Climate Resilience Alliance

Senegal

Heat early warning system: Current status and recommendations

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Practical ACTION

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Introduction and objectives

This case study examines the current state of the heat early warning system (HEWS) in Senegal, 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 across key pillars and identify good practices, gaps, and enabling conditions for people-centred, impact-based early warning for extreme heat.

Key messages

- **Senegal has built a strong and growing evidence base on extreme heat, but accessible impact data remain limited and uneven.** Research shows increasing heat extremes, clear regional variability, and links to mortality, hospitalizations, livelihoods, food security, and energy demand. However, routinely available health and impact data remain geographically uneven and operationally limited, constraining systematic evaluation and threshold refinement.
- **Since 2022, Senegal has operated a national impact-oriented heat-health early warning system.** The operational heat-health bulletin is co-produced by Agence Nationale de l'Aviation Civile et de la Météorologie (ANACIM) and the Ministry of Health and integrates probabilistic heat forecasts with vulnerability and exposure data to produce spatially explicit risk maps.
- **A major strength of the system is its use of context-specific heat metrics, locally differentiated thresholds, and vulnerability-informed risk analysis.** Heat risk is treated as multi-dimensional: maximum temperature is used in dry inland regions, while the Heat Index is applied in more humid coastal areas such as Dakar. This locally tailored approach, combined with vulnerability mapping, helps make warnings more relevant and targeted.
- **Senegal has developed a layered warning dissemination system that supports accessibility, trust, and behavioural response.** Heat warnings are disseminated through the national bulletin and amplified via television, radio, SMS, WhatsApp, social media, Common Alerting Protocol (CAP) alerts, and community-based outreach by the Senegalese Red Cross and community health workers. Accessible design, local interpretation, and iterative evaluation have strengthened uptake, although first-mile reach, translation, and structured feedback mechanisms still need improvement.
- **Strong cross-sector collaboration underpins the system, but preparedness, formal trigger-action linkages, and long-term sustainability remain key challenges.** A national climate-health technical committee has enabled co-production, coordination, and institutional learning, and pilots have demonstrated practical responses such as adjusted work schedules, school measures, and improved health readiness. However, preparedness remains largely decentralized and discretionary, with no formal national heat-health action plan or trigger-action protocols, while long-term sustainability is constrained by limited resources and dependence on external funding.

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 Senegal. Two interviews were conducted between October 2025 and January 2026 with stakeholders across meteorology and humanitarian response (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. Given the limited number of interviews conducted, the findings draw substantially on peer-reviewed and grey literature and should be interpreted accordingly.

Interviews were conducted with:

- The National Agency of Civil Aviation and Meteorology (Agence Nationale de l'Aviation Civile et de la Météorologie; ANACIM)
- Ministry of Health and Public Hygiene of Senegal (Ministère de la Santé et de l'Hygiène publique – Directorate General of Health (DGS)

List of acronyms used

ANACIM - National Agency of Civil Aviation and Meteorology

CAP - Common Alerting Protocol

CRD - Regional Development Committee

DGS - Directorate General of Health

ECMWF - European Centre for Medium-Range Weather Forecasts

EW4All - Early Warnings for All

EWS - Early Warning System

GESI - Gender Equality and Social Inclusion

GIS - Geographic Information System

HEWS - Heat Early Warning System

HI - Heat Index

NGO - Non-governmental organizations

NOAA - National Oceanic and Atmospheric Administration

SOFF - Systematic Observations Financing Facility

Tmax - Maximum temperature

WRF - Weather Research and Forecasting

Early warning systems

Early warning systems (EWS) 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

Climate trends and observed heat patterns

A range of studies have documented rising temperatures across Senegal, increasing numbers of hot days and nights, and more frequent heatwaves, with particularly strong warming signals since the early 2000s and minimum temperatures rising faster than maximum (Ly et al., 2025; Nakalembe et al., 2025).

Heatwaves are most frequent and intense during the late dry season in spring (March–May), but also occur outside this period, and show diverse patterns across coastal, inland, northern, and eastern regions (Ly et al., 2025; Nakalembe et al., 2025; Sow and Gaye, 2024). Studies show that these heat events are linked to large-scale weather patterns and the movement of hot, dry air from North Africa, showing that extreme heat in Senegal has clear physical causes and some seasonal predictability (Sambou et al., 2020; Guigma et al., 2021). Recent work highlights that spring heatwaves in Senegal frequently coincide with elevated desert dust, which can amplify thermal stress, particularly at night, pointing to compound heat-air quality risks (Diouf et al., 2024). Most studies use weather station data, along with satellite and model data, to understand where and how extreme heat occurs across the country.

Climate projections consistently indicate that extreme heat will intensify further throughout the 21st century. Model-based studies project substantial increases in the frequency, duration, and severity of heatwaves under both moderate and high-emissions scenarios for Senegal, with particularly rapid increases in minimum (night-time) temperatures, which exacerbate cumulative heat stress and limit nocturnal recovery (Ly et al., 2025; Sarr et al., 2019; Sow and Gaye, 2025; Sylla et al., 2018). By mid- to late-century, hinterland Senegal may experience near-continuous heatwave conditions during the hot season under high-emission scenarios (Sambou et al., 2021).

Recent studies have also shown that heatwaves and their impacts are increasingly predictable. Advanced machine-learning approaches have demonstrated the ability to extend the prediction of extreme heat to subseasonal timescales (1–2 weeks) (Kenne et al., 2024), while heat-related hospitalizations can be anticipated using statistical and machine-learning models, as shown for northeastern Senegal (Toure et al., 2025). Together, these advances create a critical opportunity to strengthen anticipatory action, preparedness, and targeted response through HEWS.

Figure 1. People walking on a dusty road in Bignona, Senegal, 2025. Source: Sweder Breet on Unsplash https://unsplash.com/photos/people-walking-on-a-dusty-road-in-a-village-oJAgysXbWpw

Heat-related health impacts and epidemiological evidence

There is also growing local evidence linking extreme heat in Senegal to health impacts. Epidemiological and mixed-methods studies show that heatwaves are associated with increases in mortality, morbidity, hospitalizations, and health facility visits across different regions in Senegal (Faye et al., 2021; Sy et al., 2022; Brimicombe et al., 2024; Toure et al., 2025).

Evidence from south-eastern Senegal further shows that heatwave definitions based on three consecutive days with both high minimum and maximum temperatures best capture observed mortality patterns, serving as useful underpinning for a health-relevant heat definition for that region (Faye et al., 2021). Another study showed a statistically significant delayed increase in hospitalizations three to five days after heat (Toure et al., 2025). Urban studies further show that extreme heat increases electricity demand in cities such as Dakar, exacerbating the probability of blackouts during peak heat periods, indirectly increasing vulnerability (Aissatou et al., 2017). Heat also acts as a risk multiplier. For example, heat can alter behaviours such as sleep, with people choosing to sleep outside, avoid bed nets, or wear less clothes, which undermines malaria prevention practices, as has been shown in rural southeast Senegal (Sherman, 2025).

Health impacts are unevenly distributed across the population, with vulnerability factors such as socioeconomics, age, gender, housing quality, occupation, access to drinking water, and living conditions mentioned in both the literature and by interviewees (Faye et al., 2021; Sy et al., 2022). Studies from northern Senegal report higher self-reported heat-related illness, health-care utilization, and mortality risk, particularly among women and older adults (Faye et al., 2021; Sy et al., 2022). During severe events such as the May 2013 heatwave, medical staff reported an approximately 12 per cent increase in heat-related mortality, with older women disproportionately affected (Sy et al., 2022). These patterns are interpreted as reflecting gendered exposure and vulnerability pathways, including greater involvement in outdoor and domestic activities, limited

access to cooling, and cumulative health burdens (Sy et al., 2022). Furthermore, large multi-country analyses using a thermal heat metric (the Wet Bulb Globe Temperature) demonstrate that heat significantly increases mortality risk among children under five in Senegal (Brimicombe et al., 2024).

At the same time, interviewees emphasized that the operational use of health-related risk knowledge remains constrained by data gaps. Despite the growing body of scientific evidence, basic and routinely accessible health data on heat impacts in Senegal are limited, therefore studies often rely on survey-based or self-reported health data. Interviewees highlighted the need for sustained financial and human resources, as well as closer collaboration with researchers to develop shared protocols and capitalize on existing data, to further improve heat warnings and action plans.

Vulnerability assessments

Beyond epidemiological evidence, Senegal has undertaken structured efforts to operationalize heat vulnerability assessment through multi-stakeholder processes. In October 2023, a national workshop held in Dakar brought together ANACIM, the Ministry of Health, civil protection, researchers, and humanitarian actors to co-develop and validate heat vulnerability indicators integrating demographic, socio-economic, health access, housing, and occupational exposure dimensions. These indicators were explicitly designed to support impact-based heat early warning and to inform the spatial targeting of alerts and preparedness actions. This marked an important step toward institutionalizing heat vulnerability assessment in Senegal and bridging scientific evidence with operational early warning and preparedness planning.

Risks to livelihoods, food security, and critical sectors

Beyond health evidence, research shows that extreme heat in Senegal poses significant risks to livelihoods, food security, and critical services. Agricultural and experimental studies show that combined heat and drought stress reduce crop yields, including rice in the Senegal River Valley, although heat-tolerant varieties offer some adaptive potential (Moukoumbi and El-Namaky, 2025). Livestock systems, central to rural livelihoods, are highly sensitive to rising temperatures, with heat stress affecting pasture availability, animal health, and productivity, particularly among pastoral and agropastoral communities with limited adaptive capacity (Eeswaran et al., 2022). A pilot evaluating heat warnings in the Fatick region also highlighted that the community was interested in learning about the impact of heat on animal and plant health, as well as livelihoods (USAID, 2024) (for more details on the Fatick pilot, see later sections on “Warning dissemination and communication” and “Preparedness and response capabilities”). This broader evidence base highlights the importance of designing HEWSs that extend beyond health-only metrics and explicitly incorporate livelihood, food security, and service continuity considerations.

Overall, this growing body of heat risk evidence provides a strong foundation for HEWSs in Senegal. However, much of this evidence has emerged only in recent years and remains geographically uneven. As a result, heat risk knowledge has yet to be fully consolidated or systematically translated into operational decision-making nationwide.

Observations, monitoring, analysis and forecasting

Observations and monitoring of extreme heat

Senegal's monitoring and forecasting of extreme heat is led by the ANACIM, which operates the national meteorological observation network and holds the legal mandate for weather forecasting, early warning, and climate services. The agency acts as the technical backbone of the HEWS, ensuring consistency across observation, forecasting, and translation of climate information into health-relevant risk products.

There are some gaps in Senegal's weather observation infrastructure, especially in the country's eastern region, but observational capacity is expected to improve through the Systematic Observations Financing Facility (SOFF) under the Early Warnings for All (EW4All) initiative (Verver, 2024). This initiative is expected to enhance both global numerical weather prediction skill and the quality of national forecasts, while strengthening the long-term sustainability of Senegal's meteorological observing system (Verver, 2024).

Forecasting

Forecasting draws on a combination of national observations and international modelling tools. ANACIM integrates surface weather station data with satellite products and outputs from global numerical weather prediction systems, including National Oceanic and Atmospheric Administration (NOAA) ensemble systems (GEFS, CFSv2) and European Centre for Medium-Range Weather Forecasts (ECMWF), complemented by national climate analytics (Thiaw et al., 2021; Verver, 2024). Senegal also runs a high-resolution Weather Research and Forecasting (WRF) model (~3 km) (Verver, 2024). Forecasting operates across multiple timescales, from seasonal outlooks to sub-seasonal forecasts and short-term products (weekly, daily, and nowcasting). Probabilistic modelling plays a central role: forecast outputs are expressed in probability categories. The system relies on technical and financial support from NOAA, which provides access to global forecasting models and expertise[1].

The development of an impact-oriented heat-health warning system

Senegal is among the earliest African countries to have developed an explicitly impact-oriented heat-health early warning system, built on sustained dialogue and collaboration between the meteorological and health sectors. Early workshops and consultations, initiated in 2015 and reinforced through subsequent regional and national meetings, laid the institutional and technical foundations for the co-production of the operational heat-health bulletin launched in 2022[2]. This development reflects an accumulation of efforts since 2015, including structured exchanges between meteorological and health services and the establishment of a dedicated climate and health committee (GHHIN et al., 2025). Since its launch, the bulletin has become the backbone of Senegal's heat early warning efforts and is issued regularly during the main heat season, from March to June (USAID, 2024). Between 2022 and July 2025, 35 heatwave bulletins were produced (GHHIN et al., 2025).

Senegal's heat-health early warning system is embedded within international early warning initiatives. Through collaboration with NOAA's Climate Prediction Center, Senegal has been identified as a priority country for advancing heat-health early warning in Africa. This collaboration has focused on strengthening sub-seasonal to seasonal heat forecasting, integrating vulnerability

[1] NOAA/NCEP African Heat Forecast Products available through: https://ftp.cpc.ncep.noaa.gov/International/global_heat/afr/index.html
[2] All bulletins are available through: https://www.anacim.sn/spip.php?article1018

data into outlooks, and institutionalizing co-production between meteorological, health, and humanitarian actors (Thiaw et al., 2022).

Operational products

The heat-health bulletin is Senegal's primary operational product for the heat-health early warning. It is a multi-page, impact-oriented bulletin that combines probabilistic heat forecasts with spatially explicit vulnerability and exposure information and recommended actions (Figure 1). The bulletin typically includes a heat-health alert and highlights at-risk areas through a colour-coded risk map, health information and populations most at risk, practical and simple recommendations to reduce heat impacts, and on the last page, background information on the expected meteorological conditions. Designed for use by both professionals and communities, the bulletin prioritizes usability through visual maps and simple messaging.

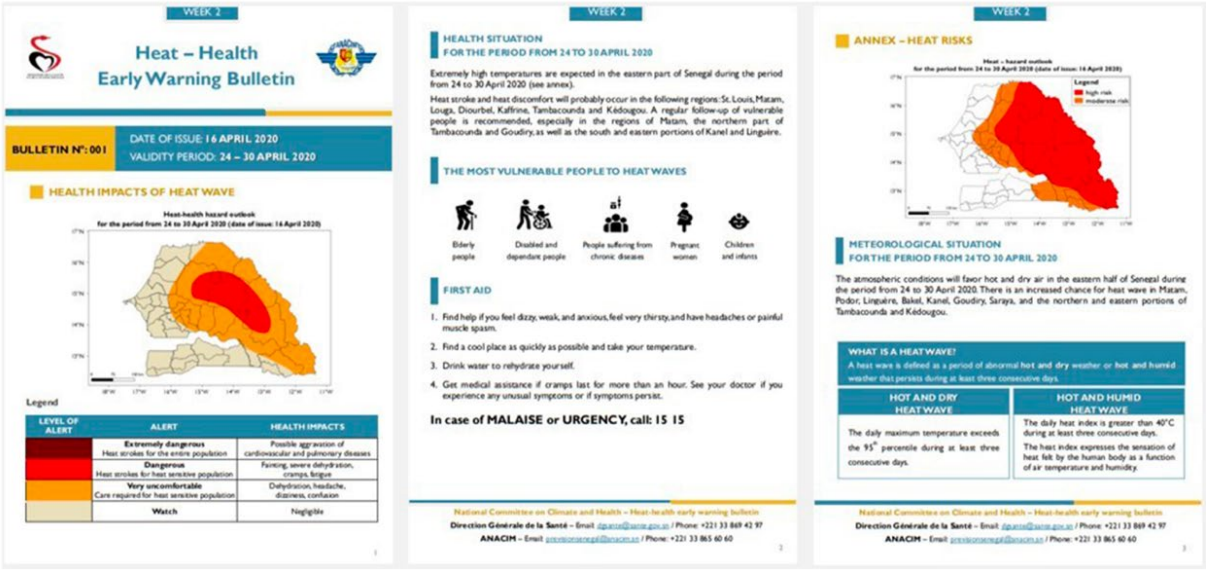

Figure 2. Heat-health early warning bulletin (page 1: The heat-health alert, page 2: Recommended actions to mitigate the impacts of heat, page 3: Hazard background information). Source: www.anacim.sn & Thiaw et al., 2022

Context-specific heat indicators and metrics

A key strength of Senegal's system is the context-specific definition of heat. Heat is treated as a multi-dimensional phenomenon; thus, Senegal uses multiple heat indicators, and thresholds are defined locally. In dry northern and north-eastern regions, where humidity is low during the heat season, maximum temperature (Tmax) is the most relevant metric, with extreme values exceeding 45–49 °C during severe events. In contrast, in coastal areas (e.g. Dakar), where humidity is high, the Heat Index (HI), combining temperature and humidity, is used by ANACIM to define heat. Thresholds are based on moving percentiles and vary by location, with heatwaves defined as three or more consecutive days above the location-specific 90th percentile of historical daily maximum temperature (roughly 38–45 °C, depending on region). Recently, a hybrid index combining Tmax and HI was developed by ANACIM to better capture heat sensitivity under conditions of strong solar radiation, low wind speed, and limited cloud cover.

Stakeholder consultations have consistently highlighted the importance of forecast lead time for effective early action. Workshops with health authorities indicated that lead times of approximately 7–10 days are sufficient to enable coordination and preparedness at community level (Thiaw et al., 2022). In collaboration with NOAA's Climate Prediction Center, ANACIM meteorologists gained access to global models and training to predict heatwaves up to two weeks in advance (Thiaw et al.,

2022). Subsequent pilots demonstrated the feasibility of issuing one- to three-week outlooks of heatwave likelihood for specific regions, updated weekly (every Tuesday) throughout the heat season, providing a meaningful window for anticipatory health planning (USAID, 2024).

Impact-oriented design and vulnerability integration

Another defining feature of the forecasting system is its explicitly impact-oriented design. Interviewees repeatedly stressed that meteorological forecasting alone is insufficient to capture heat risk. As a result, heat forecasts are combined with socio-economic and health vulnerability information through collaboration between ANACIM, the Ministry of Health, and the Ecological Monitoring Centre. Two main types of maps are produced in the bulletin: (i) an impact-oriented heat–health risk map that overlays forecast heat exposure with vulnerability indicators to identify populations most at risk, and (ii) a meteorological heat map showing forecasted conditions. Vulnerability indicators include population density, access to health facilities, access to air conditioning/ventilation, access to drinking water, access to natural cooling (beach, pool, etc.), access to electricity, and demographic characteristics (older people, pregnant women, children, and people with heatwave-prone diseases). This integration enables more targeted alerting and supports prioritization by health authorities.

Gaps and challenges

Several challenges remain. Recent experience has highlighted the limitations of a strictly seasonal framing of heat risk. Recent warm conditions outside of the traditional March–June period, including unusually warm winters, have shown the need for a more continuous, year-round understanding of heat risk under climate change; also considering impacts on sectors other than health. Furthermore, despite strong technical capacity, forecasting operations remain constrained by resource limitations. Current activities rely largely on external funding, operational forecasting depends heavily on external models and project-based technical support, and many services developed through projects face sustainability challenges once project funding ends (Verver, 2024). Interviewees noted that planned initiatives to strengthen data integration, evaluation, and forecasting capacity were delayed or cancelled due to external funding decisions (Verver, 2024). Sustained investment in national observation networks, data assimilation, and human capacity is therefore essential for long-term resilience and continued progress to adapt to changes.

Vulnerability maps used in the heat-health warning system were historically produced by dedicated services, with some limitations in terms of update frequency and automation. As part of ongoing work with NOAA, efforts are under way to improve and automate vulnerability mapping in collaboration with Geographic Information System (GIS) experts. Efforts to fill the current geographical gaps in the system are also under way by non-governmental organizations (NGOs) such as Practical Action, funded by donors such as the L'Oreal Foundation and the Sanofi Foundation. Opportunities have arisen to integrate areas such as Kaolack (with humid heat, high urban density, and open-air markets) and Matam (with extremely high temperatures and documented heat-related hospitalizations) into the operational vulnerability mapping.

Lastly, the limited availability of long-term health and other impact data remains a persistent challenge, constraining the setting of impact-relevant thresholds. This gap has been addressed pragmatically by combining global evidence (e.g. World Health Organization guidance), emerging national studies, and stakeholder expertise, showing the importance of adaptive approaches in data-scarce contexts.

Warning dissemination and communication

Multi-channel dissemination of the heat-health bulletin

Heat warning dissemination in Senegal is centred on the national heat-health bulletin, which functions as the primary public-facing warning product during the main heat season (March–June). The bulletin is co-produced by ANACIM, the Ministry of Health, and the Ecological Monitoring Centre, and distributed via the media and social networks with the support of the Senegalese Red Cross at community level. Operationally, the system aims to provide warnings at least 24 hours in advance. As mentioned before, interviewees emphasized that communication focuses on translating forecasts into actionable risk information, rather than communicating abstract temperature values.

Dissemination relies on a deliberately layered, multi-channel strategy designed to maximise reach across diverse population groups. At national level, bulletins are disseminated through institutional platforms, including the ANACIM website (www.anacim.sn) and Ministry of Health channels, and amplified via mass media such as television, national and community radio, print media, and social media (Verver, 2024). A free call-in mechanism is also available, with phone numbers listed on the bulletin. Digital dissemination also plays an increasingly important role, including SMS alerts, WhatsApp groups managed by ANACIM to share messages and voice audio, and social media accounts around 38,000 followers at present and growing reach. WhatsApp groups exist for both the broader public with followers from all backgrounds, as well as a smaller working group for end-users (decision-makers, local authorities, community relays/influencers, NGOs, and humanitarian actors). SMS alerts are used in a targeted manner, particularly for authorities, technical services, and selected at-risk groups. These messages are intentionally short and action-oriented, providing concise alerts and key recommendations to support rapid decision-making and early action at institutional and community levels.

Alerts are issued using the CAP format, ensuring consistent formatting across all hazards. Voice messages have been piloted to reach non-literate audiences, using simple spoken alerts disseminated via telephone services, often with support from local start-ups. While effective, this approach remains resource-intensive and difficult to scale systematically.

Community-based dissemination is another critical layer, led primarily by the Senegalese Red Cross in close collaboration with the health sector. The bulletin is cascaded from national authorities to regional and district health directors, who may mobilize community health workers and Red Cross volunteers for direct, person-to-person dissemination. As one interviewee explained: *'I send it to the authorities by email, to all health directors and all regional health directors, and it is then up to them to disseminate it'*.

Figure 3. Dissemination of alerts by ANACIM. From webinar: https://ceh.unicef.org/events-and-resources/events/timely-alerts-safer-futures-leveraging-heat-health-early-warnings

For example, during heatwave alert issued from 1–3 November 2023 in the Fatick region (selected as a pilot site to test community-level decision-making), the alert was disseminated through channels including: local radio stations (RTS Fatick and Ndef Leng FM), WhatsApp relay groups (nine groups totalling 783 members), the local technical working group (16 members), the Regional Development Committee (CRD; 60 members), and a local climate–health group (30 members).

Accessible design of the bulletin

Furthermore, the bulletin itself is explicitly designed for accessibility. It uses visual layouts, pictograms, and simple language, and includes a dedicated section with simple and practical recommendations (e.g. hydration, seeking shade, avoiding outdoor activity during peak heat). Interviewees stressed that messages are intended to be explained orally and easily passed on, supporting communication in low-literacy contexts. Community radio stations play a key role in translating bulletin content into spoken local languages, although interviewees noted that more systematic translation remains an area for improvement. This is crucial, as Senegal has over 30 languages and dialects spoken in the country as of 2013, and only 37 per cent of the population speaks French, and mostly as a second language (Clear Global, n.d.). The bulletin has a section on the *'most vulnerable groups to heatwaves'*, mentioning older adults, disabled and dependent people, people with chronic illnesses, pregnant women, and children and infants (Figure 1).

Targeted outreach and awareness activities

Beyond mass dissemination, Senegal combines nationwide alerts with targeted outreach and awareness activities at the level of the pilot sites. Health and meteorological authorities have organized workshops with women's groups, youth organizations, outdoor workers, and health professionals to build shared understanding of heat risk and warning interpretation. Interviewees reported generally high levels of uptake and trust in the alerts, noting that messages resonate because they align with lived experience of extreme heat.

Monitoring, evaluation, and learning

Importantly, Senegal has invested in monitoring and learning around communication effectiveness of the warnings. Iterative learning has been integral to system development, and feedback from communities and stakeholders has been used to refine the bulletin.

A pilot, co-led by ANACIM, Ministry of Health, and local authorities, was launched in Fatick in 2023. As part of this pilot, Red Cross volunteers conducted surveys with approximately 600 respondents in the Fatick region across farms, restaurants, public transport, health facilities, and households (ANACIM, n.d.; USAID, 2024). These evaluations provided insights into message clarity, channel effectiveness, and behavioural responses. Feedback directly informed adaptations to the bulletin, including the introduction of voice recordings for users with limited literacy following feedback from farmers. Additional pilots demonstrated cross-sectoral benefits; for example, collaboration with the education sector led to the bulletin being used to adjust school timetables and plan temporary closures during extreme heat.

Gaps and challenges

Despite these strengths, interviewees and evaluations highlight challenges. Although the use of the heat-health bulletin continues to be monitored and evaluated, for example with help from the Red Cross, systematic feedback mechanisms are still limited, largely due to human and technical capacity constraints (Verver, 2024). Interviewees acknowledged that not all populations are reached and that institutions currently lack robust tools to identify underserved groups; delivery in rural areas with limited connectivity remains an area for improvement (Verver, 2024). This has prompted growing interest in more structured evaluation of warning uptake and impact, including household and health facility surveys and community feedback mechanisms. Sustaining and scaling resource-intensive communication channels, such as voice messages, was identified as a particular challenge requiring dedicated funding and institutional support. Lastly, procedures linking meteorological warnings to disaster management agencies and sectoral responders remain partly informal.

Overall, Senegal's heat-health warning dissemination demonstrates strong practice in multi-channel communication, community engagement, and iterative learning. Key lessons include the value of working through existing community structures, empowering trusted local actors as messengers, and iteratively refining communication based on user feedback. At the same time, strengthening institutionalized feedback loops, formalizing inter-agency procedures, and ensuring sustainable resourcing remain important priorities for enhancing the effectiveness and equity of heat warning dissemination and communication.

Preparedness and response capabilities

From warning to action: Pilot experiences

Anticipatory action and response to extreme heat in Senegal are primarily enabled through the heat-health early warning bulletin, which is explicitly designed to support anticipatory action. The bulletin includes a dedicated section with behavioural recommendations and awareness messages for communities, such as guidance on hydration, shade-seeking, and reducing outdoor activity, and is also intended to act as a preparedness cue for health services. Interviewees noted that health staff use the bulletin to anticipate increased needs among vulnerable populations during forecasted heat events. Evidence from pilot regions suggests that forecast lead times of around eight days are sufficient to trigger practical anticipatory action measures when institutional coordination is in place (Thiaw et al., 2022).

Pilot implementations, particularly in the Fatick region in 2023, have demonstrated that warnings have translated into action. For example, football teams have adjusted training schedules to avoid peak heat, shepherds have limited herd movement during the hottest periods, schools have planned breaks, early closures, and water distribution, and health services have improved readiness to support vulnerable groups (ANACIM, n.d.; USAID, 2024). However, preparedness actions remain largely decentralized and discretionary, with implementation left to local actors rather than triggered through mandatory or standardized mechanisms such as a national Heat(-Health) Action Plan. This is because the warning product is not yet formally linked to predefined response protocols. Thus, in practice, the system currently functions more as an enabling signal than as a fully operational trigger–action framework.

In Fatick, the pilot phase also led to the strengthening of local heat governance mechanisms. Following recurrent heat alerts and their observed impacts, the regional Governor issued an administrative decree establishing a multisectoral heat response committee. This committee brings together civil protection services, firefighters, the Red Cross, health authorities, security forces, meteorological services, and local government representatives. The committee is mandated to translate heat warnings into concrete protective decisions, including the temporary suspension or rescheduling of outdoor activities during extreme heat, such as school classes, football matches, and mass gatherings. It also supports the identification of cooling and rest areas, public awareness measures, and anticipatory coordination among emergency and health services. This local governance innovation represents a critical step toward formalizing trigger–action linkages and embedding heat preparedness within routine territorial decision-making.

In Kaolack, market and field workers, and in Matam, agropastoral communities with little access to water, lack predefined action protocols related to heat warnings (e.g. time adjustments, water distribution, shadow areas). NGOs such as Practical Action are planning to develop sector-specific plans for community groups, which could support new sectoral early action protocols that could be replicated at the national level.

Institutional coordination and governance

Institutionally, anticipatory action and response are coordinated through a governance structure that connects climate and health actors. A technical committee on climate and health, embedded within the Ministry of Health's broader multisectoral environment and health working group, brings together ANACIM, the Ministry of Health, the Ecological Monitoring Centre, the Senegalese Red Cross, and other partners. Interviewees described this committee as the main mechanism through which heat-health preparedness is coordinated, emphasizing that *'early warning cannot be carried out by a single entity.'* Coordination is described as largely collaborative and informal, relying on

regular communication and virtual meetings rather than formalized agreements, which interviewees viewed as sufficient for current operational needs.

Local engagement

Local engagement plays a critical role in translating warnings into practical preparedness, especially for groups with high exposure or limited access to information. Education and outreach activities by ANACIM and health authorities, including workshops with women's groups, youth, outdoor workers, and health professionals are used to build shared understanding of what constitutes a heatwave and how warnings should be interpreted. At community level, Red Cross volunteers and community health workers support preparedness through direct, person-to-person engagement, complementing national dissemination via radio and other mass channels. While this layered approach helps reach populations without reliable internet access, interviewees acknowledged that participation in bulletin design remains largely top-down. To address this, the pilot initiative in Fatick has begun establishing local climate–health committees modelled on the national structure, as mentioned above, aimed at strengthening local capacity and anchoring preparedness more firmly at sub-national level.

Learning and evaluation are recognized as essential components of preparedness in Senegal. Following each heat season, small-scale evaluations, often conducted by the Red Cross, are used to assess uptake, identify gaps in reach, and explore whether warnings influenced behaviour or helped reduce health impacts. Interviewees stressed that while not all populations can be reached, such evaluations are critical for identifying underserved groups and refining preparedness strategies over time.

Long-term adaptation and resilience

Beyond short-term preparedness, longer-term heat adaptation measures are emerging, particularly in urban areas. Remote-sensing studies in Dakar show that rapid land-use change, urban expansion, and loss of vegetation and wetlands have intensified the urban heat island effect, strengthening the evidence base for greening and heat-sensitive urban planning (Cissé et al., 2024). Municipal climate and resilience strategies in Dakar increasingly recognize heat risk and provide entry points for longer-term measures such as expanding urban green space, protecting cooling land covers, and improving urban design for thermal comfort. Pilot initiatives in Dakar on cool roofs using reflective coatings to reduce heat absorption have been implemented on selected public buildings, although these efforts remain limited in scale and evaluation.

Gaps and challenges

Preparedness and response remain unevenly institutionalized and heavily reliant on external funding and project-based support. Interviewees and programme evaluations highlighted that sustained response capacity is constrained by limited financial and human resources, as well as the absence of predefined, multi-sector trigger–action protocols that would link warnings to specific response measures across sectors (Verver, 2024; USAID, 2024). This limits scalability and consistency, particularly beyond pilot regions.

Overall, Senegal's preparedness and response system for extreme heat demonstrates strong institutional coordination and growing local engagement, but remains constrained by the absence of formal trigger–action protocols, limited resourcing, and partial localization. Strengthening the linkage between warnings and predefined response actions, expanding local participation, and embedding preparedness more firmly within national health and disaster risk governance frameworks represent key opportunities for advancing heat preparedness and resilience.

Multi-hazard approach

Although Senegal's heat early warning system was initially developed around extreme heat and health impacts, it is increasingly framed as part of a broader multi-hazard climate–health risk management approach. Strategically, Senegal is positioning its heat early warning efforts within a longer-term vision for a comprehensive climate–health warning system. Health-sector interviewees described ongoing efforts to expand beyond heat to include other climate hazards affecting health, such as dust storms, floods, drought, and coastal erosion. A recent study has highlighted the role of desert dust as a compounding factor during extreme heat events (Diouf et al., 2024). Operationally, the heat warning system already benefits from shared infrastructure and protocols used for other hazards, including dissemination through the CAP, allowing heat alerts to sit alongside other weather and climate warnings. Community feedback from pilot regions further reinforced the interest for multi-hazard and multi-impact information. Respondents frequently raised concerns not only about human health, but also about impacts on animal and plant health, as well as livelihoods. In response, Senegal has broadened stakeholder engagement to include sectors such as livestock and education, enabling heat warnings to inform protective actions beyond the health sector. At the same time, a fully integrated multi-hazard early warning system remains at an early stage. While capacity is growing, operational integration across hazards, particularly in terms of shared thresholds, combined risk products, and coordinated trigger–action protocols, has not yet been fully realized.

Gender and social inequalities addressed inclusively

Gender equality and social inclusion (GESI) are primarily enabled through explicit identification of vulnerable groups and deliberate adaptation of warning formats to reduce social and informational barriers. Health-sector interviewees identified priority groups for heat risk, including older people, pregnant and breastfeeding women, young children, people with disabilities, those with chronic illness, and individuals working outdoors. Accessibility is reinforced through design choices. The heat-health bulletin uses simple language, pictograms, and visual layouts, explicitly aiming to support oral explanation and peer-to-peer transmission in low-literacy contexts. Dissemination through community radio in local languages, alongside face-to-face communication, further reduces exclusion linked to language and education. Evaluation practices also play an enabling role: post-season surveys and community feedback provide a mechanism to identify who was reached and who remains underserved. GESI is further strengthened through the active involvement of women's groups in both design and implementation. In the Fatick pilot, women's leadership networks were engaged as key communicators and advisors, contributing insights on how heat risks are experienced and how messages could be better framed for households and communities (USAID, 2024). These networks enhanced trust and reach, particularly among women.

Gender-sensitive vulnerability dimensions identified in epidemiological studies have also been explicitly incorporated into operational discussions on heat risk management. During national vulnerability workshops and pilot activities, women's groups, health workers, and Red Cross volunteers highlighted differentiated exposure patterns linked to domestic labour, caregiving roles, and limited access to cooling and water resources. These insights directly informed the prioritization of women and elderly populations in the heat–health bulletin messaging and outreach strategies.

At the same time, challenges remain. Not all local languages are consistently covered, and social inclusion is stronger in dissemination than in design of the bulletin. A key lesson emerging from the pilots is that deeper involvement of several marginalized groups earlier in the design process rather

than primarily during dissemination, which has been done through a local advisory committee, further strengthens equity and relevance. It is crucial to have formal feedback mechanisms in place to continue to engage feedback from people, especially vulnerable groups.

Local community involvement

Local community involvement has also been a defining enabling condition of Senegal's HEWS, particularly at the level of dissemination, education, and feedback. While bulletin design remains largely centralized, local actors play a critical role in explaining warnings, translating messages into local contexts, and supporting behavioural change. The Senegal Red Cross has been central to first-mile delivery. Integrated within community health systems, Red Cross volunteers and community health workers disseminate alerts directly through door-to-door engagement, visits to fields and markets, and person-to-person awareness-raising. This model allows warnings to reach households and occupational groups with limited access to digital media and reinforces trust through familiar intermediaries.

Community involvement was particularly strong during the pilot phase in 2023. In Fatick, a local advisory group comprising civil society actors, including women's groups, youth sports associations, teachers, firefighters, and Red Cross volunteers, was consulted on message framing and communication channels. These actors also supported post-alert surveys with approximately 600 community members, generating feedback that directly informed revisions to the bulletin. However, participation remains uneven. Interviewees acknowledged that community involvement in earlier, design phases can be strengthened. Although this pilot was limited to Fatick, there are plans to replicate this approach to Matam and Diourbel.

Interviewees stressed the importance of institutionalizing local climate–health committees, modelled on the national governance structure. Pilot discussions in Fatick explored the establishment of local advisory groups involving local authorities, community leaders, women's associations, and technical services, with the objective of anchoring heat preparedness and feedback mechanisms at sub-national level. This is crucial, as sustaining community engagement at scale remains challenging, particularly given reliance on volunteers and limited resources.

Effective governance and institutions

Effective governance underpins Senegal's heat early warning system through sustained cross-sector collaboration, clear role differentiation, political support, and iterative learning. Governance is anchored in a technical committee on climate and health, embedded within the Ministry of Health's broader environment-and-health platform, which brings together meteorological, health, environmental, and civil society actors and is widely described by interviewees as essential, reflecting the shared understanding that early warning cannot be carried out by a single entity. This governance arrangement combines formal and informal mechanisms.

In 2016, ANACIM, with NOAA's facilitation, convened the first meeting between national meteorological and health authorities. Thereafter, Memoranda of Understanding (MoUs) were established to formalize the partnership: ANACIM and the Ministry of Health designated focal points in each agency to work on climate–health issues and set a joint work plan (2019–2020) to develop the heat–health bulletin. This formal governance mechanism ensured that roles and responsibilities were clear. At the same time, day-to-day coordination is sustained through regular communication, virtual meetings, and personal networks, with interviewees describing the governance as lightweight and functional rather than heavily formalized.

High-level political support has also been a critical enabling factor. Engagement of regional and national decision-makers, particularly following evidence of increased heat-related hospitalizations and the demonstrated effectiveness of the bulletin in pilot regions, helped secure legitimacy and visibility for the heat–health bulletin, and Senegal's approach has since been recognized regionally as an example of innovation in public service delivery (ANACIM, n.d.).

Effective governance in this case has also meant iterative improvement and accountability: agencies committed to monitoring pilot outcomes through surveys and evaluations and jointly learning from them to refine the programme, which proved vital for scaling up.

Governance innovations have also emerged at sub-national level. In Fatick, political leadership played a decisive role in operationalizing heat early warning information. The establishment of a regional multisectoral heat committee through a formal administrative order strengthened vertical coordination between national warning systems and local decision-making structures. This arrangement enabled early warnings to be rapidly discussed within existing governance platforms such as the CRD and translated into enforceable preventative measures. It illustrates how decentralized governance can enhance the effectiveness of heat early warning systems by aligning scientific information with locally legitimate authority and sectoral coordination.

On the other hand, governance remains vulnerable to resource scarcity. Much of the system relies on staff time rather than dedicated budgets, and long-term sustainability is threatened by dependence on external funding. Strengthening institutionalization through stable financing, clearer trigger–action protocols, and integration into the national health and disaster risk framework, remains a key challenge.

Key recommendations

- **Strengthen trigger-action linkages:** Senegal's heat early warning system provides timely, impact-oriented information, but preparedness and response remain largely discretionary and decentralized. The absence of predefined, multi-sector trigger–action protocols limits the ability of warnings to consistently activate coordinated responses. Formalizing these linkages, potentially through a national or local heat–health action plan, represents a key opportunity to translate early warning into consistent action. These developments align closely with the objectives of Senegal's National Adaptation Plan (Climate–Health), which emphasizes anticipatory action, decentralized governance, and the integration of climate information into health and territorial planning. The Fatick pilot demonstrates how national policy frameworks can be translated into operational local mechanisms when early warning systems are coupled with political leadership and multisectoral coordination.
- **Strengthen data, vulnerability, and impact assessment for operational decision-making:** Despite growing scientific evidence on heat-related health impacts, the routine availability, digitisation, and operational use of health and vulnerability data remain key constraints. Health data are still largely paper-based at facility level, inconsistently recorded, and not systematically accessible at daily resolution, which limits robust evaluation of acute heat impacts and avoided losses. Even where digital systems exist (e.g., District Health Information Software 2 - DHIS2), indicators are typically aggregated monthly, whereas extreme heat operates on a daily timescale, making it difficult to detect short-term signal-response relationships and validate warning thresholds operationally. Vulnerability indicators, while increasingly well-defined through multi-stakeholder processes, remain difficult to operationalize, update, and maintain consistently at scale due to data gaps, limited harmonisation across sectors, and resource constraints. Also, Senegal's climate is extremely diverse. Together, these limitations constrain the refinement of health-relevant thresholds, systematic evaluation of warning effectiveness, and the justification of sustained investment in anticipatory action. Addressing them will require sustained investment in health data digitisation and standardization, improved access to weekly or daily health outcomes for climate-sensitive conditions, harmonised and routinely updated vulnerability datasets, and institutionalized monitoring frameworks to assess warning performance across diverse climatic zones.
- **Deepen equity and first-mile reach:** Senegal has made important progress in inclusive communication through visual bulletins, local languages, and trusted community networks and women groups, but gaps remain in reaching all vulnerable groups and localities, particularly in remote geographies. Expanding and formalizing community engagement, partnering with community radio networks and train them in ANACIM's information, strengthening and formalizing feedback mechanisms, further integrating gender equality and social inclusion into design and evaluation, can help ensure warnings translate into equitable outcomes.
- **Consolidate and institutionalize financing and capacity:** The system has benefitted from strong technical collaboration and capacity building, but remains heavily reliant on external, project-based funding and staff time. Long-term sustainability will require stable national financing, continued investment in observation and forecasting infrastructure, and institutionalized capacity development across meteorological, health, and community actors, not only to maintain but also to improve and adapt systems. At the same time, there is a need to broaden collaboration beyond core government institutions to include researchers, the education sector, civil society organizations, and the private sector. These actors can play a key role in strengthening risk knowledge, innovation, communication, and community engagement.
- **Advance toward integrated, multi-hazard climate-health warning systems:** Heat warnings currently benefit from shared infrastructure and emerging compound-risk knowledge (e.g. heat and dust), but full multi-hazard integration is still at an early stage. Building on the HEWS to incorporate other climate hazards and cross-sector impacts offers a strategic pathway toward more comprehensive, climate-resilient early warning and preparedness systems. This should be accompanied by stronger integration of early warning systems into national disaster risk management and preparedness plans, ensuring that warnings are systematically linked to coordinated early action and response.

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Front cover image: *Opening the window to increase ventilation in Thiafoura, Senegal, 2022*. Photo by E. Diop on Unsplash.

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