



Transforming community disaster preparedness: PHEDM model evaluation in Uttarakhand, India

Pankaj K. Singh ¹, Rajeev Sharma* ², Surya Parkash ³, Jugal Kishore ⁴, Amrita Gupta ⁵,
Ajay Dogra ⁶, Neha Pandey ⁷, Reema Pant ⁸

¹ Integrated Disease Surveillance Programme, Directorate General of Health Services, Government of Uttarakhand, Dehradun, India

² Department of Medical Care and Hospital Administration, National Institute of Health and Family Welfare, New Delhi, India

³ Division of GMR and EOC, National Institute of Disaster Management, Delhi, India

⁴ Department of Community Medicine, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, India

⁵ Public Health Expert and Independent Researcher, New Delhi, India

⁶ Data Scientist and Independent Researcher, New Delhi, India

⁷ National AIDS Control Organization, New Delhi, India

⁸ Department of Environmental Science, Graphic Era Hill University, Dehradun, Uttarakhand, India

Abstract

In rural India, disaster and health emergency management typically follows a top-down approach. This study compared Nausar (intervention) and Salmata (control) panchayats in the Udham Singh Nagar district of Uttarakhand. The initial two tiers of the PHEDM five-tiered model were executed over seven phases, beginning with structured risk assessments and followed by capacity enhancement in Tiers I and II. Nausar exhibited notable advancements, such as an increase in the composite preparedness index from 14.5 to 36.5 (Cohen's $d = 1.12$, $p < 0.001$), a rise in adaptive capacity by +9.4 ($p = 0.04$), an expansion of Community Emergency Response Team (CERT) members from 6 to 48, an improvement in WASH coverage from 73% to 95%, and an increase in drill participation from 12% to 68%. The control panchayat showed no significant changes, and the Difference-in-Differences analysis confirmed the causal effect. These results indicate that the PHEDM's community Tier I and II model effectively enhances scalable village preparedness.

Keywords: Community Resilience, PHEDM, VDMP, THIRA, CEMT, CERT

Received: Feb 09, 2026

Revised: Mar 03, 2026

Accepted: Mar 05, 2026

Citation

Singh, P.K. et al. 2026.
Transforming community
disaster preparedness:
PHEDM model evaluation in
Uttarakhand, India. *Int. J.
Disast. Studies Climate Resil.*
2(1), 66–80.
[https://doi.org/10.64866/
j.ijdsr.2026.10024](https://doi.org/10.64866/j.ijdsr.2026.10024)



1 Introduction

Global environmental degradation and climate change exacerbate extreme weather events, including floods, landslides, cyclones, wildfires, droughts, and heatwaves, all of which threaten human and planetary health (IPCC, 2022). The severity of these impacts is contingent on the intensity of the hazards and the vulnerability profiles of the affected areas (IPCC, 2022). The Royal Society's People and the Planet report (The Royal Society, 2012) underscores how the intertwined trends of population growth and consumption place unsustainable pressures

on finite ecosystems, endangering long-term human well-being. The Rockefeller Foundation–Lancet Commission (Whitmee et al., 2015) cautioned that environmental degradation could negate the health advancements achieved over the past century. Meanwhile, the Lancet Global Syndemic projects, as outlined by the Lancet Commission (Swinburn et al., 2019), suggest that obesity, undernutrition, and climate threats could undermine the Sustainable Development Goals (SDGs) by 2050. The United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP), particularly COP28's UAE Declaration

*Corresponding author. Email: drpankajmph@gmail.com (PKS), rsharma1@me.com (RS), spnidm@gmail.com (SP), drjugalkishore@gmail.com (JK), amritamph@gmail.com (AG), ajay3682@gmail.com (AD), nehapandey.amy@gmail.com (NP), Pant4570@gmail.com (RP)

tion on Climate and Health, emphasises the importance of climate-resilient health systems (COP28 UAE Declaration, 2023). COP28 acknowledges that climate change is responsible for 250,000 annual deaths (due to heat, malnutrition, and malaria) and \$2–4 billion in economic losses by 2030, highlighting the need for community-level adaptation in vulnerable regions such as India's Himalayas (COP28 UAE Declaration, 2023). Vulnerable groups, including pregnant women, children, the elderly, and those with chronic illnesses, face disproportionate risks, as quantified by the WHO: pregnant women have a 20% higher risk of miscarriage, and children have a 15% increased risk of respiratory admissions (WHO Climate Change, 2024). While climate change is the most pressing environmental issue threatening the well-being of current and future generations, it is essential to recognise that it is not the sole environmental hazard affecting human health. Other significant threats include geological hazards (such as landslides and earthquakes), chemical disasters (such as industrial accidents), biological emergencies (such as infectious disease outbreaks), and technological risks (including cyber-physical infrastructure failures). India's Himalayan regions, particularly Uttarakhand, face compounded hydrometeorological, geological, and biological threats. In their 2017 study (Maikhuri et al., 2017) conducted a socio-ecological vulnerability assessment of the Kedarnath Valley following the 2013 flood, finding that nearly 70% of the area was categorised as high- or very-high risk (CVI 0.72). The main contributors to this significant socio-ecological threat are steep slopes, glacial lake outburst hazards, and widespread deforestation. The Government of Uttarakhand (USDMA, 2020) characterises the state as highly susceptible to disasters due to its geotectonic configuration, steep Himalayan landscape, delicate geomorphology, and severe weather conditions. These elements collectively render the region vulnerable to a range of natural and human-induced disasters, including earthquakes, landslides, cloudbursts, flash floods, avalanches, droughts, lightning, cold waves, hailstorms, industrial accidents, fires, and drought-like conditions. Rural and peri-urban communities in these areas face compounded risks due to fragile infrastructure, limited access to health and emergency services, and persistent under-preparedness (Singh, 2023). Climate change is driving significant shifts in hazard patterns, with projections for Uttarakhand indicating an increase in monsoon precipitation of 13–16% by 2050 and up to 36% by 2100, exacerbating the frequency and intensity of climate-induced events such as floods and landslides (Vinodhkumar et al., 2022). Recent indicator-based assessments (Dasgupta and Badola, 2020) have revealed that socioeconomic resilience in the Indian Himalayas remains low, with future scenarios indicating persistent vulnerability and limited adaptive capacity. These findings underscore the need for comprehensive, evidence-based, and participatory strategies to build resilience in the Indian Himalayan Region.

In the Indian context, Gram panchayats, which consist of over 2.68 lakh rural local governance units, act as the frontline in disaster management alongside other sectors (Ministry of Panchayati Raj, 2026). The National Health Policy 2017 (NHP, 2017) and the Indian Public Health

Standard 2022 (IPHS, 2022) emphasise the importance of community health resilience through the integration of primary care and community mobilisation. Although these are vital for local health emergency plans and resilience-building, they face systemic gaps in Public Health Emergency and Disaster Management (PHEDM), capacity constraints, and a lack of staff, technical support, and institutional preparedness (NDMA, 2014). The legal and institutional framework supporting the National Disaster Management Plan 2019 (NDMA, 2019) mandates tiered planning from the national to the village panchayat levels, including for biological emergencies. However, most gram panchayats lack functional Village Disaster Management Plans (VDMPs). Additionally, communities and first responders are often the initial victims and the first line of defence in emergencies. Therefore, there is an urgent need to establish and train community responders, enhance the skills of existing first responders, and develop or update village-level plans, procedures, and protocols such as VDMPs. The 2018 Kerala floods highlighted the effectiveness of community social capital over institutional strategies (Joseph et al., 2020). Evidence showed that community-led responses were significantly faster due to pre-existing neighbourhood networks, volunteer coordination, and localised resource pooling during the crisis, which claimed hundreds of lives and displaced over a million people. Grassroots communication bypassed disrupted official channels, while self-organised relief efforts outpaced government logistics. These findings underscore the critical importance of community empowerment and capacity development in emergencies, establishing a trained community workforce as the essential first line of defence before formal systems activate. The Community Planning Toolkit (Community Planning Toolkit, 2014) emphasises participatory engagement through informing, consulting, and co-creating resilience plans with communities, building trust and local ownership, which are essential for effective emergency response workforce development. The Government of India–United Nations Development Program (GoI–UNDP) in Bihar/Odisha achieved a 40% mortality reduction through Village Disaster Committees and drills (ADPC, 2009). These initiatives laid the groundwork for embedding participatory planning and capacity building in rural disaster management, serving as models for expanding resilience efforts across rural areas in India. Furthermore, systematic reviews and program evaluations globally and in India demonstrate that community engagement enhances early disaster response capacity, reduces mortality, and enables sustainable risk reduction when implemented with attention to local context, social diversity, and inclusive training (Sufri et al., 2020).

Despite significant investments in disaster and public health emergency management, past responses in India have often been marked by top-down, institution-centric strategies that have sometimes underutilised local knowledge and excluded direct community participation from decision-making. This approach has occasionally led to delayed responses and suboptimal outcomes, particularly affecting smallholder farmers and marginalised populations, whose specific vulnerabilities, such as reliance on livestock and exposure to industrial risks, were inadequately addressed

in conventional planning frameworks (Ramsbottom et al., 2018). There is growing recognition, both nationally and internationally, that institutional preparedness alone is insufficient. Therefore, effective preparedness, response, and recovery necessitate robust partnerships between institutions and communities, leveraging both technical expertise and grassroots engagement to incorporate local and traditional knowledge, as recommended by contemporary public health and resilience scholarship (WHO Climate Change, 2024).

Recognising these challenges, India's National Disaster Management Plan (NDMP) advocates for a decisive shift from reactive to proactive disaster risk governance, emphasising decentralised, participatory, and multisectoral approaches (NDMA, 2019). The NDMP specifically calls for empowering local institutions and communities as central actors in disaster risk assessment, planning, and response—an approach that mirrors the Sendai Framework's emphasis on inclusive, locally anchored resilience (Sendai Framework, 2015). This policy evolution has been strongly reinforced by India's pandemic response, where whole-of-society and whole-of-government efforts proved essential for agile and integrated emergency actions (PIB, 2014). NITI Aayog has recognised the need to develop a roadmap for pandemic preparedness and released a comprehensive report titled "Future Pandemic Preparedness and Emergency Response: A Framework for Action." This framework serves as a strategic blueprint for India to address future public health crises, drawing heavily on lessons learned during the COVID-19 pandemic. The central goal is to enable a "100-day mission mode" response to any new outbreak (NITI Aayog, 2024).

In alignment with the national vision to integrate public health and disaster management, a collaborative effort was initiated by the National Institute of Disaster Management (NIDM) and the National Centre for Disease Control (NCDC), under the guidance of NITI Aayog and with technical support from the U.S. Centers for Disease Control and Prevention (CDC), India, along with other key stakeholders. This partnership organised a series of consultative meetings and workshops that engaged stakeholders at the national, state, district, and community levels. During these sessions, participants systematically evaluated prominent global and national risk assessment frameworks and capacity development models, such as the WHO's Strategic Tool for Assessment of Risks (WHO STAR, 2021), the International Federation of Red Cross and Red Crescent Societies' Vulnerability and Capacity Assessment (IFRCRCS, 1999), the NDMA's Hazard Vulnerability Capacity and Risk Assessment (NDMA, 2014), and the U.S. FEMA's Threat and Hazard Identification and Risk Assessment (THIRA) (FEMA, 2018). In addition to these risk assessment tools, Bloom's Taxonomy was assessed as a foundational framework for tiered capacity development (Adams, 2015). This cognitive model ensures that training progresses from basic knowledge (Remembering/Understanding) to operational implementation (Applying/Analysing) and ultimately to strategic leadership (Evaluating/Creating). The review underscored ongoing gaps in both risk assessment and capacity development, including insufficient attention to major accident hazards (MAH), insufficient emphasis on agricultural and livestock vulnerabilities, insufficient attention to cli-

mate change, and inadequate consideration of current public health threats within the existing framework.

The collaboration between NIDM and NCDC has led to the creation of an innovative five-tiered PHEDM framework, which was tested and published in the NIDM journal (Sharma et al., 2025). This framework systematically evaluates risk at the community level and strategically enhances competencies across all levels by incorporating mentorship from one level up. It empowers communities by training community volunteers, frontline workers, and professional responders, while integrating risk assessment and preparedness at both district and state levels. This hierarchical, scalable solution aligns with the NDMP's biological/public health emergencies pillar (NDMA, 2019), the primary care mandates of NHP 2017 (NHP, 2017), the Health and Wellness Centre-Sub Health Centre standards of IPHS at gram panchayat levels and above (IPHS, 2022), and the priorities of the Sendai Framework and UNFCCC-COP, which are crucial for the multi-hazard contexts of India and the region. Tier I of the PHEDM focuses on building community capacity through Panchayati Raj Institution (PRI) leaders, ASHAs, and community volunteers, who conduct community risk assessments and develop VDMPs. Tier II equips the frontline workforce with tactical response skills, including mastery of triage and the Incident Response System (IRS) protocols. Tier III operationalises state and district EOC surveillance and multisectoral coordination through the disaster management institutional and legal framework. In contrast, Tier IV enhances strategic institutional preparedness by integrating climate risks at national and sub-national levels. Tier V provides apex governance and whole-of-society policy leadership.

The PHEDM framework in this study operationalises the COP28 health-climate nexus by promoting scalable, decentralised resilience, directly addressing the multi-hazard vulnerabilities of Uttarakhand. This research will focus on testing and evaluating only Tiers I and II, following the identification of community risks. Uttarakhand exemplifies India's extreme multi-hazard context, representing approximately 13 million people across the Himalayan foothills and Indo-Gangetic plains. The state showcases national disaster risk heterogeneity while demonstrating strong leadership (PHEDM pilot commitment). Among Uttarakhand's 13 districts, Udham Singh Nagar District is prioritized based on five compelling criteria: peak flood vulnerability (Zone II), exposure to Seismic Zone IV (Government of Uttarakhand, 2017), social vulnerability with 28% SC/ST and 40% BPL (Census 2011), recent disaster burden, and strategic policy alignment, making it a state-recommended PHEDM pilot site. This district, located at the Terai-Himalaya interface and home to 1.6 million people, bridges floodplains and seismic foothills, making it an ideal PHEDM pilot for scalable national replication across India's 2.68 lakh gram panchayats.

This scalable and practical pathway connects structured, participatory assessments with capability development and decentralised governance, helping create climate-resilient, self-reliant communities ready to meet future demands. These efforts are part of India's broader vision for Viksit Bharat 2047, which prioritises resilience, health secu-

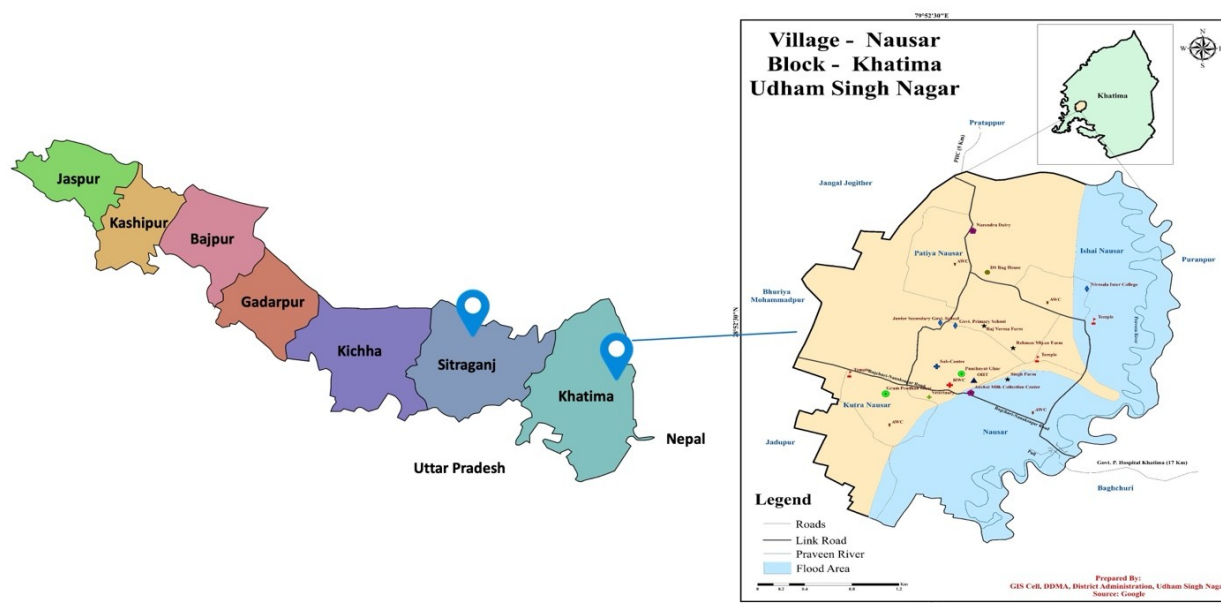


Fig. 1. Study area map showing Khatima (intervention block) and Sitarganj (control block) in Udham Singh Nagar District, Uttarakhand, with Nausar gram panchayat highlighted.

rity, and inclusive and sustainable rural development as key national objectives (Viksit Bharat, 2026). Despite increasing recognition of community participation in disaster preparedness, there remain gaps in implementing structured, locally led approaches that link risk assessments to actionable capacity-building. This study seeks to evaluate the impact of the PHEDM model in rural village panchayats of Uttarakhand, examining its effectiveness in enhancing community resilience through a comparative design. The specific objectives are: (1) to quantify changes in preparedness domains and composite indices; (2) to assess Tier I-II implementation fidelity and community mobilisation; and (3) to identify scalability barriers and facilitators.

2 Method

2.1 Study Design and Setting

A quasi-experimental matched-pair design with Difference-in-Differences (DiD) analysis was conducted from March 2022 to February 2023 in two purposively matched gram panchayats of Udham Singh Nagar District, Uttarakhand (Fig. 1). **Nausar** (intervention site, Khatima block, 349 households) and **Salmata** (control site, Sitarganj block, 298 households) (Gertler et al., 2016).

This study included pre- and post-intervention assessments at both sites, with the intervention applied only at Nausar to evaluate its effectiveness relative to the control site. This approach allowed for within-group (pre-post in Nausar) and between-group (Nausar vs Salmata at endline) comparisons while controlling for external factors through site selection based on similar demographic and risk profiles.

2.2 Site Selection Rationale

Uttarakhand State is selected for extreme multi-exposure (seismic Zones IV/V, flood Zone II Terai, recur-

rent landslides), plus state leadership and Panchayat commitments for piloting Public Health Emergency and Disaster Management.

Udham Singh Nagar District prioritized among 13 districts based on: (1) peak flood vulnerability (Zone II), (2) seismic Zone IV, (3) social vulnerability (28% Scheduled Caste/Scheduled Tribe, 40% Below Poverty Line (BPL) (Census 2011)), (4) recent disaster burden, (5) strategic NIDM-NCDC guidance.

Matching Criteria (Table 1): Six standardised criteria ensured baseline equivalence (all $p > 0.39$) and 8 km geographic separation prevented intervention contamination between sites.

2.3 Unit of Analysis and Sample Size

Individual household respondents from PHEDM assessments participated in pre- and post-survey assessments. Nausar: $n = 48$ paired respondents (14% response rate from 349 households). Salmata: $n = 41$ endline respondents (14% from 298 households). Complete case analysis used for paired t-tests ($n = 89$ total analytic sample).

2.4 Development of the Panchayat Public Health Emergency and Risk Assessment Tool (Community PHEDM Risk Assessment Tool)

The Threat Hazard Identification Risk Assessment (THIRA) methodology from the US Federal Emergency Management Agency was adapted through rigorous stakeholder consultations with the NIDM, NCDC, CDC and Uttarakhand State/District/community representatives. Following consensus, the THIRA framework was localised to develop a Community PHEDM tool specifically designed for multi-hazard risk assessment and intervention strategy development at the gram panchayat level.

Table 1. Baseline matching characteristics - Nausar vs Salmata gram panchayats.

Criterion	Nausar (Khatima)	Salmata (Sitarganj)	Test Statistic
Flood Vulnerability	Zone II (Sharda/Gola)	Zone II (Sharda/Gola)	Equivalent
Households	349	298	-
Population	1,893	1,780	-
SC/ST (%)	28%	24%	p = 0.45
Population Below Poverty Line (BPL) (%)	40%	38%	p = 0.62
Health Infrastructure Primary Health Centre (PHC)	2.8 km	3.2 km	≤3 km (both)
Geographic Separation	-	-	8 km apart
PRI Leadership	Stable (3+ years)	Stable (3+ years)	Equivalent
Baseline CPI	2.1±0.8	2.3±0.9	t = 0.89, p = 0.39

This collaborative approach ensured that the tool was comprehensive, user-friendly, and responsive to gaps identified in earlier models. Refinements targeted five critical areas: (1) incorporation of Major Accident Hazards (MAH) into General Information, enhancing the risk assessment framework for improved emergency preparedness and response based on stakeholder feedback; (2) integration of livestock-related data into Demographic Information, recognizing their economic and health significance in rural communities for a holistic assessment of vulnerabilities and resources; (3) expansion of Threat and Hazard Identification to include infectious diseases and public health emergencies, guided by the NCDC, aligning with current health priorities; (4) emphasis on medical institutions within Educational Institutions to underscore their role in emergency preparedness and healthcare surge capacity; and (5) introduction of a community-level questionnaire for Ascertainment of Core Capabilities, capturing local perspectives to ensure assessments were grounded in community realities and identified tailored strengths and vulnerabilities. These enhancements have made the PHEDM tool a robust instrument for public health emergency preparedness and disaster management.

Overall, these updates mark a significant advancement over the previous versions. By incorporating stakeholder feedback and addressing critical gaps, the revised PHEDM Assessment Tool offers a more comprehensive, context-sensitive, and practical resource for public health emergency preparedness, risk assessment, and decision-making.

The refined PHEDM Assessment Tool was integrated throughout a seven-step protocol of community-based PHEDM intervention model to support systematic data collection and analysis: (1) stakeholder preparation and timeline, (2) community engagement and baseline assessment, (3) intervention implementation (Tier I-II, risk assessment, Village Disaster Management Plan, triage training, CEMT, CERT), (4) ongoing monitoring, (5) endline assessment, (6) data analysis (paired t-tests, Difference-in-Differences) and (7) reporting and scalability recommendations

2.5 Stakeholder Preparation and Timeline

The process began with advocacy and leadership meetings, including engagements with the Director of NCDC and the state Secretary of Health and Disaster Management.

These meetings introduced a five-tiered PHEDM framework focused on piloting Tiers I and II through Community Emergency Management Teams (CEMT) and Community Emergency Response Teams (CERT). Administrative approvals were secured, and village panchayats were selected as intervention (Nausar) and control (Salmata) sites in the Udham Singh Nagar District. Orientation, role clarification, and intervention alignment sessions were conducted with local leaders, frontline workers, and community representatives (Table 2).

2.6 Integration of the PHEDM Assessment Tool: Seven-Phase Application

The PHEDM Assessment Tool was applied in both Nausar and Salmata through a seven-phase process embedded within community engagement and capacity-building activities.

- 1. General Profile:** Collected detailed information about the Gram Panchayat's physical, demographic, socio-economic, and resource characteristics to build local context understanding.
- 2. Threat and Hazard Identification:** Threats and hazards were systematically identified and prioritized through community adapted FEMA THIRA methodology integrating historical data for each hazards based in the number of events that have occurred in the GP in the past 10 years from Indian Meteorological Department/National Disaster Management Authority (IMD/NDMA), Integrated Disease Surveillance Programme (IDSP), and stakeholder consultations with district/block officials, frontline workers (ASHAs/AWWs), and community leaders/volunteers.

Calculated Priority Risk Index (CPRI) Formula. To prioritise its threats and hazards, the CPRI criteria were used, which include four categories: (1) probability, (2) magnitude/severity, (3) warning time, and (4) duration. The CPRI tool is used to quantify and prioritise risks by assigning numerical ratings to factors such as probability, magnitude, warning time, and event duration. It typically produces a score (e.g., 0–4) that helps categorise risks as (Highly Likely, Likely, Possible, or Unlikely) to guide mitigation.

Table 2. Public Health Emergency and Disaster Management (PHEDM) timeline overview.

Phase	Timeline	Key Activities
Preparation	Month 1–2	Obtain permissions and approvals Team formation and orientation Design and pretest PHEDM Tier I and II training modules Update PHEDM Assessment Tool and field test
Baseline Data Collection	Month 2	Conduct risk assessments Community mapping Focus Group Discussions (FGDs)
Intervention Implementation	Months 3–10	Develop a detailed micro plan Tier I and I implementation Formation of CERT/CEMT Training of CEMT and CERT members Development and activation of VDMP with Standard Operating Procedures (SoPs)
Monitoring & Supportive Supervision	Months 3, 6, 9, 12	Tier I and II pre- and post-test analysis Periodic progress checks Mid-term reviews Tracking and documentation of SOP implementation
Endline Data Collection	Month 12	Final risk assessments FGDs and key informant interviews Evaluate the functionality and sustainability of CERT/CEMT and VDMP
Analysis & Reporting	Month 13	Data collation and analysis Drafting and finalisation of the report Dissemination workshop/sharing of findings with stakeholders

Table 3. Calculated Priority Risk Index (CPRI).

Dimension	Weight	Score 4	Score 3	Score 2	Score 1
Probability	0.45	Highly Likely	Likely	Possible	Unlikely
Magnitude/Severity	0.30	Catastrophic	Critical	Limited	Negligible
Warning Time	0.15	<6 hours	6–12 hours	12–24 hours	24+ hours
Duration	0.10	>1 week	<1 week	<1 day	<6 hours

CPRI formula.

CPRI value = (Probability $\times$ 0.45) + (Magnitude $\times$ 0.30) + (Warning Time $\times$ 0.15) + (Duration $\times$ 0.10)

The overall threat/hazard risk is calculated by weighting each CPRI category, then combining them for a total value (Table 3).

Through this process, a ranking is created, and the top 10 are selected for PHEDM Tier I and II interventions.

3. Threat and Hazard Description and Impact:

Comprehensive data on each prioritised threat's characteristics, frequency, and effects on health, infrastructure, and livelihoods were gathered.

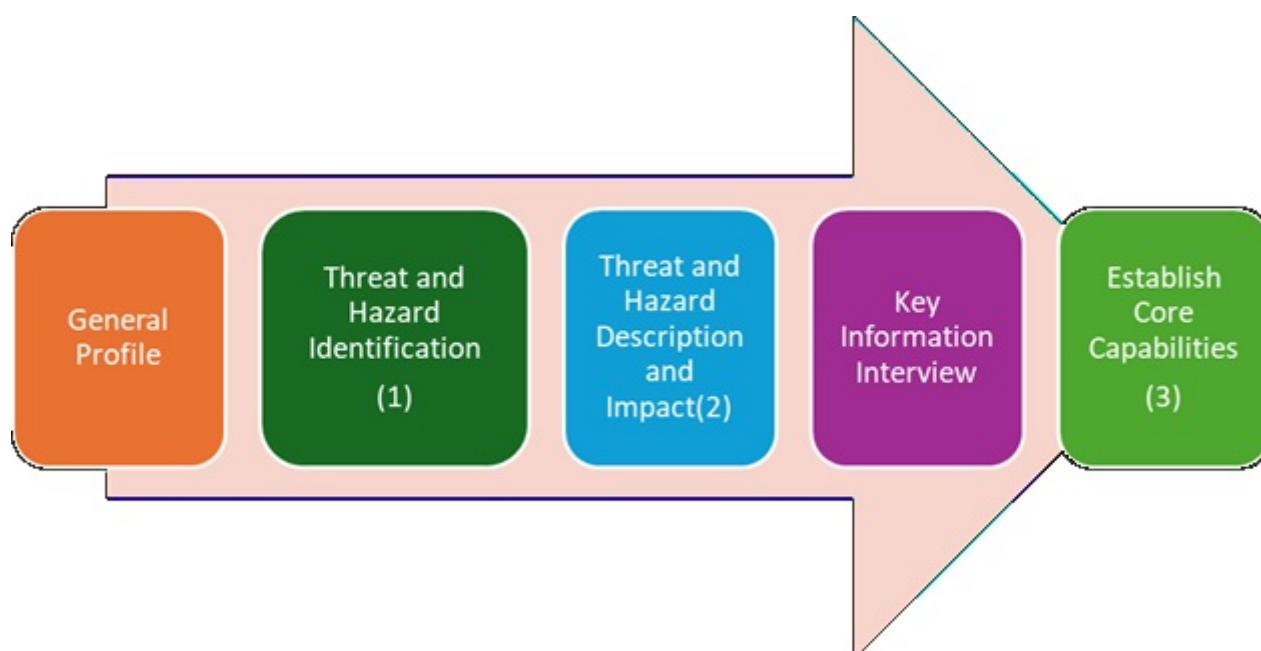
4. Key Informant Interviews: Qualitative interviews were conducted with local experts and leaders to gain insight into socio-cultural factors, vulnerabilities, and existing response capacities.**5. Ascertainment of Core Capabilities:** Evaluated preparedness using the Planning, Organisation, Equipment, Training, and Exercises (POETE) framework through discussions with local officials.**6. Community validation or additional data integration:** Community feedback was incorporated to validate and refine the data.**7. Final risk assessment consolidation, reporting, and feedback:** Synthesised findings into a risk register at the community level for reporting and action planning.

This stepwise application embedded the PHEDM tool within wider community engagement and capacity-building activities, supporting a comprehensive baseline assessment, tailored micro-planning, and resilience interventions. This participatory process fostered a decentralised, multisectoral governance structure aligned with the NDMP 2019 and centred on community-led disaster risk governance. A defined timeline and monitoring and evaluation frameworks were established to track the progress and ensure accountability.

Additionally, the THIRA tool was adapted into the PHEDM Assessment tool in collaboration with community members and key stakeholders, supporting thorough hazard identification, context analysis, and priority setting for capability development and micro-planning at the panchayat level. This approach operationalised the policy rationale, translating the NDMP and Sendai Framework principles

Table 4. Data collection tools and methods aligned with study objectives.

S. No.	Objective	Tools/Methods
1	Assess improvements in community preparedness.	PHEDM Assessment Tool (including Threat and Hazard Identification and Risk Assessment [THIRA]), Participatory Rural Appraisal (PRA), GIS-based risk and resource mapping, domain scoring (Hazard Exposure, Vulnerability, Adaptive Capacity, Resource Availability, Composite Preparedness Index [CPI]), pre/post Preparedness Index assessments, household and ward audits, institutional reviews.
2	Evaluate the fidelity of intervention implementation.	Implementation fidelity checklists, training logs, Standard Operating Procedure (SOP) adherence records, Community Emergency Management Team (CEMT) and Community Emergency Response Team (CERT) roster updates, supervisor logs, after-action reviews, and quarterly Preparedness Index dashboard updates.
3	Measure community mobilisation	Participation records (training sessions, community drills, Gram Sabha meetings), Village Disaster Management Plan (VDMP) development and endorsement tracking, community-based organisation (CBO) engagement logs, quantitative metrics of participant diversity (inclusion of frontline workers, adolescents, self-help groups [SHGs]), and community drill performance scores.
4	Capture qualitative insights into governance trust and response confidence.	Focus Group Discussions (FGDs) with community members; Key Informant Interviews (KIIs) with local leaders and stakeholders; thematic coding based on the STAR dimensions (likelihood, severity/impact, vulnerability, coping capacity); and qualitative surveys on perceived trust in local governance and confidence in emergency response capabilities.

**Fig. 2.** PHEDM Assessment Process (adapted from THIRA Tool).

into shared ownership and preparedness at the village level, and laying the groundwork for baseline assessments and targeted interventions.

2.7 Community Engagement and Baseline Assessment

Community engagement commenced with preliminary visits to the two selected village panchayats, during which the study's purpose and scope were communicated to community members. Subsequently, a local team was recruited and trained in the PHEDM principles, community ethical conduct and participatory methods (Table 4).

The baseline assessment utilised PHEDM's three-step THIRA methodology (threat/hazard identification, impact evaluation, and capability target setting), as shown in

Fig. 2, by employing participatory rural appraisal (PRA), GIS-based resources, transect walk and risk mapping, household and ward audits, and institutional reviews. Five domains were assessed: (1) Hazard Exposure, (2) vulnerability, (3) Adaptive Capacity, (4) Resource Availability, and (5) Composite Preparedness. The indicators were scored on a Likert scale (0–2), normalised to 0–1, and averaged for each domain. A THIRA-style risk register uses weighted criteria (probability, severity, warning time, and duration) to generate a hazard profile.

The assessment process enables both communities to understand their risks and determine the capabilities required to address them. It focuses on identifying potential threats and hazards, assessing their impacts, and establishing capability targets to mitigate these risks.

2.8 Intervention Implementation

The PHEDM five-tier model's Tier I and II resilience packages operationalise capability targets through concrete community-level actions, including establishing and training Community Emergency Management Teams (CEMTs) and Community Emergency Response Teams (CERTs). The PHEDM Assessment findings—identifying hazards, vulnerabilities, and risk factors—serve as the foundation for developing both the Tier I and Tier II training packages and for guiding the preparation of the Village Disaster Management Plan (VDMP) and accompanying Standard Operating Procedures (SOPs).

The VDMP was collaboratively developed, approved, formalised, and ratified by the Gram Panchayat. These SOPs cover early warning, evacuation, first aid, continuity of Water, Sanitation, and Hygiene (WASH) services, and critical aspects such as case clustering, outbreak identification, reporting protocols, and community-level response mechanisms, ensuring alignment with local capability targets and resource availability.

Capacity building focuses on critical thematic areas, including first aid, cardiopulmonary resuscitation (CPR), WASH (with an emphasis on community infection prevention and control), fire safety, snake and animal bite management, drowning prevention, integrated child development services (ICDS) within the Panchayati Raj Institution (PRI) governance framework, and community-level disease prevention, detection and response.

This approach integrates pre- and post-training knowledge assessments and community drills to reinforce preparedness behaviours and operational readiness, following the timelines defined by the PHEDM's measurable capability targets. This strategy complies with the national guidelines for the health system's integration, proactivity, and preparedness. Together, these efforts develop measurable, scenario-specific capacities that are systematically monitored and evaluated through end-line assessments, linking program implementation directly to outcome metrics.

2.9 Ongoing Monitoring

The Preparedness Index dashboard was updated quarterly, tracking metrics such as implementation fidelity, participation, equipment uptime, CERT/CEMT status, VDMP/SOP adherence, outbreak reporting, WASH functionality, and drill performance. This is aligned with the THIRA-Stakeholder Preparedness review for gap tracking. Iterative reviews via supervisor logs, after-action reports, and feedback sessions enabled mid-course adjustments.

2.10 Endline Assessment

The endline assessment exactly replicated the PHEDM/THIRA baseline battery at both the intervention and control locations to calculate the domain scores and the Composite Preparedness Index (CPI). This enables paired comparisons within the intervention site and independent comparisons between sites to evaluate the impact of Tier I and II packages on preparedness and governance.

The community risk register, modelled on the THIRA

framework, is updated to reflect changes in hazard profiles, projected impacts, and capability targets. This process is supported by STAR-like risk matrices that guide prioritised recommendations for subsequent panchayat planning cycles. Qualitative endline data collection included focus group discussions (FGDs) and key informant interviews (KIIs) that explored themes of local governance trust, community ownership, utilisation of early warning systems, and drill experiences. These qualitative insights establish convergent validity by linking intervention activities to the observed preparedness outcomes, as detailed in the Results section.

2.11 Data Analysis

Qualitative data were thematically coded using the STAR dimensions (likelihood, severity/impact, vulnerability, and coping capacity) to explore governance, ownership, and response confidence issues.

Quantitative analysis used individual household respondents as the unit (Nausar $n = 48$ paired; Salmata $n = 41$ paired; total $n = 49$).

Primary Test: Paired t-tests ($df = 47$): Nausar pre-post changes across four domains (Hazard Exposure, Vulnerability, Resource Availability, Adaptive Capacity) + Composite Preparedness Index (0–100 scale).

Independent t-tests ($df = 87$): Endline between-site comparisons

Difference-in-Differences: Causal intervention effect

Effect size: Cohen's d ($0.2 = \text{small}$, $0.5 = \text{medium}$, $0.8 = \text{large}$, $1.0 = \text{very large}$).

Assumptions verified: normality (Shapiro-Wilk $p > 0.05$), equal variances (Levene $p > 0.10$).

Sensitivity analyses confirmed stability under alternative weights (0.20–0.30 range).

2.12 Ethics Approval and Consent

Approvals were sought from the Secretary, Health, the Secretary, Disaster Management, the District Magistrate, and the Gram Pradhan of both villages. **Consent:** Adult participants (18 years) provided written informed consent. **Low Literacy:** Verbal consent with a thumb impression (independent witness present). **Participation:** Voluntary participation and no incentives were provided.

Aggregate reporting: Ensure anonymity. **Rationale:** No formal EC required per ICMR rural public health guidelines for non-clinical interventions with administrative approvals (ICMR, 2017).

2.13 Reporting

The findings were compiled into a report shared with the community, district, state, and partner agencies, linking policy rationale to assessments, interventions, monitoring, and outcomes for scalability.

2.14 Participant Selection Criteria

Participants were selected via Gram Sabha, guided by past disaster experiences and initial FGDs. The inclusion criteria were local residents who were willing to learn or volunteer. The exclusion criteria were non-residency and

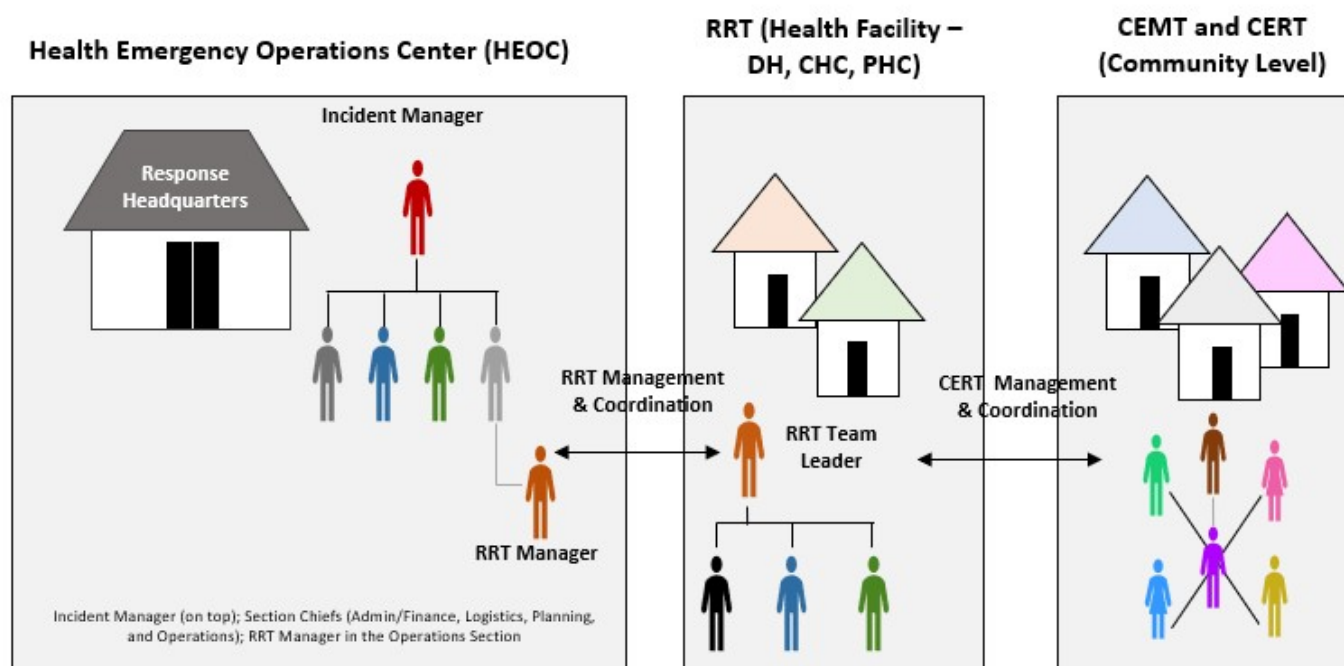


Fig. 3. Formation of Community Emergency Management Teams (CEMTs) and Community Emergency Response Teams (CERTs).

inability to commit. Nausar (four villages: Nausar, Ishai Nausar, Patiya Nausar, and Kutra Nausar) formed one CEMT and five CERTs (one per village plus a backup).

2.15 PHEDM at Community Level

CEMT and CERT are innovated for village/ward-level equipping with knowledge/capacity for emergencies/disasters, linked to Rapid Response Teams (RRTs) and Disaster Response Forces for collaboration, as described in Fig. 3.

2.16 Measuring Change Over Time

Twelve months after the intervention, the same assessment tools and methodologies used at baseline were reapplied in both Nausar and Salmata to measure changes in community resilience. This includes repeating the THIRA-based risk and vulnerability assessment, resource mapping, and recalculation of the composite risk index.

By using consistent metrics across both time points and sites, this study identified specific changes in key indicators, including preparedness levels, local governance participation, and community response capacity. The observed improvements in the intervention panchayat were interpreted in the context of the structured interventions, while the control site served as a benchmark for comparing the results.

3 Results

3.1 Baseline Characteristics

At baseline, Nausar comprised 349 households and a population of 1,893, with 28% of households belonging

to Scheduled Castes/Scheduled Tribes (SC/ST) and 40% living below the poverty line. Functional Water, Sanitation, and Hygiene (WASH) facilities were present in 73% of households, and a primary health centre/sub-centre was located within 3 km. Nausar had six trained frontline health workers (FLWs), no Village Disaster Management Plan (VDMP), and the Gram Pradhan had served for two years. The community reported exposure to flooding with a high score of 3 and moderate participatory risk awareness (PRA score = 1), and two active community-based organisations (CBOs).

Salmata, the control site, had 298 households, a population of 1,780, 24% SC/ST, and 38% of the population below the poverty line. WASH coverage was 65%, with no nearby PHC/SC, five trained FLWs, no CERT teams or VDMP, and similar Gram Pradhan tenure. Flood exposure was reported at a score of 2, PRA-based risk awareness was very low (score = 0), and there was one active community organisation in the village. These characteristics were comparable between the sites, supporting the quasi-experimental design shown in Table 5.

3.2 Risk and Hazard Prioritization

Using the CPRI as per the PHEDM tool, floods (3.4) and vector-borne diseases, dengue, and malaria (3.2), including heat waves (3.2), were the top hazards in Nausar, aligning with PRA rankings and community consultations. Other identified threats included electrocution, flash floods, Snakebites, Dam failure, typhoid fever, and diarrhea, which informed the prioritized interventions displayed in (Table 6).

Table 5. Baseline demographic characteristics and risk-related infrastructure in the Nausar (intervention) and Salmata (control) village panchayats.

Indicator	Nausar Baseline (Intervention)	Salmata Baseline (Control)	Nausar Endline (Intervention)	Salmata Endline (Control)
Total Households	349	298	349	298
Population	1,893	1,780	1,893	1,780
% SC/ST Population	28%	24%	28%	24%
% Population Below Poverty Line	40%	38%	40%	38%
Functional WASH Facilities (%)	73	65	95	68
PHC/SC Availability within 3 km	1	0	1	0
Trained FLWs (ASHA/ANM)	6	5	48	5
Gram Pradhan Tenure (years)	2	2	2	2
Village Disaster Plan (VDMP)	0	0	1	0
Exposure to Floods (last 5 years)	3	2	3	2
PRA-based Risk Awareness	1	0	1	0
Community-based Organizations	2	1	2	1

Table 6. Calculated Priority Risk Index (CPRI) for Nausar village hazards.

S. No.	Hazard	CPRI Score
1	Flood	3.4
2	Dengue	3.2
3	Malaria	3.2
4	Heat Wave	3.2
5	Flash Floods	3.1
6	Electrocution	2.95
7	Snakebites	2.8
8	Dam Failure	2.8
9	Typhoid Fever	2.8
10	Diarrhoea	2.8

3.3 The Domain Scores and Composite Preparedness Index (CPI)

Domain scores (0–100 scale, Likert normalization) provided a THIRA-aligned evaluation of preparedness across four domains.

Baseline: Nausar exhibited moderate Vulnerability (34.0 ± 8.49), low Resource Availability (25.33 ± 41.28), minimal Adaptive Capacity (2.10 ± 2.20), high Hazard Exposure (3.00), and low Composite Preparedness Index (14.50 ± 24.00). Salmata profiles similar (all $p > 0.65$) as shown in (Table 7).

Endline, Nausar demonstrated significant paired improvements in Adaptive Capacity ($p = 0.04$, Cohen's $d = 0.89$ large) and CPI ($p = <0.01$, $d = 1.12$ very large). Salmata remained stable. Between-site endline comparisons non-significant (CPI $p = 0.63$; descriptive only), consistent with Difference-in-Differences confirming intervention effect (+21.7 points, $p < 0.001$).

Sensitivity analyses confirmed score robustness across weighting scenarios.

In comparison, Salmata, the control site, maintained relatively stable scores across all domains and the composite index, with negligible changes from baseline to endline, highlighting the impact of targeted interventions in Nausar. These domain scores and the CPI offer valuable insights into

specific areas of strength and vulnerability within communities, guiding future risk reduction strategies and resource allocation to sustain and build on the gains achieved.

3.4 Intervention Implementation and Community Mobilization

The absence of a VDMP at baseline in Nausar underscores the urgency and focus of the intervention efforts. The intervention engaged 113 participants, including FLWs, ASHAs, PRI members, community members, and adolescents, who took part in capacity building exercises across multiple thematic modules including, (1) formation and training of CEMT and CERT teams, (2) development and successful Gram Sabha endorsement of the first VDMP tailored to local hazards and risk assessment findings, (3) conduct of multi-hazard mock drills simulating floods and disease outbreaks, which resulted in developing standard operating procedures for activation of VDMP, and (4) thematic training focusing on outbreak management (vector borne diseases), first aid, CPR, flood preparedness, snake bite management, electrocution risk, and fire safety, as added in (Table 8).

3.5 Preparedness Index Change and Effect Size

Significant improvements in Nausar included CPI (from 14.50 to 36.50; Cohen's $d = 0.85$, large effect), WASH facilities (73% to 95%; ~ 0.2 , large), trained CERT members (6 to 48; very large), and community participation in drills (12% to 68%; 1.0, very large). Salmata showed minimal changes, supporting intervention attribution, as shown in Table 9.

3.6 Validation of PHEDM Microplanning Framework

Community leaders and district authorities reported that the PHEDM tool was effective and user-friendly. Indicators of its replicability included smooth adoption by local stakeholders, Gram Sabha endorsement of SOPs, and early scale adoption in other states.

Table 7. Domain scores and Composite Preparedness Index (CPI) at baseline and endline.

Domain	Nausar Baseline (n = 48) (Mean ± SD)	Salmata Baseline (n = 41) (Mean ± SD)	p-value (Baseline)	Nausar Endline (n = 48) (Mean ± SD)	Salmata Endline (n = 41) (Mean ± SD)	p-value (Endline) Independent t (87)
Vulnerability	34.00 ± 8.49	31.00 ± 9.90	0.78	34.00 ± 8.49	31.00 ± 9.90	0.78
Resource Availability	25.33 ± 41.28	22.00 ± 37.24	0.92	32.00 ± 48.21	23.00 ± 38.97	0.85
Adaptive Capacity	2.10 ± 2.20	1.50 ± 2.38	0.65	11.50 ± 17.10	1.50 ± 2.38	0.04
Hazard Exposure	3	2	N/A	3	2	N/A
Composite Preparedness	14.50 ± 24.00	13.60 ± 22.18	0.88	36.50 ± 22.50	13.90 ± 22.96	0.63

Note: High Standard Deviations (SD) reflect rural infrastructure inequality (32% full access vs 68% limited) and binary pre/post shifts (floor to ceiling effects).

Table 8. Number of participants in capacity building exercises.

Category	Number of Participants
Health (FLWs, Officers, CHO)	9
Anganwadi/ICDS	10
PRI/Local Government	12
Disaster/SDRF/Fire	21
Community, Adolescents, SHGs	49
CBOs/NGOs/Others	12

Table 9. Pre- and post-intervention outcomes in Nausar and Salmata across key preparedness indicators.

Indicator	Nausar Baseline	Nausar Endline	Salmata Baseline	Salmata Endline	Pooled SD	Cohen's D / Effect Size
Preparedness Index (mean, SD)	14.50 ± 24.00	36.50 ± 22.50	13.60 ± 22.18	13.80 ± 22.00	22.5	0.85 / Large
Functional WASH Facilities (%)	73	95	65	68	–	–0.2 / Large
Trained CERT Members	6	48	5	0	N/A	∞ / Very Large
Community Participation (%)	12	68	15	16	–	1.0 / Very Large

3.7 Qualitative Findings

The thematic analysis of focus group discussions (FGDs) and key informant interviews (KIIs) in Nausar revealed increased community trust in governance, stronger local ownership of preparedness activities, and greater confidence in emergency response. In contrast, Salmata participants expressed an ongoing dependence on external agencies and limited engagement with formal preparedness mechanisms.

4 Discussion

This Discussion is structured around the three pre-specified objectives: Objective 1 (preparedness and adaptive capacity indices), Objective 2 (Tier I–II implementation and community mobilisation), and Objective 3 (barriers and facilitators for scaling the PHEDM model). This quasi-experimental study demonstrates that Panchayat-led PHEDM interventions significantly improved community preparedness in the intervention village of Nausar relative to the control village of Salmata. Addressing Objective 1, the observed gains in CPI, adaptive capacity, WASH coverage, and drill participation indicate that the +22-point increase in the CPI, accompanied by a very large effect size (Cohen's $d = 1.12$) and statistically significant Difference-in-Differences estimates ($p < 0.001$), provides strong evidence suggesting a causal impact of the PHEDM intervention; these Objective 1 findings provide the quantitative backbone for the PHEDM evaluation. However, to complement the Difference-in-Differences approach, future randomized or stepped-wedge evaluations would help more definitively establish causality for PHEDM-related preparedness gains. These findings reinforce the proposition that decentralized, locally anchored governance structures,

such as community management CEMT and community response forces (CERT), can serve as effective platforms for strengthening disaster preparedness and health resilience. This reflects improvements in how local actors coordinate, plan, and assume defined responsibilities, rather than formal changes in institutional structures at this stage. The magnitude of improvement observed in preparedness outcomes suggests that institutional activation at the Gram Panchayat level can meaningfully shift community readiness within a relatively short implementation period. Importantly, adaptive capacity gains (+9.4 points, $p = 0.04$) indicate not only procedural compliance but also the structural strengthening of local systems, including planning processes, role clarity, and community engagement.

These results align with Indian and global research on reducing disaster risk through community involvement, as the NDMA and United Nations interventions in India have highlighted that sustainable disaster resilience hinges on organised community mobilisation and capacity building at the grassroots level, especially through customised micro-planning and decentralised decision-making through Panchayati Raj Institutions (PRIs). In relation to Objective 2, Tier I–II implementation and community mobilisation manifested through strengthened VDMP, expanded CERT membership, and increased early-warning ownership, with dramatic increases in CERT members, WASH functionality, and community drill participation in Nausar mirroring previous multi-state evidence that awareness-raising, volunteer training, regular drills, and local institutional ownership contribute to more proactive, long-term preparedness, which is expected to reduce dependence on external responders over time, even though this outcome was not directly measured in the present study. Together,

these Objective 2 results illustrate how PHEDM translated into day-to-day practices at the community and frontline levels. Similar interventions have shown measurable results in comparable settings in India. For instance, the large-scale rollouts of the Disaster Risk Management Programme, funded by the Government of India and the UNDP, illustrated how village committees, regular iterations of simulation exercises, and sustained multi-tiered leadership involvement shifted perceptions and changed outcomes in disaster-affected areas, especially in Bihar and Odisha. Similarly, during the 2018 Kerala flood, spontaneous community actions—neighbourhood rescues and volunteer networks—demonstrated resilience mechanisms that aligned with Panchayat Health Emergency Disaster Management’s social capital activation (Joseph et al., 2020). Moreover, good practices in community-based disaster risk management indicate that community volunteers’ and local leaders’ active engagement in India and worldwide improves initial response efforts, lowers mortality rates, and supports the sustainable reduction of risk, particularly when local-specific knowledge, contextualised training, and social diversity are integrated. Additionally, a systematic review shows that early warning systems in disasters demonstrate that community engagement enhances the effectiveness of disaster early warning, with emphasis on local capacity, social networks, and community ownership (Sufri et al., 2020). Similarly, the interventions of this study, creating CEMTs and CERTs, demonstrated a significant improvement in community-level preparedness capabilities, enhancing early response capabilities, improving local-level coordination, and facilitating sustainable risk reduction, especially when local knowledge, context-driven training, and social heterogeneity are addressed.

In relation to Objective 3, this study expands on previous community preparedness work by operationalising a structured PHEDM tool, applying a mixed-methods evaluation, and explicitly aligning village-level implementation with national NDMP and international (Sendai Framework) guidance, thereby adding quantitative depth to earlier qualitative governance insights. Together, these Objective 3 insights inform how PHEDM could be adapted and scaled across other gram panchayats. While past studies report variable implementation fidelity or partial integration with official health and disaster systems, the PHEDM model’s close alignment with national (NDMA, 2019) and international (Sendai Framework) guidelines enhances its credibility and transferability. The marked improvements across preparedness indicators in Nausar, particularly when contrasted with the stability in Salmata, underscore the efficacy of the PHEDM model. Domain-specific changes, including adaptive capacity, functional WASH infrastructure, and a dramatic increase in trained CERT members, demonstrate how tailored, community-driven interventions yield measurable resilience.

However, some challenges identified in previous research were also observed here, including persistent vulnerability domains tied to wider socioeconomic issues, confirming the NDMA’s and NITI Aayog’s assessments that disaster resilience must be linked with poverty alleviation and health equity. The control village’s ongoing dependence on exter-

nal actors rather than internal mobilisation reinforces the literature’s emphasis on the critical importance of community buy-in and ongoing leadership development for sustained impact.

4.1 Sustainability and Scalability

A critical factor for the long-term success of the PHEDM intervention is institutionalising its components within local governance frameworks. Embedding Village Disaster Management Plans (VDMPs) and Community Emergency Response Team (CERT/CEMT) activities into ongoing Gram Sabha sessions and Panchayat planning processes will foster ownership and program continuity. To maintain capacity gains, continued refresher training and mentoring of frontline workers and elected leaders are vital. Moreover, resource mobilisation through government schemes and community contributions requires strategic advancement to sustain operations after the project. Coordination with district and state disaster authorities will facilitate technical support and enable replication across other vulnerable Panchayats.

4.2 Economic Feasibility

Although a comprehensive cost-effectiveness analysis is beyond the scope of this study, preliminary observations indicate that leveraging volunteers and existing frontline workers (ASHAs and ANMs) substantially enhances cost efficiency. Future research should quantify programmatic investments alongside projected reductions in disaster-related morbidity, mortality, and health system strain. Such economic evidence will be crucial in convincing policymakers and funding agencies of the value of scaling the PHEDM model in resource-constrained rural settings.

4.3 Integration with Health Systems

The synergy between the PHEDM model and formal health systems, enabled by trained frontline workers, strengthens early detection, case management, and outbreak response. Establishing routine communication channels, joint training programs, and integrated multi-hazard drills between community emergency teams and district health offices could optimise health emergency responses and resilience at multiple system levels.

4.4 Study Limitations and Recommendations for Future Research

The limited geographic scope, two-panchayat sample, short follow-up period, and context-specific challenges (e.g., local socio-political dynamics or unforeseen community resistance) warrant cautious interpretation. Additionally, while Difference-in-Differences analysis strengthens causal inference, the quasi-experimental design means that unobserved confounders cannot be entirely ruled out, necessitating cautious interpretation of direct causal links. Further research should monitor longer-term outcomes and broader environmental and social determinants to tailor interventions. The relatively low response rate (14%) in household surveys across both sites may introduce selection bias,

potentially affecting the representativeness of our sample and the generalisability of our findings even within the studied panchayats.

4.5 Broader Applicability

The adaptable five-tier PHEDM framework is suitable for diverse disaster-prone rural and peri-urban settings in India and beyond, providing a scalable model aligned with national and global resilience goals.

5 Conclusions

This study demonstrates that panchayat-led PHEDM can produce substantial and measurable improvements in community preparedness within a structured, risk-informed framework. While structural vulnerability remains, processes have improved, and community trust and ownership have been measurably strengthened. By developing a village disaster management plan, institutionalising CERT/CEMT teams, implementing risk-informed microplanning, and continuously building capacity within official villages through simulation exercises and PRI processes, preparedness indices showed marked improvement, and community trust and ownership were measurably strengthened.

To maximise and sustain these gains, future practice should focus on the deeper integration of participatory risk assessment tools into panchayat governance cycles, periodic refresher training for local teams, and leveraging digital and predictive technologies, such as artificial intelligence and machine learning. Embedding these interventions within ongoing public health and climate adaptation programs, and aligning them with NDMP and Sendai Framework goals, offers a viable blueprint for scalable, replicable rural resilience strategies across India and other disaster-prone settings.

Acknowledgements

The authors express profound gratitude to the community volunteers, frontline workers, and Gram Pradhans of Nausar and Salmata Village Panchayats in Udham Singh Nagar for their steadfast commitment. Sincere appreciation is extended to the leadership of the Secretary of Health, the Secretary of Disaster Management, the Director General of Health Services (DGHS) of the Government of Uttarakhand, and the District Magistrate of Udham Singh Nagar, the District Disaster Management, and the IDSP team for their guidance and support. The invaluable contributions of the research team, subject matter experts, and leaders at the national, state, and community levels were instrumental in developing and implementing the Public Health Emergency and Disaster Management (PHEDM) framework, including the assessment tool. Special recognition is given to Dr. Himanshu Chauhan, Dr. Sanket Kulkarni, and Dr. Shubhangi Kulsange from the National Centre for Disease Control (NCDC) for their technical expertise, as well as to the Member (Health), NITI Aayog; DGHS; Executive Director, National Institute of Disaster Management (NIDM);

Director, NCDC; and CDC India Country Director for their strategic leadership. The author also acknowledges the distinguished contributions of Shri Ajith Seth, IAS (Retd.), former Cabinet Secretary; Dr. Muzaffar Ahmad, former Member, NDMA; the late Dr. Shiv Lal, former Special DGHS; Dr. Sujeet K. Singh and Dr. A.C. Dhariwal, former Directors, NCDC; Prof. Sanjay Gupta; Dr. Bimlesh Joshi; Dr. Parveen Aswal; Dr. Alka Sharma; Dr. Deepa Meena; Uma Shankar Negi, DDMA, Udham Singh Nagar; Dr. Akhilesh Tripathi and Manoj Singh. Heartfelt thanks are extended to the community leaders, volunteers, frontline workers, NIDM and NCDC team members, implementing state partners, and CDC India for their collaboration and unwavering support throughout this initiative.

CRedit statement

Pankaj K. Singh: Conceptualisation, Methodology, Investigation, Data synthesis, writing manuscript, Review & Editing. **Rajeev Sharma:** Conceptualisation, Methodology, Investigation, Data synthesis, writing manuscript, Review & Editing. **Surya Parkash:** Conceptualisation, Methodology, Investigation, Data synthesis, writing manuscript, Review & Editing, Supervision. **Jugal Kishore:** Conceptualisation, Methodology, Investigation, Data synthesis, writing manuscript, Review & Editing, Supervision. **Amrita Gupta:** Data synthesis, writing manuscript, Review & Editing. **Ajay Dogra:** Data synthesis, writing manuscript, Review & Editing. **Neha Pandey:** Data synthesis, writing manuscript, Review & Editing. **Reema Pant:** Data synthesis, writing manuscript. All authors have read and approved the manuscript.

Data Access Statement

The datasets used and analysed in this study were provided by the Integrated Disease Surveillance Programme, Department of Medical Health and Family Welfare, Government of Uttarakhand, Dehradun, India

Declaration of Conflicting Interests

The authors declare no potential conflicts of interest with respect to the research, authorship, or publication of this article.

Funding

The authors received no financial support for the research, authorship, or publication of this study.

Trial Registration

Not applicable, because this article does not contain any clinical trials

AI-Assistance Disclosure

Large Language Model Assistance (Perplexity September 2025 version) used for scientific rigour and consistency.

Ethical Consideration

The study was conducted after receiving approval from the State Secretary, the State, and the Disaster Management. All participants provided informed consent, and the data were anonymised to protect participants' privacy. Community-level aggregate data are presented in accordance with confidentiality agreements established with the participating village panchayats.

References

- Adams, N.E., 2015. Bloom's taxonomy of cognitive learning objectives. *Journal of the Medical Library Association: JMLA* 103, 152–153. <https://doi.org/10.3163/1536-5050.103.3.010>.
- Asian Disaster Preparedness Center; Government of India UNDP Disaster Risk Management Programme (ADPC), 2009. *Evaluation and review of lessons learnt. United Nations Development Programme; 2009.* <https://www.undp.org/india/publications/government-india-undp-disaster-risk-management-programme-2002-2009-evaluation-and-review-lessons>. accessed March 3, 2026.
- Community Planning Toolkit, 2014. *Community Engagement And Community Places, 2014.* <https://www.communitycommons.org/entities/c99aece3-4159-4fd1-a504-2155d69f3605>. accessed March 3, 2026.
- COP28 UAE Declaration, 2023. *COP28 Uae Declaration On Climate And Health.* <https://www.cop28.com/en/cop28-uae-declaration-on-climate-and-health>. accessed March 3, 2026.
- Dasgupta, S., Badola, R., 2020. Indicator-based assessment of resilience and vulnerability in the Indian Himalayan Region: A case study on socio-economy under different scenarios. *Sustainability* 12, 6938. <https://doi.org/10.3390/su12176938>.
- FEMA, 2018. *Threat And Hazard Identification And Risk Assessment (THIRA) and Stakeholder Preparedness Review (SPR) Guide: Comprehensive Preparedness Guide (CPG) 201.* 3rd ed. <https://www.fema.gov/sites/default/files/2020-04/CPG201Final20180525.pdf>. accessed March 3, 2026.
- Gertler et al., 2016. Matching methods, in: Gertler, P.J., Martinez, S., Premand, P., Rawlings, L.B., Vermeersch, C.M.J. (Eds.), *Impact Evaluation in Practice*. 2nd ed.. World Bank, Washington, DC. <https://openknowledge.worldbank.org/handle/10986/25030>.
- Government of Uttarakhand, 2017. *Uttarakhand Disaster Recovery Project—Additional Financing: The World Bank Assisted Environment And Social Management Framework.* <https://documents.worldbank.org/curated/en/322511512560617379/pdf/SFG3819-EA-P164058-Box405315B-PUBLIC-Disclosed-12-6-2017.pdf>. accessed March 3, 2026.
- ICMR, 2017. *National Ethical Guidelines For Biomedical And Health Research Involving Human Participants.* https://ethics.ncdirindia.org/asset/pdf/ICMR_National_Ethical_Guidelines.pdf. accessed March 3, 2026.
- IFRCRCs, 1999. *International Federation Of Red Cross And Red Crescent Societies. Vulnerability And Capacity Assessment Guide.* <https://preparecenter.org/wp-content/uploads/2022/05/VCA-guide-ifrc.pdf>. accessed March 3, 2026.
- Indian Public Health Standards (IPHS), 2022. <https://nhsrcindia.org/IPHS2022>. Ministry of Health and Family Welfare, Government of India. Accessed March 3, 2026.
- IPCC, 2022. *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* <https://www.ipcc.ch/report/ar6/wg2/>. accessed March 3, 2026.
- Joseph, J.K., Anand, D., Prajeesh, P., Zacharias, A., Varghese, A.G., Pradeepkumar, A.P., Baiju, K.R., 2020. Community resilience mechanism in an unexpected extreme weather event: An analysis of the Kerala floods of 2018, India. *Int J Disaster Risk Reduct* 40, 101741. <https://doi.org/10.1016/j.ijdrr.2020.101741>.
- Maikhuri, R.K. et al., 2017. Socio-ecological vulnerability: Assessment and coping strategy to environmental disaster in Kedarnath valley, Uttarakhand, Indian Himalayan region. *Int J Disaster Risk Reduct* 25, 111–124. <https://doi.org/10.1016/j.ijdrr.2017.09.002>.
- Ministry of Panchayati Raj, 2026. *Government Of India. Egramswaraj Portal: Basic Statistics Of Panchayati Raj Institutions (PRIs).* <https://panchayat.gov.in/en/e-gramswaraj>. accessed March 3, 2026.
- National Health Policy (NHP), 2017. <https://www.mohfw.gov.in/sites/default/files/9147562941489753121.pdf>. Ministry of Health and Family Welfare, Government of India. Accessed March 3, 2026.
- NDMA, 2014. *Model Framework For District Disaster Management Plan.* <https://ndma.gov.in/sites/default/files/PDF/NDMA%20DDMP%20Framework.pdf>. accessed March 3, 2026.
- NDMA, 2019. *National Disaster Management Plan.* <https://ndma.gov.in/sites/default/files/PDF/ndmp-2019.pdf>. accessed March 3, 2026.
- NITI Aayog, 2024. *Future Pandemic Preparedness and Emergency Response: A Framework for Action.* Technical Report. Government of India, Sept. 2024. www.niti.gov.in/sites/default/files/2024-09/Report-of-the-Exper-Group--Future-Pandemic-preparedness-and-emergency-response_0.pdf.
- PIB, 2014. 'Whole Of Government' Approach During The COVID-19. <https://www.pib.gov.in/Pressreleaseshare.aspx?PRID=2037420®=3&lang=2>. accessed July 31, 2025.
- Ramsbottom, A. et al., 2018. Enablers and barriers to community engagement in public health emergency preparedness: A literature review. *J Community Health* 43, 412–420. <https://doi.org/10.1007/s10900-017-0415-7>.
- Sendai Framework, 2015. *Sendai Framework For Disaster Risk Reduction 2015–2030.* <https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030>. accessed March 3, 2026.
- Sharma et al., 2025. A five-tier framework for scalable public health emergency and disaster management: Enhancing pandemic and climate resilience. *Disaster Dev* 14, 37. https://nidm.gov.in/journal/PDF/Journal/NIDMJOURNAL_JanJun2025/NIDMJOURNAL_JanJun20252.pdf.
- Singh, P.K., 2023. Building community capabilities to mitigate and respond to public health emergencies due to climate change. *Indian J Forensic Community Med* 10, 59. <https://doi.org/10.18231/j.ijfcm.2023.010>.

- Sufri, S., Dwirahmadi, F., Phung, D. et al., 2020. A systematic review of community engagement (CE) in disaster early warning systems (EWSS). *Prog Disaster Sci* 5. <https://doi.org/10.1016/j.pdisas.2019.100058>.
- Swinburn, B.A., Kraak VI, Azllender, S. et al., 2019. The global syndemic of obesity, undernutrition, and climate change: the Lancet Commission report. *The Lancet* 393, 791–846. [https://doi.org/10.1016/S0140-6736\(18\)32822-8](https://doi.org/10.1016/S0140-6736(18)32822-8).
- The Royal Society, 2012. *People and the Planet*. The Royal Society, London. <https://royalsociety.org/-/media/policy/projects/people-planet/2012-04-25-peopleplanetsummary.pdf>.
- USDMA, 2020. *Uttarakhand State Disaster Management Plan 2020–21 Volume I*. https://ndma.gov.in/sites/default/files/PDF/SDMP/UK-Volume_1.pdf. accessed March 3, 2026.
- Viksit Bharat, 2026. *Vision Of Viksit Bharat 2047*. <https://viksitindia.com/>. accessed March 3, 2026.
- Vinodhkumar, B., Jose, A.M., Rao, K.K. et al., 2022. Future precipitation extremes over base Himalayan Uttarakhand region: Analysis using the statistically downscaled, bias-corrected high-resolution NEX-GDDP datasets. *Theor Appl Climatol* 149, 1239–1253. <https://doi.org/10.1007/s00704-022-04111-7>.
- Whitmee, S., Haines, A., Beyrer, C., Boltz, F., Capon, A.G., Souza Dias, B.F., Ezech, A., Frumkin, H., Gong, P., Head, P., Horton, R., 2015. Safeguarding human health in the anthropocene epoch: report of the rockefeller foundation–lancet commission on planetary health. *The Lancet* 386, 1973–2028. [https://doi.org/10.1016/S0140-6736\(15\)60901-1](https://doi.org/10.1016/S0140-6736(15)60901-1).
- WHO Climate Change, 2024. <https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health>. accessed March 3, 2026.
- WHO STAR, 2021. *World Health Organization. Strategic Toolkit For Assessing Risks: A Comprehensive Toolkit For All Hazards Health Emergency Risk Assessment*. <https://iris.who.int/server/api/core/bitstreams/650a040f-33a4-4ef2-bb57-effd6ce95c91/content>. accessed March 3, 2026.