Heat-related deaths, according to HeatWatch	Heat-related deaths, according to MoHFW data
Maharashtra	10	23
Karnataka	8	5
Kerala	7	1
Tamil Nadu	5	15
Andhra Pradesh	5	11
Delhi	193	25
Uttar Pradesh	205	52
Madhya Pradesh	13	18
Himachal Pradesh	1	9
Haryana	5	4
Gujarat	19	2
Rajasthan	44	17
Odisha	110	26
Bihar	89	37
West Bengal	4	102
Jharkhand	14	11
Assam	1	2
Total	733	360

Table 1: Heat related Causalities in India | Source: Down to Earth_13-09-2024

¹⁹ Reuters

Causes of the 2024 Heatwave

The increasing frequency and severity of heatwaves in India are closely linked to global warming, which has led to more intense and prolonged extreme heat events.²⁰ In 2024, this trend was further exacerbated by the El Niño–Southern Oscillation, a climatic phenomenon characterized by periodic warming of sea surface temperatures in the central and eastern Pacific Ocean. El Niño events are known to alter global weather patterns, and in India, they contributed to intensified heatwaves.²¹

In addition to these broader climatic factors, urban areas faced even harsher conditions due to the urban heat island effect. Cities like Delhi, with their dense infrastructure and limited green spaces, absorbed and retained more heat than their rural surroundings, leading to significantly higher temperatures. As a result, urban populations experienced prolonged heatwaves, worsening the overall impact of the extreme weather condition.²²

Impact on Human Health and Infrastructure

As temperatures soared across India, hospitals found themselves overwhelmed with patients suffering from heat-related illnesses. Emergency rooms filled with people battling dehydration, heat exhaustion, and, in severe cases, heatstroke. The most vulnerable—the elderly, young children, and those working outdoors—were hit the hardest. Construction workers, street vendors, and daily wage laborers had little choice but to endure the relentless heat, risking their health with each passing day.

The crisis extended beyond public health. As temperatures climbed, so did the demand for electricity. Air conditioners ran at full blast, pushing the power grid to its limits. In many cities, prolonged blackouts left residents struggling without fans or coolers, worsening the situation. Meanwhile, water shortages became an equally pressing concern. Reservoirs dried up faster than expected, and taps in urban households ran dry for hours, forcing people to ration every drop.

The relentless heatwave exposed the fragility of India’s infrastructure in the face of rising temperatures. As communities struggled to cope, it became clear that adapting to extreme heat was no longer a choice—it was a necessity

Distinguishing Heat waves from Other Disasters

Unlike sudden-onset disasters like cyclones or floods, heatwaves develop gradually but can be equally, if not more, deadly. Their prolonged nature affects large populations over extended periods, leading to cumulative health stresses and infrastructural challenges. The insidious progression of heatwaves often results in underreporting and a lack of immediate response, despite their severe impacts.

Conclusion

The 2024 heatwave in India serves as a stark reminder of the escalating impacts of climate change. Addressing this

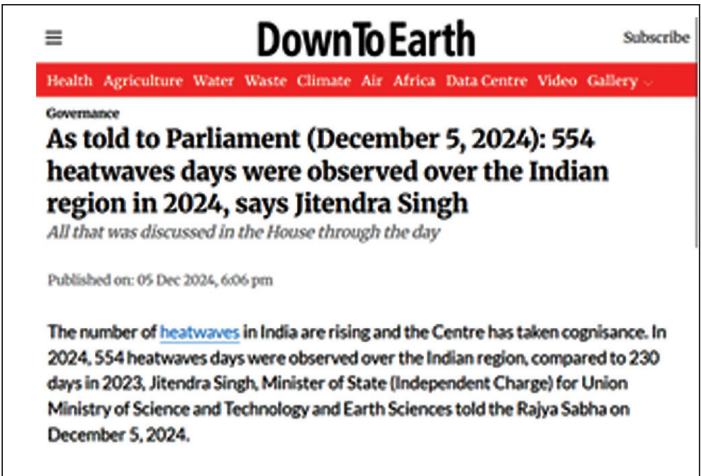


Figure 37 : News Article on heatwave situation in India in 2024 | Source: Media

²⁰ World Weather Attribution
²¹ Mongabay
²² Today as UCSD

challenge requires a multifaceted approach, including:

- **Policy Interventions:** Implementing and enforcing heat action plans at national and local levels to prepare for and mitigate heatwave impacts.
- **Urban Planning:** Incorporating green spaces and adopting building designs that reduce heat absorption to combat urban heat islands.
- **Public Awareness:** Educating communities about heat-related risks and preventive measures to reduce health impacts.

As heatwaves become more frequent and severe, proactive measures are essential to safeguard public health and infrastructure, ensuring resilience against future climate-related challenges.

2.7 Glacial Lake Outburst Floods (GLOFs) in the Himalayas

The majestic Himalayas, with their towering peaks and serene landscapes, stand as a symbol of natural grandeur. Yet, behind this picturesque façade lies a hidden danger—Glacial Lake Outburst Floods (GLOFs). Once rare, these catastrophic events are now becoming alarmingly frequent due to climate change, transforming the tranquil beauty of the region into a stage for potential disaster.

42 Glacial Lakes (GLs) are located in Sikkim out of the 100 GLs that have been identified in the Indian Himalayan Region (IHR), with Jammu & Kashmir and Ladakh having 15 each followed by Himachal Pradesh (10) and Arunachal Pradesh and Uttarakhand having 9 each.²³

A Crisis Emerging from the Depths of Change

GLOFs occur when glacial lakes, formed by the melting of glaciers, breach their natural barriers. Over the past decades, the Himalayas have experienced an alarming 1,081% expansion in the area of glacial lakes, as reported by studies spanning 2011 to 2024²⁴. Rising global temperatures have accelerated glacial melt, leading to the formation of new lakes and the enlargement of existing ones. This phenomenon is particularly acute in states like Uttarakhand and Sikkim, where steep valleys amplify the destructive potential of outburst floods.²⁵

A stark reminder of this threat came in October 2023, The Glacial Lake Outburst Flood (GLOF) in Sikkim, triggered a sudden surge in the Teesta River, causing extensive damage across the state and parts of northern West Bengal. The flood destroyed critical infrastructure, including 15 state highways, sections of NH-10, the Chungthang Dam, and 2,002 houses—1,423 of which were fully damaged. It led to the loss of 40 lives in Sikkim (including 10 army personnel) and 62 unidentified bodies were recovered downstream in West Bengal. Over 88,400 people were affected, with 4,357 individuals evacuated and 2,563 rescued. Communication networks and power supply were severely disrupted, and there were heightened concerns about public safety due to scattered ammunition from a washed-away army



Figure 38 : Army officials recover a vehicle after the incident |
Source: Media

²³ GLOF - The ticking water bomb in Himalayas

²⁴ The Hindu

²⁵ India Today

depot. Relief efforts included airlifting 1,876 stranded tourists and delivering 103,495 kg of essential supplies. However, there remains an urgent need for clean water, hygiene kits, warm clothing, and psychological support as affected communities face long-term recovery challenges.²⁶

But why now? The answer lies in the cumulative impact of climate change, rapid urbanization, and deforestation. As temperatures rise, glaciers retreat, forming unstable moraine-dammed lakes. Increased precipitation and extreme weather events—both hallmarks of a warming planet—further destabilize these natural dams, making them prone to catastrophic failure.²⁷

Different from Other Disasters

Unlike predictable disasters like cyclones or floods, GLOFs are insidious and largely unanticipated. Their triggers can be as diverse as heavy rainfall, seismic activity, or even an ice avalanche. What makes GLOFs particularly treacherous is their cascading impact: a sudden breach can release millions of cubic meters of water and debris, devastating everything in its path within minutes. Communities downstream are often caught unawares, with little to no time for evacuation.

This sudden onset and the sheer volume of destruction set GLOFs apart from other natural disasters. The floods often carry glacial debris, boulders, and sediment, magnifying their destructive power. Infrastructure such as roads, bridges, and hydropower projects, often built close to riverbanks, becomes especially vulnerable.

The Alarming Disconnect: Knowledge vs. Preparedness

The tragedy of GLOFs lies not only in their devastation but also in our lack of preparedness despite ample warnings. Comprehensive studies have long highlighted the vulnerabilities of Himalayan states.²⁸ For instance, a previous study emphasizes the escalating risk in Sikkim under climate warming, while reports also meticulously document the downstream impacts and hazards over the Indian Himalayas.

Yet, anticipatory measures remain grossly inadequate. Why? The reasons are manifold. The remoteness of these regions complicates risk assessment and mitigation efforts. Bureaucratic inertia often delays the implementation of early warning systems. Moreover, the lack of local awareness and community involvement undermines the efficacy of disaster preparedness strategies.

The Immediate and Long-term Impacts

When GLOFs strike, their impacts are catastrophic. Entire villages can be swept away in minutes. Agricultural lands are rendered barren by the thick layers of sediment and debris. The loss of life and property is

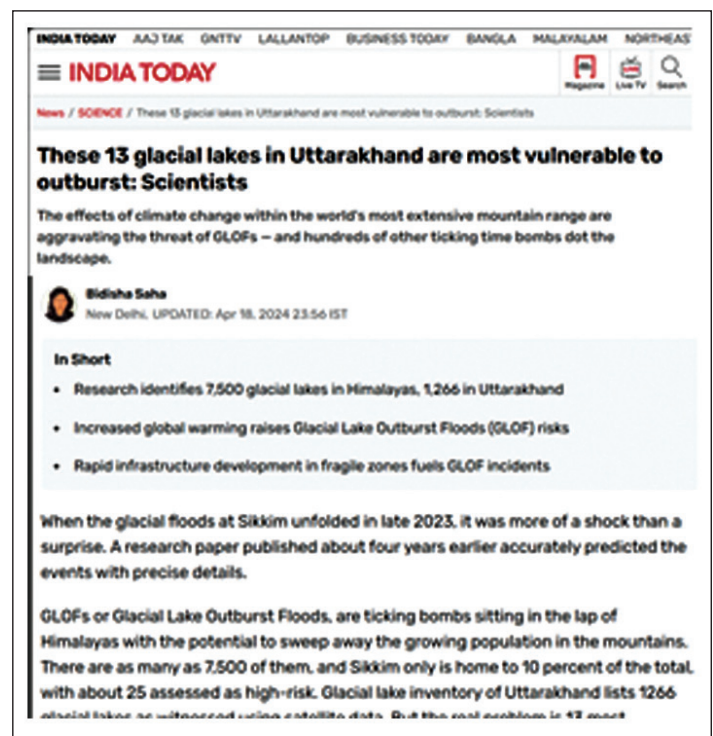


Figure 39 : News Article on GLOF

²⁶ Preliminary Assessment Report - Sphere India

²⁷ Glacial Lake Outburst Flood (GLOF) Hazard, Downstream Impact, and Risk over the Indian Himalayas

²⁸ Glacial Lake Outburst Flood (GLOF) Hazard, Downstream Impact, and Risk over the Indian Himalayas

staggering, but the repercussions extend far beyond the immediate aftermath.

The 2023 Sikkim GLOF serves as a tragic example. Beyond the immediate loss of lives and property, the event disrupted the socio-economic fabric of the region. Hydropower projects, touted as sustainable energy solutions, suffered extensive damage, leading to prolonged power outages. The destruction of critical infrastructure such as roads and bridges isolated communities, hampering relief and rehabilitation efforts. Ecologically, the Teesta River basin suffered severe sedimentation, affecting aquatic ecosystems and water quality. These long-term impacts underscore the need for robust mitigation and adaptation strategies.

The future, if current trends persist, paints an even grimmer picture. With glaciers projected to melt at unprecedented rates, the number and size of glacial lakes will continue to grow. The frequency and intensity of GLOFs will rise, posing a perpetual threat to millions living in the Himalayan foothills.

Charting a Path Forward

To combat the growing menace of GLOFs, a multi-pronged approach is essential. First and foremost, robust early warning systems must be deployed. These systems should leverage satellite imagery, ground sensors, and predictive models to monitor glacial lakes in real time. Community-based disaster preparedness programs are equally vital, empowering local populations to respond swiftly in the event of an outburst.

Infrastructure development in vulnerable areas must adhere to stringent safety standards, factoring in the unique risks posed by GLOFs. Policymakers must prioritize the implementation of recommendations from scientific studies, bridging the gap between research and action.

Finally, global efforts to mitigate climate change remain critical. The plight of the Himalayas is a stark reminder of the interconnectedness of ecosystems and the shared responsibility of nations to curb greenhouse gas emissions. The story of GLOFs in India's Himalayas is a cautionary tale of nature's fury in the face of human negligence. It underscores the urgent need for proactive measures to safeguard the fragile mountain ecosystems and the lives they sustain. As the world grapples with the realities of a changing climate, the Himalayan GLOFs serve as both a warning and a call to action—a testament to the high stakes of inaction in the face of an escalating crisis.

2.8 Rising Threat of Lightning in India

Lightning, often viewed as a sporadic natural hazard, has become an increasingly frequent and devastating phenomenon, claiming thousands of lives annually. In 2024, lightning emerged as the deadliest weather phenomenon in India, claiming 1,374 lives out of the 3,200 fatalities caused by extreme weather events.²⁹ This alarming trend calls for urgent attention to the underlying causes, impacts, and strategies to mitigate the risks.

The Alarming Surge in Lightning Strikes

According to the Annual Lightning Report 2023-2024



²⁹ IMD Summary Report- 2024

Figure 40 : News article on Lightning

by the CROPC, lightning incidents in India have surged by 53% over the past four years³⁰. From 13.8 million strikes in 2019-20, the numbers skyrocketed to 20 million in 2022-23. Tragically, these incidents have led to a significant rise in casualties, with rural areas bearing the brunt. In August 2024 alone, Bihar reported 14 lightning-related deaths in a single day, reflecting the scale of this crisis³¹.

What's Driving This Increase?

The escalation in lightning strikes can be attributed to multiple factors, with climate change playing a pivotal role. Rising global temperatures enhance atmospheric moisture, which fuels the formation of thunderstorms. For every one-degree Celsius increase in temperature, lightning frequency is estimated to rise by 12%.

Moreover, increasing air pollution contributes to the formation of storm clouds. High levels of particulate matter in the atmosphere create conducive conditions for intense thunderstorms, thereby amplifying lightning occurrences.³²

The Human and Economic Impact

The consequences of this surge are far-reaching. Beyond the tragic loss of life, lightning strikes disrupt livelihoods, especially in rural and agricultural communities. Farmers working in open fields are among the most vulnerable, often unaware of imminent danger due to limited access to early warning systems.

Infrastructure also suffers significantly. Buildings, power lines, and communication networks are frequently damaged, leading to economic losses and prolonged disruptions in affected regions.

Lightning as a National Disaster

Recognizing the severity of this hazard, experts and policymakers have advocated for classifying lightning as a national disaster. This classification would pave the way for dedicated resources and comprehensive strategies to mitigate the risks.

The National Disaster Management Authority (NDMA) and CROPC, in collaboration with the India Meteorological Department (IMD), have emphasized the need for improved lightning resilience through awareness campaigns and robust early warning systems like the Damini app. These efforts are crucial for vulnerable communities, many of whom remain disconnected from technology and critical information.

A Look Ahead: The Changing Risk Landscape

As climate change accelerates, so does the frequency and intensity of lightning strikes. Each year, thousands of lives and livelihoods are impacted by this growing threat, particularly in rural and agricultural communities. The increasing unpredictability of lightning underscores the urgent need for preparedness and resilience.

The first step forward lies in enhancing early warning systems. Real-time lightning detection and alerts must be made accessible to even the most remote areas, ensuring that farmers, outdoor workers, and vulnerable communities receive timely warnings to seek shelter. Infrastructure must also evolve to keep pace with this changing reality. Revising building codes to include advanced lightning protection systems can significantly reduce damage to homes, schools, and workplaces.

³⁰ Annual Lightning report - CROPC

³¹ Indian Express

³² Lightning Resilience in India

Beyond technology and infrastructure, awareness plays a crucial role. Large-scale education campaigns can teach communities about lightning safety—where to take shelter, how to minimize risk, and what to do during a storm. Farmers, who often work in open fields, and outdoor laborers are among the most at risk and must be equipped with the knowledge to protect themselves.

Finally, research and policy development must go hand in hand. A deeper understanding of shifting lightning patterns, driven by climate change, can help shape more effective disaster management strategies. By integrating this knowledge into national policies, authorities can ensure a proactive approach rather than a reactive one. With the right measures in place, the rising threat of lightning strikes can be met with preparedness rather than fear, safeguarding lives and communities for the future.

Conclusion

The year 2024 served as a stark reminder of the growing threat posed by lightning in India. As incidents become more frequent and intense, it is imperative to address this silent killer with robust strategies and collective action. By investing in technology, infrastructure, and awareness, India can mitigate the risks and protect its citizens from the fury of the skies.

2.9. Synthesis and Key Insights: Changing Landscape of Risk

The analysis of disaster events in this chapter reveals that India's disaster landscape is undergoing a significant transformation, characterized by the increasing frequency, intensity, and complexity of hazards. Traditionally, disasters were considered isolated events, but recent years have shown a clear shift towards multi-hazard scenarios. Areas once impacted by seasonal floods or isolated landslides are now facing cascading disasters, where one hazard triggers another.

Key observations include the rise in extreme weather events, such as lightning emerging as India's deadliest weather hazard, heatwaves causing widespread health crises, and glacial lake outburst floods (GLOFs) threatening Himalayan communities. The chapter highlights how traditional disaster-prone areas, such as Wayanad, Tripura, and Joshimath, have become epicenters of high-impact disasters, while new regions have also become vulnerable.

The lessons derived from this evolving risk landscape are clear: disaster management must adopt an integrated, multi-hazard approach. Risk assessments need to be dynamic, considering both immediate and cascading risks. The importance of localized early warning systems, robust land-use planning, and multi-stakeholder coordination cannot be overstated. The synthesis emphasizes that resilience is not merely a matter of response but a continuous process of adaptation, learning, and proactive planning.



विज्ञान एवं
प्रौद्योगिकी विभाग
MINISTRY OF
SCIENCE AND
TECHNOLOGY



RESSUMMIT 2025 WORKSHOP

Disaster Management & Infrastructure Resilience in Changing Climate and Environmental Risks

Special Focus on National Adaptation Plan w.r.t. Disaster Management and Resilient Infrastructure,
Implementation Models and ADRES Network

Venue: ICARS, Greater Noida Extension Centre, IIT-Roorkee

Date: 10-11 February 2025



*National Consultation Workshop on “Disaster Management and Resilient Infrastructure in Changing Climate and Environmental Risks”
jointly and for NDMA, MOEFCC and DST-Govt. of India*

Initiatives for Resilience

Chapter

3

Resilience is a fundamental concept in disaster management, defined as the capacity of individuals, communities, systems, and nations to anticipate, prepare for, respond to, and recover from shocks and stresses. It is not just about withstanding disasters but also about adapting and thriving in their aftermath. In the context of this report, resilience is explored through various initiatives undertaken by government agencies, private sector entities, and community organizations. These initiatives aim to enhance the capacity of individuals and systems to cope with and recover from disasters, ensuring a more sustainable and secure future. This chapter provides an in-depth analysis of these initiatives, highlighting their impact, challenges, and future directions. By focusing on innovative strategies, policy reforms, and adaptive planning, these initiatives aim to mitigate disaster risks and strengthen India's preparedness and response capabilities

3.1 Government-Led Initiatives

The disasters of 2023-2024 exposed critical vulnerabilities in various sectors, from urban planning and infrastructure to environmental sustainability and community preparedness. India has long been at the forefront of disaster risk reduction (DRR), implementing strategic initiatives that align with global frameworks like the Sendai Framework for Disaster Risk Reduction (SFDRR). Through various government-led efforts and international collaborations, the country continues to build resilience against both natural and human-induced disasters. Key agencies such as the National Disaster Management Authority (NDMA) the Coalition for Disaster Resilient Infrastructure (CDRI), and others play an instrumental role in advancing these efforts.

3.1.1 Major Initiatives by the Central Government

The Government of India has adopted a comprehensive and technologically advanced approach to disaster risk reduction (DRR), focusing on Resilience, Preparedness, response, recovery, and mitigation. Through a combination of advanced technologies, community engagement, and policy reforms, these initiatives aim to strengthen local disaster management capacities, enhance early warning systems, and mitigate the impact of natural hazards across the country.

A major initiative in this direction is the National Landslide Risk Mitigation Program (NLRMP), with an approved budget of ₹1,000 crore. This program focuses on landslide mitigation activities across 15 states, including Kerala. State governments, such as Kerala's Wayanad district, are encouraged to submit projects under this program to mitigate landslide risks and strengthen local resilience. Additionally, the National Cyclone Risk Mitigation Project (NCRMP) has significantly improved disaster preparedness in coastal regions. This project has installed Early Warning

Systems in coastal states, enhancing alert dissemination and enabling rapid evacuation. Under NCRMP, 24,007 government officials from key sectors like health, education, Panchayat Raj Institutions, urban local bodies, and rural development have been trained through 925 capacity-building sessions. Further strengthening community-level readiness, 68,988 community representatives have received training in disaster response skills—such as first aid, search and rescue, and shelter management—through 3,421 shelter-level training programs.

The Aapda Mitra Scheme is another groundbreaking initiative focused on empowering local communities. Under this scheme, 1,00,000 community volunteers—designated as Aapda Mitra (male volunteers) and Aapda Sakhi (female volunteers)—have been trained across 350 multi-hazard disaster-prone districts, covering all States and Union Territories. Each volunteer undergoes two weeks of intensive training specific to their area's disaster risks, receives an Emergency Responder Kit (ERK), and is provided with five-year insurance coverage. To further equip districts, the government has established Emergency Essential Resource Reserves (EERR), which provide critical tools for volunteers during disaster response operations.

To facilitate faster and more coordinated emergency responses, the government has implemented the Extension of Emergency Response Support System (ERSS-112). This system serves as a single distress number for all emergencies, including disaster-related calls, ensuring rapid assistance and reducing the time taken to provide life-saving aid. This initiative leverages cutting-edge technology to streamline emergency communications and minimize the loss of life and property during crises.

The Dynamic Composite Risk Atlas (Web-DCRA) and Decision Support System (DSS), developed by the National Disaster Management Authority (NDMA), offer advanced tools for cyclone risk mapping and response planning. This system has proven critical during recent cyclones like Biparjoy and Michaung, enabling real-time risk prediction and resource allocation. Additionally, the Flood Hazard Atlas, developed by the National Remote Sensing Centre (NRSC), maps flood-prone regions across major states, including West Bengal, Andhra Pradesh, Bihar, Odisha, Assam, and Uttar Pradesh. This atlas also covers moderately flood-affected states such as Kerala, Gujarat, and Jammu & Kashmir, enhancing preparedness through accurate data. To monitor Glacial Lake Outburst Floods (GLOFs)—a growing concern due to climate change—the NRSC has compiled a dataset of 28,000 glacial lakes across the Indian Himalayan Region, allowing for early detection and risk mitigation.

The government has also prioritized the Common Alerting Protocol (CAP) based Integrated Alert System, which enables geo-targeted dissemination of early warnings and disaster alerts. This system integrates key scientific agencies such as the India Meteorological Department (IMD), Central Water Commission (CWC), and Geological Survey of India (GSI) to deliver real-time alerts via SMS, television, radio, coastal sirens, satellite receivers, and internet-based notifications. More than 4,500 crore alert messages have been disseminated through this system. The Indian Tsunami Early Warning Centre (ITEWC), recognized globally by the United Nations Office for Disaster Risk Reduction (UNDRR), continues to provide real-time tsunami alerts for the entire Indian Ocean region, enhancing regional disaster preparedness.

To complement these large-scale systems, the government has developed mobile applications to deliver localized and timely disaster alerts. Notable applications include Damini (for lightning alerts), Mausam (for real-time weather forecasts), and Meghdoot (which provides climate advisories for farmers). These platforms ensure critical information reaches vulnerable communities swiftly, improving disaster readiness at the grassroots level.

Another key initiative is the Indian Universities and Institutions Network for Disaster Risk Reduction (IUINDRR-NIDM), established under the National Institute of Disaster Management (NIDM). This network connects over 330 universities and academic institutions across India, fostering research, policy innovation, and knowledge-sharing on disaster risk reduction. Through IUINDRR, the government is integrating DRR concepts into educational curricula and enhancing collaboration between academic institutions and policymakers.³³

The National Disaster Response Force (NDRF) remains a pivotal institution in disaster response, with 16 specialized battalions and 28 Regional Response Centres across the country. NDMA and NDRF regularly conduct mock drills, community awareness programs, and training exercises to strengthen community-based disaster resilience and ensure quick mobilization during emergencies.

On the global stage, India continues to play a leadership role in disaster risk reduction. The Coalition for Disaster Resilient Infrastructure (CDRI), launched by Prime Minister Narendra Modi at the United Nations Climate Action Summit in 2019, now includes 42 countries and 7 international organizations. CDRI supports disaster-resilient infrastructure development, with a special focus on Small Island Developing States (SIDS) and promoting risk-informed planning in critical sectors like energy and telecommunications. During India's G20 Presidency, disaster risk reduction was identified as a priority area, advancing global cooperation through platforms such as the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC), the Indian Ocean Rim Association (IORA), and the Shanghai Cooperation Organization (SCO).

India has also demonstrated its commitment to Humanitarian Assistance and Disaster Relief (HADR) through international missions. In 2023, under Operation Dost, India provided rapid aid to Türkiye and Syria following devastating earthquakes. This operation involved the swift deployment of NDRF teams, medical personnel, and relief materials, reflecting India's global humanitarian leadership under the ethos of "Vasudhaiva Kutumbakam" (The World is One Family).³⁴

3.1.2 Policy and Legislative Measures

The government is considering amendments to the Disaster Management Act to address emerging risks such as climate-induced disasters, Glacial Lake Outburst Floods (GLOFs), and urban flooding. Additionally, the National Adaptation Fund for Climate Change (NAFCC) has strengthened funding mechanisms for climate adaptation projects, particularly in ecologically fragile areas like the Himalayas and coastal regions. All states introduced State-Specific Action Plans (SAPCCs) that focus on risk-sensitive land use planning and eco-restoration. These policy measures aim to institutionalize disaster risk reduction and integrate climate adaptation strategies into governance structures.

Targeting 15 high-risk states, including Arunachal Pradesh, Assam, Himachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, Uttarakhand, Karnataka, Kerala, Maharashtra, Tamil Nadu and West Bengal, the National Landslide Risk Mitigation Programme has received ₹1,000 crore from the Indian government. This program uses hydrological models, sensor networks, and meteorological data to build evidence-based mitigation strategies like real-time early warning systems. Additionally, it encourages public awareness efforts to improve readiness and bioengineered slope stabilization to stop erosion. Proposals from state governments to address particular risks are welcomed and examined for sustainability and scientific value. For efficient mitigation, the program integrates geological, hydrological, and technical expertise using a data-driven methodology.

³³ PIB: 10 Dec 2024_Ministry of Home Affairs

³⁴ Press release: Ministry of Home Affairs : INNOVATIVE METHODS TO SAVE PEOPLE FROM DISASTERS

India is proactively tackling the increasing threat of lightning strikes through a science-driven, multi-faceted approach aimed at reducing fatalities and enhancing community resilience. The Lightning Resilient India Campaign, a collaborative effort by CROPC, IMD, and the Ministry of Earth Sciences, spearheads this effort by advocating for lightning to be recognized as a national disaster. This campaign promotes comprehensive strategies, including robust early warning systems and community preparedness programs.

Recognizing localized risks, states like Assam, and Himachal Pradesh have implemented targeted action plans. These plans emphasize public awareness campaigns through various media, training for first responders and vulnerable groups, localized early warning systems, and the creation of safe shelters. Furthermore, lightning safety protocols are being integrated into building codes and infrastructure projects. Public awareness and education form a cornerstone of India's strategy. Initiatives encompass educational programs in schools, targeted training for high-risk groups like agricultural workers, and the dissemination of safety guidelines via various channels, including the "Damini " mobile app that gives alerts for lightning in India. These efforts aim to foster a culture of safety and preparedness within communities.

3.1.3 Enhancing Disaster Preparedness through NDMA Initiatives

India's National Disaster Management Authority (NDMA) continues to implement robust disaster preparedness initiatives. Significant progress has been made in early warning systems for hydro-meteorological hazards, including cyclones, floods, and heatwaves. These advancements have led to a notable reduction in disaster-related casualties, demonstrating the effectiveness of India's preparedness strategies. In APMCDRR, NDMA announced 20% mitigation of landslide prone areas in the country in the next 5 years.



Figure 41 : Presentation from NDMA at APMCDRR 2024

3.2 Private Sector and CSR Contributions

The private sector plays a crucial role in enhancing disaster resilience by leveraging financial resources, technology, and innovation to support preparedness, response, and recovery efforts. Initially, private sector involvement in disaster risk reduction (DRR) was largely limited to financial support through corporate social responsibility (CSR) initiatives, such as providing essential relief materials like water, food, tarpaulin sheets, blankets, and hygiene kits

during disaster responses. However, since 2011, there has been a growing global recognition of the private sector's capacity to actively mitigate and manage disaster risks. In response, the UN Office for Disaster Risk Reduction (UNDRR) established the DRR Private Sector Partnership (DRR-PSP) Working Group to engage private entities in disaster resilience through core business arrangements, collaborative actions, sustainability initiatives, CSR programs, and knowledge transfer.

The World Economic Forum (WEF) has also emphasized the private sector's role in enhancing disaster resilience for businesses and communities by adopting best practices that prioritize preparedness, response, and recovery. With access to substantial financial and technological resources, private companies are uniquely positioned to invest in disaster-resilient infrastructure, early warning systems, and community-based initiatives. These investments not only protect business operations but also contribute to community safety, particularly in high-risk areas.

3.2.1. Innovation and Technology in Disaster Resilience

Innovation and technology are at the core of the private sector's contributions to DRR. Companies are increasingly developing and deploying advanced solutions such as AI-driven predictive models, remote sensing technologies, and Big Data analytics to enhance early warning systems and risk management strategies. Collaborative efforts between private firms and meteorological agencies have resulted in the development of AI solutions for predicting urban flooding and landslides, improving real-time response capabilities. In addition, innovative microinsurance schemes have been introduced to provide financial protection to farmers and small businesses in disaster-prone areas, helping them recover from economic losses caused by extreme weather events.

A key focus for private sector involvement in disaster resilience is business continuity and supply chain management. Companies recognize the importance of maintaining essential operations during crises and have implemented robust continuity strategies to minimize disruptions. Ensuring supply chain resilience is particularly vital, as it sustains the flow of critical goods and services during disasters, benefitting both businesses and affected communities. Furthermore, private companies contribute to infrastructure development, including transportation, telecommunications, and energy. By incorporating disaster-resistant design and construction practices, these firms help reduce vulnerabilities and improve the resilience of critical services.

3.2.2. Corporate Social Responsibility (CSR) Initiatives in Disaster Resilience

Corporate Social Responsibility (CSR) initiatives further strengthen private sector contributions to disaster resilience. Many companies engage in philanthropic activities, community partnerships, and disaster preparedness programs to support vulnerable populations. For example, organizations such as Amazon Disaster Relief, Tata One, HCL Foundation, Reliance Foundation, and Donatekart have provided emerging need items and vital logistical and supply-chain support in Wayanad, ensuring the timely delivery of essential relief materials during disaster emergencies.

A noteworthy CSR initiative is the Reliance Foundation's Disaster Preparedness Program, which focuses on strengthening community resilience through localized training sessions in flood-prone regions. In partnership with Sphere India, the 'Stronger Together' compendium was created to document real-life stories of individuals who actively contribute to disaster preparedness, mitigation, and response efforts. This initiative highlights the experiences of ten grassroots leaders and honors the many unseen contributors working to support communities during emergencies. By sharing these experiences, the compendium promotes community participation in disaster risk reduction and encourages others to engage in resilience-building efforts.

Another significant collaboration is the partnership between IndusInd Bank and UNICEF, formalized on November 21, 2024, under the 'Disaster Resilient Communities and Climate Risk-Informed Efficient Administrative Systems' initiative. This program, part of IndusInd Bank's Flagship CSR Program, aims to develop climate-informed administrative systems across five aspirational districts: Dharashiv (Maharashtra), Begusarai (Bihar), Virudhunagar (Tamil Nadu), Baran (Rajasthan), and Bahraich (Uttar Pradesh). The initiative focuses on building disaster-resilient communities, empowering local governments to implement climate solutions, and developing real-time monitoring systems, early warning mechanisms, and advisory services to mitigate climate-related risks such as droughts, floods, and heatwaves.

Public-private partnerships (PPPs) serve as a crucial mechanism for enhancing disaster resilience. By fostering collaboration between private companies, governments, and humanitarian organizations, PPPs enable joint planning, resource sharing, and coordinated disaster response. Leveraging their combined strengths, these partnerships facilitate comprehensive disaster preparedness and recovery efforts while strengthening local and national resilience frameworks.

Through financial investments, technological innovation, infrastructure development, business continuity planning, and community engagement, the private sector is shaping a more disaster-resilient future. Their active participation not only safeguards business interests but also enhances the capacity of communities to withstand and recover from disasters, contributing to the collective goal of building a safer and more resilient world.

3.3 Humanitarian and Community-Led Resilience Initiatives

Disasters, whether natural or man-made, pose significant challenges to communities, governments, and humanitarian organizations worldwide. The resilience of affected communities is shaped by both immediate humanitarian responses and long-term recovery efforts. This section explores various humanitarian and community-led resilience initiatives in response to major disasters, including the Wayanad landslide, Tripura floods, and riverbank erosion in Murshidabad, among others. These initiatives highlight the power of collaboration between government agencies, non-governmental organizations (NGOs), and local communities in ensuring effective disaster response, rehabilitation, and preparedness.

Community-led initiatives are particularly vital in disaster resilience as they harness local knowledge and foster community ownership in disaster preparedness and recovery. Large metropolitan cities not only face major disasters but also deal with daily risks that undermine their ability to address natural and climate-induced hazards. This reality has led to the emergence of international frameworks like UNISDR's "Making Cities Resilient" campaign, which emphasizes the importance of reducing urban disaster risks through local-level participation. Despite the existence of citizen-based institutions, awareness and action on disaster risk reduction (DRR) remain limited. To address this gap, SEEDS introduced a "forum" concept, a multi-stakeholder initiative designed to empower local communities to actively participate in DRR. This initiative was piloted in eight urban areas across India, with five successfully established forums in Mussoorie, Dharamshala, East Delhi, Villupuram, and Neemeli. These forums, complete with bylaws and constitutions, function as collective learning hubs, fostering connections between local stakeholders and government departments. SEEDS further supported these forums by providing training on DRR and climate change adaptation (CCA), leadership development, and facilitating collaboration with governmental bodies.

Stories from the field

1. Caritas India: Community-Based Lightning Protection Initiative – Bihar

Caritas India's initiative under its Disaster Risk Reduction (DRR) program tackles the growing threat of lightning strikes, which increased by 53.75% between 2019 and 2023 (IMD data). The project introduces an affordable lightning arrester made from local materials—bamboo, cycle rims, copper wire, and wood—designed for rural households and farmlands. Through a participatory approach, the community is engaged in vulnerability assessments, planning, and installation. Demonstrated at major platforms such as Bihar Diwas and the G20 NPDRR, and supported by IIT Patna and Patna University, the initiative combines awareness-building, capacity development, and grassroots innovation to enhance rural safety and resilience.³⁵

2. ADRA India: Anticipatory Action for Heatwave Preparedness

ADRA India is implementing a proactive humanitarian initiative focused on anticipatory action to reduce the impact of heatwaves in vulnerable regions across India. Grounded in landscape studies, the project includes community-based risk perception assessments, capacity-building, and the integration of early warning systems tailored to local needs. By aligning scientific research with community insights, ADRA India is fostering localized resilience strategies to adapt to rising heatwave threats in the face of climate change.³⁶

3. CoS-it-FloWS: Community-Sourced Impact-Based Flood Forecast and Early Warning System – Kerala

Responding to recurrent floods in Kerala's Periyar and Chalakudy river basins, this initiative—launched on September 28, 2024—is a collaboration between local communities, the tech start-up Equinoct, Community Resource Centre in Puthanvelikkara, Resilient Destinations Foundation, and the Ernakulam DDMA. Community volunteers collect data daily from over 100 rain gauges, which is transmitted via a mobile app and visualized on a climate dashboard. This decentralized system empowers the community in real-time flood monitoring and response, enhancing early warning dissemination and decision-making.³⁷

4. Community Mangrove Restoration – Rajnagar, Odisha

In Odisha's Rajnagar block, the villages of Gupti and Baghamari have restored over 27 hectares of mangroves by planting 67,500 saplings with support from the Government of Odisha, UNDP, and the Green Climate Fund. Using the fishbone irrigation technique, communities are strengthening natural buffers against cyclones and sea-level rise. These efforts are linked with sustainable aquaculture, climate-resilient farming, and eco-tourism. The initiative highlights inclusive leadership, particularly by women and youth, and bridges traditional knowledge with modern resilience practices.³⁸

5. Sphere India: "Roots of Resilience" – Wayanad, Kerala

"Roots of Resilience" is a compendium developed by Sphere India to document coordinated humanitarian response following the July 2024 landslides in Wayanad. It captures interventions such as the GO-NGO Coordination Desk, sectoral needs assessments, psychosocial support, cash-for-work programs, and the distribution of 'Back to Home' kits. Emphasizing accountability, inclusivity, and community-led action, the initiative showcases best practices in humanitarian coordination and is a replicable model for future disaster response frameworks.³⁹

³⁵ Caritas- lightning protection Initiative

³⁶ ADRA – Anticipatory action for Heatwave preparedness

³⁷ Kerala: Community-oriented flood forecast system

³⁸ Mangrove Restoration – Odisha

³⁹ Roots of Resilience – Sphere India

6. HAI: Bamboo Screening for Riverbank Erosion – Barpeta, Assam

Facilitated by HAI and AGUP, this initiative addresses chronic riverbank erosion along the Brahmaputra River. It employs bamboo screening—a low-cost, eco-friendly solution that reduces water velocity and traps sediment. Entirely community-driven, the initiative involves local planning, construction, and maintenance. This method exemplifies how traditional knowledge and local materials can provide effective, sustainable disaster risk reduction solutions.⁴⁰

7. Building Climate Resilient WASH Systems – Jaipur, Rajasthan

The Centre for Advocacy and Research (CFAR), supported by the Australian Government’s Water for Women Fund, leads this urban initiative across 75 slums in Jaipur. Focused on Gender Equality, Disability, and Social Inclusion (GEDSI), the project decentralizes WASH governance through community-led Slum Development and Sanitation Committees. With the construction of over 10 climate-risk-informed WASH facilities and outreach to 96,000 people, the initiative integrates climate adaptation with equity-focused service delivery. Strong collaboration with municipal bodies and local NGOs ensures sustainability and inclusiveness in urban resilience.⁴¹

3.3.4 The Path to Long-Term Resilience

Effective disaster response extends beyond immediate relief and rebuilding efforts—it ensures that communities emerge stronger, more self-sufficient, and better prepared for future challenges. Community-led resilience initiatives are among the most impactful approaches, as they empower local populations with the knowledge, skills, and resources needed to mitigate future risks.

A critical aspect of long-term resilience is climate adaptation. Initiatives such as flood-resistant agriculture, sustainable infrastructure, and ecological restoration play a vital role in strengthening community resilience against climate-related disasters. For example, by promoting the cultivation of climate-resilient crops and establishing early warning systems, communities can prepare and respond more effectively to environmental changes.

Preparedness remains a cornerstone of disaster management. Community-based training programs, localized disaster response plans, and early warning systems ensure that individuals and communities are equipped to respond swiftly and effectively when disasters strike. Additionally, fostering multi-stakeholder collaboration—involving government agencies, NGOs, academic institutions, and private enterprises—has proven essential for delivering comprehensive and sustainable disaster solutions.

By integrating these components—community empowerment, climate adaptation, preparedness, and collaborative governance—the path to long-term resilience becomes more achievable. The lessons learned from humanitarian and community-led initiatives in Wayanad, Tripura, and Murshidabad highlight the importance of a holistic, community-centered approach to disaster resilience, ensuring that vulnerable populations are better equipped to face future crises.

3.4 Key Learnings and Future Directions

From the landslide-stricken hills of Wayanad to the flood-affected plains of Tripura and the eroding riverbanks

⁴⁰ Bamboo screening success: HAI

⁴¹ Climate resilient Wash: CFAR

of Murshidabad, the transition from emergency relief to long-term resilience has been a defining challenge. Governments, NGOs, and local communities have come together not just to rebuild but to lay the foundation for stronger, more adaptive, and self-sustaining communities. This shift reflects a deeper understanding that disaster response is no longer just about reacting to crises but about proactively preparing for them. The future of disaster management lies in resilience-building—ensuring that when the next disaster strikes, communities are not only prepared but equipped to withstand and recover swiftly.

A key lesson from these initiatives is the need for multi-sectoral collaboration in disaster resilience. One of the most significant areas of progress has been the integration of scientific data into policy decisions. Real-time risk assessments, satellite imaging, and geospatial data have become invaluable tools in urban planning and land use policies. By incorporating scientific knowledge into decision-making, authorities can identify high-risk zones, develop early warning systems, and implement preemptive measures to mitigate potential damage.

Equally important is the strengthening of local governance and community participation. Decentralizing disaster preparedness efforts has proven to be essential in ensuring a swift and efficient response. By empowering local communities to lead localized response strategies, disaster management becomes more adaptive and context-specific. Community-led initiatives, such as disaster preparedness training and the formation of local response teams, have demonstrated their effectiveness in reducing vulnerability and enhancing recovery efforts.

Beyond immediate relief efforts, sustainable recovery planning has emerged as a critical component of resilience-building. Rather than focusing solely on short-term aid, there is a growing emphasis on long-term recovery through adaptive housing solutions, alternative livelihoods, and nature-based interventions. Investments in climate-resilient infrastructure, agroecological farming practices, and ecosystem restoration have shown that recovery can also serve as an opportunity for long-term development and sustainability.

As climate-induced risks escalate, it is clear that resilience-building must evolve to incorporate innovative technologies, inclusive policies, and community-driven approaches. The road ahead requires enhanced coordination among government agencies, private entities, and local communities. Only through this collective effort can we create a disaster-resilient India—one where communities are not just surviving disasters but thriving despite adversity.



Disaster-Risk Resilience, Response & Recovery Annual Learning and Planning Workshop: 2024

Progress in Recovery

Chapter

4

Recovery is a crucial phase in the disaster management cycle, bridging immediate humanitarian response with long-term resilience-building. The 2024 disasters in India—spanning floods, cyclones, landslides, subsidence events, and more—brought forth varied challenges, highlighting the critical need for inclusive, sustainable, and resilience-focused recovery strategies.

A very few disasters have structured recovery plans, and even fewer have comprehensive progress tracking mechanisms. This lack of monitoring creates a significant gap in ensuring that recovery efforts translate into resilience for affected communities.

This chapter evaluates the progress in recovery from major disasters in 2024, with a specific focus on the implementation of Post-Disaster Needs Assessments (PDNAs), the effectiveness of recovery plans, and the systemic challenges that hinder long-term rehabilitation. The findings underscore the need for structured follow-ups, financial mechanisms that reduce bureaucratic delays, and stronger linkages between recovery and government programs like MNREGA and other development schemes.

The analysis highlights persistent gaps in recovery frameworks, emphasizing the importance of integrating technology, strengthening community engagement, and leveraging innovations such as AI and digital tools for real-time tracking and implementation of recovery plans.

Through this analysis, the chapter emphasizes the importance of coordination, financial investment, and systemic improvements in recovery efforts to enhance resilience and better prepare for future disasters.

Key areas covered include:

- An analysis of PDNAs conducted and their role in shaping recovery efforts.
- Implementation status of recovery plans, with examples from key disasters.
- Evaluation of recovery effectiveness, focusing on timeliness, inclusivity, and sustainability.
- Innovations introduced in recovery processes.
- Persistent gaps and challenges in recovery efforts.
- Strategic recommendations for future recovery planning and execution.

4.1. Post-Disaster Needs Assessments (PDNAs) and Recovery Frameworks

PDNAs provide a structured framework for assessing disaster impact, quantifying losses, sectoral impacts, and formulating recovery strategies to rebuild communities. An international framework for assessing losses and damages in the aftermath of a disaster, it helps get recovery and reconstruction efforts right following a disaster. However, disparities and inconsistencies in PDNA data often lead to ineffective implementation. The absence of a national recovery database further weakens efforts to track progress, making it difficult to evaluate whether the recommendations of PDNAs are translated into action.

In a few states the Post-Disaster Needs Assessments (PDNAs) were initiated following major disasters in 2024. The following case studies provide insights into how PDNAs and recovery strategies have been implemented in different disaster contexts.

Case 1: Kerala's Wayanad Landslide Recovery Project

An Overview:

Following the devastating landslides in Wayanad on July 30, 2024, a PDNA was conducted under the guidance of the National Disaster Management Authority (NDMA) in coordination with the Kerala State Disaster Management Authority (KSDMA). The assessment estimated a requirement of Rs. 2,219 crores for recovery, emphasizing township development and livelihood restoration.

A major component of the recovery involved the construction of sustainable townships in Nedumbala and Kalpetta. These townships were designed with essential community infrastructure, including health centers, schools, and markets. The government also undertook a micro-plan survey to assess livelihood needs, leading to initiatives supporting agriculture, micro-enterprises, and animal husbandry.

Despite significant progress, the recovery process faced several challenges. Financial constraints and delays in fund allocation created difficulties for displaced families who relied on rental support. Additionally, community resistance to the township model highlighted the importance of incorporating local preferences into rehabilitation planning.

The 2024 Wayanad landslides were a series of landslides that occurred in Punjirimattom, Mundakkai, Chooralmala, and Vellarimala villages in Meppadi panchayat, Vythiri taluk in Wayanad district, Kerala, India in the early hours of 30 July 2024.⁴²

Following the devastating landslides, an Inter-Ministerial Central Team (IMCT) was constituted by the Central Government on 02.08.2024 to assess the damage. Kerala's recovery efforts for the Wayanad landslides were guided by a Post-Disaster Needs Assessment (PDNA) initiated in August 2024. The PDNA was conducted under the guidance of the National Disaster Management Authority (NDMA) in close coordination with the Kerala State Disaster Management Authority (KSDMA) and the Wayanad District Disaster Management Authority (DDMA). It outlined the extent of damage and identified priority actions. The PDNA estimated a requirement of Rs. 2,219 crores for recovery and reconstruction, providing a structured roadmap for addressing both immediate and long-term needs.⁴³

⁴² Wayanad Landslides - July 2024

⁴³ Press Release - PIB

The PDNA provided actionable insights into geographical vulnerabilities and needs assessment for affected families. To data-driven decision-making, a micro-planning survey by Kudumbashree was also undertaken to assess the needs of 4,658 individuals. This was to highlight the alignment of PDNA findings with the rehabilitation plan (e.g., sustainable townships, livelihood restoration).

The Kerala government initiated a comprehensive recovery plan, led by the Kerala State Disaster Management Authority (KSDMA) to rehabilitate the affected families. Key activities included surveys to demarcate safe and unsafe zones, consultations with affected communities, and the formulation of a comprehensive rehabilitation plan. This ambitious project, estimated at Rs. 750 crore, involves developing a modern township over nearly 107 hectares of land across two estates in Kottapadi and Kalpetta villages.⁴⁴

The township will provide 1,000 sq. ft. houses for displaced families, along with essential infrastructure like recreational facilities, markets, health centers, schools, Anganwadis, playgrounds, electricity, sanitation, and drinking water facilities. Each family will receive land parcels of either five or ten cents based on location. The state also plans to repurpose landslide-affected areas for productive activities, such as collective farming, to ensure sustainability and prevent reforestation without utility.

The Wayanad Reconstruction Committee, chaired by the Chief Minister, oversees this project, ensuring a participatory approach to recovery. The project reflects Kerala's commitment to building back better while addressing long-term resilience through sustainable development and community welfare.

Key Recovery Efforts

The Kerala government's recovery efforts following the devastating Wayanad landslides of July 2024 showcase a commitment to building back better while ensuring sustainability and inclusivity. The recovery plan, which aims to rehabilitate displaced families and restore livelihoods, is rooted in a multi-sectoral approach, integrating housing, infrastructure, and livelihood restoration initiatives.

A key element of the plan is the **development of two sustainable townships**. These townships, located in Nedumbala and Kalpetta, will encompass essential community infrastructure, including health centers, schools, Anganwadis, playgrounds, and markets, designed to create holistic living environments. Each displaced family will receive either 5 cents of land in Kalpetta or 10 cents in Nedumbala, based on land valuation, along with a 1,000 sq. ft. house designed to suit the topography and slope of the hilly terrain. The design incorporates geological safety considerations to prevent future disasters.

The government also prioritized livelihood restoration through a micro-plan survey conducted by Kudumbashree, which assessed the needs and preferences of 4,658 individuals from the affected areas. Key sectors identified for livelihood support included agriculture, animal husbandry, and micro-enterprises. With 192 individuals opting for agriculture and 1,034 for micro-enterprises, the government is exploring avenues to establish production units and factories to generate employment opportunities for survivors. These initiatives aim to provide economic stability to the affected families while fostering resilience.

Additionally, land use optimization has been a focal point of recovery efforts. The landslide-affected areas, demarcated as "no-go zones," are being repurposed for collective farming to ensure productive use of the land.

⁴⁴ Rs 750 crore township project unveiled for rehabilitation of Wayanad landslides victims

This approach not only mitigates risks of further habitation in hazardous areas but also supports sustainable livelihoods for the community.

Kerala's approach to recovery reflects a robust and integrated model, emphasizing not just physical rehabilitation but also economic and social resilience. While challenges remain, the recovery efforts provide valuable insights and set a benchmark for disaster recovery frameworks across the country.

Challenges Faced

While the Wayanad landslide was promptly recognized as an event of “severe nature” by the Central Government, and an Inter-Ministerial Central Team (IMCT) was deployed within days to assess the damage, delays in securing additional recovery funds were influenced by procedural requirements. The State Government's request for Rs. 214.68 crore under the National Disaster Response Fund (NDRF) was partially approved, with Rs. 153.47 crore sanctioned, contingent on SDRF adjustments.

Additionally, while the Post-Disaster Needs Assessment (PDNA) conducted by the Kerala Government estimated recovery costs at Rs. 2,219 crore, the Central Government's follow-up processes, including the review by a multi-sectoral team, are ongoing. This demonstrates the complexity and procedural timelines involved in large-scale recovery funding and coordination, which can create delays in translating needs into actionable support on the ground.

The recovery process in Wayanad following the 2024 landslides faced several challenges that underscored the complexities of post-disaster rehabilitation in vulnerable regions. While the Kerala government initiated a robust recovery plan, the transition from immediate relief to sustainable rebuilding was not without hurdles.

Financial Constraints and Limited Interim Support

Families displaced by the landslides were provided financial assistance capped at ₹300 per person per day for two family members. While this support was crucial for immediate relief, many survivors found it inadequate to cover rising rental costs in a competitive housing market. This financial limitation placed a significant strain on families attempting to secure affordable housing near workplaces or schools, further complicating their recovery journey. Many affected families voiced the need for extended interim financial support to bridge the gap until the townships were completed.

Delays in Land Acquisition

Although the Kerala High Court expedited land acquisition for the two proposed townships, logistical and bureaucratic hurdles delayed the process. These delays affected the overall timeline for township development and created uncertainty for displaced families awaiting permanent rehabilitation.

Transparency in Beneficiary Selection

A significant concern among survivors was the lack of clarity in the demarcation of “go” and “no-go zones.” The process, which classified homes within 30 to 50 meters of the landslide-affected area as unsafe, led to dissatisfaction among residents whose homes were excluded despite evident damage. This perceived lack of transparency in defining eligibility criteria created mistrust among affected populations and raised questions about the fairness of the selection process.

Community Resistance to the Township Model

While the township model aimed to provide holistic rehabilitation, some families preferred receiving direct

compensation to purchase land and construct homes tailored to their needs. In Kalpetta, residents called for an increase in land allocation from 5 cents to 10 cents, arguing that the smaller plots would not provide sufficient space for future expansion. This resistance highlighted the importance of aligning recovery strategies with community preferences and cultural contexts.

Livelihood Restoration Challenges

Although the Kudumbashree micro-plan survey identified livelihood preferences and mapped diverse economic needs, implementing tailored programs proved to be a logistical challenge. Sectors such as agriculture, animal husbandry, and micro-enterprises required substantial planning and investment to ensure long-term viability. Vulnerable groups, including elderly residents and women-headed households, particularly emphasized the need for inclusive and accessible livelihood opportunities, which were sometimes overlooked in the broader recovery framework.

Coordination and Implementation Delays:

The recovery process involved multiple stakeholders, including government agencies, contractors, and NGOs. While this multi-stakeholder approach was essential for comprehensive recovery, it also introduced complexities in resource allocation and decision-making. Coordination challenges occasionally delayed implementation, underscoring the need for streamlined processes and clearer communication channels among all involved parties.

These challenges illustrate the multifaceted nature of disaster recovery, where financial, social, and institutional factors intersect. Addressing these gaps in future recovery efforts will require a combination of proactive planning, inclusive community engagement, and adaptive implementation strategies to ensure that rehabilitation efforts are both timely and effective.

Key Learnings

The recovery process in Wayanad after the devastating landslides of 2024 offer valuable lessons that can guide future disaster recovery efforts. One of the most significant takeaways is the value of an integrated rehabilitation model that holistically addresses housing, infrastructure, and livelihoods. This approach emphasized not only providing shelter but also creating an enabling environment for affected communities to rebuild their lives, fostering resilience and sustainability in the process.

Another crucial learning is the importance of **community involvement**. Engaging local communities in planning and decision-making ensured that recovery initiatives were inclusive and aligned with the needs and preferences of those directly impacted. This participatory approach helped address community concerns and build trust, which is critical for the success of long-term recovery efforts.

The use of **innovative approaches**, such as drone surveys for land identification and micro-planning surveys conducted by Kudumbashree, underscore the role of technology in disaster recovery. These tools facilitate precise planning, enabling authorities to identify suitable land for townships and tailor livelihood programs to the specific needs of affected individuals.

The recovery process also highlighted the need for proactive **planning and coordination**. While central support was timely, delays in fund mobilization due to procedural complexities underscore the importance of streamlining financial mechanisms. Simplifying approval processes and accelerating fund allocation can help reduce delays, ensuring that recovery efforts are more effective and timely in the future.

Finally, the Wayanad recovery effort emphasized a strong **focus on sustainability**. The plan to repurpose disaster-affected lands for collective farming demonstrates the importance of integrating environmental sustainability into recovery initiatives. This approach not only addresses the immediate needs of the community but also ensures the long-term utility and resilience of the region's resources.

These lessons reflect the complexity of disaster recovery and the need for innovative, inclusive, and sustainable approaches to ensure that communities can rebuild stronger and more resilient to future challenges.

Case 2: Joshimath Landslide and Subsidence Crisis

An Overview:

The land subsidence crisis in Joshimath, Uttarakhand, beginning in January 2023, resulted in large-scale displacement. The central government allocated Rs. 1,640 crores under the 'Recovery of Reconstruction' scheme to support rehabilitation efforts.

One of the primary challenges in Joshimath's recovery has been the town's geological vulnerabilities. The Mishra Committee Report (1976) had already identified Joshimath as an ancient landslide zone, necessitating careful planning for reconstruction. The recovery process has included large-scale resettlement efforts, civic infrastructure restoration, and the establishment of early warning systems to monitor ground movement.

Despite these efforts, delays in fund utilization and inadequate community participation have hindered progress. Recovery efforts must integrate long-term urban planning strategies that incorporate risk assessments and eco-friendly construction practices.

Joshimath, a historic town in Uttarakhand, faced a severe crisis of land subsidence beginning January 2, 2023. The situation escalated quickly, with cracks appearing in numerous houses and civil structures, displacing over 1,000 residents and prompting large-scale evacuations. The case study explores the progress made in recovery efforts, highlighting key measures taken, challenges encountered, and the role of various stakeholders in addressing this disaster.

Key Developments and Initiatives:

Central Government Support

The central government has allocated a substantial relief package of Rs 1,640 crores under the 'Recovery of Reconstruction' scheme. This allocation aims to address the immediate and long-term rehabilitation needs of the affected population. The announcement was well-received, with local leaders, including the Chief Minister of Uttarakhand, emphasizing the urgency of accelerating the recovery process.⁴⁵

Sector-wise Recovery Efforts

Housing and Resettlement

Housing and resettlement have been a central focus of recovery efforts. A total of 355 families were relocated to temporary accommodations, including hotels and homes of relatives. Plans for permanent resettlement are underway, exploring retrofitting options for moderately damaged buildings. Lightweight prefabricated structures have been identified as suitable solutions for essential public buildings like schools and healthcare centers, ensuring quick and durable recovery of critical services.

Civic Amenities and Infrastructure

The restoration of civic amenities and infrastructure has been another priority. Efforts have focused on rebuilding

⁴⁵ <https://www.newindianexpress.com/nation/2025/Jan/15/central-government-allocates-rs-1640-crores-for-rehabilitation-of-joshimath>

roads and bridges to reduce pressure on the subsidence-prone areas of the town. A key development is the proposed reconstruction of the Helang-Marwari Bypass, which is expected to alleviate traffic congestion and improve connectivity.

Water and Drainage Management

To address one of the primary causes of land subsidence, water and drainage management measures are being implemented. Comprehensive studies of the town's drainage systems are being conducted to reduce water ingress into the ground. These studies have led to plans for lined drains and enhanced water channelization, which are critical for minimizing future risks and stabilizing the area.

Disaster Risk Reduction (DRR)

In terms of disaster risk reduction (DRR), significant steps are being taken to establish long-term monitoring mechanisms. Ground control points and total station monitoring systems are being installed to detect land movement in real-time. Recommendations for a ground-based early warning system are also being considered to ensure timely alerts and preparedness.

Waste Management

The management of waste and debris resulting from the disaster has adhered to environmental standards. Demolished structures are being dismantled and segregated in compliance with MOEF&CC Construction and Demolition Rules (2016) and CPCB guidelines (2017). Recycling initiatives are being promoted to repurpose debris, contributing to sustainable recovery practices.

Stakeholder Engagement

Stakeholder engagement has been vital in ensuring the inclusivity and efficiency of recovery efforts. The Municipal Chairperson has been given a pivotal role in redevelopment plans, promoting local leadership in decision-making. Collaborative efforts involving the National Disaster Management Authority (NDMA), United Nations agencies, and local institutions have provided technical and logistical support, strengthening recovery initiatives. Additionally, the Joshimath Bachao Sangharsh Samiti has played a key role in advocating for sustainable recovery practices and holding authorities accountable.

The Joshimath crisis underscores the importance of a multi-faceted approach to disaster recovery that combines government intervention, community engagement, and sustainable practices. The integration of technological solutions, such as monitoring systems, alongside traditional knowledge and local participation, highlights the potential for building resilience in the face of complex disasters.

Strategic Infrastructure Projects

The Helang-Marwari Bypass, bypassing the unstable Joshimath area, has been expedited. This project not only addresses the town's strategic and logistical needs but also aims to mitigate further risks of land subsidence by diverting traffic away from vulnerable zones.

Challenges and Mitigation Strategies

The recovery process in Joshimath has faced several challenges, underscoring the complexity of addressing a disaster in a region with unique geological vulnerabilities and socio-economic constraints. Delays in fund utilization have been a significant hurdle, as procedural bottlenecks in mobilizing allocated resources slowed the pace of recovery. While the central government announced a relief package of ₹1,640 crores, ensuring timely disbursement and use of these funds has proven difficult. This highlights the pressing need to streamline approval and allocation mechanisms, enabling quicker and more effective action in post-disaster scenarios.

Geological vulnerabilities further complicate the recovery efforts. Joshimath's location on an ancient landslide zone, as documented in the Mishra Committee Report of 1976, poses inherent risks to redevelopment. The region's unstable terrain demands comprehensive geological assessments to guide sustainable rebuilding strategies. Such assessments are vital to ensure that new structures and infrastructure are resilient to future subsidence and other geological risks.

Another critical challenge has been ensuring meaningful community participation in recovery planning and implementation. Engaging local communities in decision-making processes is crucial to the success and sustainability of rehabilitation efforts. However, logistical and communication gaps have sometimes hindered effective collaboration with residents. Building trust and ensuring transparency in recovery initiatives are necessary steps to address this issue.

Long-term urban planning also remains a key focus area for mitigating future risks. Joshimath's recovery offers an opportunity to incorporate risk assessments into urban planning strategies. Prioritizing eco-friendly construction practices, regulating land use in high-risk areas, and integrating early warning systems into city planning can help prevent the recurrence of similar crises. Sustainable urban planning will not only reduce vulnerabilities but also promote resilience in the face of evolving climatic and geological challenges.

Outcomes and Way Forward

The rehabilitation efforts in Joshimath mark a significant step towards addressing long-standing issues of land subsidence. However, sustained focus on the following is essential:

- Accelerating fund disbursement and infrastructure projects.
- Strengthening local governance and community engagement.
- Implementing long-term DRR strategies, including early warning systems and continuous monitoring.
- Promoting research and innovation to address underlying geological challenges.

The Joshimath case underscores the importance of proactive planning, collaborative efforts, and resilient recovery frameworks to safeguard vulnerable communities and build back better.

Case 3: Riverbank erosion in Murshidabad, West Bengal

An overview:

Riverbank erosion in Murshidabad has been a persistent challenge, leading to displacement and loss of livelihoods. The state government, with support from the central government, has initiated embankment reinforcement and anti-erosion measures.

A key intervention has been the use of boulder masonry works, sandbags, and vetiver plantation to stabilize eroding banks. Additionally, a Detailed Project Report (DPR) was prepared for anti-erosion measures along the Ganga-Padma stretch.

Despite these efforts, challenges persist, particularly in land allocation for displaced families and delays in funding approvals from the central government. The case underscores the need for proactive erosion management strategies rather than reactive recovery approaches.

In response to the persistent issue of riverbank erosion in Malda and Murshidabad districts of West Bengal, both the state and central governments have implemented several measures to address the issue and support affected communities.

The Government of West Bengal has taken several measures to recover from riverbank erosion in Murshidabad district, including providing relief materials, repairing breached embankments, and allocating land to displaced families.

Government Recognition & National-Level Support:

The erosion problems in Malda and Murshidabad have now been recognized as issues of national dimension, following continuous advocacy by the stakeholders including the state government. This highlights a shift from localized efforts to larger-scale intervention, ensuring better financial and technical support.⁴⁶

Anti River Bank Erosion Schemes and works executed by the state's Irrigation & Waterways Department under the 10th and 11th Finance Commission have provided critical support for erosion control in downstream areas of Farakka Barrage, a region highly vulnerable to land loss.

Embankment Repair and Anti-Erosion Measures:

The Irrigation Department conducts regular surveys to identify and repair breached embankments. In 2023, the West Bengal government allocated ₹100 crore for a ten-year plan aimed at preventing erosion in vulnerable blocks of Malda and Murshidabad districts⁴⁷. Immediate interventions have included the use of sandbags and bamboo to reinforce riverbanks, while long-term strategies involve the construction of retired embankments and boulder masonry works with falling aprons.



Figure 42 : Anti river bank erosion Schemes

Land allocation

Recognizing the displacement caused by erosion, the District Administration has allocated land to some affected families, although the process remains slow and inconsistent due to high population density and limited land availability have constrained the extent of this support.

Financial and Livelihood Assistance

For displaced families, the government aims to integrate erosion-affected communities into small-scale agriculture, pisciculture, and other income-generating activities under the Nodi Bandhan initiative.

⁴⁶ Anti River Bank Erosion schemes, Govt of West Bengal

⁴⁷ Bengal draws a plan to stop Ganga erosion in Malda and Murshidabad

Anti-erosion measures

The government has taken initiatives to prevent bank erosion in the Ganges and Fulhar rivers. The government has also prepared a Detailed Project Report (DPR) for anti-erosion measures in the Ganga-Padma stretch.

Anti River Bank erosion schemes

The Government of West Bengal has undertaken multiple measures to address the long-standing issue of riverbank erosion in Murshidabad, implementing both short-term relief and long-term mitigation strategies. These efforts have evolved through expert recommendations, state and central funding, and infrastructure interventions aimed at protecting vulnerable communities along the Ganga-Padma riverbanks.

One of the most significant developments in this process has been the official recognition of Murshidabad’s erosion problem as a national concern. Following persistent appeals by the state government, the severity of erosion in Murshidabad and Malda was acknowledged by the central government, leading to greater financial and technical assistance. Several expert committees were tasked with studying the problem, including the Pritam Singh Committee, Keskar Committee (Planning Commission), and G.N. Murthy Committee, each of which provided recommendations for priority interventions.

Based on these assessments, the Irrigation and Waterways Department initiated a series of targeted recovery measures. One of the primary focuses has been embankment reconstruction and reinforcement, particularly in regions where repeated flooding has led to extensive land loss. Over the past 25 years, the department has implemented numerous anti-erosion projects across North Bengal, including Murshidabad, using techniques such as boulder masonry works with falling aprons to stabilize embankments against further erosion.

In addition to embankment strengthening, specific high-risk areas like Akherigunj and Jalangi have been prioritized for intervention. The protection works in Jalangi have already shown positive results, demonstrating the effectiveness of implemented erosion control measures, while projects in Akherigunj remain in progress with top priority status. Meanwhile, continuous land surveys and flood assessments have guided the reconstruction of retired embankments, ensuring that vulnerable areas receive necessary protection from future river shifts and flooding.

To further strengthen its erosion management strategy, the state government has prepared a Detailed Project Report (DPR) on anti-erosion measures for the Ganga-Padma stretch, outlining long-term solutions such as vegetative reinforcement and bioengineering techniques. The use of sandbags, bamboo reinforcements, and vetiver plantations along vulnerable banks is being explored as part of a more sustainable and cost-effective approach to erosion control.

Recent Recovery Efforts

Nodi Bandhan Scheme: Integrating River Systems for Livelihood and Erosion Control⁴⁸. Recognizing the urgent need for a coordinated response, the West Bengal government launched the Nodi Bandhan scheme in February 2025 as part of the state budget. The scheme aims to interconnect small rivers, wetlands, and major river basins, providing natural flood control measures while also enhancing livelihood opportunities in riverine areas. The initiative seeks to integrate hydrological models and pilot interventions to develop nature-based solutions to prevent riverbank erosion.

⁴⁸ West Bengal government launches new scheme for rivers, funds to check erosion

To support these efforts, the state government has allocated ₹200 crore in the 2025-26 budget for erosion control in Murshidabad and Malda districts, two of the most severely affected regions. The plan includes a multi-pronged approach combining infrastructure projects, ecological interventions, and community-based livelihood programs.

Additionally, a Centrally Sponsored (CS) scheme under the Union government provides technical support and funding for critical anti-erosion interventions in the Ganga-Padma stretch.

Challenges and Gaps in Recovery

Despite these measures, significant challenges remain in Murshidabad's recovery process:

- i. **Delayed Implementation of Long-Term Plans:** While the ₹200 crore allocation marks a significant step forward, past recovery programs have often suffered from delayed execution due to bureaucratic and financial constraints.
- ii. **Inconsistent Support for Displaced Communities:** Many families continue to live in temporary shelters or face landlessness, as rehabilitation and compensation programs remain incomplete.
- iii. **Climate and Environmental Risks:** The Ganga-Padma's shifting course continues to erode farmlands and displace populations, necessitating continuous adaptation and monitoring.

Key Learnings from the Recovery Efforts

The Murshidabad case underscores the need for:

A holistic approach combining disaster risk reduction and livelihood restoration to ensure sustainable recovery.

Timely execution of allocated budgets and master plans to prevent delays in erosion control projects.

Adoption of nature-based solutions, such as those outlined in Nodi Bandhan, which integrate hydrological modeling and ecological interventions for long-term resilience.

With the new state initiatives in place, Murshidabad's recovery efforts have gained momentum, but sustained action and stronger implementation frameworks will be essential to achieve lasting resilience for affected communities.

Despite these ongoing efforts, challenges persist in the timely execution of recovery plans. Much of the funding for these initiatives is contingent upon central government approvals, leading to delays in implementation. Additionally, while some regions have benefited from embankment reinforcement, others continue to experience land loss at an alarming rate, highlighting the need for proactive intervention rather than reactive recovery.

As the government continues to scale up its efforts, the success of these recovery measures will depend on sustained funding, improved coordination between state and central agencies, and the integration of local community knowledge into erosion management strategies. The experience of Murshidabad underscores the importance of long-term resilience planning, ensuring that affected communities are not only protected in the present but also safeguarded against future disasters.

Case 4: Sikkim GLOF

An Overview:

The catastrophic GLOF event from South Lhonak Lake in October 2023 caused widespread destruction in Sikkim. The central government allocated Rs. 150 crores under the National GLOF Risk Mitigation Programme to address high-risk glacial lakes and infrastructure damage.

The state government established a High-Level Steering Committee (HLSC) and a Multi-disciplinary Task Force (MTF) to coordinate recovery efforts. Monitoring and early warning systems were enhanced with support from the Sikkim Remote Sensing Centre and the Sikkim Climate Change Cell.

Despite these advancements, challenges included inadequate early warning mechanisms, delays in fund mobilization, and skepticism from affected communities regarding institutional recovery efforts.

On October 3-4, 2023, Sikkim experienced a catastrophic Glacial Lake Outburst Flood (GLOF) originating from South Lhonak Lake. This disaster wreaked havoc downstream, devastating lives, property, and infrastructure. Recognized as one of the most severe climate-induced disasters in recent history, it highlighted vulnerabilities unique to the Himalayan region and underscored the urgent need for effective disaster preparedness and recovery mechanisms.

The National Disaster Management Plan 2019 had already categorized GLOFs as a priority hazard for the Indian Himalayan Region (IHR), but the 2023 event reinforced the urgency of implementing state-specific disaster mitigation strategies.

Key Recovery Efforts:

Following the devastating GLOF in the Teesta River basin in October 2023, recovery efforts were spearheaded by both central and state governments, focusing on understanding the disaster, mitigating future risks, and rebuilding infrastructure and community resilience. Central to this initiative was the formation of dedicated committees to drive planning and execution.⁴⁹

A high-level central committee, chaired by the ex-chairman of the Central Water Commission, was established to investigate the causes of the GLOF and assess vulnerabilities in the Teesta basin. This committee was tasked with reviewing the performance of early warning systems, evaluating dam operations during the disaster, and providing actionable recommendations to prevent future events. At the state level, the High-Level Steering Committee (HLSC) and the Multidisciplinary Task Force (MTF) were constituted by the Sikkim government. These bodies coordinated efforts with defense establishments, paramilitary forces, and central agencies to formulate glacial flood mitigation plans and regularly monitor high-risk areas. The committees also engaged subject matter experts to develop region-specific strategies and facilitate collaborative action.

Recognizing the financial and technical challenges posed by such an unprecedented disaster, the central government allocated ₹150 crore under the National GLOF Risk Mitigation Programme. This funding was directed toward mitigating risks from 189 high-risk glacial lakes across the Indian Himalayan Region (IHR). Technical support for monitoring these lakes was bolstered by the Sikkim Remote Sensing Centre and the Sikkim Climate Change Cell, which played a pivotal role in identifying vulnerabilities and providing real-time data for disaster management.

⁴⁹ GLACIAL LAKE OUTBURST FLOODS (GLOF) *The ticking water bombs in the Himalayas*

Infrastructure recovery included assessing and repairing damaged hydropower projects, such as the Teesta-III dam, which bore the brunt of the flood's destructive force. Urban disaster management plans were also initiated to address vulnerabilities in towns and cities along the Teesta River basin. Alongside structural recovery, there was a strong emphasis on building community resilience. Training programs were rolled out to equip local communities with early warning knowledge and response strategies. Additionally, capacity-building efforts focused on involving Panchayati Raj Institutions (PRIs) in monitoring glacial lakes and preparing for future GLOFs, integrating indigenous knowledge into scientific disaster management practices.

Challenges Faced:

However, the recovery process was not without challenges. Despite advisories issued by the Central Water Commission as early as 2015, early warning systems in the Teesta basin proved inadequate during the crisis. Coordination gaps between state and central agencies, as well as private dam operators, exacerbated the delays in response and recovery. Bureaucratic inefficiencies further slowed the mobilization of funds and the completion of critical assessments. Compounding these systemic issues, affected communities expressed skepticism toward institutional recovery efforts, citing inconsistent compensation measures and delayed communication as primary concerns.

Key Learnings:

Despite these challenges, key learnings have emerged from the disaster. The use of advanced technologies, such as remote sensing and real-time monitoring, has been underscored as critical for early warning and mitigation. Seamless coordination among stakeholders—including state, central, and local authorities, as well as private developers—is essential for effective disaster response and recovery. Furthermore, the involvement of local communities in preparedness and monitoring efforts enhances inclusivity and resilience. Legislative measures, such as the Disaster Management (Amendment) Bill 2024, demonstrate the increasing recognition of the need for robust policies to address climate-induced risks.

In conclusion, the Sikkim GLOF recovery efforts highlight the importance of a multi-faceted approach that integrates technological innovation, community participation, and policy reform to ensure sustainable disaster resilience. The lessons learned from this disaster serve as a roadmap for addressing future challenges posed by climate-induced events in the Indian Himalayan Region.

4.2. Gaps and Challenges

India faces recurring and diverse disasters each year, yet structured recovery frameworks remain limited. While some disasters—such as the Wayanad landslides and Sikkim GLOF—witness well-defined recovery plans, many others, including the Tripura floods and riverbank erosion in Murshidabad, lack clear post-disaster reconstruction strategies. This gap not only prolongs community vulnerabilities but also undermines efforts to build long-term resilience.

One of the primary challenges is the over-reliance on immediate relief efforts, rather than a structured transition to long-term recovery. In many cases, there is no formal mechanism to track progress beyond the initial relief phase. The absence of PDNA follow-ups further complicates recovery, leading to fragmented interventions that fail to address the full scale of damage.

i. Weak Institutional and Financial Mechanisms

Disaster recovery efforts are often delayed due to financial constraints, particularly the slow mobilization of funds from the central government and limited access to international financial aid. While central assistance is critical, bureaucratic hurdles in accessing recovery funds and complex procedural requirements slow down the implementation of much-needed interventions.

At the state level, most recovery initiatives are project-based rather than systemic, leading to short-term solutions rather than long-term resilience-building. The lack of dedicated funding streams for recovery planning and execution further limits the scope of recovery interventions.

ii. Land Acquisition and Infrastructure Challenges

Land acquisition remains a major bottleneck in the execution of recovery plans. Ownership disputes, environmental regulations, and administrative delays hinder the timely construction of resettlement projects, forcing displaced communities into prolonged displacement. For instance, in Joshimath, infrastructure planning has been delayed due to the complexities of securing geologically stable land, despite clear evidence of subsidence risks.

Similarly, the Murshidabad riverbank erosion crisis highlights long standing planning delays, where recovery interventions have been reactive rather than proactive, despite successive floods displacing thousands of people. Government-led embankment protection projects have not been systematically monitored, leading to repeated failures.

iii. Lack of Recovery Audits and Monitoring Mechanisms

A significant challenge in disaster recovery is the absence of standardized auditing mechanisms to track recovery implementation. Unlike disaster risk reduction (DRR) strategies, which are widely documented in global frameworks like IPCC reports, India lacks a uniform methodology to measure recovery progress.

The failure to conduct regular audits leads to inconsistencies in PDNA data, discrepancies in reported damages, and delays in resource allocation. In Tripura, for example, flood recovery progress remains undocumented, with no systematic tracking of rehabilitation programs for affected families.

iv. Fragmented Coordination Between Agencies

While disaster response coordination is often robust—driven by inter-agency collaboration—the same level of cooperation diminishes during the recovery phase. As relief efforts subside, recovery initiatives become fragmented across different ministries, local authorities, and humanitarian agencies, leading to gaps in execution.

One example is the lack of integration between government employment programs (like MGNREGA) and disaster-affected communities. Recovery plans often fail to incorporate livelihood restoration as a core component, prolonging economic instability for displaced populations. Similarly, rehabilitation programs in Wayanad have faced resistance from affected communities, who prefer direct compensation over government-led resettlement projects.

v. Limited Use of AI and Digital Tools in Recovery

While technology plays a crucial role in early warning systems, its application in post-disaster recovery remains underutilized. The use of AI-driven damage assessments, satellite imagery, and geospatial analysis could significantly improve real-time tracking of recovery interventions.

For example, integrating AI-based damage monitoring into PDNAs could help in reducing delays in funding approvals by providing objective, real-time evidence of losses. Similarly, a centralized digital database could enhance transparency in fund allocation and help standardize PDNA methodologies across different states.

One of the most critical gaps in disaster recovery is the lack of structured implementation and progress tracking mechanisms. Despite numerous disasters each year, only a handful receive structured recovery plans, and fewer still have documented progress updates.

4.3. Innovations in Recovery

While disaster recovery efforts in India continue to face structural challenges, 2024 witnessed several notable innovations in recovery planning and implementation across different states. These innovations span technology-driven approaches, community-led initiatives, and policy advancements, contributing to more efficient, sustainable, and inclusive recovery models.

i. AI-Driven Flood Damage Assessment in Sikkim

Following the Sikkim GLOF disaster (October 2023 - ongoing recovery in 2024)⁵⁰ AI-powered satellite imagery was used to assess flood damage in inaccessible areas. The use of remote sensing technology, supported by ISRO and state disaster authorities, helped in mapping landslides, infrastructure damage, and displaced communities, which in turn guided rehabilitation planning and land allocation for affected families.

Additionally, glacial lake monitoring systems were enhanced with AI-driven modeling to predict potential future outbursts. This was part of the national effort to strengthen disaster risk reduction (DRR) in glacial regions, linking early warning systems with long-term recovery planning.⁵¹

ii. Kudumbashree's Micro-Planning for Livelihood Restoration in Wayanad

Kerala's recovery from the Wayanad landslides (July 2024) saw an innovative community-driven approach through Kudumbashree, a state-run women's cooperative network. Kudumbashree conducted micro-planning surveys, collecting data on 4,658 affected individuals to map their livelihood needs.⁵²

- As a direct result of this, livelihood interventions such as:
- Collective farming initiatives in disaster-affected regions.
- Skill-building programs for displaced families.
- Linking affected individuals to MSME (Micro, Small & Medium Enterprises) programs for sustainable employment.

The township rehabilitation plan in Wayanad also integrates community feedback collected through Kudumbashree's participatory planning methods, ensuring affected populations have a say in their own recovery process.

iii. Nature-Based Erosion Control and Anti-Flood Measures in Murshidabad

The Nodi Bandhan initiative, launched by the West Bengal government in early 2025, introduced a nature-based recovery approach to address riverbank erosion in Murshidabad. This program integrates⁵³ :

- Vetiver plantations to stabilize riverbanks.
- Eco-friendly embankment reinforcement using bamboo and geo-textiles.
- Hydrological modeling to guide embankment repairs based on erosion risk assessment.

The program is one of the first structured post-disaster recovery plans in the region, addressing both short-term resettlement needs and long-term resilience-building.

⁵⁰ Retrospective Analysis of Glacial Lake Outburst Flood (GLOF) Using AI Earth InSAR and Optical Images: A Case Study of South Lhonak Lake, Sikkim

⁵¹ Sikkim PDNA 2023 - GLOF

⁵² Wayanad Micro Plan Inaugurated | Local Self Government Department?

⁵³ Mamata Banerjee government launches new scheme for rivers, funds to check erosion - Telegraph India?

iv. Media as a Key Stakeholder in Recovery Coordination

The role of media in tracking and reporting recovery progress has gained traction in 2024, particularly in regions like Joshimath (Uttarakhand) and Tripura (flood recovery). Several initiatives have emerged to:

- Train journalists in disaster recovery reporting to provide accurate and timely updates.
- Use crowdsourced data and citizen reporting platforms to track relief distribution and reconstruction efforts.
- Expose recovery gaps where commitments have not translated into action, ensuring public accountability.

For example, in Joshimath, national and local media⁵⁴ scrutiny highlighted delays in housing reconstruction, pushing the state government to accelerate rehabilitation efforts and release additional funds.

v. AI-Enabled Risk Mapping and Digital Twin Technology in Joshimath

Joshimath, which suffered land subsidence in early 2023, saw continued recovery efforts in 2024, with a focus on geospatial risk mapping and land stability assessment⁵⁵. The Uttarakhand government, in collaboration with IIT Roorkee, developed a digital twin model of Joshimath, using AI to:

- Simulate safe zones for rebuilding efforts.
- Monitor ground movement in real-time to prevent further collapses.
- Guide structural reinforcement of affected buildings.

This data-driven approach has improved urban planning decisions, preventing unscientific reconstruction and ensuring a safer long-term resettlement strategy.

4.4. Recommendations for Strengthening Recovery

To ensure more effective and resilient disaster recovery in India, the following recommendations are proposed based on lessons from 2024 disasters and insights from the study:

Institutionalizing Post-Disaster Needs Assessments (PDNAs) and Recovery Frameworks

Despite the occurrence of multiple disasters in 2024, only a few had structured recovery plans. Establishing a mandatory framework for conducting PDNAs and ensuring their integration into recovery planning at the national and state levels is crucial. This will provide a standardized methodology for assessing damages, estimating recovery costs, and guiding resource allocation.

Strengthening Financial Mechanisms for Recovery

Many recovery efforts faced delays due to dependency on central funding and slow disbursement of relief assistance. Establishing dedicated state-level disaster recovery funds, with pre-approved allocations for immediate rehabilitation, can help address financial bottlenecks. Additionally, leveraging international climate finance and donor-supported recovery programs can enhance funding availability for long-term resilience-building.

⁵⁴ Joshimath's economy wanes as tourists dwindle

⁵⁵ Joshimath land subsidence: CBRI identifies 14 high-risk zones - The Economic Times

Enhancing Multi-Stakeholder Collaboration

Recovery processes must involve coordinated action between government agencies, humanitarian organizations, private sector actors, and academic institutions. Creating regional recovery task forces that integrate various stakeholders—including NGOs, technical experts, and local governance bodies—can streamline implementation and oversight.

Integrating Livelihood Restoration into Recovery Efforts

Livelihood restoration remains one of the most critical yet under-addressed aspects of recovery. Linking recovery initiatives with government employment schemes such as MGNREGA can provide economic stability to disaster-affected communities. Programs that support skill development and micro-enterprise rebuilding should be prioritized in recovery planning.

Incorporating AI and Digital Technologies for Recovery Monitoring

The use of AI and digital tools, such as geospatial risk mapping, predictive analytics, and drone-based damage assessments, has proven beneficial in disasters like the Joshimath land subsidence. Expanding the use of these technologies in other disaster-prone areas can improve recovery monitoring, track progress, and enhance early warning systems.

Establishing Recovery Audits for Transparency and Accountability

A major gap in current recovery efforts is the absence of structured implementation tracking. Introducing mandatory recovery audits—conducted by independent agencies—can ensure that allocated funds are used efficiently, recovery goals are met, and communities receive the support they need. Transparent reporting mechanisms should be established to track recovery progress and share updates with the public.

Prioritizing Nature-Based Solutions for Disaster Recovery

The integration of nature-based solutions (NbS), such as riverbank stabilization through vegetative cover in Murshidabad or afforestation initiatives for landslide-prone regions, has demonstrated effectiveness. Expanding these approaches in future recovery programs will enhance resilience while maintaining ecological balance.

Strengthening Media Engagement for Recovery Advocacy

Media plays a crucial role in highlighting gaps, mobilizing resources, and holding authorities accountable. Training journalists on responsible disaster reporting and encouraging investigative coverage of recovery efforts can ensure greater transparency and responsiveness from decision-makers.

Addressing Climate Change Impacts in Recovery Planning

With shifting climate patterns exacerbating disaster risks—such as reduced snowfall affecting water availability and increasing glacial melt—recovery planning must incorporate climate projections. Developing long-term Climate Adaptation Plans at the state and district levels will help ensure disaster recovery efforts build resilience against future climate-related challenges.

Capacity Building for Local Institutions and Communities

Strengthening disaster preparedness at the local level is essential for sustainable recovery. Regular training programs for Panchayati Raj Institutions, district disaster management authorities, and community-based organizations can empower them to take proactive roles in recovery and resilience-building efforts.

By implementing these recommendations, India's disaster recovery framework can evolve from reactive relief measures to a more structured and resilient system, ensuring that affected communities not only recover but emerge stronger and more prepared for future disasters.



National consultation meeting

Lessons and

Chapter

5

Recommendations

The increasing scale, complexity, and frequency of disasters across India during 2023–2024 have underscored the urgent need for systemic improvements in disaster risk governance, resilience planning, and recovery implementation. Drawing from cross-sectoral case studies, institutional experiences, and field-level observations documented in earlier chapters, this chapter synthesizes critical lessons that emerged across preparedness, response, resilience, and recovery phases. These insights are not only meant to inform future interventions but also to support more adaptive and accountable disaster management systems. The recommendations came from the experience in 2024 disasters, provided here aim to strengthen policy frameworks, enhance community-level capacities, bridge institutional and technological gaps, and promote evidence-based planning to ensure that recovery processes are inclusive, timely, and sustainable.

Actionable Recommendations for Strengthening Disaster Risk Reduction and Recovery

- Institutionalize Post-Disaster Needs Assessments (PDNAs) as mandatory tools for planning, and establish pre-positioned state-level recovery funds to ensure timely, evidence-based, and decentralized recovery financing.
- Promote the formation of inclusive recovery task forces at state and regional levels that include government, NGOs, academia, and private actors to ensure coordinated implementation, oversight, and mutual accountability.
- Integrate livelihood restoration efforts with schemes like MGNREGA and NRLM, while also promoting micro-enterprise development and vocational training to support sustainable recovery in affected communities.
- Adopt AI tools, drones, geospatial mapping, and predictive analytics to monitor, assess, and implement recovery strategies effectively, taking inspiration from models like the Joshimath Digital Twin.
- Mandate independent and social audits of recovery programs with public reporting and grievance redressal mechanisms to strengthen trust, improve delivery, and ensure accountability in all phases of recovery.
- Expand the use of ecosystem-based interventions such as afforestation, mangrove buffers, and green embankments, supported by hydrological modeling and ecological risk assessments for long-term resilience.
- Strengthen the role of media by training journalists on ethical disaster reporting and risk communication, while promoting collaboration with community media for widespread awareness and feedback.
- Embed climate projections and adaptive practices into district and state-level recovery planning, using resilient materials, diversified crops, and local climate adaptation plans to future-proof recovery efforts.

- Enhance the capacity of Panchayati Raj Institutions, DDMAAs, and community-based organizations through regular training, simulations, and access to planning tools for localized, inclusive, and effective recovery.

5.1. Policy

The rapidly evolving risk pictured in India, fuelled by climate change, unplanned urbanization, and environmental degradation, demands strong and forward-thinking laws and regulations. Traditional response-oriented techniques have failed to address the increasing frequency, intensity, and unpredictability of disasters. To develop long-term resilience, policies must focus on proactive risk reduction, data-driven decision-making, and community-centered activities. The growing severity of disasters requires a paradigm shift in disaster governance. Moving from reactive to proactive risk reduction is critical for ensuring policies are inclusive, forward-thinking, and responsive to changing threats.

Aligning national and state policies with international frameworks like the Sendai Framework for Disaster Risk Reduction (SFDRR) and the Paris Agreement on Climate Change is an important step toward enhancing disaster governance. These frameworks emphasize the importance of predictive action, risk-informed development, and sustainability-focused planning. By incorporating these principles into national policies like the National Action Plan on Climate Change (NAPCC), State Disaster Management Plans (SDMPs), and the National Adaptation Fund for Climate Change (NAFCC), India can improve disaster preparedness, strengthen climate adaptation strategies, and reduce vulnerabilities across sectors. The Resilience Framework Agenda must prioritize regional and vulnerability-based planning, ensuring that disaster management policies reflect local risk assessments and address communities' unique needs. Events like the Wayanad landslides, which have various origins, underscore the importance of collaboration among stakeholders in disaster research and response planning. The integration of scientific research, local knowledge, and real-time data can help to make policies more flexible and inclusive.

Harnessing Data and Technology for Smarter Disaster Management

One of the most significant shortcomings in disaster management is a lack of primary data collection and scattered climate vulnerability mapping. Different agencies and institutions employ varying risk assessment methodologies, resulting in variations in disaster planning and decision-making. Policies require the standardization and unification of climate vulnerability data in order to provide a consistent approach to risk assessment. To fill data shortages, a volunteer network of student researchers and community organizations should be established to gather real-time disaster effect data. This initiative may result in quicker damage assessments, improved resource allocation, and more accurate disaster forecasts. AI and machine learning could enhance data-driven decision-making by improving risk prediction models, impact assessments, and early warning systems. Geospatial technologies, mobile early warning systems (EWS), and remote sensing tools must all be improved to deliver region-specific disaster notifications. Policies should encourage the use of low-cost, community-based technological solutions, ensuring that even vulnerable people with restricted access receive timely and useful data.

Building Back Better: Sustainable Recovery & Livelihoods

Along with reconstructing infrastructure, disaster recovery must place a high priority on livelihood security and economic resilience. Long-term healing depends on livelihood restoration, which is frequently disregarded. While vital infrastructure is being rebuilt, impacted populations can receive immediate income by being connected to job programs like MGNREGA. In order to promote climate-resilient agriculture, disaster-resistant construction, and alternative livelihoods, recovery initiatives should go beyond providing immediate aid and instead concentrate on skill development, vocational training, and financial availability. Support for women, marginalized groups, and informal workers must be guaranteed by social security programs like cash transfers and unemployment

insurance. Combining short-term jobs with long-term economic plans increases community resilience, promotes self-sufficiency, and lessens need for aid

Social Inclusion and Protection

In order to guarantee that underprivileged populations, such as women, children, the elderly, people with disabilities, and indigenous communities, have fair access to relief, rehabilitation, and recovery programs, disaster recovery must place a high priority on social inclusion. Since women frequently shoulder an imbalance of the burden during disasters, including difficulties in finding work, accessing healthcare, and making decisions, gender-sensitive recovery planning is crucial. Policies that encourage these groups' active involvement in recovery planning and resource distribution must be developed by governments. Governments should establish flexible social safety nets that go beyond short-term assistance in order to improve social protection. Long-term assistance for disaster-affected communities should be the goal of programs like direct cash transfers, food security programs, extended access to healthcare, and housing help.

Sustainable Land Use and Disaster Risk Reduction

Rebuilding after a disaster requires incorporating sustainable land use plans to lower the likelihood of reoccurring disasters like floods and landslides. Recovery plans in landslide-prone areas should promote afforestation and soil conservation to stabilize slopes, enforce strict zoning regulations, and prohibit uncontrolled hillside building. Eco-engineering solutions, such bio-shielding and stabilization of slopes techniques, must be incorporated into landslide mitigation initiatives in order to strengthen susceptible terrains. Wetland restoration, river basin management, and natural flood barriers should all be included in disaster recovery plans for flood-prone locations in order to increase resilience. To lower the risk of waterlogging, governments should enhance urban drainage systems and prohibit development into floodplains. Rainwater collection, urban green areas, and mangrove restoration are examples of nature-based solutions that can reduce flooding sustainably while fostering environmental preservation.

Climate Resilient Infrastructure

Climate resilience must be given top priority while rebuilding infrastructure to make sure that homes, public buildings, bridges, and roadways can survive severe weather incidents in the future. In post-disaster rehabilitation operations, it should be common practice to include earthquake-resistant structures, flood-resistant housing, cyclone-proof shelters, and resilient transportation networks. In building, using sustainable, locally sourced materials can lower environmental impact and increase cost-effectiveness. The design of major infrastructure projects, such roads, dams, and urban drainage systems, needs to take climate adaptation strategies into consideration. To lessen the effects of flooding and severe rains, governments should spend money on permeable pavements, green roofs, and intelligent stormwater management systems. Furthermore, recovery operations can be made more sustainable by including renewable energy solutions like small power plants and solar-powered infrastructure.

Climate Adaptation and Risk Mitigation Strategies

A major policy gap in disaster preparedness is the inability to detect changing climatic patterns, particularly decreased snowfall and winter precipitation, which are affecting water supply, agriculture, and risk of disasters in alpine and riverine regions. Policies must incorporate these changing tendencies into national and state disaster risk assessments to ensure that climate adaptation strategies cover both extreme and slow-onset occurrences. Infrastructure planning should include risk-sensitive construction methods, especially for mountain routes, flood-prone metropolitan areas, and coastal regions exposed to rising sea levels. For example, landslide mitigation measures should be required in highway construction projects, and road safety regulations should take into account environmental degradation hazards in mountainous areas. Furthermore, national policies should improve

long-term weather monitoring, seasonal risk forecasting, and integrated water resource management. Close collaboration among meteorological organizations, disaster management authorities, and local governments is required to guarantee that accurate climate estimates lead to disaster planning and response programs.

Aims to Close Knowledge Gaps for Stronger Resilience Strategies

Unlike risk assessments, which are widely documented in IPCC reports, recovery and resilience measuring frameworks are still in development. A structured technique for measuring resilience must be developed in order to track the progress of disaster risk reduction (DRR) efforts across time.

A 25-year research plan should be developed, concentrating on the following points:

- Developing resilience measuring methods to track annual improvement.
- Scenario-building for unanticipated disasters, given that prior data may not accurately forecast future climatic extremes.
- Improving disaster-related research access by combining data into an integrated information centre for policymakers, academics, and local governments.
- Greater collaboration with academic institutions, particularly public universities and centres of excellence, is essential for ensuring that scientific research informs policy and implementation.
- Policymakers must also aim to improve data transparency and accessibility, addressing current constraints in data exchange between agencies.

Building Capacity & Enhancing Media's Role in Disaster Resilience

The function of the media must be extended beyond disaster reporting in order to ensure proper disaster communication and public awareness. Media organizations must be taught as active participants in disaster planning and response, with journalists receiving specialized training in disaster literacy, climate reporting, and misinformation control. This can improve the quality of disaster-related news coverage while also increasing community preparation. Furthermore, digital platforms and artificial intelligence-powered technologies should be used for public disaster education. To deliver essential information to remote and underprivileged areas, YouTube-based training modules, multilingual AI tools, and digital storytelling platforms can all be harnessed.

Enhancing Governance & Multi-Stakeholder Collaboration

A multisectoral multistakeholder governance approach is required for implementing disaster resilience into national, state, and local policy. This requires Increased participation with CSR and humanitarian organizations to better coordinate with business sector donations with national resilience goals. Involvement of regional and local governance institutions ensures that disaster-affected communities and local government authorities are actively involved in resilience planning. Institutionalize state/regional engagements to ensure that disaster management policies take into consideration local realities and dangers.

By integrating scientific research, local knowledge, and multi-stakeholder engagement into disaster policy, India can move toward a future where resilience is a continuous and evolving practice. Achieving this vision requires coordinated action across government agencies, the private sector, academia, and civil society, embedding disaster risk reduction into national development priorities. Moving forward, India must adopt a multi-sectoral, forward-thinking, and climate-sensitive approach to disaster governance, making resilience a fundamental pillar of sustainable development.

5.2. Research

Disaster risk management and resilience development require an adequate basis of scientific research, data-driven analysis, and innovative methods. However, present research initiatives tend to be fragmented, reactive, and isolated from real-world implementation, limiting their impact on disaster planning and response. While great progress has been achieved in risk assessment and forecasting, there is still a need for standardized resilience measuring frameworks, complete post-disaster impact assessments, and predictive modelling for new hazards. To develop a sustainable and adaptable disaster management system, research must move beyond historical data analysis and incorporate forward-thinking methodologies that take into consideration climate uncertainties, socioeconomic vulnerabilities, and cascading risks. To address these problems, a multi-tiered research program is required, with an emphasis on short-term improvements in data collecting, medium-term breakthroughs in policy integration, and long-term investments in technology-based resilience measures.

This section emphasizes the critical research gaps and goals across these three timeframes, ensuring that disaster resilience efforts remain evidence-based, future-ready, and inclusive of all stakeholders and also make sure that disaster studies contribute not only to academic discussion but also to practical gains in risk mitigation, recovery, and community resilience.

Immediate Needs

To improve disaster preparedness and response in the short term, research should focus on filling important knowledge gaps and increasing data accessibility. Key priorities include:

- **Improving Primary Data Collection:** Current disaster risk assessments rely mainly on secondary data, which frequently lacks real-time precision. To improve disaster effect assessments, an organized strategy to primary data collecting should be devised that draws on local scholars, student networks, and community engagement.
- **Standardizing Post-Disaster Needs Assessments (PDNAs):** Inaccuracies in PDNA methodology cause variations in damage and loss estimates. Research should create consistent data collection techniques to ensure that assessments are comparable, transparent, and regionally adaptable.
- **Enhancing Climate Sensitivity Mapping:** Current climate risk maps differ from one another, creating complexity in policy decisions. To improve accuracy and reliability, a centralized and consistent vulnerability mapping strategy is required.
- **Scenario Planning for Unexpected Disasters:** Historical data alone may not convey the changing character of disasters, particularly climate-related hazards. Research on disaster and climate resilience should explore alternative scenario-building models that incorporate climatic projections, socioeconomic trends, and environmental changes should be investigated further.
- **Advancing the Role of AI and Smart Technology:** Opportunities for AI-powered early warning systems, risk prediction models, and automated impact assessments should be investigated for quick deployment, especially in high-risk locations.
- **Bridging the Research-Policy Gap:** Academic and field research findings must be integrated into real-time decision-making processes to ensure that scientific information influences policy and response strategies.

Medium-Term Needs

To develop resilience at the national and regional levels in the longer term, research should focus on capacity building, systemic changes, and multi-sectoral collaboration. The key priority areas include:

- **Creating a Resilience Measurement Framework:** In contrast to risk assessment, resilience and recovery measurement frameworks are still in development. An organized methodology should be developed to monitor annual progress, assess resilience-building activities, and identify persistent vulnerabilities.
- **Assessing Disasters' Socioeconomic Impacts:** Research must look into the long-term economic, psychological, and social consequences of disasters, particularly for marginalized groups. This involves assessing the efficacy of livelihood restoration programs, financial safety nets, and post-disaster employment schemes.
- **Combining Indigenous and Tribal Knowledge:** Many communities in India use local adaptation measures that have proven beneficial in reducing disaster risks. Research should describe, verify and incorporate these approaches into formal DRR frameworks.
- **Developing Nature-Based Solutions (NbS) for Disaster Mitigation:** The usefulness of reforestation, wetland restoration, and environmentally friendly infrastructure in mitigating disaster risks should be investigated and included into development planning.
- **Promoting Forecasting for Compound Disasters:** As multi-hazard disasters become more common (for example, cyclones followed by floods or earthquakes causing landslides), research should focus on developing predictive models that analyze cascading effects and aid in the design of multi-hazard preparedness strategies.
- **Optimizing Disaster-Resilient Infrastructure Development:** To limit vulnerability to hazards in both urban and rural settings, land use planning, zoning restrictions, and climate-resilient construction practices must be investigated.
- **Strengthening Cross-Sector Collaboration in Research:** Partnerships between government agencies, business sector actors, universities, and humanitarian organizations should be expanded to ensure that research findings are consistent with policy and practice.

Long-Term Needs

In the long run, research efforts must be directed toward developing a forward-thinking, adaptable, and technology-driven disaster resilience agenda. This includes:

- **Creating a 25-Year Research Roadmap for Resilience and Recovery:** To ensure continuity in disaster research, research institutions should collaborate on a long-term resilience roadmap that takes into account slow-onset hazards such as rising sea levels, intense heat waves, and shifts in monsoon patterns.
- **Integrating Climate Change Adaptation into Governance Systems:** Researchers must investigate how disaster risk reduction, land use regulations, and climate adaptation measures may be properly integrated into national and state governance frameworks.
- **Improving Impact-Based Forecasting and Tailored Early Warning Systems:** Future research should focus on hyper-localized, impact-based forecasting models that provide communities with targeted, actionable alerts based on their individual dangers.
- **Establishing Community-Led Disaster Research:** Policies must ensure that local communities actively participate in disaster risk research, shifting away from top-down scientific assessments and toward community-driven knowledge development.
- **Developing a National information Hub for catastrophe Research:** A centralized platform should be created to integrate research findings, enhance information exchange between institutions, and give open-access catastrophe data to policymakers and practitioners.

5.3. Capacity building

To improve preparedness, response, and recovery, disaster management needs regular investments in institutional, community, and individual skills. Resilience is dependent on improving decision-making, coordination, and adaptive skills at all levels, even while rules and infrastructure act as a foundation. Initiatives to increase capacity must be expanded to include government agencies, local authorities, first responders, academic institutions, corporate sector stakeholders, and communities due to the increasing complexity and unpredictability of climate-related disasters. To guarantee that disaster-prone communities have tailored training programs, risk assessments, and response plans appropriate for particular hazards including landslides, floods, cyclones, and heatwaves, a multi-tiered strategy is necessary.

Institutional capacity building

Building institutional capacity is essential for improving interagency cooperation, disaster preparedness, and effective utilization of resources. Response efforts may be hampered by the absence of technical know-how, connected information systems, and sufficient funding in many disaster management agencies. To improve coordination and prevent duplication of effort, legislative and policy improvements must make clear the roles and duties of agencies. Government representatives, urban planners, and emergency responders should all receive structured training in disaster-resilient infrastructure planning and ecosystem-based adaptation. Institutional preparedness can be enhanced by frequent emergency response exercises, simulation drills, and technological developments. Continuous learning and skill development will be encouraged by the establishment of specialized disaster training facilities at both the national and state levels. Providing specific funds for disaster preparedness at the municipal, state, and federal levels is another way to improve financial stability and provide long-term financing for emergency response, recovery planning, and early action.

Individual and Professional Capacity building

In the context of 2024's disaster events, several critical gaps emerged in the individual and professional capacities across response teams, frontline workers, local volunteers, and technical personnel. These gaps, highlighted in early response efforts—particularly in Wayanad, Tripura, and Joshimath—exposed the limited training in multi-hazard response, psychological first aid, and long-term recovery planning among key responders.

While institutional systems were activated swiftly, many individuals lacked updated knowledge on risk assessment tools, community engagement approaches, and evolving challenges like compound disasters and climate-induced displacements. Inadequate understanding of recovery frameworks (e.g., Build Back Better), limited awareness of digital tools for monitoring and coordination, and insufficient training in localized risk communication were among the most frequently reported concerns.

Addressing these issues requires a strategic shift towards structured professional development programs. This includes standardized and certified disaster management training for district officials, engineers, public health workers, educators, and CSO field staff. Emphasis must be placed on building inter-sectoral skills, fostering adaptive leadership, and embedding a culture of learning within local governance systems.

Recommendations include:

- Development of modular, on-demand training platforms tailored to the roles of specific professionals.
- Mandatory refresher trainings linked to national and state response frameworks.
- Greater investment in training-of-trainers (ToT) models to cascade capacity within districts.

- Integration of local universities, technical institutions, and DRR networks in designing curriculum based on recent field evidence.

Ultimately, enhancing individual and professional capacities is central to sustaining institutional resilience and ensuring that disaster risk reduction efforts are not just systems-based but also people-driven.

Community Based Capacity Building

Communities are not only the direct sufferers but also the first line of defence against disasters. Hence, Effective risk management requires empowering local populations with information and resources. Preparedness can be greatly improved by strengthening community-based disaster risk reduction (CBDRR) programs through local emergency response training, early warning system distribution, and participatory risk assessments. Neighbourhoods will gain useful disaster response skills by receiving training from grassroots organizations, self-help groups, and local volunteers. Integrating marginalized populations, including women, youth, and indigenous communities, into disaster preparedness and governance is a crucial component of community capacity building. Incorporating disaster education into school and university curriculum is another way to promote a preparedness culture from a young age.

Role of private sector

Through financial investment in resilience-building projects, advances in technology, and corporate social responsibility (CSR) initiatives, the private sector significantly contributes to disaster capacity building. Companies should invest in climate-resilient infrastructure, create strategies for disaster preparedness, and encourage safety training for staff members. Public-private partnerships (PPPs) can finance community resilience initiatives, promote creative risk reduction strategies, and assist disaster education initiatives.

Role of media

Additionally, public awareness, disaster communication, and eliminating false information are all greatly aided by the media. Specialized training in misinformation control and ethical disaster reporting should be provided to journalists and other media practitioners. Through e-learning platforms, virtual simulations, and AI-based training modules, digital tools and emerging technologies can improve capacity-building initiatives. Communities can obtain fast updates and preparedness instructions through real-time communication via digital early warning systems, smartphone applications, and social media. Technologies for interactive risk mapping can assist in visualizing possible dangers and directing local emergency preparation.

Non-Governmental Organisations (NGO) and Civil Society Organisations (CSO)

Civil society organizations (CSOs) and non-governmental organizations (NGOs) are essential to disaster management, especially in underprivileged and marginalized areas. These groups are able to react to emergency requirements in a timely and effective manner because of their strong community networks and local understanding. They promote inclusive disaster governance, offer emergency aid, and assist communities in participating in disaster risk reduction (DRR) programs. NGOs and CSOs provide equitable and thorough disaster preparation and response by giving priority to vulnerable groups.

International Organisations and Donor Agencies

By offering financial assistance, technical know-how, and the promotion of international cooperation, international institutions like the United Nations (UN), World Bank, and other donor agencies play a vital role in enhancing resilience. These groups provide funding for disaster risk reduction initiatives, assist in developing capacity in low-

resource nations, and exchange best practices and global expertise. Their participation is particularly important in areas that lack the resources necessary to control climate change risks and respond to disasters.

Academia and Research Institutions

Research groups and academic institutions have an essential role for creating innovative approaches to risk reduction and disaster management. By conducting research on resilience strategies, climate adaptation, and disaster risk assessment, these stakeholders give disaster planning and policymaking a solid scientific foundation. Furthermore, they provide specific education and training programs that give aspiring disaster management experts the know-how to tackle new issues in disaster resilience.

Religious Institutions and Faith-Based Organizations

Faith-based organizations (FBOs) and religious institutions can provide communities with emotional and spiritual assistance both during and after disasters. These groups can help coordinate relief operations, provide information about disaster preparedness, and boost morale during emergencies because they frequently have close ties to the local community. Religious organizations can also support community-wide engagement for disaster risk reduction initiatives by utilizing their networks and trusted positions.

A multi-stakeholder strategy that unites a wide range of actors, from local communities to international organizations, is necessary for disaster resilience. Disaster management can be made more inclusive, flexible, and successful by incorporating NGOs, academic institutions, municipal authorities, religious organizations, financial institutions, and the business sector. This cooperative framework guarantees that initiatives to increase resilience are based on local realities, supplemented by international knowledge, and maintained through enduring collaborations. Societies will be able to effectively plan for, respond to, and recover from the growing frequency and severity of climate-related disasters with the help of such a holistic approach.

5.4. Stakeholder engagement

Disaster risk reduction and resilience-building require a multi-stakeholder strategy in which governments, communities, private sector entities, academic institutions, humanitarian organizations, and the media work together to improve preparedness, response, and recovery systems. Effective stakeholder involvement ensures that disaster management solutions are inclusive, well-coordinated, and long-lasting, utilizing various skills, resources, and capacities to address complex hazards. Without strong relationships and cross-sectoral coordination, disaster response operations can often become fragmented, resulting in difficulties in strategy, allocation of resources, and long-term recovery.

Disaster preparedness and response operations are closely coordinated by governments at the national, state, and local levels. Their duties include policy formulation, money allocation, infrastructure development, and emergency response coordination. However, disaster governance must go beyond top-down approaches and actively involve local governments, district authorities, and municipal organizations, as they are directly accountable for putting disaster risk reduction (DRR) initiatives into action at the community level. Establishing multi-agency coordination frameworks can increase cooperation among disaster management authorities, urban planning departments, climate agencies, and social welfare groups, ensuring that resilience measures are integrated into all sectors.

Local communities are frequently the first responders in disasters, making their participation in resilience-building significant. Community-based organizations (CBOs), self-help groups, and local non-governmental organizations (NGOs) all play important roles in spreading early warnings, conducting risk assessments, and organizing response

actions. Encouraging participatory disaster planning, in which communities actively participate in hazard mapping, emergency drills, and evacuation planning, ensures that disaster risk reduction methods are culturally and locally driven. Furthermore, incorporating traditional knowledge and indigenous adaptation techniques into formal disaster management frameworks might improve the success rate of risk reduction measures, especially in rural and environmentally sensitive areas.

The corporate sector is an important but frequently overlooked partner in disaster resilience. Businesses face direct economic risks from disasters such as supply chain interruptions, infrastructure damage, and financial losses, thus they must engage in disaster risk preparedness and business continuity planning. Companies can help by building climate-resilient infrastructure, investing in new risk-reduction technology, and providing disaster relief assistance through corporate social responsibility (CSR) activities. Public-private partnerships (PPPs) should be promoted to promote knowledge sharing, financial investment, and technology-driven disaster response solutions, hence increasing overall resilience at the national and local levels.

Scientific research and technology innovation have become essential for developing evidence-based disaster policies and risk assessment methods. **Universities and research institutes** play an important role in climate modelling, disaster risk mapping, resilience measurement, and post-disaster effect assessments. Collaborations between academia and policymakers can assist bridge the research-to-implementation divide, ensuring that scientific results are directly applied to urban planning, infrastructure development, and emergency preparedness. Additionally, student-led research activities can be used to collect field-based data, track disaster trends, and assess the success of resilience programs.

International and national humanitarian organizations, including non-governmental organizations (NGOs), development agencies, and faith-based organizations, play vital roles in disaster relief and recovery. Their experience in emergency relief, capacity building, and community resilience programs ensures that vulnerable populations receive swift assistance. Humanitarian organizations also play an important role in campaigning for changes in legislation, mobilizing resources for disaster-affected communities, and ensuring that disaster risk reduction measures focus on disadvantaged and underprivileged populations. Increasing collaboration between civil society organizations and government institutions can improve disaster response coordination, relief distribution efficiency, and encourage inclusive recovery planning.

The **media** is an extremely effective tool for disaster awareness, early warning distribution, and public education. Journalists and media outlets must report correctly on disasters, highlight preparedness efforts, and challenge misinformation that could cause panic or misunderstanding. Training programs should be developed to provide reporters with disaster literacy, ethical reporting requirements, and crisis communication tactics, ensuring that they are trustworthy sources of information during disasters. Furthermore, social media platforms, mobile-based alert systems, and community radio stations should be used to guarantee that early warning messages reach a broad population in real time.

Disaster hazards are becoming more global in character, necessitating worldwide collaboration and cross-border knowledge sharing. International organizations, donor agencies, and local partnerships all play important roles in disaster risk reduction projects by creating capacity, providing financial support, and sharing technology. Strengthening involvement in global resilience networks, climate adaptation forums, and international disaster response frameworks can provide countries with access to best practices, technical expertise, and financial aid mechanisms to help them prepare for disaster.

Disaster resilience can become a shared duty by encouraging inclusive, participatory, and well-coordinated partnerships, ensuring that all sectors contribute significantly to risk reduction, life-saving, and long-term recovery.

Insights for 2025 DR3 Report

- The Disaster Risk Resilience and Recovery (DR3) Report 2025 will consolidate critical insights on India's evolving disaster risk landscape, building on the mandate, purpose, and journey of the DR3 initiative. Reflections and lessons emerging from the 2024 report preparation process will inform improvements in analytical depth, data integration, and stakeholder engagement.
- A comprehensive geographical risk profile of India will be presented, alongside a mapped overview of major disaster events in 2025. Key impacts mortality, morbidity, affected population, economic and infrastructure losses, livelihood disruptions, and implications for women, children, and vulnerable groups will be highlighted to provide a multidimensional understanding of disaster consequences.
- Emerging risk patterns observed in 2025 will be examined, including changes in seasonality, intensity, spatial spread, compound and cascading risks, and climate-linked extremes. A structured disaster matrix will summarize major events by timing, season, scale, costs, and documented analyses by agencies and researchers.
- The report will present a concise review of the status of disaster research in India, based on a systematic keyword and time-range approach, identifying thematic trends, research gaps, and innovations. A sector-wise loss and damage matrix will also be included, covering impacts on key sectors, cities, infrastructure, health, livelihoods, and social dimensions, with specific attention to the role of climate change.
- Insights on disaster financing in 2025 will be provided, outlining fund mobilization, allocation, utilization patterns, and associated challenges. Recovery interventions undertaken during the year will be assessed to distill practical lessons and gaps.
- The report will conclude with forward-looking insights for research, policy and planning, training and education, community organizations, civil society, and the private sector. Relevant maps, datasets, and analytical tables will be annexed to strengthen transparency and evidence-based reporting.

References

- Awasthi, S., Jain, K., Sahoo, S., Kumar, R., Goswami, A., Joshi, G. C., Kulkarni, A. V., & Srivastava, D. C. (2024). Analyzing Joshimath's sinking: Causes, consequences, and future prospects with remote sensing techniques. *Scientific Reports*, 14(1), 1–25. <https://doi.org/10.1038/s41598-024-60276-3>
- Bera, B., Saha, S., & Bhattacharjee, S. (2023). Sinking and sleeping of Himalayan city Joshimath. *Quaternary Science Advances*, 12, 100100. <https://doi.org/10.1016/j.qsa.2023.100100>
- Chakraborty, S. (2025, February 13). Mamata Banerjee government launches new scheme for rivers, funds to check erosion. *Telegraph India*. <https://obeta.ttef.in/west-bengal/mamata-banerjee-government-launches-new-scheme-for-rivers-funds-to-check-erosion/cid/2083278>
- Chakraborty, S. (2025, February 13). *Telegraph India*. Mamata Banerjee government launches new scheme for rivers, funds to check erosion - *Telegraph India*
- Contributors to Wikimedia projects. (2025, February 3). 2024 Wayanad landslides. *Wikipedia*. https://en.wikipedia.org/wiki/2024_Wayanad_landslides
- Contributors to Wikimedia projects. (2025, February 3). 2024 Wayanad landslides - *Wikipedia*
- CROPC. (2024, June). Annual Lightning Report 2023-24. https://www.cropc.org/static/media/Annual_Lightning_Report_2023-2024_Ex_Summary.1edff6ec97a35d6c3de9.pdf
- DST. (2024). District-Level Climate Risk Assessment for India. https://cstep.in/drupal/sites/default/files/2024-12/Full%20Report_District-Level%20Climate%20Risk%20Assessment%20for%20India_Mapping%20Flood%20and%20Drought%20Risks%20Using%20IPCC%20Framework.pdf
- Dubey, S., & Goyal, M. K. (2020, April 14). Glacial lake outburst flood (GLOF) hazard, downstream impact, and risk over the Indian Himalayas. *Wiley*. https://www.researchgate.net/publication/340097371_Glacial_Lake_Outburst_Flood_GLOF_Hazard_Downstream_Impact_and_Risk_over_the_Indian_Himalayas
- Express News Service. (2025, January 2). Rs 750 crore township project unveiled for rehabilitation of Wayanad landslides victims. *The New Indian Express*. <https://www.newindianexpress.com/states/kerala/2025/Jan/02/rs-750-crore-township-project-unveiled-for-rehabilitation-of-wayanad-landslides-victims>
- Express News Service. (2025, January 2). Rs 750 crore township project unveiled for rehabilitation of Wayanad landslides victims. *The New Indian Express*. <https://www.newindianexpress.com/states/kerala/2025/Jan/02/rs-750-crore-township-project-unveiled-for-rehabilitation-of-wayanad-landslides-victims>
- FICCI. (n.d.). FICCI: Industry's voice for policy change. FICCI, Federation House. Retrieved February 20, 2025, from <https://ficci.in>
- GLACIAL LAKE OUTBURST FLOODS (GLOF) The ticking water bombs in the Himalayas. (n.d.). *Sikkimexpress*. Retrieved February 20, 2025, from <https://www.sikkimexpress.com/news-details/glacial-lake-outburst-floods-glof-the-ticking-water-bombs-in-the-himalayas>
- GLACIAL LAKE OUTBURST FLOODS (GLOF). GLACIAL LAKE OUTBURST FLOODS (GLOF) The ticking water

bombs in the Himalayas - Sikkimexpress

- Gogoi, M., & Malsom, T. (2024, August 27). Tripura's floods 'classic example' of climate change intensifying extreme weather events: Experts. Down To Earth. <https://www.downtoearth.org.in/natural-disasters/tripuras-floods-classic-example-of-climate-change-intensifying-extreme-weather-events-experts>
- Govt of W.B. (n.d.). Irrigation & Waterways Department. https://www.wbiwd.gov.in/index.php/applications/anti_erosion
- GSI. (2023). Recent Event of Ground Subsidence at Joshimath, District Chamoli, Uttarakhand. GEOLOGICAL SURVEY OF INDIA. <https://usdma.uk.gov.in/PDFFiles/GSI.pdf>
- Gupta, P. S., & Choudhary, S. (2024, December 14). Nearly 85% of India's highest flood-risk districts in 6 states, 1 UT, shows new climate report. News18. <https://www.news18.com/india/nearly-85-of-indias-highest-flood-risk-districts-in-6-states-1-ut-shows-new-climate-report-9155742.html>
- IAG Assam & Sphere India . (2024, May). JRNA - Assam Floods. <https://www.sphereindia.org.in/sites/default/files/2024-08/JRNA%202024%20-%20IAG%20Assam-%20Final.pdf>
- IMD. (2024). Annual Climate Summary .
- Irrigation & Waterways Department. (n.d.). Retrieved February 20, 2025, from https://www.wbiwd.gov.in/index.php/applications/anti_erosion
- Khanna, B. (2024, November 21). Lightning deaths more frequent than ever, research classifies it as national disaster. The New Indian Express. <https://www.newindianexpress.com/cities/bengaluru/2024/Nov/21/lightning-deaths-more-frequent-than-ever-research-classifies-it-as-national-disaster>
- MHA, GOI. (2024, December 10). PIB. disaster preparedness and climate resilience
- MHA, GOI. (2024, December 10). PIB. disaster preparedness and climate resilience
- MHA. (2024). CENTRAL FINANCIAL ASSISTANCE FOR WAYANAD LANDSLIDE VICTIMS
- MHA. (2024). CENTRAL FINANCIAL ASSISTANCE FOR WAYANAD LANDSLIDE VICTIMS
- Ministry of Environment, Forest and Climate Change. (n.d.). Retrieved February 20, 2025, from <https://moef.gov.in>
- Mitra, P. (2024). RIVER BANK EROSION AND HUMAN DISPLACEMENT – A CASE STUDY OF THREE DECADES OF BHAGAWANGOLA-II BLOCK OF MURSHIDABAD DISTRICT, WEST BENGAL. International Journal of Current Research, 16(02).
- Mohan, C., Dr.V.Geetha, S, R. B., & B, S. (2024, November 18). https://www.researchgate.net/publication/385907260_A_Study_On_Landslide_Events_In_The_Western_Ghats_Assessing_Causes_Impacts_And_Strategies_For_Building_Resilience
- Nag, J. (2023, May 5). Bengal draws a plan to stop Ganga erosion in Malda and Murshidabad. Economic Times. https://economictimes.indiatimes.com/news/india/bengal-draws-a-plan-to-stop-ganga-erosion-in-malda-and-murshidabad/articleshow/100020911.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst
- Nag, J. (2023, May 5). Economic Times. Bengal draws a plan to stop Ganga erosion in Malda and Murshidabad - The Economic Times
- News, B. (2023, January 24). Joshimath: What's the future of India's sinking Himalayan town? BBC News. https://www.bbc.com/news/world-asia-india-64369752?utm_source=chatgpt.com

- Post-Disaster needs assessment - Kerala. (n.d.). UNDP. from <https://www.undp.org/publications/post-disaster-needs-assessment-kerala>
- Post-Disaster needs assessment - Kerala. (n.d.). UNDP. Retrieved February 20, 2025, from <https://www.undp.org/publications/post-disaster-needs-assessment-kerala>
- Prasad, S. (2022, October 21). Down To Earth. How to assess disasters: 8 Indian states adopt global standards
- Prasad, S. (2022, October 21). How to assess disasters: 8 Indian states adopt global standards. Down To Earth. <https://www.downtoearth.org.in/natural-disasters/how-to-assess-disasters-8-indian-states-adopt-global-standards-85589>
- PTI. (2024a, July 12). Assam flood situation unchanged, nearly 14 lakh people affected. The Hindu. <https://www.thehindu.com/news/national/assam/assam-flood-situation-unchanged-nearly-14-lakh-people-affected/article68395771.ece>
- PTI. (2024b, November 3). Himalayan glacial lakes saw 10.81% area expansion from 2011 to 2024: Report. The Hindu. <https://www.thehindu.com/sci-tech/energy-and-environment/himalayan-glacial-lakes-saw-1081-area-expansion-from-2011-to-2024-report/article68825163.ece>
- Ramnani, V. (2023, January 8). Joshimath crisis: Why a 43-year-old report on the Uttarakhand city is prophetic. Moneycontrol. <https://www.moneycontrol.com/news/business/joshimath-crisis-why-the-1976-mishra-committee-report-on-joshimath-is-prophetic-9829361.html>
- Saha, B. (2024, April 18). These 13 glacial lakes in Uttarakhand are most vulnerable to outburst: Scientists. India Today. <https://www.indiatoday.in/science/story/glacial-lakes-uttarakhand-most-vulnerable-to-outburst-2528989-2024-04-18>
- Sajwan, R. (2023, October 19). Joshimath sinking: Over 50% of Joshimath high-risk area, finds IIT-Roorkee. Down To Earth. https://www.downtoearth.org.in/urbanisation/joshimath-sinking-over-50-of-joshimath-high-risk-area-finds-iit-roorkee-92389?utm_source=chatgpt.com
- Sangomla, A. (2024a, July 4). Assam floods 2024: Unprecedented timing and fury grips state. Down To Earth. <https://www.downtoearth.org.in/natural-disasters/assam-floods-2024-unprecedented-timing-and-fury-grips-state>
- Sangomla, A. (2024b, August 14). Wayanad landslides: Without global warming, rainfall would have been 11% less intense, finds attribution study. Down To Earth. <https://www.downtoearth.org.in/climate-change/wayanad-landslides-without-global-warming-rainfall-would-have-been-11-less-intense-finds-attribution-study>
- Sphere India. (2023). Sikkim Flash Flood. https://www.sphereindia.org.in/sites/default/files/2023-10/Sikkim_FlashFlood_Third_PreliminaryAssessmentReport_17-10-23_0.pdf
- Sphere India. (2024, September). JRNA Report - Tripura Floods. https://www.sphereindia.org.in/sites/default/files/2024-09/Tripura%20Floods%20JRNA%20Report-compiled_05%20Sep-SI%20%281%29.pdf
- Srivastava, S. (n.d.). LIGHTNING RESILIENCE IN INDIA.
- USDMA. (2023). PDNA Joshimath Landslide and Subsidence Crisis. USDMA. https://usdma.uk.gov.in/PDFFiles/PDNA_NDMA.pdf



National Consultation workshop

Annexure I

“Expert/Stakeholder members who contributed in the consultations and developing the report”

Name	Designation	Department
1.	Dr. Ananda Kumar Das	– India Meteorological Department (IMD)
2.	Sh. Vivek Anand	– GIZ India
3.	Dr. Rajasree Ray	– Ministry of Environment, Forest & Climate Change (MoEFCC)
4.	Ms. Bedoshruti Sadhukhan	– ICLEI South Asia
5.	Sh. Akil Ahmad	– Ministry of Road Transport & Highways (MoRTH)
6.	Dr. V. K. Soni	– India Meteorological Department (IMD)
7.	Dr. Vandana Singh	– CEST, Department of Science & Technology (DST)
8.	Dr. Sudha Shukla	– University of Delhi
9.	Dr. Swati Jain	– CEST, Department of Science & Technology (DST)
10.	Dr. M. K. Goel	– Indian Institute of Technology (IIT) Indore
11.	Dr. Vishal Chaudhary	– Government of India
12.	Sh. Ritesh Khattar	– Flood Management Planning, Central Water Commission (CWC)
13.	Sh. Pooran Chand	– Power Development, Monitoring & Load Forecasting Division, Central Electricity Authority (CEA), Ministry of Power
14.	Dr. J. Rajeswar	– Environment Protection Training & Research Institute (EPTRI), Hyderabad
15.	Dr. Vijay Teotia	– Ministry of Fisheries, Animal Husbandry & Dairying
16.	Dr. Sameer Saran	– National Remote Sensing Centre (NRSC), ISRO
17.	Prof. V. K. Sharma	– Indian Institute of Public Administration (IIPA)
18.	Dr. G. P. Ganapat	– Centre for Disaster Mitigation & Management, Vellore Institute of Technology (VIT)
19.	Dr. Ankit Gupta	– CSIR–National Environmental Engineering Research Institute (NEERI)
20.	Sh. S. P. Subudhi	– State Environment Conservation & Climate Change Directorate, Uttarakhand
21.	Shri. Prem Krishnan S	– IAS, District Collector, Pathanamthitta
22.	Dr. Ratnesh Kumar	– Coalition for Disaster Resilient Infrastructure (CDRI)

23.	Dr. Raman Sharma	– CSIR–NEERI
24.	Sh. Maganbir Singh	– Punjab State Climate Change Knowledge Centre, Punjab State Council for Science & Technology
25.	Dr. Albert Chiang	– Meghalaya Basin Development Authority (MBDA), Government of Meghalaya
26.	Dr. Saptarshree Bhattacharjee	– Meghalaya Basin Development Authority (MBDA), Government of Meghalaya
27.	Dr. G. Dheebakaran	– Agro Climate Research Centre, Tamil Nadu Agricultural University
28.	Dr. Akshay Dwivedi	– Indian Institute of Toxicology Research (IITR)
29.	Dr. Kapil Kesarwani	– National Institute of Hydrology (NIH), Roorkee
30.	Dr. Manish Pandey	– Indian Institute of Technology (IIT) Kharagpur
31.	Dr. Akshaya Verma	– National Institute of Hydrology (NIH), Roorkee
32.	Representative	– Nagaland State Climate Change Cell (SCCC)
33.	Dr. Rakesh Kumar	– Natural Resource Management Division, ICAR
34.	Representative	– Mizoram State Climate Change Cell (SCCC)
35.	Shri Kirtiman Awasthi	– GIZ India
36.	Representative	– Meghalaya State Climate Change Cell (SCCC)
37.	Mr. Vijay Khadgi	– ICIMOD (Forest, Environment & Climate Change)
38.	Dr. Anish Chatterjee	– GSDP, GIZ India
39.	Dr. Akanksha Rajput	– Independent Expert
40.	Dr. Amrita Gupta	– Independent Expert
41.	Dr. Padma Sharma	– Independent Expert
42.	Dr. Sonali	– Rishihood University
43.	Dr. Kuljit Kaur	– Independent Expert
44.	Mr. Shashikant Chopde	– TARU Leading Edge
45.	Dr. Rituparna Das	– Independent Expert
46.	Ms. Nupur Tyagi	– Sphere India
47.	Dr. Aradhna	– Independent Expert
48.	Mr. Utkarsh Dwivedi	– Sphere India
49.	Mr Vishnu P	– Sphere India
50.	Mr. Surya Kumar Maurya	– Independent Expert
51.	Sh. Rajesh Kumar	– Supreme Court of India

52.	Ms. Divya Gupta	– SEEDS
53.	Dr. Henna Hejazi	– Change Alliance
54.	Dr K V Uday	– IIT Mandi
55.	Dr. Kaneez Fatima	– UPSDMA
56.	Prof. B. Anjan Kumar Prusty	– Berhampur University
57.	Dr Vivek Gupta,	– IIT Mandi
58.	Dr Raj Kumar Pammi	– NIRDPR
59.	Prof Deeksha Katyal	– USEM, GGSIPU
60.	Mr. Himanshu Shekhar Mishra	– Senior Editor
61.	Ms. Nidhi Jamwal	– Independent Env Journalsit
62.	Mr. Jitendra Choubey	– Senior Assistant Editor- The New Indian Express

About the authors



Prof. Anil Gupta Full Professor, at, IIT Roorkee is renowned Disaster Resilience and Adaptation Policy Strategist. he is dedicated to strengthening the link between policy, research, and practice to advance disaster resilience, climate adaptation, and sustainable development. With over three decades of experience including roles at IIT Roorkee, NIDM, he has guided policy, led capacity-building initiatives, and translated research into policy and practical solutions for governments and international organizations.



Ms Fatima Amin is DRR professional specializing in mountain systems, water risk, integrated resilience planning, and policy-oriented research, contributing to capacity building, publications, and national knowledge initiatives.



Mr Vishnu P is a disaster management professional at Sphere India, coordinating multi-agency responses, assessments, and capacity building for inclusive, evidence-based humanitarian action across India.



Ms Nupur Tyagi is a development professional at Sphere India, leading programme implementation, research, and capacity building for resilient, inclusive systems and impact-driven action.



Ms Mishel Mohan is a climate researcher and analyst specializing in climate adaptation, disaster resilience, capacity strengthening and knowledge systems across humanitarian networks.

This image shows a full page of a handwriting practice worksheet. It consists of multiple rows of horizontal dashed lines spaced evenly down the page, providing a guide for letter height and placement. The background is plain white, and there are no margins or additional markings.

NOTES.....

This image shows a full page of white paper with horizontal ruling lines. The lines are evenly spaced and extend across the width of the page, providing a template for handwriting practice or general note-taking. There are no margins, text, or other markings on the page.



ICARS



Indian Institute of Technology Roorkee, Greater Noida Campus (NCR)