World Health Organization India

CDRI
Coalition for Disaster Resilient Infrastructure

A Roadmap for Resilient Health Infrastructure

Lessons from CDRI-WHO collaborative project in Sikkim (India)

2025

Acknowledgement

This summary document is a part of the collaborative project “Resilient Health Infrastructure for Sikkim" undertaken by CDRI and WHO India to provide technical assistance to the Sikkim State Disaster Management Authority (SSDMA) and the Department of Health and Family Welfare, Government of Sikkim, India.

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We acknowledge the leadership at CDRI and WHO India for their encouragement and unconditional support. The WHO India project team is led by Dr Saurabh Dalal, Dr George Joseph Kodickal and Amit Alok. CDRI project team is led by Dr Ratnesh Kumar with guidance from Ranjini Mukherjee, Director; and contributions from Amrutha Balan, Vasuki Rayapati, and several other colleagues. The Communications team at CDRI has contributed the elegant design of this report.

Disclaimer

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1. Background

In 2023, disasters affected more than 93 million people globally and led to the loss of nearly 90,000 lives.[1] For every life lost, an additional 1000 people were affected, including through injuries or disruption of regular healthcare services.

Disasters impact public health, healthcare services and health infrastructure, disrupting essential services when they are needed the most. In February 2023, a series of earthquakes hit Türkiye; a hospital building in Iskenderun was damaged during the first shock and collapsed during the second, resulting in many fatalities. In the same year in Africa, Cyclone Freddy[2] caused massive damages to 300 health facilities, exacerbating the health crisis during response and recovery phases.

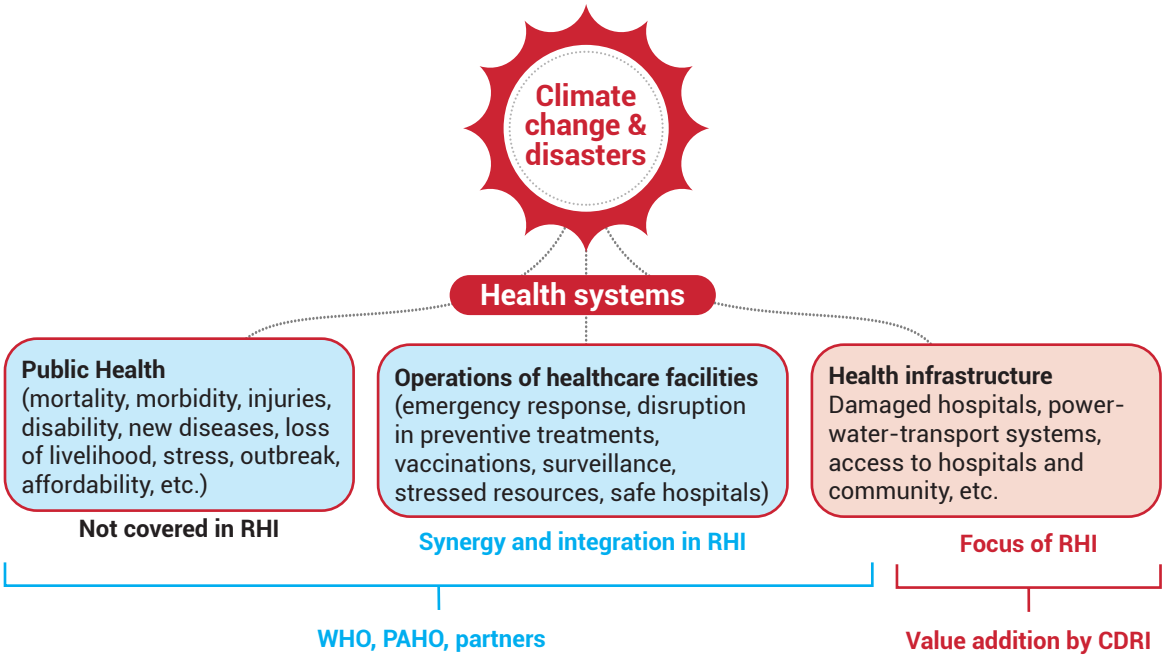


Figure 1: Impact of Climate Change and Disasters on Health Systems
(RHI - Resilient health infrastructure)

[1] *Emergency Events Database (EM-DAT) report, Centre for Research on the Epidemiology of Disasters, 2023. https://files.emdat.be/reports/2023_EMDAT_report.pdf*

[2] *Cyclone Freddy deepens health risks in worst-hit countries, WHO Africa Region, 2023. https://www.afro.who.int/news/cyclone-freddy-deepens-health-risks-worst-hit-countries*

It is essential that health infrastructure functions optimally and has the capacity to expand its support for impacted communities during and immediately after a disaster. The scale and frequency of climate-induced disasters are increasing, disrupting health systems and increasing pressures on emergency services, creating an urgent need for building resilience of health systems, including health infrastructure.

One of the global targets of the Sendai Framework for Disaster Risk Reduction 2015-2030 is "to substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030" (global target D). There is also an increasing emphasis on hospital safety, preparedness, emergency response and building disaster resilient health systems in global commitments towards Disaster Risk Reduction (DRR).

Evolution of Health in Global Commitments

HYOGO Framework 2005-2015

Health was acknowledged as a critical aspect of disaster risk reduction

SENDAI Framework 2015-2030

Strengthening of health systems, including disaster-resilient health facilities and services, is emphasized to ensure effective response and recovery from disasters, thereby safeguarding public health

Paris Agreement 2015

Acknowledges the importance of addressing climate change to protect human health and well-being. Mitigation and adaptation efforts indirectly contribute to reducing health risks associated with climate change

Sustainable Development Goals 2030

Goal no. 3 - Good health and well-being

Goal no. 13 - Climate Action

Goal no. 9 - Industry, Innovation and Infrastructure

COP 28 2023

The COP28 UAE Declaration on Climate and Health signified a global commitment to proactively address climate-related health impacts

G20 New Delhi 2023

Promote One Health, resilient health systems including health infrastructure

Figure 2: Evolution of Health in Global Policies and Frameworks

2. Approach to Resilience of Health Infrastructure

The **Resilient Health Infrastructure (RHI)** initiative of the Coalition for Disaster Resilient Infrastructure (CDRI) focuses on the infrastructure components of health systems that are critical to healthcare delivery during and immediately after disasters.

CDRI is partnering with the World Health Organization (WHO), the Pan American Health Organization (PAHO) and other key stakeholders to assist governments and stakeholders in integrating resilience in health infrastructure.

Based on the learnings from a pilot initiative in the Indian state of Sikkim, and through further consultations with a wide range of global experts and stakeholders including WHO and PAHO, CDRI has developed a Framework for RHI. This Framework builds upon WHO's Hospital Safety Index (2008, 2015),[3] WHO's Operational framework for building climate resilient health systems (2015), PAHO's Framework for resilient hospitals (2024),[4] WHO's Health emergency and disaster management (Health EDRM) framework (2019), and other similar guidelines.

CDRI has constituted a Community of Practice on RHI to leverage the capacities of various experts from across the world in finalizing and operationalizing the RHI framework. The proposed framework will remain dynamic in nature and will be further refined periodically based on the learnings that will emerge through its implementation across various geographies and by different partners.

[3] *WHO Hospital safety index: guide for evaluators, 2nd ed, 2017*

[4] *An inter-regional guidance on strengthening resilience to health emergencies and disasters in health facilities, PAHO, 2024.*

The proposed RHI framework comprises five components:

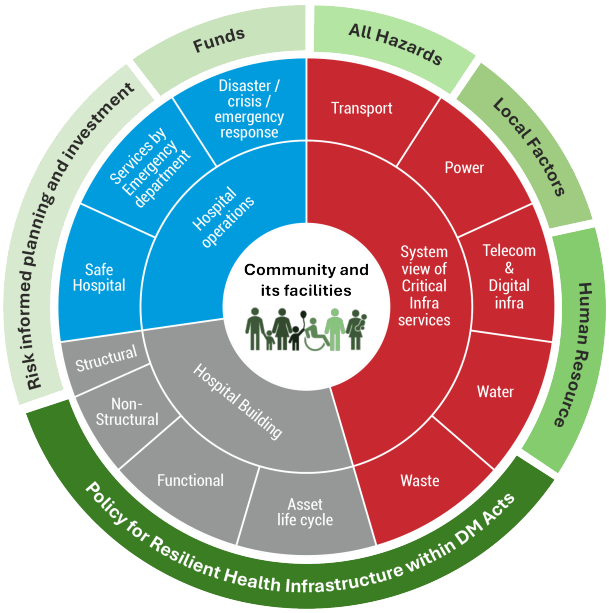


Figure 3: Outline of the proposed RHI Framework

Improving preparedness of hospital operations

For a hospital to remain functional during a disaster, the safety of its buildings, the efficiency of its emergency department, and the preparedness of emergency response laid out in the hospital disaster management plan are paramount. The RHI Framework aims to integrate the existing disaster management provisions in hospital operations through the lens of climate change and disaster resilience.

Resilience of hospital buildings

For hospitals to minimize the impact of disasters, resilience needs to be integrated into the asset life cycle covering planning, construction, operations and maintenance of facilities. Often safety and resilience of functional and non-structural elements can be improved with low cost minor interventions, though structural elements may require major interventions.

Resilience of critical infrastructure services

Hospitals are dependent on services such as power, transport, telecommunications, internet, water, sanitation, waste management and others. Resilience of these supporting infrastructure services is critical for operational continuity and reliable performance of hospitals during crises.

Resilience of community-level health systems

Resilience of local health systems can significantly improve the capacity of affected populations to respond to the health needs of the community, especially in remote areas such as high mountains and small islands. Further, aspects like gender, equality, disability and social inclusion are vital for ensuring community level resilience.

Strengthening funding, policy and governance

The RHI Framework pushes for integration of all interventions for RHI within existing disaster management, health systems and institutional mechanisms, and aims to support governments with a long-term policy roadmap for RHI. Such interventions may include multi-hazard risk assessments, local preferences and knowledge, capacity building of human resources, risk informed planning and investments, and identifying wider sources of funds to support RHI.

3. Towards Resilient Health Infrastructure: Lessons from Sikkim (India)

In 2023, CDRI and WHO implemented a pilot initiative in the state of Sikkim to improve the resilience of its health infrastructure.

Sikkim presented a fitting case for embedding resilience in health infrastructure, as the state has been building many health facilities over the past few years. The state also lies in the Himalayan region and is prone to earthquakes, flash floods, landslides, forest fires, Glacial Lake Outburst Floods (GLOF) and the hazardous impacts of climate change.

The goal of this pilot initiative in Sikkim was to assist the state government in developing a Policy Roadmap for building RHI for the state and equip it with local capacity, know-how, and asset level interventions.

The pilot initiative in Sikkim also led to the development of the Framework for Resilient Health Infrastructure.

Key Challenges in Sikkim

High risks and vulnerabilities for all 178 health facilities in Sikkim

- All 178 health facilities in Sikkim lie in the highest earthquake risk zone (Indian earthquake code IS 1893:2023). Many facilities lie on steep slopes, adding more vulnerabilities.
- 17 health facilities are situated closed to the Teesta basin, vulnerable to floods and GLOF. Seven of them suffered some damages during the 2023 GLOF.
- A number of smaller healthcare facilities are old buildings and require renovation, retrofitting, or replacement.

Capacity gap for disaster management and resilience among healthcare and infrastructure staff

- Limited training to healthcare workers on disaster management and resilience.
- Existing Hospital disaster management plans lacked details and were neither updated nor simulated through mock drills.
- Hospitals faced shortage of trained fire safety officers and operational fire hazad management systems.
- Rapid increase of health infrastructure capacity has created shortage of trained human resources.

Limited considerations of systemic aspects of critical infrastructure services that support hospitals

- Departments of critical infrastructure services (public works, power, water, telecommunications, transport, waste, etc.) that support hospital operations were not considered in health system disaster preparedness and resilience.

Opportunities to augment policies and their linkages between health and disaster management, and other departments

- Limited linkages between the "health" component in the state disaster management plan; and the "disaster management" component within the state health policies.
- Limited emphasis on risk-informed planning and investment, as well as structured access to funds.

The state was keen to undertake long-term measures to augment disaster preparedness and resilience of hospitals.

Consultative Project Design

The CDRI-WHO RHI project was designed through an extensive stakeholder engagement. To determine the shape of the pilot project, CDRI-WHO organized a two-day high-level multisectoral consultation featuring over 60 participants from 12 state departments and stakeholder groups from Sikkim.

Highlights of this high-level multi-sectoral stakeholder consultation included:

- Participation of the honourable minister of Health, and Disaster Management, Secretaries, Directors, external experts.
- Brainstorming group work based on four scenarios:
  - A: Preparedness and response by the state referral hospital to a major mass casualty incident.
  - B: Preparedness and resilience of a remote community to a health emergency due to avalanches.
  - C: Infrastructure guidelines and interventions required to augment major hospitals.
  - D: State-level policy interventions required to achieve targeted emergency preparedness and resilience improvements in the health system.

This consultation helped define focus and scope of CDRI-WHO project in Sikkim.

4. Highlights of RHI Initiative

Six capacity development workshops

- One workshop was organized to cover each of Sikkim's six districts, resulting in sensitization of over 500 stakeholders representing policymakers and practitioners from the departments of disaster management, health, public works, infrastructure services, law and order, defence, fire, mines and geology, and finance, and also from civil society.
- Field works for Rapid Visual Vulnerability Assessments (RVVA) and tabletop exercises were undertaken to support development of hospital-specific disaster risk management and resilience plans.
- Mock drills and simulation exercises were also carried out in all major hospitals for sensitization on emergency response and mass casualty management.

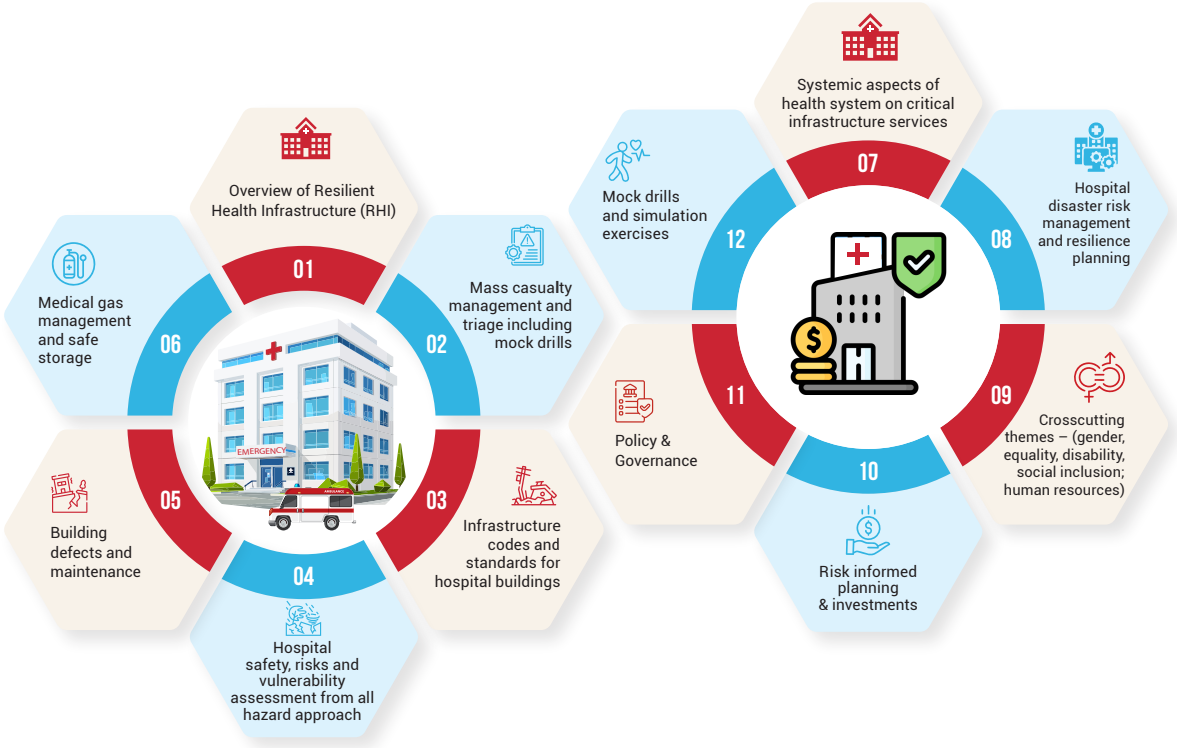
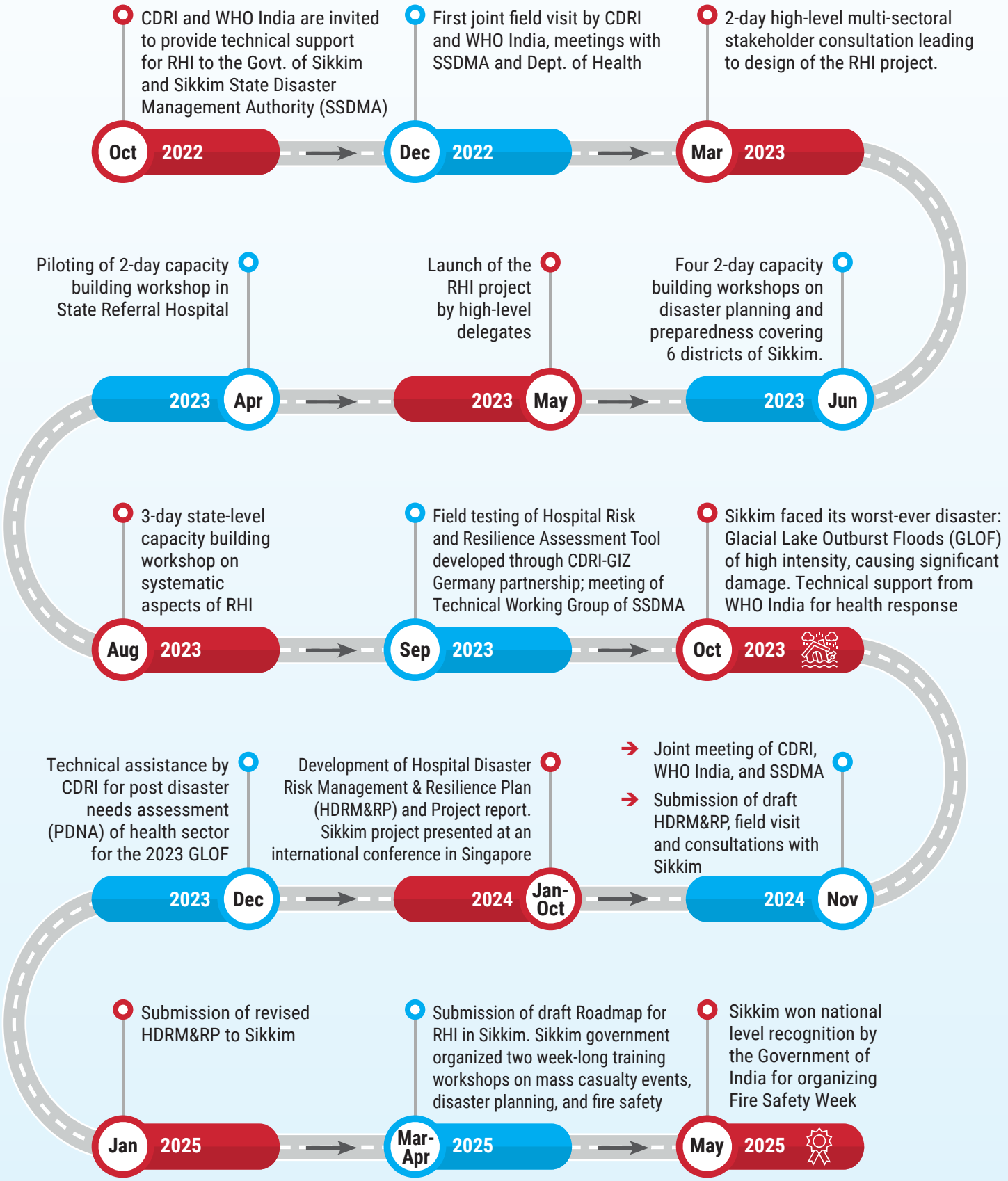


Figure 5: Themes covered during the capacity building workshops

Project Implementation & Timelines



Risk and Resilience Assessment

- Risk and resilience assessment at asset level was done through Rapid Visual Vulnerability Assessment (RVVA) of all six major hospitals and select smaller health facilities like Community Health Centres (CHCs) and Primary Health Centres (PHCs), as shown in Figure 6.

- Hospital managements were part of the screening and vulnerability assessment exercises. Subsequently, actions were taken by the state government to address the issues identified.

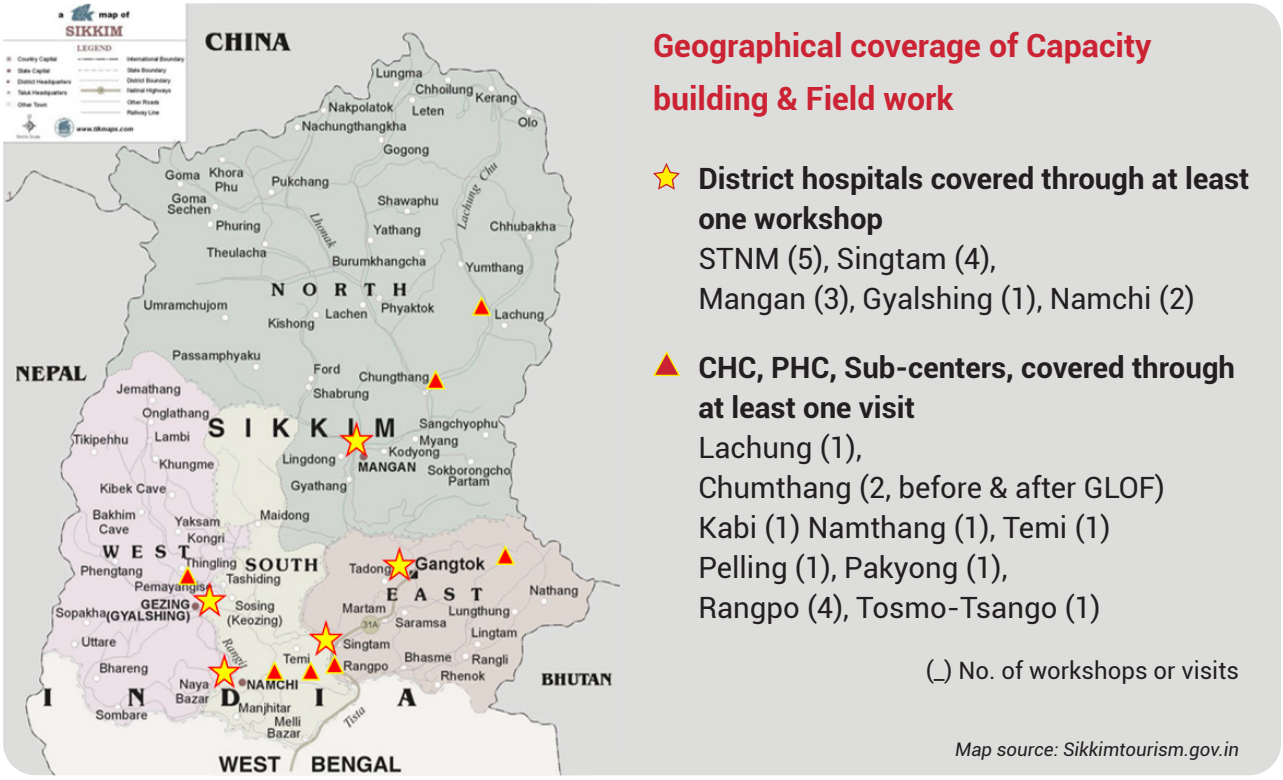
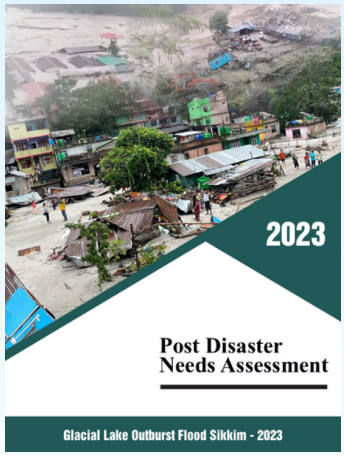


Figure 6: Health facilities covered during capacity building and field work

Technical Assistance

- Development and adoption of a comprehensive Hospital Disaster Risk Management & Resilience Plan (HDRM&RP) for the 1100-bedded state referral tertiary hospital. HDRM&RP with necessary customization will be adopted by other hospitals.



- On 3-4 October 2023 Sikkim faced one of its worst-ever disasters – a major glacial lake outburst flood (GLOF) – resulting in loss of lives, major disruptions of hydro electric energy projects and road networks, and damages to buildings, including six health facilities. The stakeholders from the health system acknowledged benefits from the recently concluded capacity building workshops by CDRI and WHO. CDRI also provided technical support for the Post-Disaster Needs Assessment (PDNA) of the health sector after the GLOF. The experiences and lessons from PDNA informed the next steps of the project and accelerated proactive adoption of resilience measures such as strengthening statewide capacity, infrastructure and inter-departmental coordination. A majority of recommendations for "build back better" have been endorsed by the government in PDNA report.

Overview of Hospital Disaster Risk Management and Resilience Plan (HDRM&RP)

- A model HDRM&RP was developed consultatively for the 1100-bedded state referral hospital STNM in Sikkim by integrating the Hospital Disaster Management Plan (HDMP) and interventions for Resilience of Hospital infrastructure (RP). The composition of its nine chapters are summarized below:
- Chapter 1: Outlines the role of state's health and disaster management departments during disasters, and applicable global, national and state policies for disaster preparedness and resilience.
- Chapter 2: overview of the hospital, its departments, organizational structures, assets, hospital-specific vulnerabilities and risks, etc.
- Chapter 3: Hospital Disaster Management Plan, disaster management committee, Incident Response System (committee), and role and job cards for each cadre, department, and individuals in the hospital.
- Chapter 4-7: Actionable measures for Mass Casualty Management and Triage, Fire and Life Safety, Hospital Evacuations, and Service Continuity Plan when the hospital is impacted by disasters.
- Chapter 8: Measures to improve safety and infrastructure resilience of the hospital (RP).
- Chapter 9: Action Plan to adopt HDRM&RP to improve preparedness of the hospital.

Policy and Governance

A detailed project report summarizes key actionable lessons from the project aligned with the RHI Framework: Highlights include:

a. Current status and actionable recommendations on all components of the RHI Framework.

b. Thumb rules and comprehensive references from applicable codes, standards, policies, acts, guidelines, handbooks and training materials with success stories.

c. A compendium of sources of funds outside health or disaster management departments that can be leveraged for RHI in Sikkim, and India in general.

d. A list of policy interventions required to mainstream RHI including capacity development, human resources, community engagement, etc.

Impact & Recognition

- More than 500 staff were sensitized between April-August 2023, contributing to effective health sector response during the Sikkim GLOF in October 2023.
- Recommendations for build back better in the post disaster needs assessment report of 2023 GLOF are endorsed by the government.
- The state referral hospital (STNM) has adopted the HDRM&RP updated its Hospital Incident Response System (HIRS).
- A dedicated Fire Safety Officer has been appointed at the hospital along with state-level Fire Safety Committee, and Fire Audit (August 2024 onwards). Sikkim has been recognized by the Government of India for for fire safety initiatives (May 2025).
- Sikkim is now taking state-level initiatives for capacity building of staff across the health system inducing health infrastructure department.
- Sikkim organized state-level Inter departmental meeting to disseminate the findings.

5. Lessons from Sikkim RHI Project

Component A: Disaster Planning, Preparedness and Resilience of Hospital Operations

➔ **In Numbers**

- An emergency department should be equipped to manage 10% and 15% of hospital bed capacity during peacetime and disasters, respectively, without affecting routine services.
- Peak patient loads at hospitals during disasters can reach 200-300% of hospital capacity (as observed during Sikkim GLOF at Singtam DH.
- Providing lifesaving interventions within first 60 minutes (referred as the Golden Hour) significantly increases chances of survival.

➔ State referral hospital (STNM) has adopted the comprehensive Disaster Risk Management and Resilience Plan (HDRM&RP) and is undertaking a graded action plan to improve preparedness. It to serve as a centre of excellence to guide other major hospitals.

➔ Hospitals should prepare digital Disaster Management Dashboard with all relevant details, and accessible to all relevant stakeholders.

➔ In India, hospitals can leverage various provisions of National Health Mission, Indian Public Health Standards 2022, and other policies to strengthen their health systems.

➔ Assessment using WHO/NDMA guidelines for Hospital Safety can significantly reduce operational vulnerabilities in hospitals.

[5] *Based on estimates for super specialty medical equipment required at a 300-bedded district hospital under IPHS, 2022.*

Component B: Asset-level Resilience of Hospital Buildings

➔ In Numbers

- Experts suggest that the cost implications of adopting earthquake resilience measures (e.g., base isolation techniques) ranges from '-5% (cost saving)' to '+10% (increase)' of construction costs, and only 2% of replacement costs of damaged hospitals.
- Marginal incremental investment will safeguard all mechanical, electrical and plumbing systems, constituting about 70% of hospital construction costs. Such investments will also save speciality critical medical equipment worth more than INR 500 million,[5] priceless lives, and health workers.

➔ Structural

- Promote strict compliance with the latest standards and codes for new hospitals, and graded plan to retrofit existing hospitals.
- The recently updated Indian earthquake-resistant design code (IS 1893:2023) has shifted from deterministic to probabilistic risk assessment. This code defines four performance levels: Collapse prevention; Life safety, Immediate occupancy; and Fully operational.
- Updated code IS 1893:2023 prescribes "Immediate occupancy" after a seismic event, with options to designers to adopt "Fully operational" performance levels.
- Experience from Japan, Türkiye, and Myanmar highlights critical infrastructure like hospitals must remain "fully operational" after disasters like earthquakes; hence higher resilience with "fully operational" performance levels should be adopted.
- With increasing global temperature, extreme summers and construction of high-rise hospitals, adoption of passive fire safety measures such as compartmentalization, refuge area, fire shaft, etc is required.
- Newly constructed hospitals at Sikkim have adopted earthquake resilience as per prevailing codes and standards.
- Hospitals should document various building defects, cracks, and repair needs to pre-empt any structural vulnerabilities.

➔ Non-structural

- Hospitals must adopt Maintenance schedule to ensure preventive and regular maintenance.
- It is critical to engage stakeholders from power/electrical, water, telecommunication, and waste management departments in maintenance planning.

➔ Functional

- Functional vulnerabilities are first to fail even during minor hazards, and are easiest to manage with minimal cost implications or behaviour change.

➔ Asset life cycle

- Design and planning stages are most suitable for resilience interventions.
- For system-level resilience all relevant departments and user groups should be consulted during the design and construction phase of hospital projects.
- If any disaster occurs during construction phase, adequate measures will ensure resilience in future.

Fire and Life Safety

- Fire is the most frequent hazard for Indian hospitals. About 85-90% of fire accidents are rooted in "overloaded" and "poor" electrical connections.
- ICUs and neonatal intensive care units (NICUs) are most vulnerable to fire due to high concentration of residual and occupancy load beyond design capacity. Oxygen concentration above 47% may become explosive.
- Fire can create disasters within seconds. There is rarely enough time to refer to SOPs or the Hospital Incident Response System (HIRS) during fire incidents.
- Most deaths in hospital fire are caused by smoke.
- Staff present in the immediate vicinity of fire has to make decisions about switching off power supply, containment of smoke, and immediate evacuation as necessary. Thus, fire safety training should be mandated for all staff and workers in a hospital.
- In hospitals with beds more than 200, Indian Public Health Standards (IPHS) 2022 recommends identifying a nodal fire safety officer with adequate training.
- Fire and life safety can be significantly improved by adoption of provisions of latest codes and standards such as National Building Code of India (2016) and revisions.
- The state should institutionalize Fire Incident Reporting System to ensure compliance and periodic audit, including audit of electrical systems.

Component C: System level resilience with critical infrastructure services

For a hospital to remain operational and resilient to disasters, its interface with critical infrastructure services such as power/energy, water, transportation, telecommunication, and waste management must remain functional.

Power

In Numbers

- The government guidelines (IPHS 2022) stipulate electrical power demand of 2-3 KW per bed per day.
- Studies suggest a 10% annual increase in power demand of hospitals, which may further accelerate due to impacts of climate change and extreme weathers.
- Energy usage pattern in hospitals include HVAC (heating, ventilation and air-conditioning) 30-65%, lighting 30-40%, water pumping 10-12%, others 5-15%.[5] These trends may vary in developed and less developed economies.
- Type of power back up required depends on the classification of medical locations and medical equipment, which are divided into three categories.
  - Life safety critical: Uninterrupted power supply (UPS) with less than 0.5 second short break. Recommended backup is for minimum 90 minutes.
  - Critical: Automatic inverters with less than 15 seconds medium break. Recommended backup for 24 hours which can be reduced to 3 hours if hospital evacuation can be completed within 3 hours.

[6] *Energy Efficiency in Hospitals, Best Practice Guide, USAID, (endorsed by Govt. of India), 2009. https://beeindia.gov.in/sites/default/files/HospitalEnergyEfficiencyBestPracticesGuide.pdf*

- Important: Generators with more than 15 seconds long break. Recommended minimum backup 24 hours.

- WHO/PAHO guidelines recommend 72 hours of power backup. Total power demand can be planned for all three types of backup: UPS (uninterrupted power supply), automatic inverter, and generator.
- Wherever applicable, battery backup should operate for 90 minutes.
- Redundancy estimates for power backup should adopt N+1 principles.

➔ Set up state-level mechanisms for coordination between hospitals and power supply/distribution companies to ensure supply-demand estimations and emergency measures, including electrical audits of hospitals.

➔ Wherever practical and economically feasible, hospitals should aim for two or more lines of power supply from independent sources.

➔ Local hazards should be considered to decide the location of generators. For example, generators in basements are vulnerable to flooding, and on rooftops they are exposed to heat, wind, frost, and lightning hazards.

Water

➔ In Numbers

- Average water demand for health facilities for up to 100 beds is 340 litres per day, and for larger hospitals 450 litters per day. These requirements are in addition to water demand for firefighting, laundry, and kitchen requirements.
- WHO suggests hospitals should have water backup for 72 hours.
- WHO[7] suggests above per day requirements can be reduced during water crisis:
  - Health centres and hospitals: 40-60 litres per bed and 5 litres per OPD patient.
  - Operation theatres/Maternity: 100 litres per case.
  - For survival: 7.5 to 15 litres per person.
- Average consumption patterns of water include sanitation (42%), HVAC (23%), medical processes (14%), cafeteria and food processes (9%), laundry (5%), and miscellaneous and unaccounted consumption 9%.[7]

➔ Set up state-level mechanisms for coordination between hospitals and water supply department to ensure supply-demand estimations and emergency measures, including water usage audits of hospitals.

➔ Review/estimate water demand and usage patterns in normal and emergency situations. Identify essential services critical for patient health and safety and estimate minimum water demand. Also, identify services whose supplies can be restricted.[8]

➔ Extreme cold and hot regions may require additional infrastructure interventions to ensure resilience of water supply to hospitals.

➔ Ensure adequate preventive maintenance of plumbing and fire hydrant lines.

➔ Create redundant water storage capacity in the vicinity of hospitals, especially at higher grounds if available.

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[7] *Emergency Water Supply Planning Guidelines for Hospitals and Health facilities, CDC, 2019. https://www.cdc.gov/water-emergency/media/pdfs/2024/07/emergency-water-supply-planning-guide-2019-508.pdf*

[8] *Water Use Case Study: Norwood Hospital, Massachusetts Water Resources Authority. http://ftp.mwra.com/04water/html/bullet1.htm*

Transport

➔ In Numbers:

- Access to lifesaving interventions within first 60 minutes of health emergency significantly increases the chances of survival.
- Recommended norms for ambulance population ratio[9]:
  - ♦ Basic Life Support (BLS): 1 ambulance per 100,000 or 70,000 people in plain or hill/ remote regions, respectively.
  - ♦ Advanced Life Support: 1 ambulance per 500,000 or 250,000 people in plain or hill/ remote regions respectively.
  - ♦ More ambulances can be added in cases of persistent saturated utilization.
- Studies suggest that the average response time of ambulance in India is 20 minutes in urban areas and 30 minutes in remote areas.

➔ Remote location and steep mountains make the road network the most critical component of Sikkim's Resilient Health Infrastructure. To support the health sector, challenges of transportation can be mitigated from three perspectives: transportation of patients, transportation of healthcare workers, and transportation of medical consumables.

➔ Set up a state-level mechanism to

- Monitor and improve response time, performance, and usage patterns of ambulances, and cold-chain and other vehicles used in health systems.
- Identify vulnerable/choke points in the road network and allocate ambulances at these points to facilitate connecting transport.
- Develop a strategy for facilitating priority routing of health/emergency vehicles during disasters, with mapping of alternative routes.
- Explore a mechanism for helicopter ambulance for quicker health response during disasters. Use scope of free flying hours allocated in national aviation policies.
- Explore provisions for helipads in the vicinity of health facilities and other modern technologies like heavy duty drones for medical supply.
- Explore options to install AEDs (Automated External Defibrillators) or portable AEDs at critical locations along the road network, especially close to tourist hotspots.
- Promote training of tourist/taxi drivers on first aid and setting up calling booth/AED devices.

➔ Integration of traditional and indigenous knowledge like:

- Pony ambulance used in Amarnath pilgrimage (India), and/or horse-riding by healthcare workers to access remote areas.
- Mapping of trekking routes and building bamboo/wooden bridges for emergency access after disruption of transport networks.

[9] Update on National Ambulance Services (NAS) Scheme, Ministry of Health and Family Welfare, Govt. of India, 2025. https://mohfw.gov.in/?q=en/pressrelease-231

Telecommunications and Digital Infrastructure

Efficient telecommunications networks are essential for disaster early warning and coordination for evacuation, response, and recovery.

➔ In Numbers:

- The national guidelines on telemedicine for Health and Wellness centres requires a stable connection of minimum 2 Mbps, which should be increased considering actual demand and network quality.

➔ A comprehensive statewide policy supported by system upgradation and dedicated budget is required to strengthen telecommunications systems and network for health infrastructure. Such a policy may consider the following points:

- **Telemedicine:** Establishing telemedicine and tele-ICUs are good modes for providing specialized healthcare to remote areas during emergencies, for which funds are available under the India's National Health Mission (NHM).
- **Digital health ecosystems:** India's National Digital Health Mission (2020)[10] aims to create a digital version of the health ecosystem including e-Hospital software, Online Registration System (ORS), e-Blood bank, Digi-locker, etc.
- **Interdepartmental collaborations:** Collaborate with key stakeholders such as the Department of Information Technology (DIT), Department of Telecommunications (DoT), National Informatics Centre (NIC), Department of Health and Family Welfare, and SSDMA to augment telecommunications policy to ensure resilient connectivity for healthcare facilities in the state.
- **Guidelines for strengthening telecom infrastructure:** CDRI in collaboration with the Government of India has published guidelines for strengthening resilience of telecommunication networks for emergency preparedness[11] and telecom infrastructure.[12]
- **Power backup for telecom-related equipment:** Electrical load of telecom systems in hospitals must be factored in the hospital emergency power backup plans.
- **Early warnings:** Disaster management plans of hospitals should consider response planning with respect to early warnings and Common Alert Protocol.
- **Artificial Intelligence:** A health system equipped with resilient telecom and health infostructure can leverage the benefits of latest advancements in the medical field[13] based on AI, nanomedicines, robotic surgery, predictive health analytics, etc.

[10] National Digital Health Mission: Strategy overview, NITI Ayog, India, 2020. https://www.niti.gov.in/sites/default/files/2023-02/ndhm_strategy_overview.pdf

[11] Recommendations on Telecom network failures during emergencies and disasters- Priority routing of calls of persons engaged in 'response and recovery'. Telecom Regulatory Authority of India (TRIA), 2013. https://www.trai.gov.in/sites/default/files/2024-11/Priority_Press_Release0001-26112013.pdf

[12] National and Sub-national Disaster Risk and Resilience Assessment and Roadmap for India's Telecommunication Sector, 2025. https://cdri.world/upload/pages/1823666979417817_202502101045telecomreport.pdf

[13] National Strategy for Artificial Intelligence, NITI Aayog, 2018.

Waste management

➔ In Numbers:

- On an average, hospitals generate 85% general waste (domestic wastes, solid wastes, plastic wastes, etc. similar to offices and homes) and 15% Bio-Medical Waste (BMW) that requires specialized treatment processes.[14]
- Sikkim generates an average BMW of 586 kg/day.

➔ Review the State action strategy for compliance with the Bio-Medical Waste Management Rules 2016. Consider impacts of major disasters on solid waste and BMW management.

➔ There is a need to link various components of waste management policies (BMW, olid waste, plastic waste, construction waste), with the state's health and disaster management plans and policies. Hospitals and disaster management offices can actively engage with the state and district BMW and solid waste management committees for guidance.

➔ Training of cleaning staff in these specialized protocols is often most neglected and should be improved using National Guidelines for Clean Hospitals - Applicable to Tertiary Care Hospitals, Hospitals associated with Medical Colleges & Super-specialty Hospitals in India' (2015).[15]

➔ Explore the feasibility of engaging mobile BMW treatment facility/equipment in cases of disasters. A long-term strategy may be to explore feasibility of establishing a Common Hazardous Waste Treatment Storage and Disposal Facility within Sikkim.

➔ Future BMW Action plan should integrate additional measures for disaster scenarios and WHO guidelines on Safe management of Waste from Healthcare activities (2nd ed., 2014).[16] Adherence to BMW protocols during routine hospital work will ensure the efficacy of the protocols during disasters.

Component D: Community and its infrastructure

The RHI framework and the initiative in Sikkim keeps the community at the centre and promotes gender, equity, disability, and social inclusion aligned to national and international guidelines. This includes proactive considerations of the needs of women and children, the elderly, people with visible or invisible disabilities, tribal populations, and socially marginalized populations. Migrants and tourists are two vital components of the Sikkim community who should be considered in the RHI interventions.

Suitable community infrastructure such as schools, town halls, auditoriums, religious buildings, multi-level parking, etc. should be assessed for their resilience level and explored for repurposing to temporary health camps during disasters. Such infrastructure should be assessed for supply and backup of power and water, transport accessibility, disability inclusion, sanitation and waste management (including bio-medical waste). Normally schools become first choice for health camps; however, disruption to education should also be factored in.

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[14] Safe management of wastes from healthcare facilities, 2nd ed., WHO, 2014. https://iris.who.int/bitstream/handle/10665/85349/9789241548564_eng.pdf?sequence=1

[15] National Guidelines for Clean Hospitals, Govt. of India, 2015. https://mohfw.gov.in/sites/default/files/7660257301436254417_0.pdf

[16] Safe management of wastes from health-care activities, 2nd ed. WHO, 2014. https://www.who.int/publications/i/item/9789241548564

Component E: All Hazard Approach and Climate-change

The planning and design of new hospital buildings and related infrastructure services should consider disaster risks from all hazards, including climate change, by adoption of latest codes and standards. Wherever feasible and practical, existing health infrastructure should be assessed for retrofitting to comply with new standards. Recently Indian Standards for Earthquake Resistant designs (IS 1893:2023) has been significantly revised with new earthquake zonation map and higher seismic performance level of critical buildings like hospitals. The entire state of Sikkim is now in the Seismic Zone IV, indicating the highest level of vulnerability.

Component F: Governance and Policy

Human resources

In the last decade, the hospital bed capacity in Sikkim has almost tripled. The size and capacity of human resources are keys to efficient utilization of new infrastructure and improving disaster planning, preparedness, response and resilience. The prevailing practices of health systems rarely integrate human resource needs from infrastructure departments engaged in design, construction, operations and maintenance of hospitals. The RHI project in Sikkim underlines training needs for the human resource from both health and infrastructure domains.

In the short term (0-3 years) Sikkim may focus on filling current positions gaps through ad-hoc recruitment and deputations, and skill gaps through training workshops. Over the long term (3-10 years) Sikkim should integrate healthcare and emergency courses into the medical curriculum and on-job training (DNB, Diplomate of National Board) aligned to National Health Mission and IPHS guidelines. Similarly, courses related to infrastructure resilience need to be added to local engineering and vocational training institutions, along with provisions for recruitment for the same.

Risk-informed planning, investment, and funds

The RHI initiative aims to strengthen Sikkim's existing policies and guidelines for risk-informed planning and investment considering all aspects of the RHI framework. The state should also set up a mechanism to document and monitor the value of health infrastructure assets. Risk-informed planning will not only safeguard the investment but also make stakeholders aware about the value of assets at risk. Experts suggest 2-5% of the health budget can be earmarked for "emergency health care, disaster management and RHI" to ensure holistic integration.

To support RHI, a state level-advisory can facilitate leveraging of funding from various sources as listed below:

1. Pradhan Mantri (Prime Minister) Ayushman Bharat Health Infrastructure Mission (PM-ABHIM 2021), including the National Health Mission
2. Members Of Parliament Local Area Development Scheme (MPLADS)
3. North-East Special Infrastructure Development Scheme (NESIDS) under the Ministry of Development of Northeastern Region (DoNER)
4. Ministry of Tribal Affairs (MOTA)
5. Ministry of Minority Affairs (MOMA)
6. District Mineral Foundation (DMF), set up under the Mines and Minerals (Development and Regulation) Amendment Act, 2015.
7. Pradhan Mantri (Prime Minister) Jan Vikas Karyakram (PMJVK)
8. XV and XVI Finance Commission (National and State Disaster Mitigation Funds)

9. All India Council of Technical Education (AICTE) – Grant for Augmenting Infrastructure in North-East Region (GAINER)
10. Border Area Development Programme (BADP)
11. Aspirational Districts Programme (ADP)
12. Funds for areas affected by Left Wing Extremism (LWE)
13. Panchayati Raj Institutions (PRI)
14. Untied grants of Panchayati Raj Institutions (PRI) and Urban Local Bodies (ULB)
15. Corporate Social Responsibility (CSR)
16. National Action Plan on Climate Change and Human Health (NAPCCHH)
17. Pradhan Mantri (Prime Minister) Janjati Adivasi Nyaya Maha Abhiyan (PM JANMAN).

Policy interventions

1. Strengthening state governance and policy to promote resilience of health infrastructure:

- ➔ Strengthen the health component in state disaster management plans (e.g., State Disaster Management Plan 2022) and the disaster management and resilience component in health policies. Emphasize the resilience of health infrastructure from a systemic lens.
- ➔ Disaster management and resilience should be an integral part of departmental planning, specially wherever funding is available for the health sector. Requirements of hospitals in disaster scenarios need to be integrated so that stand-alone requirements of funding during disasters can be reduced.
- ➔ Action plan to adopt and operationalize Hospital Disaster Risk Management & Resilience Plans (HDRM&RP) in all healthcare facilities.

2. Strengthening health response during emergencies and disasters: In phases and timebound manner, operationalize state/district/smaller hospitals to meet golden hour protocols in their respective catchment area. This should include addressing operational challenges, mechanisms to monitor performance and time of responses by hospitals and ambulances, and exploring the feasibility of supplies through drones or other supply chain networks.

3. **Constituting an inter-departmental committee** under the chairpersonship of the Chief Secretary, with Secretary Health as member secretary, for delineating roles and responsibilities of various departments for health sector actions before, during and post-disaster. Institutionalize periodic meetings of this committee to significantly enhance coordination of health department with critical departments like public works, power/electrical, forest and environment, transport, law enforcement, fire, IT and telecommunication departments, water, municipality, pollution boards, and civil society.

4. **Integrating resilience in health infrastructure:** Strengthen existing policies and compliance mechanism in consultation with the departments of Health, SSDMA, Public Works, Public Health Engineering Departments, Urban Development, Finance, Banks, and other relevant entities. New infrastructure should strictly comply with updated standards and codes, and existing infrastructure may be evaluated for retrofitting.

The state may aim to develop certain hospitals or part of them as **Disaster Base Hospitals**[17] by adopting "fully operational performance level". These facilities will be equipped to provide assured services during low frequency high intensity disasters.

5. **Promoting public-private partnership (PPP)** with Corporate Social Responsibility (CSR) and public relations (PR) agencies, to leverage financial and technical support for various RHI initiatives. This can include display of IEC (Information, Education and Communication) materials, organizing sensitization events and additional human resources during emergencies, disaster response, and implementing resilience measures. It may also include mandating travel medical insurance and promoting Sikkim for medical tourism.

6. Way forward

Lessons from the mock drills and capacity building workshops as part of the RHI initiative in Sikkim enabled healthcare and infrastructure practitioners to better respond to the glacial lake outburst flood (GLOF) of October 2023. With technical assistance from CDRI-WHO, the state government has also implemented measures for improving fire safety at hospitals, for which Sikkim has received national-level recognition from the Government of India.

Insights from Sikkim, especially in development of the Hospital Disaster Risk Management & Resilience Plan (HDRM&RP) and the Roadmap of RHI for Sikkim (India), have demonstrated potential for scale in terms of bolstering resilience in health infrastructure across geographies and contexts.

Elsewhere, in Nepal, CDRI collaborated with WHO South-East Asia Regional Office (WHO-SEARO) and provided technical assistance for safety and resilience assessment of seven provincial hospitals in Nepal using a customized Hospital Safety Index. These lessons are helping stakeholders improve safety and resilience at the hospital and systems level[18].

Building on these RHI initiatives, CDRI aims to design and implement a global Resilient Health Infrastructure Programme aligned with the RHI Framework. The programme offerings will include capacity development, risk and resilience assessment, technical assistance and provision of policy recommendations. CDRI will work with country governments and partner organizations to customize these offerings to country contexts.

To support the RHI initiative, CDRI, in collaboration with WHO, has launched a global Community of Practice on Resilient Health Infrastructure (CoP-RHI)[19], which currently has 26 members from 16 countries. CDRI is also anchoring development of capacity building modules for RHI.

CDRI looks forward to engaging with potential partner organizations and interested countries to roll out the global Resilient Health Infrastructure Programme.

[17] Preparing health systems for shocks, Japan's experience of enhancing the resilience of its health systems, World Bank, 2025. http://documents.worldbank.org/curated/en/099121324152034698

[18] Assessment of Selected Hub Hospitals Using Nepal Customized Hospital Safety Index, Ministry of health and population, Government of Nepal, 2025. https://heoc.mohp.gov.np/uploads/publications/file/686e29beac1ec.pdf

[19] DRI Connect, https://driconnect.cdri.world/communities/152-resilient-health-infrastructure


Resilient Health Infrastructure for Sikkim
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CDRI
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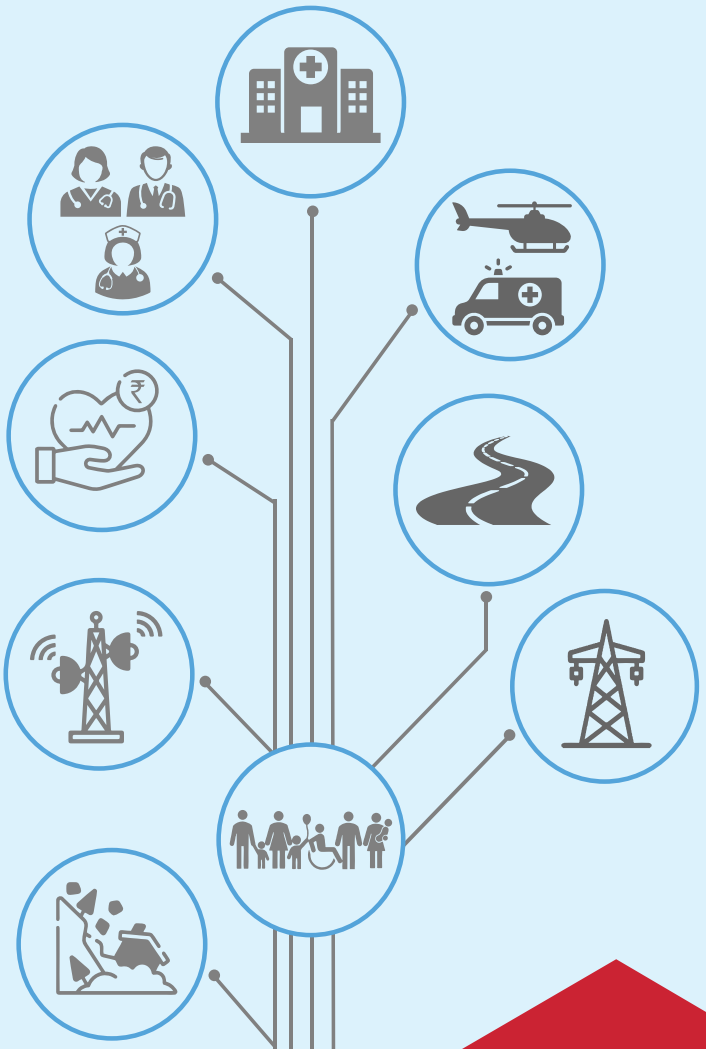
HOSPITAL INCIDENT
COMMAND CENTER


PHC
INCIDENT
PLANNING
LOGISTICS
HOSPITAL INCIDENT
RESPONSE SYSTEM
DEPUTY INCIDENT
TRIAGE
FIRE
LIAISON
INFORMATION &
MEDIA OFFICER



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