Climate Resilience Alliance

Pakistan

Heat early warning system: current status and recommendations

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Introduction and objectives

This case study examines the current state of the heat early warning system in Pakistan, including how heat risk is understood and monitored, and how warnings are issued, communicated, and acted upon across institutions. It forms part of a series of case studies conducted across eight countries of the Zurich Climate Resilience Alliance, which applies a common analytical framework to assess heat early warning systems (HEWSs) across key pillars and identify good practices, gaps, and enabling conditions for people-centred, impact-based early warning for extreme heat.

Key messages

- **Pakistan has a strong and growing evidence base on extreme heat, documenting increasing heat trends, health impacts, urban heat islands, socioeconomic vulnerability, and losses to labour productivity**. However, limited availability of disaggregated local health data and weak integration of vulnerability information into risk assessments constrain the ability of early warning systems (EWS) to deliver targeted, impact-based, and actionable warnings.
- **Pakistan has a national heat monitoring and forecasting system led by the Pakistan Meteorological Department (PMD) with regionally and monthly differentiated heatwave thresholds**, as well as complementary Heat Index information. However, warnings remain primarily hazard-based, presenting an opportunity to incorporate health impacts, local vulnerability, and exposure into impact-based warning services.
- **Pakistan has well-established warning dissemination pathways through government agencies, media, and telecommunications providers**. Nevertheless, first-mile communication remains a key challenge, with digital exclusion, language and literacy barriers, and insufficiently actionable warning messages limiting effective reach and response among vulnerable populations.
- **Pakistan has a strong and formalized preparedness architecture for extreme heat at national, provincial, and city levels**, supported by national contingency planning, provincial and city-level heat action plans, and innovative anticipatory action mechanisms. However, implementation capacity remains uneven across districts, highlighting the need to strengthen local resources, institutional coordination, and the translation of warnings into timely action.

Methodology

This case study is based on a combination of semi-structured interviews and a targeted review of peer-reviewed literature and grey documentation related to extreme heat and the heat early warning system in Pakistan. Four interviews were conducted between October 2025 and January 2026 with stakeholders across meteorological, health, and humanitarian sectors (see list of organizations below). Evidence was synthesized using the four pillars of early warning systems (1) disaster risk knowledge; 2) observations, monitoring, analysis, and forecasting; 3) warning dissemination and communication; and 4) preparedness and response capabilities) alongside enabling components for effective systems.

Interviews were conducted with:

- Concern Worldwide
- Pakistan Meteorological Department (PMD)
- Start Network Pakistan
- Focal point health facility, District Nawabshah, Sindh Province

List of acronyms used

DDMA – District Disaster Management Authority

DRF – Disaster Risk Financing

DRM – Disaster Risk Management

EWS – Early Warning System

GESI – Gender Equality and Social Inclusion

GFS – Global Forecast System

GLOF – Glacial Lake Outburst Flood

GSM – Global Spectral Model

HEWS – Heat Early Warning System

HI – Heat Index

NDMA – National Disaster Management Authority

NGO – Non-Governmental Organization

PDMA – Provincial Disaster Management Authority

PMD – Pakistan Meteorological Department

Early Warning Systems

Early warning systems (EWSs) are one of the best-proven and effective measures for saving lives and minimizing losses and harm caused by disasters. They help those at risk of floods, heatwaves, wildfires and other climate hazards to take risk-informed, timely, meaningful, and impactful early action to keep themselves and their assets safe. The Alliance works across all eight components of EWS so that they deliver essential services for the most vulnerable women, men, and children, supporting communities to be resilient to climate hazards, enabling them to thrive.

Disaster risk knowledge

Heat hazard and climate trends

Extreme heat is a well-documented hazard in Pakistan, particularly in Sindh and Punjab, where temperatures can exceed 45–50°C during the peak heat period (pre-monsoon) between April and June. Pakistan's exposure to heatwaves occurs alongside other climate extremes such as floods and droughts (Nasim et al., 2018; Usman et al., 2025). One of the most severe events occurred during the 2015 Karachi heatwave, where 1,200 people died in less than 10 days and 40,000 were treated in hospitals, showing the significant public health risks posed by extreme heat (Commissioner Karachi, 2024).

Scientific studies confirm that extreme heat has increased across Pakistan over recent decades. Analyses of long-term temperature datasets show statistically significant warming trends in several regions, particularly across major agricultural areas such as Punjab (Nawaz et al., 2020; Arshad et al., 2022; Li and Bao, 2023). For example, an assessment of multiple gridded temperature datasets for 1979-2015 found consistent warming in mean and minimum temperatures across Punjab, with a pronounced warming transition around the early 2000s (Nawaz et al., 2020). Future projections indicate that heat extremes are likely to intensify further. One modelling study projects substantial increases in heat accumulation across Pakistan under different emission scenarios, estimating increases of approximately 17–32 per cent by 2030, 49–54 per cent by 2060, and up to 62–140 per cent by 2090, with the strongest increases projected for Sindh and southern Punjab (Nasim et al., 2018).

At the institutional level, meteorological knowledge on heat hazards is primarily produced and consolidated by the Pakistan Meteorological Department (PMD), which maintains observational records and climate analyses across the country. Disaster risk knowledge across hazards, including heatwaves, is coordinated nationally by the National Disaster Management Authority (NDMA), which integrates heatwaves into broader multi-hazard disaster risk management (DRM) frameworks and national risk assessments. The NDMA Heatwave Guidelines include district-level illustrations of populations, infrastructure, agriculture, and livestock potentially exposed to heatwaves (NDMA, 2024).

Heat-related impacts, vulnerabilities, and exposure

Research across Pakistan shows that extreme heat affects multiple sectors, including public health, maternal and child health, agriculture, and livelihoods.

Extreme heat has already placed significant pressure on health systems in Pakistan. Studies from Karachi report sharp increases in heatstroke cases and emergency hospital admissions during severe heat events, with healthcare facilities experiencing surges in demand during summer heatwaves. Limited medical resources, including shortages of hospital beds, cooling infrastructure, and medical supplies, further constrain the ability of health systems to respond to heat-related illnesses (Saleem et al., 2024).

Several studies also highlight the risks that extreme heat poses to maternal and child health in Pakistan. Research from rural Sindh indicates that exposure to high temperatures during pregnancy can negatively affect fetal development, with heat exposure during early pregnancy associated with reduced birth length and smaller head circumference among newborns (Shankar et al., 2023). National-level research analyzing 17,077 birth records across Pakistan found that exposure to moderate and extreme heat during the month of conception was associated with an increased risk of low birth weight (Fatima et al., 2025). Qualitative research highlights structural vulnerabilities faced by pregnant women, particularly in rural areas where women often continue agricultural

labour and household work during periods of extreme heat while having limited access to healthcare or cooling resources (Bhanbhro and Ali, 2025). Environmental conditions may also influence child health through indirect pathways. Analysis of national nutrition survey data indicates that higher temperatures and precipitation are negatively associated with child growth indicators among children under two years old (Islam et al., 2025).

Heat stress also affects agriculture and livelihoods, which remain central to Pakistan's economy. Long-term analyses suggest that increasing temperatures influence vegetation health and crop productivity across Pakistan, highlighting risks for food systems and rural livelihoods under continued warming (Latif et al., 2024). Heat exposure is found to have significant economic implications: large population-weighted labour losses (estimated at over 10 billion hours annually) are found for Pakistan, driven by a combination of large working-age populations, seasonal heat exposure, and large fractions of the population that work in agriculture and construction industries (Parsons et al., 2021). Surveys of rural farmers in Punjab indicate that extreme heat, alongside floods and droughts, is widely perceived as a major threat to agricultural production and rural food security (Usman et al., 2025). Future scenarios show that rising temperatures and climate variability are likely to reduce crop yields and rangeland productivity in the future, with intensified heatwaves, erratic rainfall, and drought conditions projected to affect agricultural production (Shah and Chen, 2025).

Urbanization and the urban heat island

Urban heat island effects have also been widely documented in Pakistani cities, where urban areas are consistently warmer than surrounding rural regions. Studies using satellites and station data show that surface urban heat island intensity averages around 2-3°C and has increased over time, is likely to continue to increase by 2030, and found particularly strong nighttime heat islands linked to rapid urbanization and land-cover change (Tariq et al., 2022; Mehmood et al., 2023).

Risk perception, communication, and adaptive behaviour

Research across Pakistan shows that risk perception of extreme heat remains relatively low, even in areas frequently exposed to heatwaves. Interviewees mentioned how heat risk is shaped by structural deprivation in parts of Pakistan. For example, in rural Sindh, where a lack of electricity, weak communication systems, and under-resourced health facilities with poor ventilation, unreliable electricity, and limited cooling capacity increase vulnerability during extreme heat.

A household survey of 251 respondents in Faisalabad found that 57 per cent of urban respondents and 66 per cent of peri-urban respondents had low perceived risk of heatwaves (Rauf et al., 2017). Higher heat risk perception was strongly associated with knowledge and access to information. Education, age, gender, and access to health services significantly influenced awareness and perception, with older respondents showing higher heat risk perception. Female respondents had lower levels of heatwave knowledge, while married respondents perceived themselves as less vulnerable, possibly due to stronger social support networks. Adaptation behaviour was shaped by both socioeconomic and behavioural factors: lower-income households showed lower adaptation levels, and larger family size reduced the likelihood of adopting protective measures. Adaptation was also influenced by perceived benefits of protective actions, perceived barriers, and cues to action.

A recent nationwide study surveying 686 volunteers from the Non-Governmental Organization (NGO) the Alkhidmat Foundation in Pakistan also found that adaptive behaviours during heatwaves strongly depend on perceived benefits, cues to action, and self-efficacy, rather than risk perception alone (Ullah et al., 2024). Individuals who believed that protective actions were effective and felt capable of implementing them were significantly more likely to adopt such actions.

Evidence from an evaluation of a forecast-based heatwave messaging campaign in Karachi also highlights the importance of effective risk communication within HEWSs (START Network and HANDS Pakistan, 2020). Following an anticipatory messaging campaign that reached more than one million people through SMS, social media, radio, and television, participants demonstrated high recall of key protective behaviours such as drinking water and avoiding outdoor activities during the hottest hours. However, translating knowledge into behaviour remained more challenging, with relatively few participants adopting new protective practices. Most respondents expressed willingness to receive future heat warnings, and 84 per cent reported they would be more likely to follow advice if messages explicitly included a warning of impending extreme heat. The evaluation concluded that repeated, targeted messaging and clear warning information should be integral components of future heatwave response programmes.

Qualitative research from Karachi also shows that communities generally recognize heat-related symptoms such as dehydration, and identify vulnerable groups including elderly people, men working outdoors, and school children (Khan et al., 2021). However, the study found that responses are often informal and household-based, relying on home remedies and individual coping strategies rather than institutional support. Limited access to water, electricity, and shaded public spaces was identified as a key factor increasing vulnerability during heat events.

Finally, urban vulnerability studies show that coping capacity and adaptation options vary strongly between socioeconomic groups (Ahmad et al., 2022). Research comparing formal and informal settlements in Lahore found that residents of informal settlements often have lower coping capacity and fewer adaptation options, due to poor housing conditions, limited access to cooling, and constrained infrastructure.

Knowledge gaps

Interviews confirm that extreme heat is widely recognized by institutions and communities as a serious and growing risk. However, they also highlight that existing knowledge remains fragmented across domains. While meteorological and climatological information is relatively well developed, health and social vulnerability knowledge is not yet systematically integrated into national heat risk assessment or decision-making. The absence of disaggregated, local-level health data, such as heat-related morbidity, mortality, or hospital admissions disaggregated by age, sex, disability, or location was identified as a critical gap limiting the understanding of health impacts.

At community level, local organizations and NGOs contribute to increased risk knowledge through awareness-raising and education initiatives. These efforts are motivated by what interviewees described as a disconnect between nationally produced hazard knowledge and local understandings of heat impacts. Academic insights on vulnerability and coping capacity are not often operationalized in a way that directly informs community-level preparedness or anticipatory action. As a result, despite the existence of scientific studies and relatively high institutional awareness, the effectiveness of this knowledge remains uneven, with important limitations in its translation, targeting, and integration with health and livelihood outcomes.

Observations, monitoring, analysis, and forecasting

Observations, monitoring, and forecasting of extreme heat in Pakistan are led by the PMD, which is the national authority for weather forecasting and heat warnings, in coordination with the NDMA and provincial disaster management authorities (NDMA, 2025). The PMD has long monitored extreme temperature events and issued heatwave advisories, but following the 2015 Karachi heatwave, these efforts were significantly strengthened, including the development of heat action plans and early warning coordination mechanisms at city and provincial levels.

Heatwave warning definition and complementary metrics

The PMD applies region-specific heatwave thresholds, which are based on both absolute temperature thresholds and temperature anomalies relative to climatological normals. According to national guidelines, a heatwave is declared in lowland regions when maximum temperatures reach 40°C or higher and exceed the local monthly normal by 4.5-6.4°C for at least three consecutive days. A severe heatwave is declared when temperatures exceed the local normal by more than 6.4°C over the same duration. In hilly or mountainous regions, lower absolute thresholds (around 30°C) apply, while the anomaly-based criteria remain the same. Thresholds are adjusted monthly to reflect seasonal variations in baseline temperatures.

In addition to temperature-based thresholds, the PMD also produces and reports Heat Index (HI) values in forecasts and advisories which combine temperature and humidity. The PMD has been adopting and reporting HI-based criteria as part of its heat monitoring and advisory framework since 2011. Although the HI is not used as the primary trigger for national heatwave declarations, it is recognized as an important complementary metric, particularly in southern and monsoon-affected regions where humidity substantially amplifies health risks. In parallel, a heat stress index is used within the PMD's cloud-based early warning system to support crop-related advisories.

For Karachi, specific hot day and heatwave thresholds were developed, including both maximum and minimum temperatures in the heatwave definition (Box 1 (Commissioner Karachi, 2024)). These were developed based on climatological analysis, in light of limited health data. In 2016, the PMD established Heatwave Early Warning Centres in Karachi which operated round the clock, and issued heatwave warnings three days in advance (CDKN Asia, 2016). The PMD also coordinated with Karachi's electric utility (K-Electric) which was a novel aspect; they warned the power company three days ahead and then daily, so that load-shedding (power outages) were halted during the peak heatwave days, preventing aggravating the crisis.

Box 1: Karachi's warning criteria

A three-tier heat warning system was developed for Karachi following the 2015 heatwave, as detailed in Karachi's Heatwave Management Plan (Commissioner Karachi, 2024). These thresholds were developed through a combination of historical climate analysis (2006-2015), alignment with WMO heatwave definitions, and lessons from the 2015 heatwave.

Type of alert	Thresholds
Hot day advisory	40-41.9°C
Hot day warning	≥42°C
Heatwave emergency	Max. ≥42°C and minimum temperatures ≥30°C for two or more days; or when significant increase in heat-related illness or mortality

Next to heatwave warnings, the PMD issues monthly and seasonal outlooks which state the likelihood of above-normal temperatures. In addition, interviewees highlighted monitoring of soil moisture and drought-like conditions associated with prolonged heatwaves. Severe heat lasting 1-2 weeks can rapidly deplete surface soil moisture; where rainfall/irrigation relief is absent, advisories may be issued even without meeting heatwave criteria, due to impacts on crops, vegetation, and livestock.

Observations networks and forecasting models

The PMD maintains long-term observational records, with historical temperature data available since the late 1990s for a network of key stations across Punjab, Sindh, and Balochistan-regions (Nasim et al., 2018). Forecasting is conducted across multiple time scales. Forecast products span short-range operational forecasts (typically 3–5 days), monthly outlooks with temperature anomaly maps, and seasonal outlooks covering approximately three months. As lead times increase, forecasts shift toward probabilistic framing (e.g., "likely" or "very likely"), to reflect increasing uncertainty.

At short to medium ranges, the PMD operates a multi-model forecasting framework that integrates global and regional numerical weather prediction systems (PMD, n.d). For 3–7 day forecasts, the PMD primarily draws on global models including the Global Forecast System (GFS), the Global Ensemble Prediction Suite, and the Global Environmental Multiscale Model (GEM/CMC), which provide gridded forecasts of maximum, minimum, and mean temperature at resolutions ranging from approximately 25 km to roughly 100 km and are updated daily.

For higher-resolution short-term forecasting (up to 72 hours), the PMD complements global guidance with mesoscale and regional models such as the Weather Research and Forecasting model (run at ~5 km resolution), the ICON model, and the Global Spectral Model (GSM). These models allow more detailed analysis of temperature, humidity, and wind. Interviews indicate that while Pakistan has access to high-performance computing and international model outputs, national forecasters largely operate as advanced users rather than developers of modelling systems, relying on external partners and licensed products for model improvement.

The NDMA's technical team monitors global and regional climate indicators and produces seasonal heatwave projections with lead times of approximately 3-6 months (NDMA, 2024).

Heat monitoring and forecasting by humanitarian actors

Humanitarian anticipatory action in Pakistan is supported by the Start Ready Disaster Risk Financing (DRF) system, which uses a dedicated heatwave forecasting model developed with the University of Reading for the START Network (START Network, 2021, 2022). This model is designed specifically to trigger pre-agreed humanitarian financing and early action when forecast thresholds are expected to be exceeded. The model is based on NOAA's GFS, using forecast temperature and dew point to calculate HI values, and provides forecasts up to ten days in advance.

The model combines approximately 30 years of historical climatology with weather forecasts to derive district-specific trigger thresholds. For most monitored locations, triggers are based on forecast HI thresholds that must be exceeded for two consecutive days and are monitored up to seven days before the expected onset of a heatwave. In Karachi, an additional trigger follows the Karachi Commissioner Office Heatwave Management Plan, requiring maximum temperatures of at least 42°C and minimum temperatures of at least 30°C for two consecutive days (Commissioner Karachi, 2024). Following evaluations of earlier monitoring seasons, the system was refined to improve forecast performance, including revised district-specific thresholds, the introduction of a 95th percentile pre-trigger threshold to provide earlier indication of approaching extreme conditions, and routine monitoring of minimum temperature and observational station data.

For anticipatory action programming, the operational monitoring period extends from early April until the end of July, with preparedness activities beginning in March. However, interviewees noted that extreme heat increasingly persists beyond this operational window into August and occasionally even September. Interviewees also explained that the monitoring strategy evolves throughout the season: from March to June, monitoring relies primarily on temperature, whereas HI becomes increasingly important from late June onwards as humidity rises ahead of, and during, the monsoon. Forecasts with lead times of six to seven days are routinely cross-checked against PMD forecasts and other available guidance before humanitarian triggers are confirmed, balancing opportunities for early action against increasing forecast uncertainty. Interviewees further highlighted that the increasingly long and variable heat season presents operational challenges for anticipatory action, requiring preparedness activities and trigger-based financing to remain active for extended periods despite limited financial resources.

Gaps and challenges

Several heat forecasting and warning challenges persist. Both literature and interviews indicate that heat warnings remain largely hazard-based, with few linkages to expected health or livelihood impacts, and no documented post-event evaluation of forecast performance or threshold effectiveness (NDMA, 2025). A key technical challenge is lead time and tailoring at local scales. While interviewees characterized forecasts as ‘quite accurate’ at regional scales, they noted that forecasts are less tailored for very specific locations. Interviewees mentioned that lead time could also be improved. Resource constraints, including limited specialized staff, model development capacity, and dedicated IT support for tailored applications, may limit Pakistan’s heat warning system.

Warning dissemination and communication

Heat warnings in Pakistan are disseminated through a multi-layered institutional system coordinated by the PMD and the NDMA. The PMD is responsible for producing weather forecasts and heatwave advisories, which are formally transmitted to the NDMA and subsequently cascaded to Provincial and District Disaster Management Authorities (PDMAs and DDMAs) for interpretation and onward dissemination (NDMA, 2025). This decentralized structure allows alerts to be adapted and communicated at provincial and district levels, while maintaining a centralized source.

Formal dissemination responsibilities are explicitly defined in national contingency planning. The Pakistan Summer Contingency Plan assigns mass communication of alerts to the Press Information Department and the Ministry of Information & Broadcasting, with the aim of maximizing reach through television, radio, print media, and translation into local languages (NDMA, 2025). Interviewees confirmed that media actors play a central role in amplifying warnings: the PMD maintains a dedicated WhatsApp group with journalists and media outlets, enabling rapid circulation of alerts that are then broadcast through national and local media channels, alongside publication on official websites and social media channels. Additional channels include SMS alerts issued through the Pakistan Telecommunications Authority in at-risk areas, email notifications, press releases, and official mobile applications operated by the NDMA and PDMAs (NDMA, 2025; PMD, 2025).

At the sub-national level, local heat action plans (e.g., Karachi and Lahore) specify tailored communication approaches. The Karachi Heatwave Management Plan assigns communication responsibilities across multiple sectors, including health services, utilities, education, emergency responders, and the media, ensuring that warnings are disseminated through multiple complementary channels while simultaneously triggering sector-specific preparedness actions (Commissioner Karachi, 2024). Official alerts issued by PDMAs typically include projected temperatures, identification of vulnerable groups, and general behavioural recommendations, and are disseminated to district administrations for dissemination (PDMA, 2025).

Digital tools are increasingly used to support dissemination and awareness. For example, the PDMA Madadgar App provides hazard information and preparedness guidance, while the PMD Meteorogram platform allows users, primarily technical users and decision-makers, to access district-level forecast outputs, including temperature trends and rainfall (Jan et al., 2025; PMD, n.d.). Seasonal outlooks are updated at least monthly during the summer period, with advisories issued dynamically as conditions evolve. For example, in 2025, the PMD and NDMA warned in April of significantly above-normal temperatures (6-8°C above average) in the coming weeks, which was subsequently disseminated by the PDMA Sindh to district authorities with instructions to implement the provincial Heatwave Standard Operating Procedures (SOPs) (PDMA, 2025).

Figure 1. Details of the PDMA Madadgar app tabs. Source: Jan et al., 2025.

Evidence from an evaluation of a heatwave messaging campaign in Karachi further highlights the importance of using multiple communication channels (START network and HANDS Pakistan, 2020). Although participants reported receiving messages through SMS, television, radio, and social media, social media (particularly Facebook) was both the most accessed and the channel perceived as most effective. Communication preferences also varied across population groups; for example, women were relatively more likely to receive messages through social media and television than through radio or informal networks. Respondents also recommended expanding communication through television, pamphlets, schools, and community awareness sessions, reinforcing the value of combining mass media with community-based communication approaches

Beyond formal institutional channels, interviews highlighted a wide range of complementary dissemination practices. Sectoral departments such as agriculture, irrigation, and health receive advisories directly from the PMD and issue sector-specific guidance to farmers, livestock keepers, and health facilities. NGOs and humanitarian partners, including those affiliated with the Start Network, further help dissemination through schools, hospitals, community centres, radio broadcasts, social media, wall posters, and announcements in mosques, often translating messages into local languages and adapting them to local contexts (NDMA, 2024).

Both literature and interviews emphasize persistent first-mile challenges. Access to warnings is uneven, particularly among poor and vulnerable populations. Digital exclusion remains a major barrier, with many households not having smartphones or reliable internet access, limiting the reach of app-based or online warnings. Language diversity and low literacy further constrain accessibility, as national-level alerts are commonly issued in Urdu and rely heavily on text-based formats that are not easily understood by all communities. As a result, warnings may circulate effectively within institutions and media networks, but fail to reach or be understood by those most exposed to or at risk from heat. Interviewees highlighted that information does not always reach the public and/or the information is too technical/scientific. For example, one interviewee stated:

'While PMD and disaster management authorities generate accurate forecasts, the major gap is that the information flow to the right beneficiaries at the ground level… they sometimes miss those information [sic]. Like those information [sic] are too scientific for them.'

Interviews consistently stressed that effectiveness depends not only on whether warnings are received, but on whether they are trusted, understood, and actionable. A key limitation identified was the lack of clear, practical guidance accompanying many heat warnings. Advisories often communicate temperature thresholds or the occurrence of a heatwave without specifying concrete actions for individuals, households, or livelihood protection. This contributes to risk normalization, with some communities perceiving extreme heat as "normal" in the absence of clear actions. Forecast uncertainty, such as instances where predicted heat coincides with rainfall, can further erode trust over time.

At the same time, interviewees described several promising pilot initiatives and project-based approaches to heat risk communication. These included SMS alerts and voice messages in local languages, test calls explaining protective behaviours, and community-based engagement through Village Climate Adaptation Forums, where trained representatives translated meteorological information into locally relevant advice for different groups, including women, older people, and people with disabilities. In some pilot programmes, investments in connectivity and communication devices also led to sustained engagement with warning information, with communities continuing to access, and in some cases pay for, these services after recognizing their value. However, these initiatives remain largely isolated pilots or donor-funded projects that have yet to be institutionalized or scaled up within Pakistan's wider HEWS.

Figure 2. Children are bathing in the water of a village hand pump to cool down during the heatwave. Source: Arif Shad/Concern Worldwide

Preparedness and response capabilities

Pakistan has formal preparedness and response planning for extreme heat across national, provincial, and city levels. The heatwave in 2015 in Karachi was a turning point where a state of emergency was declared. Early local plans, such as the Karachi Heatwave Management Plan developed in 2015 after the devastating heatwave, helped institutionalize the plans, clarifying stakeholder roles, and introducing routine pre-season review processes to incorporate lessons learned (Commissioner Karachi, 2024; NDMA, 2024). Building on these city-level precedents, additional local governments (e.g., Lahore, Multan, Sindh) have developed heat response guidance, while the NDMA now integrates heatwaves into national Summer Contingency Planning and issues dedicated SOPs that define responsibilities for meteorological services, provincial and district authorities, health departments, utilities, and other operational actors. This creates a structured pathway from warnings to action, with thresholds intended to activate staged measures across agencies.

Interviews however suggest that the link between warnings and protective action remains uneven. Plans exist, but there are gaps in implementation and inconsistent translation of guidance into actionable, locally relevant information that reaches communities. This gap in the translation of warnings is compounded by institutional mandate boundaries. Meteorological actors focus on issuing timely warnings, while implementation of preparedness activities and follow-through relies on other agencies, creating ambiguities in the handover of responsibilities. Interviews also highlight that impact-based planning remains limited at national scale, with district-specific triggers and impact estimates still underdeveloped and lacking targeted actions.

Despite these constraints, Pakistan has several strong examples of preparedness programming that makes heat warnings actionable through training, community structures, and pre-positioned response capacity. Karachi's plan includes an annual heatwave awareness campaign aimed at the general public, communicating risk characteristics, prevention measures, and appropriate behaviour during extreme heat (NDMA, 2024). At the provincial level, heat emergency training has been delivered to key stakeholders such as traffic police, civil society organizations, and response actors, including through collaboration with the Pakistan Red Crescent and provincial disaster management authorities.

Humanitarian anticipatory action initiatives provide a further operational layer, with the Start Network's Start READY Pakistan Disaster Risk Financing system combining forecast-based triggers with pre-agreed financing, coordination arrangements, and contingency planning to enable early action ahead of extreme heat (START Network, 2022). The READY Pakistan anticipatory action programme was launched as a pilot in 2019 by Welthungerhilfe Pakistan with support from the START Network (Amad and Riaz, 2025). The heatwave component was first activated in 2022 and subsequently expanded through Concern Worldwide in 2023-2024. Interviews describe an explicit sequencing in these models, distinguishing a preparedness period (positioning partners and resources in targeted districts) from post-trigger interventions implemented within defined time windows. Activities include training community leaders in disaster preparedness and first aid, opening shelters in schools and other communal spaces, spreading public awareness on heatstroke prevention and identification of symptoms, establishing helplines, and setting up health emergency camps that provide cold drinking water and medicines.

Response measures described across literature and interviews span both public health protection and livelihood support. Common interventions include dissemination of action-oriented information, education and communication materials (e.g., on heat illness prevention, emergency contacts, and cooling locations), distribution of heatwave kits (e.g., water bottles, umbrellas etc), and

establishment of temporary cooling points with health staff to identify and manage heat-related illness. In anticipatory action activations, Start Network partners and implementing NGOs contribute by carrying out key anticipatory actions. As an interviewee mentioned:

'Our partners provide and install cooling centres near hospitals, markets, and bus stations. Additionally, they request minimum [electricity] load shedding in these areas and support heatstroke centres by installing equipment such as air conditioning, and upgrading systems with solar panels to ensure continuous electricity during daylight hours at hospitals.'

Figure 3. Sami Foundation Team serving the cold drinking water to Students returning from school. Community Ali Bux Khokhar in Shaheed Benazirabad district. Source: Hyder Awan, Sami Foundation.

Multi-hazard approach

Heatwaves in Pakistan are addressed within a broader multi-hazard summer planning framework. At national level, heatwaves are integrated into the NDMA "Summer Hazards Contingency Plan", which covers a range of seasonally overlapping hazards including heatwaves, droughts, floods, forest fires, cyclones, and glacial lake outburst floods (GLOFs). These hazards occur during the same season, and place simultaneous pressure on the health system, agriculture, water resources, and infrastructure.

A key early document is the "National Multi-Hazard Early Warning System Plan", published by the NDMA in 2012 (Mukhtar, 2018). This document establishes common institutional and operational architecture for early warning across hazards, including shared monitoring responsibilities, dissemination pathways, and coordination mechanisms between the PMD, disaster management authorities, and sectoral departments.

In both national plans and interview evidence, extreme heat is explicitly linked to drought and agricultural risk. Studies highlight how prolonged extreme heat accelerates soil depletion, exacerbates drought conditions, and leads to crop stress and livestock losses, particularly in arid and semi-arid regions. Interviewees described heatwave-induced soil moisture deficits as a form of 'rapid-onset drought,' reinforcing the operational link between heat monitoring, agricultural advisories, and drought preparedness. This linkage is reflected in coordinated advisories issued to agriculture and livestock departments during extreme heat periods. In northern Pakistan, rapid glacier melt increases the risk of GLOFs and landslides and threatens water supplies. During the 2022 heatwave, the Pakistani government warned that the extreme heat was likely to increase the risk of GLOFs (Zachariah et al., 2023).

However, while hazards are planned for together, there is limited evidence that compound or cascading risks are operationalized through adjusted triggers or thresholds. Heatwave thresholds do not change when heat coincides with other hazards, with integration primarily occurring at the planning, coordination, and response level, through shared arrangements, seasonal preparedness timelines, and cross-sectoral response.

Gender and social inequalities addressed inclusively

A growing body of research has documented how gender, socioeconomic status, disability, occupation, and place of residence shape heat vulnerability, access to warnings, and the capacity to take protective action in Pakistan. While formal heat warning thresholds remain predominantly based on meteorological conditions, with limited systematic integration of health outcomes or social vulnerability into the definition of warning triggers, Gender Equality and Social Inclusion (GESI) considerations are more evident in preparedness, communication, and response activities.

Official warnings are cascaded through the NDMA, PDMAs, and DDMAs and disseminated through mass communication channels with the aim of maximizing reach and translating messages into local languages. However, both the literature and interviews identify barriers to equitable access, particularly for people with low literacy, limited digital connectivity, women in rural settings, older adults, persons with disabilities, and communities living in informal settlements or remote areas. For example, women in rural Pakistan are disproportionately represented in agricultural work, increasing their exposure to extreme heat (Abdulqadir et al., 2024). Similarly, studies from Pakistan show that gender, education, income, access to information, and settlement type influence heat risk perception, adaptive behaviour, and coping capacity (Rauf et al., 2017; Ahmad et al., 2022; Ullah et al., 2024). Interviewees described first-mile exclusion caused by limited mobile phone

ownership, difficulties interpreting technical meteorological information, and warnings that are insufficiently actionable.

GESI-oriented approaches appear strongest in humanitarian and community-based delivery models. Concern Worldwide describes applying an explicit “GESI lens” through the Village Climate Adaptation Forums and Union Council-level committees. These committees are intentionally composed to ensure representation that includes women, older people, persons with disabilities, and minorities. Committee members receive trainings on early warning interpretation and early action and then act as community focal points, translating messages to their respective groups. An example of tailored messaging is gender-specific dissemination, where heat warnings are shared directly with women through representatives, especially in domains linked to agriculture and livestock; this was reported to improve understanding and uptake of warnings. Start Network also noted the use of disaggregated census data (age, sex, disability) to support hotspot targeting and prioritization during heatwaves. Across interviews, these strategies are complemented by accessible formats and trusted channels, including SMS/voice formats, community intermediaries, and radio dissemination where television and smartphones are less available.

Despite these promising examples, both the literature and interviews indicate that GESI remains unevenly institutionalized within Pakistan's HEWS. Communication is still largely one-directional, with limited mechanisms to assess whether warnings are received, understood, trusted, and acted upon by different population groups. Interviewees also noted that social vulnerability is not yet systematically incorporated into warning triggers or impact assessments, meaning that inclusive approaches remain concentrated within humanitarian programmes rather than being embedded consistently across the national system.

Local community involvement

Local community involvement is increasingly recognized as key in Pakistan’s HEWS to bridge the gap between centrally issued warnings and local action. Interviews consistently highlighted that community-based structures are essential for turning technical information into guidance that is understood, trusted, and acted upon.

Humanitarian actors described the use of structured community mechanisms, such as Village Climate Adaptation Forums operating at village and Union Council levels, to build early warning literacy and support inclusive participation. These forums are designed to represent women, older people, and persons with disabilities, and focus on practical understanding of early warning and early action for hazards including heatwaves. Trained representatives act as trusted “change agents” sharing information within their social networks and supporting locally relevant preparedness.

Beyond dissemination, interviews also highlighted how community engagement can improve and add value to warnings. In remote areas, locally embedded actors, such as trained shepherds, have functioned as informal monitors and messengers, demonstrating how trusted local intermediaries can complement institutional systems and enable rapid life-saving action.

Overall, local community involvement strengthens early warning effectiveness by enhancing interpretation, trust, and uptake of heat-related information. However, interviews suggest that such approaches remain uneven and often dependent on project-based support, pointing to the need for more systematic integration of community structures within national and sub-national early warning frameworks. Establishing user- and GESI-friendly feedback mechanisms that enable different population groups to communicate whether warnings were received, understood, trusted,

and acted upon are crucial. Such feedback can help identify barriers to access, improve message design and dissemination, and ensure that early warning systems remain responsive to the needs of vulnerable populations.

Effective governance and institutions

Governance of heat early warning in Pakistan is embedded in the broader DRM mechanism and follows a structure with responsibility passing from federal, to provincial, district, and sub-district/community levels. At the centre of the system, the PMD functions as the technical agency for monitoring, forecasting, and issuing weather-based advisories, while the NDMA provides coordination and translates seasonal outlooks into preparedness guidance for relevant stakeholders. The “Summer Hazards Contingency Plan” and the “National Disaster Response Plan” are designed to formally prepare for several hazards, including heatwaves, within an integrated planning framework.

The Contingency Plan illustrates how responsibilities are distributed across institutions and sectors. It assigns shared anticipatory and early response roles to the PMD, NDMA, PDMAs, and the health sector for monitoring temperature and humidity and disseminating advisories and precautionary measures to the public. It further signals a coordination intent through proposals such as establishing control rooms for information management and coordination during the heat season, and developing Union Council-level Heatwave Response Units (with NDMA/PDMAs and health authorities) to enable more timely local response. The plan also frames risk communication as a whole-of-government task by assigning heat-health awareness campaigning (pre-season) to the Ministry of Information and Broadcasting together with the PMD.

At the operational level, interviews confirm that the institutional flow is widely understood: the PMD generates the hazard information and shares it through formal channels and direct coordination with relevant line departments (e.g., agriculture, irrigation, health), while the NDMA and PDMAs play a key role in dissemination and coordination. Multiple interviewees described an established DRM structure, with the NDMA at national level, PDMAs at provincial level, and DDMAs at district level, supported by emergency response actors such as Rescue 1122 and civil defence structures.

Interviews highlight three potential governance limits that shape the overall effectiveness of the HEWS. First, community-centric implementation remains low. One respondent summarized that dissemination often fails to reach the most exposed groups. Second, impact-based and district-targeted governance is underdeveloped: interviewees noted that national-level messaging tends to remain generic (“heatwave-like conditions”) without systematic estimation of expected impacts. Third, access to basic services and resources shapes how useful warnings are in practice. Warnings may fail to translate into action if communities and local systems lack feasible options to respond, particularly where electricity load-shedding, limited cooling options, or weak service provision reduce the ability to act on advice. This resonates with the Contingency Plan’s emphasis on cooling centres, trained coordination staff, and health-system readiness, but interviews suggest these enabling measures are unevenly realized and highly dependent on resources and local governance capacity.

Key recommendations

- **From hazard warning to impact-based heat warnings**: Pakistan has a technically strong heatwave monitoring and forecasting system, but warnings remain largely hazard-based and generic. Thresholds are defined meteorologically, with no integration of health outcomes, livelihood impacts, or district-specific vulnerability. Progressing towards impact-based heat warnings that link forecast thresholds to anticipated impacts at the district level would enable more targeted preparedness, communication, and response.
- **Strengthen the warning to action flow across institutions**: While institutional responsibilities for forecasting, coordination, and warning dissemination are well defined, interviews identified persistent gaps in translating warnings into timely action. Meteorological responsibilities largely end with warning issuance, whereas protective measures depend on sectoral agencies without consistently defined trigger-action protocols. Strengthening coordination between the PMD, disaster management authorities, health services, utilities, and local governments through pre-agreed, sector-specific trigger-action protocols would help ensure that warnings consistently activate protective measures. These protocols should explicitly incorporate GESI considerations to ensure that actions address the needs of vulnerable population groups.
- **Operationalize multi-hazard and compound risk management**: Heat is well integrated into Pakistan's national multi-hazard planning architecture, including the National Multi-Hazard Early Warning System Plan and the Summer Hazards Contingency Plan. However, developing operational protocols that account for interacting hazards and cascading impacts, such as concurrent heat and drought, heat-induced power outages, or water shortages, would strengthen preparedness and improve coordinated responses during complex emergencies.
- **Strengthen inclusive first-mile communication and feedback**: Although Pakistan employs multiple dissemination channels, important barriers remain in ensuring that warnings reach and are understood by all population groups. Limited literacy, language diversity, rural connectivity, unequal access to mobile phones, and the technical nature of warning messages can all reduce warning effectiveness. Strengthening locally tailored, multilingual, and accessible communication, supported by trusted community intermediaries, would improve warning reach and uptake. Equally important is establishing user- and GESI-friendly feedback mechanisms that enable different groups to report whether warnings were received, understood, trusted, and acted upon, allowing continuous improvement of warning services.
- **Institutionalize and resource community-based early warning and preparedness**: Community-based mechanisms, such as Village Climate Adaptation Forums, have demonstrated their value in improving the interpretation, trust, and uptake of heat warnings. However, these approaches remain largely dependent on humanitarian or project-based initiatives and have not yet been systematically embedded within government-led early warning and preparedness frameworks. Scaling these approaches will require sustained investment in local implementation capacity and long-term institutional support. It also requires strengthening the interface between science and practice by translating nationally produced hazard information and academic evidence on vulnerability, exposure, and coping capacity into locally relevant preparedness and anticipatory action. Embedding this knowledge within community-led planning processes would help ensure that EWSs are both scientifically robust and responsive to local needs.

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Front cover image: *In Shaheed Benazirabad, during an extreme heatwave, a street vendor prepares and stocks large ice blocks. With poverty and no electricity in the villages, people are compelled to buy ice to have cold drinking water.* Photo: Arif Shad/Concern Worldwide

About the Zurich Climate Resilience Alliance

The Zurich Climate Resilience Alliance is a collaboration between humanitarian, NGO, research and private sector partners, working to build resilience to climate hazards in rural and urban contexts.

Formerly the Zurich Flood Resilience Alliance, we have over a decade of experience in generating evidence of communities' current levels of climate resilience and identifying appropriate solutions.

Through long-term community programmes, new research and stakeholder influencing, we strive to deliver systemic change at scale and realize our vision of a world in which communities are more resilient to climate hazards, and able to thrive.

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