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Technology Executive Committee

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Draft policy on brief advancing community-based early warning systems

Cover note

A. Background

1. As per activity A.3.1 of the rolling workplan, the Technology Executive Committee (TEC) is to identify and analyse emerging and transformational technologies for adaptation (e.g. early warning systems and disaster risk management), including the role of finance and the private sector in supporting their deployment.

2. At TEC 30, the TEC considered and welcomed a proposal by the International Organization for Migration (IOM) on potential areas for collaboration. The TEC agreed to consider engagement with IOM on emerging and transformational adaptation technologies.[1]

3. At TEC 31, the TEC agreed to develop a policy brief on advancing community-based early warning systems, with a focus on people-centred early warning. The policy brief is to emphasize on low-technology, accessible, last-mile solutions that are aligned with the pillars of Early Warnings for All initiative of the United Nations Secretary-General[2], highlight adaptation-friendly technologies, and include consideration of migrants and other mobile populations. The TEC requested the open-ended activity group to prepare the first draft of the policy brief for consideration at TEC 32.[3]

B. Scope of the note

4. The annex to this note contains the draft policy brief on advancing community-based early warning systems.

C. Possible actions by the Technology Executive Committee

5. The TEC will be invited to consider the draft policy brief and provide guidance to the open-ended activity group.

[1] TEC/2025/30/17, paras 42 and 44.
[2] https://www.un.org/en/climatechange/early-warnings-for-all.
[3] TEC/2025/31/6, paras 17 and 19.

Annex

Draft policy brief on advancing community-based early warning systems

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I. Executive Summary

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[to be finalized]

II. Why This Brief?

Early warning systems are now widely recognized as a core public good for climate adaptation, disaster risk reduction, and resilience-building. Multi-hazard early warning systems (MHEWS) underpin the ambition of the Early Warnings for All (EW4All) initiative[4] to ensure universal protection by 2027, contribute directly to the implementation of the Sendai Framework for Disaster Risk Reduction[5], and support the achievement of the Paris Agreement goals by reducing avoidable loss of life, livelihoods, and displacement as climate risks intensify.

At the same time, progress has been uneven. While investments in hazard monitoring, forecasting, and national-level warning capabilities have expanded, persistent gaps remain in how warnings reach people and are translated into timely life-saving action. These gaps are most visible at the "last mile," particularly for displaced, mobile, and otherwise marginalized populations, and in contexts characterized by limited infrastructure, weak connectivity, geographic isolation, and constrained institutional capacity. Least Developed Countries (LDCs), Small Island Developing States (SIDS), and many diverse global contexts continue to face structural barriers that limit the effectiveness of early warning systems precisely where risks are highest.

The intended audience includes national policymakers and technical agencies responsible for disaster risk management (DRM), adaptation, and hydrometeorological services; local governments and community organizations implementing last-mile preparedness; humanitarian actors operating in displacement settings; donors and climate funds financing adaptation and risk reduction; and private sector partners including telecommunications and data providers whose systems shape warning dissemination.

The joint TEC–GEO policy brief *Realizing Early Warnings for All: Innovation and technology in support of risk-informed climate resilience policy and action* underscored the critical role of innovation and technology in strengthening climate and disaster risk information and assessment. Building on that foundation, this brief addresses a complementary and increasingly urgent question: how early warning systems can be designed, governed, and sustained so that they work in practice for people on the ground, especially those who are displaced, mobile, or living in high-risk and under-resourced settings.

This joint brief by the TEC and the International Organization for Migration (IOM) aims to shift the focus from technology availability to operational effectiveness. It examines how people-centered early warning systems are implemented, how low-tech and hybrid solutions function in real-world conditions, and how governance, capacity, and financing arrangements shape last-mile delivery. Particular attention is given to community-driven approaches, and accessibility for mobile populations.

The brief is organized around three key areas:

(a) **Promoting community-driven, low-tech and hybrid early warnign systems (EWS) solutions** that integrate local knowledge, are understandable and actionable, and are governed and maintained locally.

(b) **Improving accessibility for mobile and displaced populations**, including culturally and linguistically appropriate messaging, trusted intermediaries, and inclusive feedback loops.

(c) **Bridging financing, capacity, and technology for last-mile delivery,**

[4] https://earlywarningsforall.org/site/early-warnings-all

[5] Sendai Framework for Disaster Risk Reduction 2015-2030 | UNDRR

including models that translate risk data into targeted investment and locally led action.

Across these sections, the brief remains aligned with EW4All pillars and principles, while bringing a focused contribution: ensuring that early warning systems are designed to work for vulnerable and mobile communities so that no one is left behind.

Developed as part of the Technology Executive Committee's rolling workplan for 2023-2027, and informed by collaboration with international organizations and practitioners, the brief translates global commitments into practical, implementation-oriented insights. It draws on case studies from diverse contexts to show how national and regional warning capabilities can be connected to local action through trusted institutions, appropriate technology choices, and sustained investment.

The brief is intended to provide:

(a) Policy-relevant insights on strengthening the people-centered dimensions of MHEWS, including governance, capacity, and financing at the community level;

(b) Concrete case studies illustrating how low-tech and hybrid early warning solutions operate effectively in displacement-prone and infrastructure-constrained environments; and

(c) Actionable recommendations for policymakers, technical agencies, humanitarian and development actors, and private sector partners across the early warning system value chain.

By centering the experiences and needs of those most exposed to climate and disaster risks, this brief aims to support decision-makers in advancing early warning systems that are not only technically sound, but usable, trusted, and capable of reducing avoidable loss, damage, and displacement.

III. Note on Methodology

This policy brief is based on a qualitative review and synthesis of existing policy, technical guidance, and applied practice related to multi-hazard early warning systems, with a particular focus on people-centered delivery and last-mile effectiveness. The analysis draws on authoritative sources from multilateral processes on climate change and disaster risk reduction, operational guidance from humanitarian and development actors, and peer-reviewed academic literature on community-based and inclusive early warning approaches.

The brief is informed by a set of illustrative case studies selected to reflect diverse hazard profiles, geographic contexts, and institutional settings, including displacement-prone and infrastructure-constrained environments. Examples are drawn from documented operational experience and secondary sources and is used to highlight practical implementation lessons rather than to provide comprehensive evaluations of individual systems.

The methodology emphasizes comparative learning across contexts rather than prescriptive or exhaustive assessment. It does not introduce new primary data or modeling, nor does it seek to rank technologies or approaches. Instead, it focuses on identifying common enabling factors, constraints, and transferable lessons relevant to policymakers and practitioners working across the early warning system value chain.

IV. Introduction: The Imperative for People-Centred Early Warnings

Extreme weather and climate-related hazards are intensifying and shifting in ways that are already reshaping where and how people live.[6] [7] As risks evolve, so do patterns of mobility, displacement after sudden-onset events, seasonal and circular movements linked to livelihoods, and longer-term relocation where slow-onset stressors erode the limits of adaptation.[8] [9] In this context, early warning systems (EWS) are not simply technical instruments for forecasting hazards: they are a core public good that determines whether people can act in time, protect lives and livelihoods, and avoid preventable displacement.

At the end of 2024, 83.4 million people worldwide were living in internal displacement, according to IDMC.[10] While 9.8 million people remained displaced due to disasters at year's end, disasters triggered 45.8 million new internal displacements over the course of the year, underscoring the increasingly cyclical and cumulative impacts of climate- and hazard-related shocks.

The United Nations Secretary-General's Early Warnings for All (EW4All) initiative has set an ambitious but necessary goal: by 2027, every person on Earth should be protected by life-saving multi-hazard early warning systems.[11] EW4All's architecture is built around four mutually reinforcing pillars (1) disaster risk knowledge, (2) detection/monitoring/forecasting, (3) warning dissemination and communication, and (4) preparedness to respond, supported by enabling policy, investment, and capacity.

Recent global status reporting shows measurable progress in MHEWS coverage, but also persistent gaps and uneven maturity across pillars and regions. Global reporting shows progress, but uneven and incomplete coverage: 119 countries, around 60 per cent worldwide[12] report having a multi-hazard early warning system, though many systems remain partial, fragmented across EW4All pillars, or unable to consistently reach communities most at risk, including displaced and mobile populations.These gaps are most pronounced in contexts where risk is already concentrated: Least Developed Countries (LDCs), Small Island Developing States (SIDS), fragile and conflict-affected settings (FCAS), and underserved rural or peri-urban areas.[13] Critically, even where national capabilities exist, warning systems often fail at the "last mile"- the point where information must be received, understood, trusted, and acted upon by communities, including people who are displaced, on the move, or excluded from formal systems.

This policy brief is developed as a successor and operational companion to the joint

[6] Intergovernmental Panel on Climate Change (IPCC). *Sixth Assessment Report (AR6), Working Group I: The Physical Science Basis*. Geneva, 2021.

[7] United Nations General Assembly. *Report of the Secretary-General on Climate Change and Disaster Risk Reduction*. A/77/248, 2022.

[8] Intergovernmental Panel on Climate Change (IPCC). *AR6 Working Group II: Impacts, Adaptation and Vulnerability*. Geneva, 2022.

[9] *International Organization for Migration (IOM). World Migration Report 2024: "Climate change, food insecurity and human mobility: interlinkages, evidence and action."* IOM, 2024.

[10] Internal Displacement Monitoring Centre (IDMC). *Global Report on Internal Displacement 2025*. Geneva, 2025.

[11] World Meteorological Organization (WMO) and United Nations Office for Disaster Risk Reduction (UNDRR). *Early Warnings for All: Executive Action Plan 2023–2027*. Geneva, 2023.

[12] United Nations Office for Disaster Risk Reduction and World Meteorological Organization (2025). Global Status of Multi-Hazard Early Warning Systems. Geneva, Switzerland.

[13] United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States and United Nations Office for Disaster

Technology Executive Committee (TEC) and Group on Earth Observations (GEO) policy brief, Realizing Early Warnings for All: Innovation and technology in support of risk-informed climate resilience policy and action,[14] launched under the EW4All initiative. The TEC–GEO brief advances the global evidence base on how innovation and technology can strengthen climate information and risk knowledge, including the enabling environments needed for technology deployment and uptake. Building on those insights, the present brief focuses on a persistent and under-addressed question: how to ensure early warning systems work for people and communities living with mobility, displacement, and heightened vulnerability—especially in under-resourced settings where EWS investments remain fragmented and project-based.

A persistent coverage gap: mobility, displacement, and exclusion

People who are displaced or mobile frequently face compounding barriers that reduce their access to timely and actionable warnings. These may include linguistic and cultural barriers, limited access to trusted information networks, restricted connectivity, legal and administrative constraints, and reduced trust in formal authorities. [15] [16] Displaced communities may also reside in hazard-prone locations steep slopes, floodplains, informal settlements, or camps where exposure is high and evacuation options are constrained. In many settings, EWS are designed around fixed administrative boundaries and stable populations; as a result, warning pathways do not adequately reflect cross-border movement, transient residence, evolving camp or informal settlement layouts, or the reliance on community intermediaries.[17] These dynamics are illustrated within case studies within this brief from Cox's Bazar, Burundi, and Peru, where mobility, informality, and trust deficits shape how warnings are received and acted upon.

A people-centered EWS approach starts from the opposite premise: that effective warning systems are co-produced with users, designed for accessibility, and validated through feedback and real-world experiences.[18] This includes combining scientific forecasts with local and indigenous knowledge, ensuring redundant and context-appropriate communication channels, and embedding preparedness and response capabilities that allow households and communities to act.[19] It also requires shifting from short-term, technology-heavy pilots to sustainable systems that are locally governed, financed, maintained, and continuously improved. The Dominica, Burundi and Philippines case studies that follow in this policy brief demonstrate how locally anchored governance and hybrid communication approaches strengthen trust and usability over time.

From top-down alerts to community-driven systems that people trust and use

Evidence across diverse contexts shows that the effectiveness of an EWS depends less on the sophistication of a single technology than on the integrity of the full warning chain risk knowledge, monitoring and triggers, dissemination practices, and preparedness to respond

Risk Reduction (2024). *Status of Multi-Hazard Early Warning Systems in the Least Developed Countries*. New York, United States of America.

14 UNFCCC & GEO 2024. Realising Early Warnings for All: Innovation and Technology in Support of Risk-Informed Climate Resilience Policy and Action. United Nations Climate Change Secretariat. Bonn.

15 United Nations Office for Disaster Risk Reduction (UNDRR). *Early Warning Systems and Early Action in Fragile, Conflict and Violence-Affected Contexts*. Geneva, 2022.

16 World Meteorological Organization (WMO). *Global Status of Multi-Hazard Early Warning Systems 2024*. Geneva, 2024.

17 UNDP, UNDRR. *The technology dividend: Empowering and protecting communities through early warnings.* 2025.

18 UNDRR. *Inclusive early warning early action: checklist and implementation guide*. 2023

19 WMO. Early Warnings for All. Executive Action Plan 2023-2027. 2022.

supported by clear governance and sustainable resources.[20] Global reporting increasingly emphasizes co-development with local communities to ensure systems are understood and acted upon and highlights the need for targeted investment where gaps persist.[21]

In under-resourced settings, community-driven and low-tech (or hybrid) approaches can be decisive. Simple river markers, flag systems, megaphones, community radio, or town-crying methods may outperform purely digital tools when connectivity is unreliable, people reside outside of major cities, literacy is low, or trust is mediated through local leaders and volunteers.[22] At the same time, appropriately designed digital tools such as targeted SMS, localized apps, or interoperable alert protocolls can extend reach, improve speed, and enable cross-border coordination when they are accessible and embedded in trusted governance structures.

Many countries and communities face a patchwork of EWS investments. This includes short project cycles, limited maintenance budgets, insufficient training, and weak integration between national systems and community action. To close last-mile gaps-especially for mobile and displaced populations-means of implementation must be treated as a bundle:

- **Financing** that is predictable, flexible, and able to reach local actors;
- **Capacity** development for risk interpretation, communication, inclusive engagement, drills, and governance;
- **Technology access** that is appropriate, maintainable, and interoperable with national systems.

This brief adopts a practical lens, seeking to highlight what works and is working in real world settings to connect national and regional warning capabilities to inclusive community action, including for people on the move.

Box 1
EWS for Mobile Populations:

The EWS for Mobile Populations: Operational Guidance is a forthcoming practical, field-oriented resource that has been in development since the spring of 2025. Co-developed by UNDRR and IOM, the guide has been supported by key global partners including IFRC, UNHCR, and WMO. Scheduled for publication in 2026, it was created to address the systemic exclusion of displaced and mobile groups from disaster warning systems.

This guidance serves as a standardized framework to support any stakeholder–including National Disaster Risk Reduction and Management Authority (NDRMAs), UN agencies, NGOs, and community organizations–seeking to implement or scale early warning systems. It is a primary tool for the universal rollout of EW4All, offering specific methods to identify and include people who are often invisible to formal systems, such as those in informal urban settlements, remote transit corridors, or crossing international borders.

The guidance provides a roadmap for stakeholders to design and implement systems that ensure the inclusion of mobile populations by:

- Shifting from static population assumptions to a human mobility lens that recognizes movement as a dynamic modifier of risk across all stages of a warning system.

[20] UNDRR. *Global Assessment Report on Disaster Risk Reduction (GAR 2022).*
[21] United Nations Office for Disaster Risk Reduction and World Meteorological Organization (2024). *Global Status of Multi-Hazard Early Warning Systems*. Geneva, Switzerland.
[22] Sneddon & Budimir. University College London. *Community Based Early Warning Systems Briefing Note*. 2023.

- Integrating a human layer into system architecture by formalizing the roles of community brigades, camp wardens, and trusted local intermediaries to bridge trust and communication gaps.
- Promoting identity-neutral system design, ensuring that life-saving alerts and access to safe spaces are provided to all individuals regardless of their legal documentation or formal residency.
- Scaling high- and low-tech solutions through a hybrid approach that combines authoritative satellite monitoring and common alerting protocol (CAP)-enabled digital alerts with analogue redundancy, such as megaphones and community radio, to ensure reach in connectivity-challenged environments.

By providing clear operational steps and drawing on the collective expertise of UNDRR, IOM, and their partners, this guidance serves as a critical bridge between high-level policy and the practical requirement of ensuring no one is left behind as early warning coverage expands globally.

V. Promoting Community-Driven, Low-Tech EWS Solutions

Key takeaways for policymakers from this section:

- People-centered early warning systems work when they are designed as socio-technical systems, not stand-alone technologies.
- Low-technology and hybrid solutions are essential for last-mile reliability, especially in displacement-prone and infrastructure-constrained contexts.
- Community leadership, predictable financing for maintenance and training, and redundancy in communication channels are decisive success factors.
- For SIDS, effective early warning depends on regional cooperation, interoperable systems, and partnerships that extend reach without undermining local ownership.

Harnessing Local Knowledge and Capacity

Community-driven early warning systems are most effective when they build on local knowledge, social organization, and existing coping practices, rather than attempting to replace them with externally designed technical solutions. Evidence from disaster risk reduction, humanitarian action, and climate adaptation consistently shows that early warning systems function as socio-technical systems: their effectiveness depends as much on trust, comprehension, and the ability to act as on the accuracy of forecasts themselves.[23]

Indigenous and traditional knowledge as foundational for EWS;

(i) Indigenous, traditional, and local knowledge systems play a critical role in understanding hazard dynamics, environmental change, and locally appropriate response strategies. Peer-reviewed research and global assessments recognize that integrating these knowledge systems with meteorological and hydrological science can improve the relevance, credibility, and uptake of warnings, particularly in contexts where formal observation networks are sparse or risks manifest at highly

[23] Pescaroli, G., et al. (2025). "Bridging gaps in research and practice for early warning systems: new datasets for public response." *Frontiers in Communication*. https://www.frontiersin.org/journals/communication/articles/10.3389/fcomm.2025.1451800/full

localized scales.[24]

(ii) In practice, such knowledge often includes observation of river behavior, rainfall intensity, wind patterns, soil saturation, coastal conditions, or ecological indicators that provide early cues of impending hazards. When these indicators are formally recognized and incorporated into early warning systems—such as through locally defined thresholds or community monitoring—they translate abstract risk information into signals that are meaningful and actionable for households. This approach strengthens both trust and response, especially in displacement-prone and resource-constrained settings.[25]

Simple, understandable, and actionable warning signals;

(i) Across diverse hazard contexts, the effectiveness of early warnings is closely linked to whether messages are simple, understandable, and clearly connected to specific actions. Research shows that overly technical alerts or complex messaging can undermine response, particularly where literacy levels vary, multiple languages are spoken, or access to digital communication is limited.[26]

(ii) Low-technology warning signals—such as graduated river markers, color-coded flags, megaphone announcements, community radio, or door-to-door outreach—remain highly effective in under-resourced settings because they are visible, familiar, and easily interpreted. These approaches are most effective when used redundantly, ensuring that if one communication channel fails, others continue to function.[27] The Burundi and Dominica case studies illustrate how simple signals, reinforced through trusted community intermediaries, can outperform more sophisticated tools when infrastructure is disrupted or access is uneven.

Empower communities to co-design and manage EWS to ensure relevance and sustainability.

(i) People-centered early warning systems require communities to be involved not only as recipients of information, but as co-designers and managers of warning processes.[28] Evidence from community-based early warning initiatives and Red Cross and Red Crescent practice demonstrates that participation in system design, testing, and maintenance improves ownership, compliance, and long-term sustainability.[29]

(ii) Decentralized governance arrangements such as community disaster risk reduction committees, village councils, or volunteer networks—enable warnings to be interpreted in context, disseminated rapidly through trusted channels, and validated

[24] Motsumi, M. M., & Nemakonde, L. D. (2025). "Indigenous early warning indicators for improving natural hazard predictions." *Jàmbá: Journal of Disaster Risk Studies*, 17(1). https://doi.org/10.4102/jamba.v17i1.1754

[25] Risk-informed Early Action Partnership (REAP). (2025). *Reframing Indigenous and Local Knowledge in Early Warning Systems: A Call to Rethink, Respect and Rebalance*. https://www.early-action-reap.org/blog/reframing-indigenous-and-local-knowledge-early-warning-systems-call-rethink-respect-and

[26] Kuratle, L. D., Dallo, I., Stauffacher, M., & Marti, M. (2025). (Un-)desired tailored warnings – An assessment of the preference for tailored heat warnings of the Swiss public. *International Journal of Disaster Risk Reduction*, *118*, 105205. https://doi.org/10.1016/j.ijdrr.2025.105205.

[27] Cvetković, V. M., et al. (2026). "Community-Based Disaster Risk Reduction: Overcoming Barriers to Build Stronger Communities." *ResearchGate/Journal of Crisis Management*. https://www.researchgate.net/publication/399368063_Community-Based_Disaster_Risk_Reduction.

[28] World Meteorological Organization (WMO). (2025). "Co-production: A Key to Sustainable Early Warning Systems." *WMO Magazine*. .

[29] Global Commission on Adaptation. (2019). *Adapt Now: A Global Call for Leadership on Climate Resilience*. https://gca.org/reports/adapt-now-a-global-call-for-leadership-on-climate-resilience/.

through feedback. These structures are especially important in settings affected by displacement or mobility, where population composition and exposure can change rapidly.[30] When supported by predictable training, resources, and institutional linkages, community-managed systems provide a durable bridge between national warning capabilities and household-level action.

Case Study: Burundi - Localized Flood Warning

Context & hazard profile: *Flooding linked to intense rainfall, river overflow, and Lake Tanganyika water-level rise is a primary driver of displacement in the basin, including among communities hosting IDPs, returnees, refugees, and vulnerable host populations.*[31]

System architecture & governance: *Burundi's EWS architecture includes national risk mapping and forecasting capacity, supported by a decentralized disaster risk management structure extending from national to community levels.*[32]

Warning chain: *Community-level DRR committees (trained members representing diverse local groups) monitor graduated river/lakeshore markers that translate hydrological conditions into visible thresholds. Once triggers are reached and confirmed through authorities, dissemination uses* ***redundant channels****: community radio, megaphones, and door-to-door outreach by committees and volunteers.*[33]

Inclusion features: A distinctive practice is verification of reception and comprehension: household-level confirmation and prioritization *of people with reduced mobility or heightened vulnerability (older persons, persons with disabilities, female-headed households, recently displaced families).*[34]

Technology mix: *Deliberately low-tech at last mile (markers, radios, megaphones) to remain functional under poor connectivity and infrastructure constraints; designed to complement developing national systems.*

Financing & capacity*: Sustainability hinges on recurring support for committee training, equipment upkeep, and local contingency planning.*

Transferable lessons

- *Locally observable triggers can make warnings tangible, trusted, and actionable.*
- *Redundancy + reception verification improves inclusion and reduces failure risk.*
- *Decentralized governance increases compliance and local ownership.*

In many climate-vulnerable regions, the operational success of an Early Warning System (EWS) depends on the integration of community-led protocols that function independently of high-bandwidth infrastructure. These initiatives utilize established local tools to bridge the "last-mile" gap:

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30 ASEAN Secretariat. (2024). *Strengthening ASEAN Multi-Hazard End-to-End Early Warning System for Natural Disasters*. https://asean.org/wp-content/uploads/2024/04/ASEAN_E2E_EWS_Report_Final.pdf.

31 IFRC. (2024). *Burundi: Floods and Landslides - DREF Operation n° MDRBI020 Update #3*. https://reliefweb.int/report/burundi/burundi-floods-and-landslides-dref-operation-ndeg-mdrbi020-update-3.

32 World Bank. (2024). *Burundi: Combatting flood risk and building resilience*. https://www.worldbank.org/en/news/press-release/2024/07/01/burundi-combatting-flood-risk-afe-and-building-resilience.

33 Red Cross Red Crescent Climate Centre. (2024). *Burundi: Early Warning Early Action Case Study*. https://preparecenter.org/wp-content/uploads/2024/03/IFRC_Burundi-EWEA_Case-study-incl-add-on.pdf.

34 UNDRR. (2023). *Global Status of Multi-Hazard Early Warning Systems 2023*. https://www.undrr.org/media/91954/download.

- ***Hydrological and Environmental Monitoring:*** *Communities employ graduated river markers and color-coded staff gauges to provide real-time, visual thresholds for rising water levels, which are then cross-referenced with formal meteorological data.*
- ***Redundant Communication Protocols:*** *When primary telecommunications networks are compromised, localized FM community radio and amateur radio networks (such as the Dominica Amateur Radio Club) serve as the primary relay for emergency information.*
- ***Visual and Acoustic Signaling:*** *Manual sirens, megaphones, and flag-based systems provide immediate, localized alerts that are not dependent on external power grids or cellular connectivity.*

The efficacy of these decentralized systems is demonstrated by their high survivability during extreme weather events. In environments where digital infrastructure is prone to failure, low-technology solutions provide the necessary redundancy to maintain the warning chain. Evidence from the 2024 flood cycles in East Africa indicates that community-verified alerts-delivered via interpersonal networks and local signaling-resulted in significantly higher evacuation compliance compared to automated digital notifications alone.[35] The localized nature of these tools ensures they are culturally accepted, technologically accessible, and easily maintained without reliance on external supply chains.

Operational experience highlights that the sustainability of an EWS is contingent upon continuous community engagement and social institutionalization. Key lessons learned include:

(a) **The Imperative of Recurring Maintenance:** Systems frequently fail when funding is allocated solely for initial procurement rather than recurring operational costs. Sustainable models prioritize long-term financing for essential upkeep, such as battery replacement for radios and the physical restoration of monitoring equipment.[36]

(b) **Standardization of Community Training:** Effectiveness is driven by "muscle memory" developed through regular, unannounced simulation exercises. Training must go beyond technical operation to focus on the autonomous interpretation of signals by local leaders.[37]

(c) **Integration of Indigenous and Scientific Knowledge:** Systems achieve the highest levels of trust and response when they synthesize traditional environmental indicators with formal forecasting models, ensuring that technical warnings are contextually relevant to the local population.[38]

Case Study: Dominica: Strengthening "last-mile" reach after Hurricane Maria

Context & hazard profile: *Dominica is highly exposed to tropical cyclones and associated flooding and landslides. Hurricane Maria (2017) triggered a major reset of national disaster risk management and early warning approaches; official assessments estimated total*

[35] WMO. (2024). *2024 State of Climate Services*. https://wmo.int/publication-series/2024-state-of-climate-services.

[36] REAP (Risk-informed Early Action Partnership). (2024). *Early Action: The State of Play 2023*. https://www.early-action-reap.org/sites/default/files/2024-02/20240227_REAP_StateofPlay2023.pdf

[37] UNDRR. (2023). *Words into Action: Multi-Hazard Early Warning Systems*. https://www.undrr.org/publications/words-action.

[38] UNDRR. (2022). *Words into Action: Using Traditional and Indigenous Knowledges for Disaster Risk Reduction*. https://www.undrr.org/publication/words-action-guidelines-using-traditional-and-indigenous-knowledges-disaster-risk

*damage and losses at **226% of 2016 GDP**.*[39]

***System architecture & governance:** The Office of Disaster Management (ODM) serves as a national coordination hub within the National Emergency Planning Organization (NEPO). Hazard information is produced through specialized agencies (ex. meteorological and seismic services) and disseminated through national and district structures, including District Disaster Management Committees and Community Disaster Management Committee.s*[40]

***Warning chain (production → dissemination → action):** Dominica adopted the **Common Alerting Protocol (CAP)** to standardize messaging and improve consistency across platforms. Warnings are disseminated through multiple channels including radio, phone, social media, and community structures such as village councils—explicitly to address the "capital-to-community" transmission gap identified during Maria.*[41]

***Inclusion features:** The multi-channel approach intentionally targets remote and hard-to-reach areas, including mountainous communities and the Kalinago Territory, where connectivity and access can be constrained.*

***Technology mix** Hybrid model: standardized CAP messaging + "low-tech" redundancy via community intermediaries; augmented communications via amateur/ham radio.*

***Financing & capacity:** External partners supported capacity strengthening; for example, IOM supported ODM and the Dominica Amateur Radio Club (DARCI) to strengthen communications, including through ham radio.*[42]

Transferable lessons

- *Standardized protocols (CAP) help, but last-mile reliability still depends on redundancy and trusted local intermediaries.*
- *Hybrid comms (digital + radio + local governance channels) reduces single-point failure.*
- *Investments should include maintenance, drills, and local readiness—beyond equipment.*

SIDS face a distinct set of challenges for early warning systems, shaped by high exposure to multiple hazards, geographic isolation, and limited technical and institutional capacity. Many SIDS are simultaneously exposed to tropical cyclones, storm surge, flooding, landslides, drought, volcanic activity, and sea-level rise, often within compressed geographic areas. This concentration of risk increases the demand for multi-hazard early warning systems while constraining the resources available to develop and maintain them.[43]

Geographic dispersion across islands, mountainous terrain, and reliance on maritime or air transport complicate observation, communication, and emergency response. At the same time, many SIDS operate with small national meteorological and disaster management

[39] Government of the Commonwealth of Dominica. (2017). *Post-Disaster Needs Assessment (PDNA) Hurricane Maria*. https://www.gfdrr.org/sites/default/files/publication/Dominica_mp_012418_web.pdf

[40] Office of Disaster Management (ODM). (2001/rev. 2022). *National Disaster Plan*. ODM Dominica

[41] United Nations Development Programme (UNDP). (2019). *Community Alerts Project (CAP) Final Evaluation*. ReliefWeb/UNDP

[42] International Organization for Migration (IOM). (2019, March 20). *Empowering Communities, Strengthening Dominica's Emergency Telecommunications Network*. https://reliefweb.int/report/dominica/empowering-communities-strengthening-dominica-s-emergency-telecommunications-network

[43] Stacy-ann Robinson, 2017. "Climate change adaptation trends in small island developing states," Mitigation and Adaptation Strategies for Global Change, Springer, vol. 22(4), pages 669-691, April.

services, limited redundancy in observation networks, and restricted capacity for data processing, modeling, and interpretation. These constraints heighten dependence on regional systems, partnerships, and locally anchored dissemination mechanisms to ensure last-mile reach.[44]

In response to these challenges, SIDS have increasingly adopted adaptation-friendly and hybrid early warning approaches that combine standardized digital systems with locally trusted communication channels. The use of interoperable alerting protocols, such as the Common Alerting Protocol (CAP), enables consistent warning messages to be disseminated simultaneously across radio, mobile networks, social media, and community-based channels, improving reach despite limited national capacity.[45] [46] [47]

Partnerships with private sector actors, particularly telecommunications providers, broadcasters, and amateur radio networks, have proven instrumental in extending coverage, enhancing redundancy, and sustaining communication during extreme events. Regional disaster management organizations and humanitarian actors have also played a key role in supporting shared infrastructure, training, and maintenance across island states. reducing duplication and strengthening resilience.[48]

The Dominica case study illustrates how these partnerships, when embedded within national authority and community governance structures, can strengthen last-mile reliability without displacing local leadership. This aligns with the mandates established at the Fourth International Conference on Small Island Developing States (SIDS4) in 2024. The resulting outcome document, the Antigua and Barbuda Agenda for SIDS (ABAS) 2024–2034, explicitly prioritizes the scaling of multi-hazard early warning systems (MHEWS) through the "Early Warnings for All" initiative. ABAS emphasizes that for SIDS, resilient prosperity depends on closing the capacity gap in climate information and ensuring that technological innovation is accessible, interoperable, and serves the most vulnerable populations over the next decade.[49]

Operationalizing Low-Tech Solutions and context aligned solutions

Low-technology solutions are not substitutes for national early warning systems; rather, they are essential complements that enable systems to function end-to-end in real-world conditions.

Operationalizing such approaches requires:

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[44] United Nations Department of Economic and Social Affairs and United Nations Office for Disaster Risk Reduction (2022). Gaps, Challenges and Constraints in Means of Implementing the Sendai Framework for Disaster Risk Reduction in Small Island Developing States. https://www.undrr.org/publication/small-island-developing-states-sids-gaps-challenges-and-constraints-means-implementing

[45] GSMA (2026). Innovating early warning systems in Pacific Small Island Developing States for climate resilience. https://www.gsma.com/solutions-and-impact/connectivity-for-good/mobile-for-development/blog/early-warning-systems-in-pacific-small-island-developing-states/.

[46] The Americas and the Caribbean Multi-Hazard Early Warning Systems (MHEWS) Regional Multi-Stakeholder Forum Report (2024). https://www.undrr.org/media/104657/download.

[47] UNDP. (2020). *Desk Review of Early Warning Systems (EWS) in the Caribbean*. https://dipecholac.net/docs/xfiles/1054-DESK%20REVIEW-OF-EARLY-WARNING-SYSTEMS-EWS-IN-THE-CARIBBEAN.pdf.

[48] Connecting Business Initiative (2024). How private sector actors are building disaster resilience through mobile technologies in Asia and the Pacific https://www.connectingbusiness.org/news-events/news/connectivity-resilience-AsiaPacific.

[49] United Nations. (2024). *The Antigua and Barbuda Agenda for SIDS (ABAS) – A Renewed Declaration for Resilient Prosperity*. https://www.un.org/ohrlls/sites/www.un.org.ohrlls/files/abas-booklet.pdf.

- **Local leadership** in system design, testing, and maintenance;
- Clear roles and responsibilities across national, local, and community actors;
- Sustainable financing for training, equipment upkeep, and periodic drills; and
- Where appropriate, **scalable public–private partnerships**, including with telecommunications providers and community media, to extend reach without undermining local ownership.

The Burundi and Dominica examples demonstrate that **context-aligned, low-tech and hybrid early warning solutions** can deliver reliable last-mile coverage, even in infrastructure-constrained environments, when they are embedded in trusted governance structures and supported over time.

Integrating traditional methods with basic modern tools

Operational experience shows that effective systems do not choose between "traditional" and "modern" approaches, but **layer them deliberately**. Global early warning guidance recommends combining:

- **Local indicators and practices** (i.e. river observation, environmental changes and observations) with **formal forecasts** to improve local relevance and trust;
- **Visible, low-tech triggers** (markers, flags, megaphones) with **standardized digital dissemination**, such as radio, SMS or CAP-enabled platforms, to ensure consistency across channels;
- **Face-to-face communication** with mobile or broadcast technologies, maintaining redundancy so warnings remain functional during power or network outages.

Both the Burundi and Dominica case studies illustrate this layered approach: low-tech community signals and interpersonal dissemination are used alongside national forecasting and standardized messaging, ensuring continuity across the full warning chain.

Local leadership is a **design requirement**, not an implementation add-on. Community actors must have clear roles in interpreting warnings, activating dissemination pathways, and coordinating preparedness actions. The Red Cross and Red Crescent experience similarly highlights that early warning systems perform best when local volunteers and institutions are empowered to act on warnings, rather than merely transmit them.

At the same time, scalable public–private partnerships can strengthen reach when they are aligned with public authority and community governance. Examples include:

- **Telecommunications partnerships** supporting geo-targeted alerts or cell broadcast, consistent with EW4All Pillar 3;
- **Standardized alerting partnerships** using the Common Alerting Protocol (CAP) to ensure one validated warning can populate multiple platforms simultaneously;
- **Community media partnerships**, including local radio and amateur radio networks, are embedded in formal alert protocols and accountability structures.

The Dominica case study demonstrates how such partnerships, when combined with local governance and redundancy can strengthen last-mile reliability without undermining community ownership.

VI. Improving Accessibility for Mobile and Displaced Populations

Key takeaways for policymakers from this section:

- Technical coverage is not equivalent to effective coverage. Early warning systems must be designed for populations who are mobile, undocumented, linguistically diverse, or living in informal and high-risk settlements.
- Digital expansion alone will not close accessibility gaps. With 2.6 billion people still offline globally (ITU, 2024), warning systems must be layered and interoperable across digital and non-digital channels.
- Mobility must be treated as a design parameter, not an exception. Early warning dissemination should explicitly account for cross-border movement, evolving settlement layouts, and populations outside formal registries.
- Trusted local intermediaries are governance assets. Volunteer networks, site committees, and migrant associations are not auxiliary actors, they are core components of the warning chain.
- Humanitarian coordination structures can bridge gaps, but should progressively align with nationally owned systems.

This section examines how early warning systems can adapt to mobility and displacement contexts, drawing on operational examples from Bangladesh and Peru.

Mobile and displaced populations often face compounded barriers that limit access to timely and actionable warnings. These include linguistic differences; low literacy,[50] limited or shared access to mobile phones; irregular electricity access; lack of SIM registration or formal addresses; and distrust of authorities. In addition, displaced households frequently reside in hazard-prone locations, steep slopes, floodplains, informal settlements, or densely populated camps, where exposure is high and evacuation options are constrained.[51] [52]

Conventional early warning systems are typically designed for stable, territorially bounded populations. As a result, they may not adequately account for cross-border movement, evolving camp layouts, informal settlements, or reliance on community intermediaries.

Adaptive strategies include multilingual messaging; geo-targeted alerts where feasible; layered dissemination combining digital and non-digital channels; structured roles for community focal points; and systematic feedback mechanisms. Therefore, improving accessibility requires hybrid design, digital tools where reliable, complemented by interpersonal and community-based dissemination to prevent exclusion.

Early warning systems are only effective when they are accessible, trusted, and actionable for the full population at risk. While national systems may achieve technical coverage, access to warnings remains uneven across geography, income, language, legal status, and social networks. Global assessments of Early Warnings for All (EW4All) progress emphasize that coverage gaps persist not only in hazard detection, but in dissemination of warnings (Pillar

[50] Obiero, L. M., Olaka, L. & Mutune, J. (2025) *Factors Impeding Comprehension and Inclusion of Early Warning Messages in Kolwa East Ward, Kisumu County, Kenya*, Research Paper, IFRC Global Disaster Preparedness Center. Available at: https://tinyurl.com/IFRCpreparecenter.

[51] Climate Center (2022). Anticipatory Action in Refugee and IDP Camps: Challenges, Opportunities, and Considerations. https://www.climatecentre.org/wp-content/uploads/Anticipatory_Action_in_Refugee_and_IDP_Camps.pdf.

[52] OHRLLS, UNDRR, Early Warning for All (2024)**. *Status of Multi-Hazard Early Warning Systems in the Least Developed Countries 2024.*** https://www.un.org/ldcportal/content/status-multi-hazard-early-warning-systems-least-developed-countries-2024-ohrlls-undrr-early.

3) and preparedness to respond (Pillar 4) particularly among marginalized and hard-to-reach populations.[53]

Expanding digital connectivity alone does not resolve these gaps. According to the International Telecommunication Union (ITU), an estimated 2.6 billion people-roughly one-third of the global population, remained offline in 2024, with the majority living in Least Developed Countries and low-income settings.[54] Even among those counted as internet users, meaningful connectivity is uneven: mobile broadband access remains significantly lower in rural areas, and gender and income gaps persist across regions.

These disparities are highly relevant to early warning systems. Where warnings are disseminated primarily through mobile applications, SMS alerts, or online platforms, populations with limited connectivity, irregular phone access, shared devices, or language barriers may still be excluded. This is particularly acute for displaced and mobile populations, who may lack SIM registration, formal addresses, stable electricity access, or the ability to receive location-based alerts.

Improving accessibility therefore requires a layered approach: digital systems should be strengthened where feasible, but always complemented by low-technology, community-based, and interpersonal dissemination channels. Accessibility is not simply a function of signal reach; it depends on whether warnings are received, understood, and acted upon by people whose mobility, legal status, housing conditions, or social exclusion may place them outside conventional administrative or communication pathways.

Case StudyBangladesh: Inclusive multi-hazard warning in refugee camp settings in Cox's Bazar

Context & hazard profile: *Cox's Bazar hosts one of the world's largest displaced populations in a multi-hazard environment (cyclones, floods, heavy rainfall, landslides). Dense settlements, steep terrain, and constrained evacuation options make warnings and preparedness decisive.*[55]

System architecture & governance: *National warnings are adapted through collaboration between government, humanitarian agencies, and the Red Cross/Red Crescent Movement. Camp-level governance and coordination mechanisms (including Camp Disaster Management Committees/DMCs) function as key preparedness and dissemination platforms.*[56]

Warning chain Warnings are disseminated through door-to-door visits, megaphones, warning flags, community briefings, community and religious leaders, and (where feasible) mobile phones.[57]

Inclusion features: *The system prioritizes Rohingya-language messaging, low-literacy communication methods (visual aids, color coding), and gender-balanced volunteer structures to reach women and girls inside households. Feedback and rumor management*

[53] WMO (2024). *Global Status of Multi-Hazard Early Warning Systems 2024.* https://library.wmo.int/records/item/69085-global-status-of-multi-hazard-early-warning-systems-2024.

[54] ITU (2024). Measuring digital development – Facts and Figures 2024. https://www.itu.int/itu-d/reports/statistics/facts-figures-2024/.

[55] ISCG (Inter Sector Coordination Group). (2025). *2025-26 Joint Response Plan: Rohingya Humanitarian Crisis*. https://rohingyaresponse.org/wp-content/uploads/2025/03/JRP-2025-26.pdf.

[56] BDRCS (Bangladesh Red Crescent Society). (2024). *Cyclone Preparedness Programme (CPP) Operational Overview*. https://bdrcs.org/cyclone-preparedness-programm-cpp/

[57] UNDRR. (2025). *Case Study: Community-led approaches to anticipatory action.* https://www.undrr.org/resource/case-study/community-led-approaches-anticipatory-action

are treated as essential functions.

Technology mix: *A high-reliability "low-tech first" approach (in-person dissemination, flags, megaphones) complemented by available digital communications and localized monitoring (rain gauges) to support anticipatory action.*

Financing & capacity: *Sustained volunteer training and coordination are recurring requirements; the "system" is as much people and governance as hardware.*

Transferable lessons:

- *Camp contexts require continuous adaptation (layouts change; populations move).*
- *Redundancy is not optional; it is the design principle.*
- *Trusted messengers and two-way feedback determine whether warnings are acted on.*[58]

(i) Diverse communication channels (community volunteers, religious leaders, camp management, mobile phone networks);

In Türkiye, the Disaster and Emergency Management Authority (AFAD) complements national SMS alerting with mosque loudspeaker systems to disseminate earthquake and severe weather warnings, ensuring reach beyond registered mobile users and reinforcing alerts through trusted community institutions. This dual-channel approach proved critical during the February 2023 earthquakes, when power outages and network congestion disrupted digital communications.[59]

In northern Kenya, county-level disaster management units combine radio broadcasts in local languages with community focal points and ward administrators to relay flood and drought advisories issued by national authorities. Local FM stations-often the most trusted information source in pastoralist areas-play a decisive role in reaching mobile populations who may not be continuously connected to mobile networks.[60] [61]

These approaches demonstrate that communication ecosystems vary significantly across mobility contexts, requiring channel diversification based on social trust and infrastructure realities.

(ii) *Approaches to reaching vulnerable displaced populations with critical warnings;*

In Haiti, early warning dissemination for tropical storms has incorporated neighborhood-level civil protection committees trained to identify households requiring assisted evacuation before landfall. This includes mapping persons with disabilities, elderly residents, and female-headed households in high-risk informal settlements, enabling targeted follow-up

[58] UNDRR. *Bangladesh: Advancing Early Warnings for All*. https://www.undrr.org/implementing-sendai-framework/sendai-framework-action/early-warnings-for-all/bangladesh.

[59] Eren, M. (2025). Development of earthquake early warning systems in Marmara region: A hybrid model utilizing mosque loudspeakers. International Journal of Environment and Geoinformatics, 12(1), 61-71. https://doi.org/10.26650/ijegeo.1639063

[60] Kenya NDMO, Drought Information Service. https://ndma.go.ke/drought-information/

[61] Diba, Ali. **The Utility of a Community Radio in Mitigating Drought Effects. A Case Study of Jangwani Radio in Marsabit County**. African Multidisciplinary Journal of Research (AMJR) Special Issue II, Vol II 2025, ISSN 2518-2986 (378-396) https://www.researchgate.net/publication/399582113_The_Utility_of_a_Community_Radio_in_Mitigating_Drought_Effects_A_Case_Study_of_Jangwani_Radio_in_Marsabit_County/link/695ff35df357373034e0f208/

once national alerts are issued.[62]

In Somalia, flood early warning advisories issued by national authorities and regional climate centers are operationalized through local community committees and humanitarian partners who conduct pre-emptive outreach in riverine IDP settlements. Instead of relying solely on broadcast alerts, committees verify which shelters are located in flood-prone zones and organize staggered evacuation to higher ground.[63]

These examples illustrate that vulnerability must be pre-identified through settlement mapping and social organization, rather than assumed to be resolved through broadcast alerts alone.

(iii) *Strategies for multilingual messaging and visual aids.*

In India, the Odisha State Disaster Management Authority issues cyclone warnings in multiple regional languages, supported by standardized iconography that indicates wind intensity, storm surge risk, and evacuation urgency. Visual dashboards and color-coded warning levels are used across television, mobile alerts, and public notice boards, ensuring consistency across channels.[64]

In the Pacific, Fiji's National Disaster Management Office[65] uses simplified graphical advisories and color-coded alert levels disseminated through radio, social media, and village notice systems. In outer islands where literacy levels and connectivity vary, pictorial guidance on evacuation routes and safe shelters is distributed in advance of cyclone season.[66]

These approaches demonstrate that multilingual messaging must be planned in advance and standardized across platforms to avoid confusion during rapidly evolving hazard events.

Case Study — Peru: Integrating migrants into local disaster preparedness and warning pathways

Context & hazard profile: *Peru is highly exposed to floods, landslides, earthquakes, and El Niño–associated impacts. Migrants may face barriers including language, insecure access to services, limited trust in institutions, and increased exposure due to precarious housing.*

System architecture & governance: *Disaster risk management is led by national entities (CENEPRED; INDECI), supported by platforms such as SIGRID and SINPAD. These systems compile risk and event information but may not systematically incorporate migrants in preparedness and community mechanisms.*[67]

Warning chain: *This case focuses less on forecast production and more on strengthening the "human layer" that connects warnings to action: trained community preparedness groups that can support dissemination, response organization, and two-way communication.*

Inclusion features: *IOM-supported disaster preparedness brigades include migrant*

[62] UNDRR. *Haiti: Advancing Early Warnings for All*. https://www.undrr.org/implementing-sendai-framework/sendai-framework-action/early-warnings-for-all/haiti

[63] Center of Excellence Climate and Disaster Resilience (2023). *Early warning systems and early action in fragile, conflict, and violent contexts: Addressing growing climate & disaster risks.* https://www.undrr.org/publication/early-warning-systems-and-early-action-fragile-conflict-and-violent-contexts-addressing

[64] World Bank (2023). Odisha's turnaround in disaster management has lessons for the world https://www.worldbank.org/en/news/opinion/2023/11/03/odisha-s-turnaround-in-disaster-management-has-lessons-for-the-world.

[65] Government of Fiji. NDMO. https://www.ndmo.gov.fj/hazard-information/.

[66] UNDRR. Multi-hazard early warning systems in Fiji.

[67] **IOM. (2025).** ***Why Including Migrants in Disaster Preparedness Can Save Lives?*** https://lac.iom.int/en/blogs/why-including-migrants-disaster-preparedness-can-save-lives.

populations (including Venezuelan migrants) and link them into local civil defense structures, including in migrant-dense urban areas (example: Chosica, Lima outskirts), where brigades have been recognized as first responders.[68]

Technology mix: *Primarily "low-tech" and social infrastructure: trained brigades, manuals incorporating intercultural elements, structured linkages to civil defense systems; can complement any formal warning channels.*

Financing & capacity: *Capacity building is the core investment: training, structured roles, and practical tools (manuals) that improve readiness and trust.*[69]

Transferable lessons

- *Inclusion can be operationalized through formal roles (brigades) rather than "awareness" alone.*
- *Community structures can reduce trust deficits and improve warning comprehension and follow-through.*[70]
- *Migrant skills and networks are assets for risk communication and response.*

Regional early warning dissemination systems are often structured around national meteorological services and government-to-government notification channels. In mobility contexts, this is insufficient unless regional products are accessible beyond formal administrative registries and can be operationalized at settlement level**.**Concrete examples illustrate how this can work in practice:

In Africa, the **Africa Multi-Hazard Early Warning and Early Action System (AMHEWAS)**[71] under the African Union provides continent-wide hazard monitoring and advisory products, including cyclone and flood outlooks. These products are publicly disseminated and accessible to humanitarian actors, enabling translation of regional forecasts into localized preparedness measures in displacement-affected areas such as the Horn of Africa and Southern Africa cyclone corridors.

Similarly, in the Horn of Africa, the **IGAD Climate Prediction and Applications Centre (ICPAC)** issues seasonal climate outlooks and flood guidance that are used not only by governments but also by humanitarian partners working in displacement-prone regions, including cross-border pastoralist and refugee-hosting areas. These outlooks are routinely integrated into anticipatory action planning for drought and flood displacement.[72]

In Central America, the **Regional Committee on Hydraulic Resources (CRRH)** of SICA(**Central American Integration System**)[73] provides tropical cyclone and hydrometeorological information that supports coordinated preparedness across borders in a highly mobile region. Bulletins are publicly available and feed into national and humanitarian dissemination systems, including in contexts where populations move across borders during

[68] **IOM. (2024).** ***Strengthening Preparedness in LAC: 2024 Report.*** https://lac.iom.int/sites/g/files/tmzbdl2601/files/documents/2025-08/strengthening-preparedness-in-lac-2024-report.pdf.

[69] **IOM. (2025).** ***When Families Prepare, Communities Grow Stronger: Lessons from Peru and Chile.*** https://lac.iom.int/en/blogs/when-families-prepare-communities-grow-stronger-lessons-peru-and-chile

[70] **IOM (2025).** ***When Courage Becomes Way of Life for Migrants in Peru.*** https://storyteller.iom.int/stories/when-courage-becomes-way-life-migrants-peru

[71] African Union (2023). Shaping the Future: Africa's Drive for Multi-Hazard Early Warning Systems, https://au.int/en/pressreleases/20230730/shaping-future-africas-drive-multi-hazard-early-warning-systems

[72] IGAD (2025). Climate Change and Human Mobility in the IGAD Region; https://igad.int/climate-change-and-human-mobility-in-the-igad-region-a-growing-challenge-a-coordinated-response/

[73] WMO (2025). New Seasonal Hydrological Outlooks for Central America Launched on the WMO HydroSOS Portal https://wmo.int/media/magazine-article/new-seasonal-hydrological-outlooks-central-america-launched-wmo-hydrosos-portal

hurricane season.

Operational inclusion in these contexts involves:

- Linking regional outlooks to displacement tracking data to identify high-risk settlements;
- Using regional flood or cyclone advisories to trigger anticipatory action financing in displacement-prone districts;

Where displacement patterns are predictable, such as seasonal river flooding in South Sudan, cross-border cyclone impacts in Mozambique–Malawi–Zimbabwe corridors, or drought-driven mobility in the Sahel regional dissemination products provide the early signal. Humanitarian and local actors then translate these signals into settlement-level warnings and preparedness measures for populations that may not appear in formal civil registries.

In mobility contexts, the key shift is this: regional alert systems must be treated not only as intergovernmental information exchanges, but as operational inputs into humanitarian coordination and settlement-level dissemination pathways.

(i) *Mobile-based platforms and trusted community intermediaries;*

In Chile, the National Disaster Prevention and Response Service (SENAPRED) operates the Sistema de Alerta de Emergencia (SAE),[74] a cell broadcast system that delivers geo-targeted emergency alerts for earthquakes, tsunamis, wildfires, and other hazards directly to mobile phones without prior registration. While SAE ensures rapid technical dissemination, local municipalities and neighborhood emergency committees are responsible for contextualizing alerts—clarifying evacuation routes, confirming safe assembly areas, and assisting households requiring support.

In Indonesia, the BMKG InaTEWS tsunami early warning system[75] pushes alerts through SMS gateways, television, radio, and mosque loudspeakers. However, village-level disaster preparedness groups (Destana) are tasked with activating sirens, conducting rapid outreach, and supporting evacuation in coastal communities. This layered structure recognizes that mobile alerts alone do not guarantee response; trusted local actors translate warnings into movement.[76]

These examples illustrate that mobile-based platforms can increase speed and geographic precision, but trusted community intermediaries remain essential for converting alerts into coordinated protective action—particularly where infrastructure is disrupted or where vulnerable populations require targeted assistance or face barriers to their inclusion.

(ii) *Regional cooperation for multilingual and cross-border alerts.*

Hazards frequently cross borders before warning messages do. For regions with high levels of cross-border labor mobility, commuting, or displacement, regional cooperation must ensure that alert terminology, severity classifications, and visual signals remain consistent across jurisdictions.

In Europe, the Meteoalarm platform, operated through EUMETNET - provides a useful model. While warnings are issued nationally, the system uses harmonized color-coded alert levels and standardized severity categories across participating countries. This reduces

[74] GSMA Mobile for Development (2025). **Chile's emergency alert system: The role of MNOs in Early Warning Systems.** https://www.preventionweb.net/publication/documents-and-publications/chiles-emergency-alert-system-role-mnos-early-warning

[75] BMKG- Meteorology, Climatology, and Geophysical Agency. Government of Indonesia. Indonesia Tsunami Early Warning System. https://inatews.bmkg.go.id/

[76] UNDESA. Indonesia Tsunami Early Warning System (InaTEWS), https://sdgs.un.org/partnerships/indonesia-tsunami-early-warning-system-inatews

confusion for people who move across borders and ensures that a "red alert" carries equivalent meaning regardless of the issuing state. The technical standardization of message format and visual presentation is what enables clarity across jurisdictions.[77]

Similar regional coordination mechanisms exist elsewhere, for example, through the ASEAN AHA Centre[78] and regional climate service centers in Africa, which support shared situational awareness and aligned advisories during multi-country hazard events. However, regional cooperation becomes operationally meaningful only when it translates into consistent public-facing messaging, interoperable dissemination standards (such as CAP), and agreed translation protocols.

For mobility contexts, the design implication is clear: cross-border early warning is not only about shared forecasting. It requires harmonized alert levels, multilingual messaging strategies, and technical interoperability so that warnings remain coherent and actionable as hazards and people move.

Towards Inclusive Warning Dissemination

(i) Mobile-based platforms;

Where connectivity permits, targeted SMS, cell broadcast, and simplified mobile applications can significantly extend the reach and speed of early warnings. Cell broadcast systems, for example, allow geo-targeted alerts to be pushed to all active devices within a defined geographic area without requiring prior registration, an important feature in contexts where displaced populations may lack formal SIM registration or stable residency. Interoperable standards such as the Common Alerting Protocol (CAP) allow a single validated warning to populate multiple dissemination channels simultaneously, reducing delays and inconsistencies.

Mobile platforms can extend access to critical information when they are designed around existing user capacities and everyday needs, rather than assuming universal connectivity or internet access. A strong operational example is Sauti East Africa, a mobile information service used by over 150,000 farmers and traders, that combines trusted datasets with simple delivery channels such as USSD, SMS, and WhatsApp to reach users without smartphones or internet.[79]

Sauti uses humanitarian and climate-related datasets, including market prices, food security indicators, and rainfall information, sourced from the Humanitarian Data Exchange (HDX) and other open data platforms, and then translates them into short, simple messages in local languages that can be delivered to basic feature phones.

This approach shows how tailored mobile services can meet people where they are: in areas with limited connectivity but high rates of basic mobile ownership. For example, in parts of East Africa more than 85 percent of people own a mobile phone, even where fewer than 30 percent have internet access, creating an opportunity to reach underserved populations through platforms like SMS and USSD.

For early warning system purposes, similar platforms could deliver critical hazard information, such as rainfall trends or flood risk indicators, in plain language and in multiple languages, directly to basic phones. The value lies in precise, usable messaging that supports decision-making at the household level, not in assuming that more digital sophistication

[77] Staudinger, Michael. Meteoalarm Extended Features. https://ec.europa.eu/echo/files/civil_protection/civil/prote/pdfdocs/1_pres_meteoalarm.pdf

[78] AHA Centre: A Journey Towards Enhanced Disaster Resilience (2024). https://theaseanmagazine.asean.org/article/aha-centre-a-journey-towards-enhanced-disaster-resilience

[79] Center for Humanitarian Data (2025). *How HDX and Sauti East Africa are Putting Data in People's Hands.* https://centre.humdata.org/how-hdx-and-sauti-east-africa-are-putting-data-in-peoples-hands/.

automatically equates to broader accessibility.

Box 2
Digital maturity as a determinant of warning accessibility

The effectiveness of digital early warning dissemination depends not only on connectivity but on the broader digital maturity of the systems and populations involved. UNDP's assessment of data and digital maturity for disaster risk reduction highlights that functioning digital warning ecosystems rely on enabling factors such as infrastructure, interoperable data systems, governance frameworks, and user capacity - not simply the presence of mobile networks or digital platforms (UNDP–UNDRR, Data and Digital Maturity for Disaster Risk Reduction, 2022). In practice, many people counted as "connected" rely on shared devices, intermittent electricity, prepaid data, or basic feature phones, while migrants and displaced populations may face additional barriers such as language differences, lack of SIM registration, or frequent movement across jurisdictions. As a result, the same digital alert can be highly effective in one context and largely inaccessible in another. Designing inclusive early warning systems therefore requires aligning dissemination strategies with the real digital capabilities of users, ensuring digital alerts are complemented by low-bandwidth and non-digital channels so warnings remain accessible to populations with diverse levels of connectivity and digital literacy.

(ii) *Importance of trusted communication points within displaced communities;*

Trusted intermediaries remain central to effective warning dissemination, particularly in displacement contexts where institutional trust may be low. Community volunteers, religious leaders, women's groups, migrant associations, camp management teams, and Red Cross/Red Crescent volunteers often function as the final link in the warning chain.[80] [81]

Operational experience from anticipatory action and community-based early warning initiatives demonstrates that warnings are more likely to prompt protective behavior when delivered by known and trusted local actors who can contextualize the message and answer questions. In camp settings and informal settlements, trained volunteer networks conduct door-to-door dissemination and clarify evacuation routes. In urban neighborhoods, preparedness brigades or community focal points relay official alerts and support household-level preparedness planning.[82]

Trusted communication points also enable two-way information flow: they can surface misinformation, identify households unable to evacuate, and relay feedback to authorities. In this sense, they are not merely dissemination channels but governance actors that help translate warnings into coordinated action.

(iii) *Role of humanitarian actors in dissemination.*

In displacement settings, early warning dissemination often relies on established inter-agency coordination structures under the Inter-Agency Standing Committee (IASC) cluster system. These mechanisms provide a structured interface between national authorities and humanitarian responders, helping adapt warning dissemination and preparedness measures

[80] Global Disaster Preparedness Center. *Early Warning & Anticipatory Action Resource Hub.* https://preparecenter.org/toolkit/ewaa-resource-hub/

[81] GNDR (2025). Localising Early Warning Systems & Anticipatory Actions through CSOs: Global Survey Analysis Report. https://www.gndr.org/wp-content/uploads/2025/06/LEWS-Global-findings-survey-report.pdf

[82] ICLEI (2025). *Early Warning Systems for Disaster Risk Reduction in Informal Settlements: Durban's CBFEWS.* https://africa.iclei.org/wp-content/uploads/2025/11/FINAL-CBFEWS-full-briefing-doc-2.pdf.

to camp and settlement contexts.

The newly established **Shelter, Land and Site Coordination (SLSC) Cluster**,[83] led globally by IOM and IFRC, brings together the mandates of the former Shelter Cluster, Camp Coordination and Camp Management (CCCM) Cluster, and the Housing, Land and Property (HLP) Area of Responsibility. While still in its early stages, this unified structure promotes a place-based, people-centered approach to coordination-recognizing that shelter conditions, land tenure, and site planning shape exposure to hazards and access to warning information. Building on prior Shelter and CCCM coordination practice, the SLSC platform can progressively strengthen linkages between national early warning authorities and displacement-site governance structures.

Beyond coordination architecture, humanitarian actors also play a direct operational role in warning dissemination and preparedness to respond. For example, IOM's **Displacement Tracking Matrix (DTM)**[84] provides near real-time data on population movements and site conditions, which can support identification of highly exposed locations and inform dissemination of alerts around sudden-onset hazards such as floods and fires, including in contexts such as Sudan.[85] In such environments, where state capacity may be constrained, humanitarian partners often support rapid alert circulation through community focal points, site management teams, and local radio or mobile messaging systems.

More broadly, humanitarian actors contribute to Pillar 3 (warning dissemination) and Pillar 4 (preparedness to respond) of EW4All by:

- Translating and contextualizing official warnings for displaced populations;
- Supporting evacuation planning, simulation exercises, and contingency planning at site level;
- Facilitating rumor management and two-way feedback loops;
- Ensuring that warning information reaches persons with disabilities, women, children, and other at-risk groups.

As displacement levels continue to grow, maintaining coordination and operational dissemination capacity is essential to ensure continuity in warning pathways. Strengthening connections between national early warning systems and humanitarian coordination mechanisms, including SLSC Cluster at country level, can reduce fragmentation while supporting gradual transition toward nationally owned and sustainable systems.

VII. Bridging Financing, Technology, and Capacity for Last-Mile Delivery

Key takeaways for policymakers from this section:

- Last-mile delivery is a governance and financing challenge as much as a technical one. Early warning systems fail when dissemination, preparedness, and local institutional capacity are under-resourced, even where forecasting capacity exists. Sustained subnational financing, clear mandates, and regular drills are essential to translate

[83] IOM and IFRC Assume Co-Leadership of Global Shelter, Land and Site Coordination Cluster (February 2026). https://www.iom.int/news/iom-and-ifrc-assume-co-leadership-global-shelter-land-and-site-coordination-cluster https://news.fundsforngos.org/2026/02/20/iom-and-ifrc-take-joint-leadership-of-global-shelter-cluster/

[84] IOM Displacement Tracking Matrix. https://dtm.iom.int/.

[85] IOM Displacement Tracking Matrix Sudan Country Page: https://dtm.iom.int/sudan [scroll to bottom of page to access all reports including latest Flash Alerts].

warnings into action, particularly for migrants and displaced populations.

- Targeting matters: risk-informed investment improves effectiveness. Integrating forward-looking climate modeling with displacement and mobility analysis helps identify where early warning and preparedness investments are most urgently needed. Tools that connect granular risk analysis to flexible financing can significantly strengthen operational relevance.
- Flexible, locally accessible financing is critical to closing last-mile gaps. Small-scale grants decentralized contingency funds, and simplified climate finance access-especially under mechanisms such as the Fund for Responding to Loss and Damage-can enable municipalities and community actors to maintain dissemination systems and preparedness capacity.
- Equity and fragility must be built into financing architecture. SIDS, LDCs, rapidly urbanizing areas, and fragile or conflict-affected contexts face structural barriers to accessing climate finance. Without simplified procedures, urban inclusion, and tailored approaches for fragile settings, early warning investments risk bypassing the populations most exposed to climate-related displacement and loss.

Early warning systems can fail for different reasons.[86] In some contexts, the constraint is technical capability (detection, forecasting, or monitoring). In others, warnings are produced but do not reach all at-risk groups in time or in an understandable form. And in many settings, including high-income countries, warnings may be received yet still not lead to protective action because of risk perception, trust, past experience, competing constraints, or limited ability to evacuate safely.[87]

For migrants, displaced persons, and other mobile populations, these failure modes often converge at the last mile. Mobility can place individuals outside formal registries, telecommunications databases, or stable administrative jurisdictions. Displaced households may reside in informal settlements, temporary shelters, or high-exposure areas where infrastructure is weak and evacuation options are constrained. Linguistic differences, lack of SIM registration, irregular electricity access, or distrust of authorities can further limit both receipt and uptake of warnings. In such contexts, the “last mile” is not simply geographic-it is institutional, social, and legal.[88]

For policymakers, “last-mile delivery” should therefore be understood as the set of conditions required to translate warnings into action for populations who are hardest to reach. This includes (i) financing that sustains dissemination and preparedness functions at subnational and community levels; (ii) capacity for interpretation, inclusive communication, drills, and local governance; and (iii) access to appropriate, interoperable technologies aligned with local infrastructure realities. These elements are most effective when designed together and paired with measures that address behavioral uptake-such as trusted messengers, multilingual messaging, and feasible protective options tailored to displacement contexts.[89]

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[86] Sattele, Brundl & Straub (2015). *Reliability and effectiveness of early warning systems for natural hazards: Concept and application to debris flow warning.* Reliability Engineering and System Safety. https://doi.org/10.1016/j.ress.2015.05.003.

[87] Nicholas JP, Donovan A, Oppenheimer C, Bell L, Van Wyk de Vries M. How trust shapes individual resilience to natural hazards: a systematic review. Nat Hazards (Dordr). 2026;122(2):48. doi: 10.1007/s11069-025-07816-w. Epub 2026 Jan 19. PMID: 41567873; PMCID: PMC12816113. https://pmc.ncbi.nlm.nih.gov/articles/PMC12816113/.

[88] Finnish Red Cross (2024). Policy Paper 1: *Why early warnings are not leading to early action?* https://www.anticipation-hub.org/Documents/Policy_Papers/hazard_perception_study_2024.pdf.

[89] Global Disaster Preparedness Center (GDPC) (2025). *Strengthening Early Warning Systems for All: Evidence and lessons from last-mile communities*.

(a) The Last-Mile Challenge in EWS

The last-mile challenge in early warning systems is not confined to communication technology. It reflects the cumulative effect of financing gaps, uneven local capacity, weak institutionalization, and insufficient integration of updated climate risk information into operational triggers.

In displacement-prone and mobility-affected settings, last-mile gaps often manifest in three ways:

- Warning messages do not reach temporary or informal settlements;
- Communities receive warnings but lack clear evacuation routes, safe sites, or transportation;
- Local actors lack the authority, equipment, or resources to activate dissemination and preparedness plans consistently.[90]

Robust early warning systems therefore require sustained investment beyond forecasting infrastructure. Dedicated, flexible financing is needed to support local governance structures, simulation exercises, volunteer mobilization, equipment maintenance, and adaptation of triggers as climate patterns shift.[91]

As climate change alters hazard frequency, intensity, and spatial distribution, early warning systems must move beyond historical exposure patterns and incorporate forward-looking climate modeling and dynamic risk analysis. However, climate change is not only reshaping hazard footprints, it is also reshaping settlement patterns and mobility dynamics.

In many regions, climate-related livelihood stress, resource scarcity, and environmental degradation are accelerating rural–urban migration and internal displacement.[92] As populations move toward cities and urban peripheries in search of income, services, and safety, rapid and often unplanned settlement expansion can increase exposure to flooding, extreme heat, landslides, and water scarcity. Informal settlements frequently emerge in high-risk zones, floodplains, steep slopes, reclaimed land, or heat-intensive urban corridors, where infrastructure, drainage, and service provision lag behind population growth.[93]

At the same time, climate change is intensifying extreme heat, altering rainfall patterns, and increasing competition over resources such as water. In densely populated and under-served urban areas, these stressors compound vulnerability and can trigger further mobility or secondary displacement. Governments may struggle to extend infrastructure, urban planning, and early warning coverage at the pace required to match expanding and shifting populations.

Early warning design must therefore account not only for evolving hazard profiles, but also for climate-driven mobility and settlement expansion. This requires integrating climate projections with urban growth scenarios, displacement data, and spatial planning tools to identify emerging risk concentrations, particularly in peri-urban areas and informal

https://www.preventionweb.net/publication/documents-and-publications/strengthening-early-warning-systems-all-evidence-and-lessons

[90] EW4All (2025). Early Warning Systems for Displaced People and Other Vulnerable Populations in Conflict and Post-Conflict Situations. https://www.un.org/ohrlls/sites/www.un.org.ohrlls/files/brief_2_-_displaced_populations_english.pdf

[91] REAP (2025). Enhancing Finance for People-Centred Early Warning Systems, Risk-informed Early Action Partnership and Zurich Climate Resilience Alliance. https://www.early-action-reap.org/sites/default/files/2025-07/REAP-enhancing%20people%20centred%20finance%20report_web.pdf

[92] IIED (2024). Climate resilience and informal settlements: the urgent need to focus on how power and knowledge interact. https://www.iied.org/climate-resilience-informal-settlements-urgent-need-focus-how-power-knowledge-interact

[93] IPCC (2022). Sixth Assessment Report. Chapter 6: Cities, settlements and key infrastructure https://www.ipcc.ch/report/ar6/wg2/chapter/chapter-6/

settlements. Without such forward-looking integration, warning systems risk being calibrated to yesterday's population patterns rather than tomorrow's exposure realities.

The following case studies illustrate complementary dimensions of last-mile strengthening institutionalized local dissemination mechanisms, targeted displacement risk analysis to prioritize investments, and flexible financing models that enable community-level action.

Box 3
Extreme Heat

While early warning systems have traditionally focused on rapid-onset hazards such as cyclones, floods, and storms, climate change is expanding the risk profile to include extreme heat and wildfire—hazards that are increasing in frequency, geographic reach, and impact. These risks are particularly acute in peri-urban areas and informal settlements, where rapid urban expansion, limited green space, flammable building materials, and constrained access to services amplify exposure.

For displaced and mobile populations, these dynamics can be especially pronounced. People who move into urban peripheries or temporary settlements often reside in locations where heat intensity is elevated and fire risk is higher due to dense shelter construction, limited infrastructure, and inadequate emergency access. In such settings, hazard exposure is shaped not only by climate conditions but also by settlement patterns and infrastructure gaps.

(a) ***Case Study: Philippines: "Bandilyo" (town-crier) as an institutionalized last-mile dissemination tool***

Context & hazard profile: *In geographically isolated and disadvantaged areas (GIDAs) and connectivity-challenged communities, digital alerts may not reach households reliably during storms and floods.*

System architecture & governance: *"Bandilyo"[94] is institutionalized by local government units (LGUs)[95] as a public announcement mechanism for safety advisories, warnings, and preparedness actions. It is typically used alongside other community dissemination methods (word-of-mouth networks; church bells; loudspeakers).*

Warning chain: *National or meteorological advisories are translated by LGUs into locally actionable guidance and disseminated by designated community communicators using public announcement routes and community hubs.*

Inclusion features: *Bandilyo can reach households regardless of phone ownership, literacy level, or network coverage; it leverages locally trusted communicators and familiar signaling.*

Technology mix: *Low-tech core (human announcement systems) complemented by basic equipment (megaphones/loudspeakers) and, in some LGUs, experimentation with digital augmentation (e.g., integrated reporting and alert tools).*

Financing & capacity: *Effective institutionalization depends on small, flexible local financing for equipment maintenance, volunteer mobilization, and simulation exercises;*

[94] Gretchen Abuso. Heinrich Boll Stiftung, Southeast Asia. Living with Typhoons: Lessons from the Ivatans of Batanes, Philippines. 18 November 2024. https://th.boell.org/en/2024/11/18/living-ivatans-philippines

[95] Government of the Philippines, Department of the Interior and Local Government (DILG). Oplan Tag-Ulan- Preparedness Measures for the Rainy Season CY2019. https://www.scribd.com/document/446719070/MEMO-ON-OPLAN-TAG-ULAN

partnerships with CSOs/NGOs can complement.

Transferable lessons

- *"Traditional" mechanisms can be modernized without losing trust.*
- *Drills and periodic testing matter as much as the channel itself.*
- *Hybridization should serve reliability and inclusivity-not tech for its own sake.*

The Philippines case illustrates how institutionalized local dissemination mechanisms can translate national advisories into household-level action. Similar dynamics are visible elsewhere, where local governments and grassroots actors play decisive roles in operationalizing early warning.

In Nepal, municipal disaster management committees and ward-level volunteers work alongside the Department of Hydrology and Meteorology to translate flood and landslide warnings into evacuation advisories tailored to local terrain and settlement patterns.[96] Community-based disaster management committees, trained under national frameworks, activate sirens, conduct door-to-door outreach, and coordinate temporary shelter access-particularly in flood-prone river basins where internal migration and informal settlement expansion have increased exposure.[97]

In Mozambique, district disaster management authorities coordinate with community-based disaster risk reduction committees to disseminate cyclone and flood warnings in low-lying coastal areas.[98] Local committees, often supported by the Red Cross, organize evacuation routes and identify households requiring assisted movement, including displaced families resettled in cyclone-prone districts. These local structures act as operational extensions of national systems, ensuring that warnings are contextualized and actionable.[99]

These examples reinforce a consistent pattern: last-mile performance depends on whether local institutions have clear mandates, trained personnel, and operational authority, not merely on whether a warning has been issued at national level.

(i) *Small-scale, flexible funding enabling community-level infrastructure and capacity-building for preparedness;*

Across contexts, modest but predictable financing often determines whether early warning systems function reliably. Small-scale funding supports equipment maintenance (sirens, radios, megaphones), periodic drills, volunteer stipends, evacuation route signage, and localized risk mapping.

In Bangladesh, Union Disaster Management Committees receive allocated resources under national disaster management frameworks to support preparedness activities before cyclone season. These funds enable simulation exercises, maintenance of cyclone shelters, and community awareness campaigns, strengthening continuity between national meteorological

[96] ODI (2019). The Governance of Nepal's Flood Early Warning System. https://media.odi.org/documents/12904.pdf

[97] IFRC (2025). Strengthening National Disaster Risk Management Systems Through the Integration of Anticipatory Action: The Case of Nepal. https://www.ifrc.org/sites/default/files/2025-09/Strengthening_National_Disaster_Risk_Management_Systems_through_integration_of_anticipatory_action_The_case_of%20Nepal.pdf

[98] Club of Mozambique (2025). Mozambique activates flood prevention measures in central and northern regions. https://clubofmozambique.com/news/mozambique-flood-prevention-measures-activated-in-centre-north-regions/

[99] UNDRR (2025). Mozambique: Advancing Early Warnings for All. https://www.undrr.org/implementing-sendai-framework/sendai-framework-action/early-warnings-for-all/mozambique

alerts and local action.[100] [101]

In Kenya's arid and semi-arid lands,[102] county-level contingency funds have been used to support anticipatory drought action triggered by seasonal forecasts. Funding supports water trucking, livestock feed distribution, and early outreach to pastoralist communities before crisis thresholds are reached. Such decentralized funding windows demonstrate how forecast-based action mechanisms can operate at subnational scale when financing is pre-agreed and trigger-based.[103]

The lesson is consistent with both the Philippines and CMIL cases: without accessible, flexible financing at local level, dissemination structures erode over time, simulation exercises lapse, and institutional memory weakens. Financing for last-mile delivery must therefore prioritize operational continuity, not only capital investment.

(ii) *Mechanisms for direct funding to community groups.*

Direct funding mechanisms can help overcome structural barriers that prevent community actors from accessing larger climate finance streams.

Forecast-based financing mechanisms within the Red Cross and Red Crescent Movement provide one model.[104] Under these arrangements, pre-agreed triggers linked to hydrometeorological forecasts release funds directly to national societies before hazard impact, enabling early action at community level. Funds may support evacuation support, distribution of emergency kits, or temporary shelter reinforcement, demonstrating how anticipatory finance can translate forecasts into localized preparedness.

Similarly, locally managed adaptation funds in countries such as Senegal and Mali have experimented with devolved grant windows[105] that allow municipalities or community-based organizations to access small grants for climate resilience interventions.[106] While not exclusively early warning-focused, such mechanisms demonstrate the feasibility of directing climate resources to local actors through simplified procedures.

The Climate Catalytic Fund (CCF) under CMIL reflects this logic in displacement-prone contexts: risk-informed targeting via the Risk Index for Climate Displacement combined with small, matching grants that reach local actors more quickly than traditional multilateral channels. The broader policy implication is that financing architecture influences who can act. Where application processes are overly complex or co-financing requirements are prohibitive, last-mile actors remain excluded.

(b) ***Case Study: IOM Climate Mobility Innovation Lab (CMIL):From displacement risk analysis to last-mile action through RICD and the Climate Catalytic Fund***

[100] UNDRR (2025). Bridging national strategy and local action: Bangladesh's success in vertical DRR integration https://www.undrr.org/resource/case-study/bridging-national-strategy-and-local-action-bangladeshs-success-vertical-drr

[101] Start Network (2025). Layered response in Bangladesh: Cyclone Remal. https://www.preventionweb.net/news/layered-response-bangladesh-cyclone-remal

[102] REGLAP (2024). Impending drought in Kenya's drylands: Will the crisis ever end? https://www.preventionweb.net/files/24302_24302reglapwillkenyasdroughtcrisise.pdf

[103] Anticipation Hub (2025). Acting to anticipate the impacts of drought in Kenya https://www.anticipation-hub.org/news/acting-to-anticipate-the-impacts-of-drought-in-kenya

[104] Red Cross Office EU. Forecast based Financing. https://redcross.eu/projects/forecast-based-financing

[105] ODI (2019). Country Experiences with Decentralized Climate Finance: Early Outcomes. https://media.odi.org/documents/12901.pdf

[106] IIED (2020). Local climate finance mechanism helping to fund community-prioritized adaptation. https://www.iied.org/local-climate-finance-mechanism-helping-fund-community-prioritised-adaptation

Context and purpose

In many climate-vulnerable settings, early warning systems and preparedness investments are not sufficiently targeted to the locations and populations most at risk of climate-related displacement. To address this gap, IOM's Climate Mobility Innovation Lab (CMIL)[107] developed the Risk Index for Climate Displacement (RICD)[108] as a decision-support tool to identify displacement risk hotspots and inform early warning design, preparedness planning, and last-mile investment.

1. *Method and operational logic*

RICD combines macro-level hazard, exposure, and vulnerability analysis (including future climate scenarios) with micro-level, community-based research capturing displacement triggers, mobility patterns, and the feasibility and limits of adaptation. The tool is developed through co-creation with governments and national academic institutions, including partners in the Asia-Pacific region such as the University of the Philippines Resilience Institute and the Asian Institute of Technology, strengthening national and local capacity to analyze and act on displacement risk data.

How RICD supports early warning systems and last-mile delivery

RICD is not an early warning system in itself; rather, it strengthens the** EWS value chain **by:

- *identifying where early warnings and preparedness should be prioritized based on displacement risk;*
- *explaining why risk concentrates, informing locally relevant triggers and preparedness measures; and*
- *linking risk analysis directly to last-mile delivery strategies for at-risk populations.*

From risk data to action: the Climate Catalytic Fund (CCF)

RICD underpins CMIL's Climate Catalytic Fund (CCF),[109] an innovative financing mechanism established in 2025 to channel small, fast, match-funded grants to locally led preparedness and adaptation interventions in displacement-prone areas. Following successful piloting in Indonesia and the Philippines, the first regional call generated 298 proposals, with around 50 per cent securing confirmed co-funding, supported by EU financing.

In Asia-Pacific, the CCF is active in the Philippines, Indonesia and Fiji, with further rollout planned in Thailand and Vanuatu in 2026. In Fiji, national stakeholders have highlighted the CCF's value as a practical, community-led mechanism aligned with national climate adaptation and resilience priorities.

Transferable lessons:

- *Granular displacement risk analysis improves the targeting and actionability of early warnings and preparedness.*
- *Co-creation with national institutions strengthens uptake and integration into existing systems.*
- *Small, flexible financing mechanisms are critical for overcoming last-mile*

[107] https://environmentalmigration.iom.int/CMIL-AP.

[108] https://environmentalmigration.iom.int/CMIL-AP/RICD see country specific analysis and data from the Philippines, Indonesia and Fiji

[109] https://environmentalmigration.iom.int/CMIL-AP/CCF

barriers and enabling community-led action.

(a) Innovative Financing and Partnership Models

(i) *Micro-financing, community resilience funds, direct budget support to local actors;*

Micro-financing and community resilience funds can strengthen early warning preparedness by enabling small-scale, locally prioritized investments. These may include reinforcement of evacuation shelters, installation of community rain gauges, development of hazard signage, or maintenance of communication equipment.[110]

Direct budget support to subnational governments is particularly relevant in mobility-affected settings, where urban peripheries and informal settlements expand rapidly. Municipal authorities require flexible fiscal space to adapt dissemination systems, update evacuation planning, and incorporate newly arrived populations into preparedness mechanisms.[111]

Innovative financing models increasingly combine forecast-based triggers with decentralized disbursement. By pre-identifying risk thresholds and allocating funds in advance, governments and partners can avoid delays associated with post-disaster appeals.

(ii) *Public-private partnerships focused on social and leveraging novel finance models;*

Public–private partnerships can strengthen dissemination infrastructure when aligned with public oversight and inclusivity principles. Telecommunications providers may support cell broadcast systems or SMS alert platforms; community radio networks can extend reach in rural or connectivity-constrained areas; and technology firms can support interoperable alert protocols such as CAP.[112]

Partnerships can also expand access through low-bandwidth, user-centered mobile services. As illustrated earlier through the Sauti East Africa[113] platform, private technology actors can translate open humanitarian and climate datasets into simplified SMS, USSD, and WhatsApp-based services accessible on basic mobile phones. While Sauti focuses on market and climate-related information for traders and farmers, the model demonstrates how private-sector platforms can operationalize open data for underserved populations without requiring smartphone ownership or continuous internet access. Similar approaches could be adapted for hazard alerts and risk advisories in displacement-prone areas, provided they remain interoperable with national warning authorities.

[110] Sagala, S., Sulaiman, P.A., Patricia, C., Meliasari, R.P., Firmansyah, C.A. (2025). Microfinance for Disaster Risk Reduction. In: Shaw, R. (eds) Encyclopedia of Disaster Risk Reduction. Springer, Singapore. https://doi.org/10.1007/978-981-97-4547-0_19-1

[111] United Nations Human Settlements Programme (2025). Proposed Recommendations on Informal Settlements https://unhabitat.org/sites/default/files/2025/09/hsp-oewg-h.2025-inf-4_proposed_recommendations_on_informal_settlements.pdf

[112] WMO (2025). Leveraging the Common Alerting Protocol and Cell Broadcast Technology for Advancing Early Warnings for All https://wmo.int/media/magazine-article/leveraging-common-alerting-protocol-and-cell-broadcast-technology-advancing-early-warnings-all

[113] Humanitarian Data Exchange (2025). How HDX and Sauti East Africa are Putting Data in People's Hands https://centre.humdata.org/how-hdx-and-sauti-east-africa-are-putting-data-in-peoples-hands/

Emerging financial models include social impact bonds[114] and resilience bonds[115] that link infrastructure investment to reduced disaster losses. While still evolving, such models illustrate potential pathways for mobilizing private capital toward resilience outcomes, including early warning system strengthening.

However, partnerships should prioritize equity. Where mobile alerts require SIM registration, subscription-based services, or smartphone access, displaced, undocumented, and low-income populations risk exclusion.[116] [117] Public–private collaboration should therefore incorporate safeguards ensuring universal access to life-saving alerts, including zero-rating emergency messages, multilingual delivery, and interoperability with non-digital dissemination channels.

(iii) *Importance of simplified climate finance application processes.*

Access to climate finance remains a structural barrier for subnational and community actors.[118] Complex accreditation requirements, high fiduciary standards, and extensive documentation processes can prevent municipalities and local organizations from accessing funds intended for adaptation, resilience, and early warning system strengthening.[119] These constraints are particularly acute in displacement-prone areas, where local governments and community organizations often face capacity gaps yet bear the operational burden of preparedness and response.

Recent developments within the UNFCCC architecture reflect growing recognition of these challenges. The Fund for Responding to Loss and Damage (FRLD)[120] has emphasized prioritization of particularly vulnerable countries, including SIDS and LDCs, and discussions have underscored the importance of ensuring that funding modalities enable localized access.[121] Under the Barbados Implementation Modalities (BIM),[122] the Fund is currently receiving submissions under an initial USD 250 million window, with attention to simplified procedures and the potential for direct access approaches. Ensuring that such windows are accessible not only to national governments but also to subnational authorities and locally led initiatives will be critical for translating resources into operational early warning and preparedness improvements.

[114] Acclimatise (2020). Why climate resilience bonds can make a significant contribution to financing climate change adaptation initiatives https://www.preventionweb.net/news/why-climate-resilience-bonds-can-make-significant-contribution-financing-climate-change

[115] London Business School (2026). Resilience Bonds: Financing Protection Before the Storm https://wheelerblog.london.edu/resilience-bonds-financing-protection-before-the-storm

[116] Forced Migration Review (2024). The digital exclusion of refugees and IDPs in Sudan. https://www.fmreview.org/digital-disruption/mohammed/

[117] ID2020 (2017). The Implications of Mandatory SIM Registration for Refugees, Stateless and Forcibly Displaced Persons.c https://medium.com/id2020/the-implications-of-mandatory-sim-registration-for-refugees-stateless-and-forcibly-displaced-9b0d47e9eaff

[118] CGAP (2023). Climate Adaptation, Resilience, and Financial Inclusion: A New Agenda. https://www.cgap.org/research/publication/climate-adaptation-resilience-and-financial-inclusion-new-agenda

[119] Devex (2024). Why is so little climate finance going to local organizations? https://www.devex.com/news/why-is-so-little-climate-finance-going-to-local-organizations-107652

[120] UNFCCC. Fund for Responding to Loss and Damage. https://unfccc.int/fund-for-responding-to-loss-and-damage

[121] The Loss and Damage Collaboration (2025. *What Happened at The Seventh Meeting of The Board of The Fund for Responding to Loss and Damage: A Rapid Reaction.* https://www.lossanddamagecollaboration.org/resources/what-happened-at-the-seventh-meeting-of-the-board-of-the-fund-for-responding-to-loss-and-damage-a-rapid-reaction

[122] FRLD (2025). Barbados Implementation Modalities. https://www.frld.org/nodebim

Urban inclusion is also emerging as a key issue. Networks such as C40 Cities[123] have advocated for stronger recognition of urban contexts within loss and damage and adaptation finance, noting that climate-related mobility increasingly concentrates in cities and peri-urban areas. Municipal governments often manage evacuation planning, shelter provision, heat response, and informal settlement risk reduction, yet they may lack direct access to international climate finance. Aligning loss and damage and adaptation funding streams with urban governance realities could significantly strengthen last-mile warning and preparedness functions in rapidly expanding settlements.[124]

Funding barriers are particularly pronounced in fragile and conflict-affected contexts.[125] Analysis by the International Crisis Group[126] has highlighted how climate vulnerability and conflict risk frequently intersect, yet financing mechanisms often struggle to operate effectively in politically unstable environments. Fragile contexts may lack accredited entities, face sanctions or banking restrictions, or present fiduciary and security risks that deter donor engagement. As a result, some of the most displacement-prone and hazard-exposed settings experience chronic underinvestment in resilience and early warning infrastructure.

In such environments, simplified access modalities, flexible fiduciary standards adapted to risk realities, and partnerships with trusted intermediary organizations may be necessary to ensure that financing reaches affected communities. Without tailored approaches for fragile and mobility-affected settings, global commitments to expand early warning coverage risk bypassing the populations most exposed to climate-related loss and displacement.

Aligning climate finance with displacement risk analysis, as demonstrated by CMIL's RICD–CCF model, illustrates how funding streams can become more targeted and operationally relevant. More broadly, advocacy within multilateral climate finance institutions to streamline procedures for small-scale resilience investments, particularly in SIDS, LDCs, fragile contexts, and rapidly urbanizing areas, could significantly improve last-mile delivery and accessibility for migrants, displaced persons, and host communities.

VIII. Conclusion

Early warning systems can save lives and support averting, minimizing and addressing displacement, but only when they are usable and actionable for the full population at risk. Building on the TEC–GEO foundation on innovation and technology, this brief emphasizes a complementary requirement: operational inclusion at the last mile, particularly for people who are displaced, mobile, or excluded from formal systems. A people-centered approach, combining hybrid communication, trusted intermediaries, reception verification, and sustained local capacity, helps ensure warnings translate into protective action in real settings. Scaling EW4All will depend not only on improved hazard detection, but on investments and governance choices that make dissemination and preparedness work end-to-end for those most vulnerable.

[123] C40 Cities (2024) Inclusive climate action spotlight series Loss and Damage and a Just Transition in Africa https://www.c40.org/wp-content/uploads/2024/05/Inclusive-climate-action-spotlight-series-Case-studies.pdf

[124] D. Reckien, S. Juhola. Cambridge University Press (2025). Justice for Resilient Development in Climate-Stressed Cities [Elements in Climate Change and Cities]. https://www.cambridge.org/core/elements/justice-for-resilient-development-in-climatestressed-cities/6AAD1044CF94180ACF13FC2476E23B52

[125] UNDP (2022). How can climate finance work better for fragile and conflict-affected regions? https://www.undp.org/blog/how-can-climate-finance-work-better-fragile-and-conflict-affected-regions

[126] ICG (2022). Giving Countries in Conflict Their Fair Share of Climate Finance. https://www.crisisgroup.org/content/fair-share-of-climate-finance