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Technology Executive Committee

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Revised draft policy brief on 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.

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,[1] 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.[2]

4. At TEC 32, the TEC requested the open-ended activity group to prepare a revised draft for consideration at TEC 33, including key messages and recommendations, taking into account the feedback provided by TEC members.

B. Scope of the note

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

C. Possible actions by the Technology Executive Committee

6. The TEC will be invited to consider the revised draft policy brief and provide guidance to the open-ended activity group with a view to finalizing the document.

[1] See: https://www.un.org/en/climatechange/early-warnings-for-all.

[2] See document:TEC/2026/32/23.

Annex

Draft policy brief on advancing community-based early warning systems

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Abbreviations and acronyms

AFAD	**Disaster and Emergency Management Authority of Türkiye.**
AHA Centre	ASEAN Coordinating Centre for Humanitarian Assistance on Disaster Management.
Anticipatory action	Pre-agreed action taken before a forecast hazard occurs, based on triggers and risk information.
BIM	Barbados Implementation Modalities of the Fund for Responding to Loss and Damage.
BMKG	Indonesian Agency for Meteorology, Climatology and Geophysics.
CAP	Common Alerting Protocol, an international standard for exchanging public warning messages across multiple platforms.
CCF	Climate Catalytic Fund under IOM's Climate Mobility Innovation Labs.
CCCM	Camp Coordination and Camp Management.
CENEPRED	Peru's National Centre for Disaster Risk Estimation, Prevention and Reduction.
CMIL	Climate Mobility Innovation Labs, an IOM initiative linking climate mobility analysis with locally led action and financing.
CRRH/SICA	Regional Committee on Hydraulic Resources of the Central American Integration System.
DRM	Disaster risk management.
DRR	Disaster risk reduction.
DTM	Displacement Tracking Matrix of the International Organization for Migration.
EW4All	Early Warnings for All initiative, launched by the United Nations Secretary-General to ensure universal early warning coverage.
EWS	Early warning system.
FCAS	Fragile and conflict-affected settings.
FRLD	Fund for Responding to Loss and Damage.
GEO	Group on Earth Observations.
GIDA	Geographically isolated and disadvantaged area.
HLP	Housing, land and property.
ICPAC	IGAD Climate Prediction and Applications Centre.
IDMC	Internal Displacement Monitoring Centre.
IDP	Internally displaced person.
IFRC	International Federation of Red Cross and Red Crescent Societies.
IOM	International Organization for Migration.
ITU	International Telecommunication Union.
Last mile	The point at which warning information must reach people at risk and be translated into timely protective action.
LDCs	Least Developed Countries.
LGU	Local government unit.
MHEWS	Multi-hazard early warning systems.
NMHS	National meteorological and hydrological service.
Orgware	The institutional, governance and organizational arrangements that enable technology and knowledge to be used effectively.
RICD	Risk Index for Climate Displacement, developed under IOM's Climate Mobility Innovation Labs.
SAE	Sistema de Alerta de Emergencia, Chile's emergency alert system.

SBSTA	Subsidiary Body for Scientific and Technological Advice under the UNFCCC.
SIDS	Small Island Developing States.
SIGRID	Peru's information system for disaster risk management.
SINPAD	Peru's national information system for prevention and disaster response.
SLSC Cluster	Shelter, Land and Site Coordination Cluster.
TEC	Technology Executive Committee under the UNFCCC Technology Mechanism.
UNDP	United Nations Development Programme.
UNDRR	United Nations Office for Disaster Risk Reduction.
UNFCCC	United Nations Framework Convention on Climate Change.
USSD	Unstructured Supplementary Service Data, a low-bandwidth mobile communication protocol used on basic phones.
WMO	World Meteorological Organization.

I. Executive Summary

Multi-hazard early warning systems are an essential public good for climate adaptation, disaster risk reduction and resilience. Through the Early Warnings for All initiative, governments and partners have committed to ensuring that every person is protected by life-saving early warning systems by 2027. While investments in risk knowledge, monitoring and forecasting have expanded, progress remains uneven. In many contexts, warnings are produced but do not reach all people at risk, are not communicated in an accessible or trusted form, or cannot be translated into timely protective action.

These gaps are particularly pronounced in Least Developed Countries, Small Island Developing States, fragile and conflict-affected settings, informal and rapidly expanding urban settlements, and areas with weak infrastructure or connectivity. They also disproportionately affect displaced, mobile and marginalized populations, who may live outside formal administrative systems, move across jurisdictions, lack access to registered mobile services, speak different languages, or reside in locations where exposure is high and evacuation options are limited. The last mile is therefore not only geographical: it is also institutional, social, technological and legal.

Building on the TEC–GEO policy brief *Realizing Early Warnings for All: Innovation and Technology in Support of Risk-Informed Climate Resilience Policy and Action*, this brief focuses on the operational dimensions of people-centered early warning systems, with particular relevance to Early Warnings for All Pillar 3 on warning dissemination and communication and Pillar 4 on preparedness to respond. It examines how national and regional warning capabilities can be connected to community-level action through appropriate technologies, inclusive governance, trusted communication channels, sustained local capacity and accessible financing.

Evidence from the case studies demonstrates that effective early warning systems function as integrated socio-technical systems. Their performance depends not only on forecasting technologies and physical equipment, but also on the institutional arrangements, knowledge, skills, relationships and resources that enable people to act. Community-driven, low-technology and hybrid approaches -including local monitoring, community radio, visual and acoustic signals, door-to-door communication and basic mobile services -can provide essential redundancy and last-mile reach. These approaches are not substitutes for national warning systems. They strengthen the warning chain by translating authoritative information into locally relevant and actionable guidance, particularly where digital infrastructure is unreliable or inaccessible.

Accessibility must be built into early warning systems from the outset. Mobility should be treated as a design parameter rather than an exception, with warning pathways adapted to changing settlement patterns, cross-border movement, linguistic diversity, informal residency and unequal access to communications. Trusted community intermediaries -including local authorities, volunteer networks, women's groups, migrant associations, religious leaders and displacement-site governance structures -are critical components of this process. They contextualize official warnings, identify people requiring additional support, address misinformation and enable two-way communication between communities and responsible authorities.

The brief also finds that last-mile effectiveness depends on the combined availability of financing, capacity and appropriate technology. Modest but predictable resources are needed to maintain dissemination mechanisms, train and mobilize local actors, conduct drills, update evacuation arrangements and adapt systems as risks and populations change. Risk-informed analysis can improve the targeting of these investments by identifying where future climate hazards, displacement risks and settlement expansion are likely to converge. Flexible and simplified financing mechanisms can then help municipalities, community organizations and other local actors translate risk information into practical action.

Achieving universal early warning coverage will therefore require more than extending technical infrastructure. It will require governance and investment choices that ensure systems work end-to-end for the full population at risk. Early warning systems should ultimately be assessed not only by the accuracy of their forecasts or the reach of their communications infrastructure, but by whether people receive, understand, trust and act upon warnings in time to protect their lives, livelihoods and communities.

A. Key messages

1. Technical coverage does not necessarily constitute effective coverage. An early warning system succeeds only when warnings are received, understood, trusted and translated into feasible protective action by the full population at risk.

2. People-centered early warning systems are socio-technical systems. Technology must be combined with local knowledge, inclusive governance, institutional capacity, trusted relationships and preparedness arrangements across the entire warning chain.

3. Community-driven, low-technology and hybrid approaches are essential complements to national and regional systems. Their value lies in their accessibility, reliability and capacity to maintain warning dissemination when connectivity, electricity or formal communication systems are limited or disrupted.

4. Mobility must be treated as a core design consideration. Warning systems based on fixed populations, formal registries and stable administrative boundaries risk excluding displaced people, migrants, pastoralists and other mobile populations, as well as residents of informal and rapidly changing settlements.

5. Trusted local intermediaries are part of the warning system, not auxiliary communication channels. Local governments, community organizations, volunteer networks and displacement-site structures play a decisive role in contextualizing warnings, reaching excluded groups, verifying reception and connecting warnings to preparedness and evacuation.

6. Last-mile delivery requires financing, capacity and technology to be addressed together. Investments in forecasting or equipment will have limited impact unless local institutions also have clear mandates, trained personnel, operational resources and the authority to act.

7. Risk-informed targeting strengthens the effectiveness of investment. Combining forward-looking climate information with displacement, mobility and settlement analysis can help identify where early warning and preparedness resources are most urgently required.

8. Financing architecture influences who can act. Predictable subnational resources, decentralized contingency funds, anticipatory financing and simplified small-grant mechanisms can enable local actors to sustain warning and preparedness functions that larger, project-based funding frequently overlooks.

B. Recommendations

In establishing enabling governance arrangements, mandates and inclusive system design, policymakers and national authorities may wish to take into account the following recommendations:

1. **Embed people-centered governance throughout early warning systems.** Governments and implementing partners should establish clear and sustained roles for local governments, community organizations and at-risk populations in the design, testing, dissemination, evaluation and improvement of early warning systems. Community participation should extend beyond consultation to meaningful involvement in decision-making and implementation.

2. **Combine national capabilities with context-appropriate low-tech and hybrid solutions.** National meteorological, hydrological and disaster management authorities should integrate authoritative forecasts and standardized warning protocols with locally appropriate dissemination mechanisms, including

community radio, visual and acoustic signals, basic mobile services and face-to-face communication. Redundancy should be treated as an essential design principle rather than duplication.

3. **Integrate mobility and displacement into warning-system design.** Governments should assess how population movement, informal settlement, cross-border mobility and changing urban exposure affect warning coverage. Dissemination and preparedness arrangements should include multilingual and low-literacy communication, identity-neutral access to alerts and safe locations, and targeted measures for people who may not appear in formal registries or telecommunications databases.

4. **Strengthen the institutional role and capacity of trusted local intermediaries.** Local authorities, volunteer networks, women's organizations, migrant associations, religious and traditional leaders, and community or site-management structures should be formally connected to national warning and disaster risk management arrangements. Investment should support training, simulation exercises, two-way feedback, rumor management and the identification of people requiring assisted evacuation or other forms of support.

In ensuring predictable resources and targeted investment, finance and planning institutions, climate funds and development partners may wish to take into account the following recommendations:

1. **Finance operational continuity, not only initial investment.** Early warning financing should cover the recurring costs required to sustain dissemination and preparedness, including local training, drills, volunteer mobilization, communication, contingency planning and the maintenance or replacement of basic equipment. Funding should build on existing national and community systems and avoid fragmented, short-term or technology-led projects that cannot be maintained.

2. **Improve local access to flexible and anticipatory financing.** Governments, climate funds and development partners should expand decentralized contingency funds, forecast-based financing, small-grant windows and other simplified mechanisms that allow municipalities and locally led organizations to act before hazards occur. Funding arrangements should be adapted to the capacities and constraints of SIDS, LDCs, fragile and conflict-affected settings, rapidly urbanizing areas and displacement-affected communities.

3. **Use forward-looking risk and mobility analysis to target investment.** Climate projections, hazard information, displacement data, mobility analysis and urban growth scenarios should be brought together to identify current and emerging concentrations of risk. These findings should inform national and subnational early warning priorities, preparedness planning, spatial planning and the allocation of climate and disaster risk finance.

In strengthening operational delivery, locally appropriate innovation and continuous learning, implementing partners, local actors and technology partners may wish to take into account the following recommendations:

1. **Promote locally appropriate innovation and technological capacity.** Where feasible, governments and partners should support local institutions, researchers and enterprises to adapt, produce, repair and improve appropriate early warning technologies. Such support should respond to locally identified needs and strengthen national capacity without displacing simple and reliable community mechanisms or creating dependence on systems that cannot be sustained.

2. **Strengthen interoperability and partnerships while protecting universal access.** Public–private and regional partnerships can extend warning coverage through telecommunications, broadcasting, open data and standardized protocols such as the Common Alerting Protocol. These arrangements should remain under appropriate public oversight, support nationally owned systems and ensure that life-saving information is accessible regardless of documentation, income, device ownership or connectivity.

3. **Monitor whether warnings lead to action**. Evaluation frameworks should move beyond measuring the production or transmission of warnings and assess whether different population groups receive, understand, trust and act upon them. Community feedback and lessons from exercises and hazard events should be systematically used to improve warning content, dissemination pathways and preparedness arrangements.

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[3] to ensure universal protection by 2027, contribute directly to the implementation of the Sendai Framework for Disaster Risk Reduction,[4] 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 under EW4All Pillar 1 (Disaster Risk Knowledge), which underpins the rest of Pillars.

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, with particular relevance to EW4All Pillars 3 and 4 (Warning Dissemination and Communication; Preparedness to Respond).

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 can be futher leveraged 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 warning 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.

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

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

(c) **Bridging financing, capacity, and technology for last-mile delivery,** 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. In doing so, it addresses the persistent challenge of effective last-mile delivery identified in the TEC–GEO policy brief as well as the SBSTA conclusions[5].

Developed as part of the TEC'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. The principal case studies were compiled through consultation with IOM country offices and their operational partner networks. No primary interviews were undertaken. Additional country-level examples were identified through a review of published literature, technical guidance and publicly available documentation. 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.

This brief also evolved through an iterative consultation and technical review process. A late-stage draft was circulated to the EW4All Pillar 1 Working Group on Disaster Risk Knowledge and Management and the GEO Disaster Risk Reduction and Adaptation Working

[5] Available at: https://unfccc.int/documents/637062

Group, collectively bringing together hundreds of expert stakeholders and organizations across the UN system, civil society, scientific and technical institutions and the private sector. Feedback received through these consultations, together with written and verbal inputs provided through Activity Group discussions and formal TEC meetings, was considered and integrated, where relevant, to strengthen the final brief.

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.

[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.

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 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 (Pillar 1) as the foundation that enables the Pillars 2-4, 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, with a particular focus on Pillar 3 (Warning Dissemination and Communication) and Pillar 4 (Preparedness to Respond).

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

[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 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.

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 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.

These elements mirror the hardware–software–‘orgware’ approach highlighted in the previous TEC policy briefs. 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.

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

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

[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.

Box 1
EWS for Mobile Populations:

The *EWS for Mobile Populations: Operational Guidance*[23] was published on 22 July 2026 as 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, ITU, and WMO, with contributions from other humanitarian and technical partners.

The guidance addresses persistent gaps in how multi-hazard early warning systems account for displaced persons, refugees, migrants in vulnerable situations and other populations whose locations, circumstances or access to services may change over time.

The guidance provides practical direction for national disaster risk management authorities, national meteorological and hydrological services, line ministries, local authorities, humanitarian actors, civil society and community partners seeking to design, adapt or strengthen inclusive early warning systems. Rather than establishing a separate system for mobile populations, it shows how mobility considerations can be incorporated into existing national and local systems.

As an operational contribution to the implementation of EW4All, it provides methods and tools for identifying and including populations who may not be adequately represented in formal risk assessments, registration systems or conventional warning chains. These include people living in informal or temporary settlements, moving along seasonal or transit routes, crossing administrative or international borders, or unable to move because of poverty, disability or insecurity.

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.
- Incorporating mobility considerations throughout the early warning system—from risk assessment and mapping to monitoring, communication, preparedness, and early and anticipatory action—rather than addressing inclusion only at the point when an alert is disseminated.
- Establishing clear roles for local authorities, site and camp management structures, community liaison mechanisms, humanitarian actors and trusted local intermediaries, while connecting them to national meteorological and disaster management institutions.
- Promoting identity-neutral system design, ensuring that life-saving alerts and access to safe places and services do not depend on formal identification, registration or residency status.
- Combining authoritative national and regional hazard information with community observation and locally maintained monitoring tools, particularly where formal coverage and infrastructure are limited.
- Using complementary and redundant communication channels—including radio, public announcement systems, noticeboards, volunteer messengers, door-to-door outreach and, where accessible, CAP-enabled digital alerts—to

[23] UNDRR, WMO, ITU, IFRC and IOM (2026). Early Warning Systems for Mobile Populations: Operational Guidance. Geneva, Switzerland. https://www.undrr.org/publication/documents-and-publications/early-warning-systems-mobile-populations-operational.

maintain warning coverage when electricity, connectivity or individual access to devices is unreliable.
- Linking warnings to feasible actions that reflect people's actual circumstances. Depending on the context, these may include protection in place, changes to routes or travel schedules, safe-stop arrangements, livestock movement, phased movement, assisted evacuation or access to services across borders.

The guidance also includes operational templates, checklists and matrices covering stakeholder mapping, mobility analysis, risk prioritization, monitoring, message design, trigger–decision–action arrangements, and verification and feedback. By translating inclusive early warning principles into practical steps, the publication helps bridge national policy and forecasting capacity with the local systems and actions needed to reach and protect people on the move.

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. Consistent with the TEC–GEO policy brief findings, effective systems combine hardware, software and 'orgware' (or governance) measures, integrating high- and low-technology solutions according to local needs. 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.[24]

Citizen-generated data: strengthening local risk knowledge through youth and community action

(i) Citizen-generated data can complement formal observation and risk-information systems by capturing highly localized conditions, exposure and lived experience that may not be visible in national datasets. Such approaches can be particularly valuable where communities, including young people, are engaged not simply as recipients of risk information, but as producers, interpreters and users of data. When linked to public authorities and scientific institutions, citizen-generated data can strengthen local risk knowledge, improve preparedness and help connect scientific information with community-level decision-making.

[24] Pescaroli, G., et al. (2025). "Bridging gaps in research and practice for early warning systems: new datasets for public response." *Frontiers in Communication*.

Policy practice snapshots: citizen-generated data and local risk knowledge

Policy challenge	Country or region example	Approach used	Policy relevance
Filling local risk-data gaps through citizen-generated data	India, Southeast Asia, United Republic of Tanzania and Brazil	Citizen- and youth-led initiatives are using low-cost monitoring, participatory mapping and community-generated data to complement formal risk information. In Kerala, India, community members, including students and young people, collect local rainfall and flood-impact data through low-cost gauges and participatory mapping.[25] In Indonesia, youth-led U-INSPIRE[26] initiatives enable communities and students to generate hyper-local environmental and disaster-risk observations using locally operated, low-cost technologies. In Dar es Salaam, United Republic of Tanzania, Ramani Huria[27] has engaged university students and residents in open-source mapping of drainage, flood exposure, infrastructure and community assets. In Brazil, Instituto Decodifica[28] applies Citizen-Generated Data approaches with grassroots organizations in flood-affected favelas and peripheral communities, including initiatives in which young women act as community researchers and contribute to defining questions, collecting and analysing data and developing recommendations.	Citizen-generated data can help address spatial, temporal and social gaps in official datasets, particularly where localized exposure, vulnerability and impacts are poorly captured. When connected to public authorities and established risk-information systems, these approaches can strengthen locally relevant risk knowledge, support the validation and targeting of warnings, and simultaneously build community and youth capacity to understand and act on risk.

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

[25] Global Center on Adaptation. Kerala's People-Powered Climate Response: Own the Data, Own the Solution. September 2025. https://llahub.gca.org/stories/ec2d4519-f41d-488c-ba05-cb605faf7819.

[26] https://uinspire.id/.

[27] https://ramanihuria.org/en/.

[28] https://decodifica.org/.

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 localized scales.[29]

(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.[30] Such approaches also reinforce the TEC-GEO brief findings that combining indigenous, local and scientific knowledge strengthens warning effectiveness, highlighting citizen science in which communities plays central role in generating and validating local risk knowledge.

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.[31]

(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.[32] 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.[33] This aligns with TEC recommendations based on GEO-TEC policy brief to integrate technologies in ways that strengthen local stakeholder engagement and ownership. Evidence from community-based early warning initiatives and Red Cross

[29] 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

[30] 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

[31] 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.

[32] 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.

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

and Red Crescent practice demonstrates that participation in system design, testing, and maintenance improves ownership, compliance, and long-term sustainability.[34]

(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 through feedback. These structures are especially important in settings affected by displacement or mobility, where population composition and exposure can change rapidly.[35] 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.*[36]

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.*[37]

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.*[38]

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).*[39]

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.*

[34] 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/.

[35] 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.

[36] 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.

[37] 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.

[38] 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.

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

- *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:

- ***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.[40] 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.[41]

(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.[42]

(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.[43]

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

[41] 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

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

[43] 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.

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 damage and losses at* ***226% of 2016 GDP****.*[44]

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*[45]

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.*[46]

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.*[47]

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.[48]

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[44] 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

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

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

[47] 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.

[48] 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.

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 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.[49]

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.[50, 51, 52]

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.[53] These arrangements illustrate the value of public-private partnerships for extending warning reach and resilience. Open data, knowledge and EW solutions as public goods can further strengthen regional cooperation and last-mile accessibilit.

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.[54]

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[49] 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.

[50] 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/.

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

[52] 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.

[53] 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.

[54] 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.

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:

- **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;
- Preference for technologies and equipment that can be procured, repaired and maintained locally using readily available parts and skills, reducing long-term dependence on external suppliers; and
- Where appropriate, **scalable public–private partnerships**, including with telecommunications providers and community media, to extend reach without undermining local ownership.

Where feasible, countries should also support locally led innovation and the adaptation, assembly or production of appropriate early warning technologies. Collaboration with national research institutions, technical training bodies and local enterprises can strengthen endogenous technological capacity, reduce costs and improve the availability of the skills and components needed to sustain systems over time.

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.

Where institutional capacity exists, simple agreed reporting protocols can enable locally validated observations to contribute to wider situational awareness and decision-making by local and national authorities. This should not make digital integration a prerequisite for community action: in many under-resourced settings, community observations will continue to serve primarily as locally managed triggers for protective action rather than as formal inputs into national forecasting models.

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,[55] 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

[55] 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.

populated camps, where exposure is high and evacuation options are constrained.[56] [57]

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 3) and preparedness to respond (Pillar 4) particularly among marginalized and hard-to-reach populations.[58]

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.[59] 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 Study Bangladesh: 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*

[56] 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.

[57] 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.

[58] 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.

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

preparedness decisive.[60]

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.*[61]

Warning chain Warnings are disseminated through door-to-door visits, megaphones, warning flags, community briefings, community and religious leaders, and (where feasible) mobile phones.[62]

Inclusion features: *The system prioritizes Rohingya-language messaging, low-literacy communication methods (visual aids, color coding), and gender-balanced volunteer structures to strengthen the participation and learership of women while reaching out to women and girls inside households. Feedback and rumor management 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.*[63]

a. ***Policy practice snapshots: inclusive last-mile communication approaches***

Policy challenge	Country or region example	Approach used	Policy relevance
Reaching people beyond digital alerts	Türkiye[64]	National SMS alerting is complemented by mosque loudspeakers to reinforce earthquake and severe weather warnings through trusted community institutions.	Redundant channels help maintain reach when power outages, network congestion or lack of mobile registration limit digital communication.

[60] 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.

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

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

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

[64] 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.

Reaching pastoralist and mobile populations	Northern Kenya[65]	County disaster management units use local-language radio broadcasts, community focal points and ward administrators to relay flood and drought advisories.[66]	Communication channels must reflect mobility patterns, trusted information sources and uneven mobile connectivity.
Identifying people requiring assisted evacuation	Haiti[67] and Somalia[68]	Civil protection committees, community committees and humanitarian partners map high-risk households, verify exposed shelters and organize targeted outreach before storms or floods.	Vulnerability must be identified before an alert is issued; broadcast warnings alone do not ensure that people with limited mobility or high exposure can act.
Improving comprehension across languages and literacy levels	India/Odisha[69] and Fiji[70]	Authorities use regional-language warnings, standardized iconography, colour-coded alert levels and pictorial guidance disseminated through multiple channels.	Multilingual and visual communication should be standardized in advance to reduce 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*

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

[66] 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/.

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

[68] 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.

[69] 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.

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

in preparedness and community mechanisms.[71]

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 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.*[72]

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.*[73]

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.*[74]
- *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:

Policy practice snapshots: regional, mobile-based and cross-border warning systems

Policy challenge	**Example**	**Approach used**	**Policy relevance**
Translating regional hazard products into local preparedness	AMHEWAS,[75] ICPAC[76] and CRRH/SICA[77]	Regional systems provide cyclone, flood, seasonal climate and hydrometeorological information that can be used by governments and	Regional alert systems should function as operational inputs into humanitarian coordination and settlement-level

[71] 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.

[72] 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.

[73] 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

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

[75] 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.

[76] 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/.

[77] 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.

		humanitarian actors to support localized preparedness in displacement-affected areas.	dissemination, not only as intergovernmental information exchanges.
Increasing speed and geographic precision of alerts	Chile[78] and Indonesia[79, 80]	Cell broadcast, SMS gateways, television, radio and mosque loudspeakers are combined with municipal, neighbourhood and village-level actors who interpret alerts and support evacuation.	Mobile-based platforms can accelerate dissemination, but trusted intermediaries remain essential for converting alerts into coordinated protective action.
Maintaining coherence across borders	Meteoalarm[81] and ASEAN/AHA Centre[82]	Regional cooperation supports harmonized alert levels, severity categories, shared situational awareness and aligned advisories during multi-country hazard events.	Cross-border warning requires consistent public-facing terminology, multilingual messaging and interoperable dissemination standards so alerts remain actionable as people and hazards 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

[78] 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.

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

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

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

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

delivery channels such as USSD, SMS, and WhatsApp to reach users without smartphones or internet.[83]

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 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.[84] [85]

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

[83] 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/.

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

[85] 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.

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.[86]

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 to camp and settlement contexts.

The newly established **Shelter, Land and Site Coordination (SLSC) Cluster**,[87] 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)**[88] 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.[89] 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,

[86] 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.

[87] 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/.

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

[89] 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].

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 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.[90] 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.[91]

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

[90] 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.

[91] 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/.

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.[92]

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.[93]

(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.[94]

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.[95]

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.[96] As populations move toward cities and urban peripheries in search of income, services, and

[92] 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.

[93] Global Disaster Preparedness Center (GDPC) (2025). *Strengthening Early Warning Systems for All: Evidence and lessons from last-mile communities*. https://www.preventionweb.net/publication/documents-and-publications/strengthening-early-warning-systems-all-evidence-and-lessons

[94] 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

[95] 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.

[96] 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.

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.[97]

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 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"[98] is institutionalized by local government units (LGUs)[99] as a public announcement mechanism for safety advisories, warnings, and preparedness actions. It is typically used alongside other community dissemination methods*

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

[98] 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.

[99] 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.

(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; 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.

Policy practice snapshots: financing and institutional arrangements for last-mile delivery

Policy challenge	Country or mechanism example	Approach used	Policy relevance
Institutionalizing local warning dissemination	Nepal[100, 101] and Mozambique[102, 103]	Municipal, ward and district disaster management structures translate national warnings into local evacuation advisories, activate sirens, conduct door-to-door outreach and identify households requiring assistance.	Last-mile performance depends on clear local mandates, trained personnel and operational authority, not only on the issuance of national warnings.

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

[101] 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.

[102] 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/.

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

Financing recurring preparedness functions	Bangladesh[104, 105] and Kenya[106, 107]	Allocated resources and county contingency funds support simulation exercises, shelter maintenance, community awareness, water trucking, livestock feed distribution and early outreach triggered by seasonal forecasts.	Predictable subnational financing sustains operational continuity and allows local actors to act before crisis thresholds are reached.
Releasing funds before hazard impact	Red Cross and Red Crescent forecast-based financing[108]	Pre-agreed hydrometeorological triggers release funds to national societies before impact, enabling community-level early action such as evacuation support, emergency kits or temporary shelter reinforcement.	Anticipatory finance helps translate forecasts into practical preparedness measures rather than waiting for post-disaster response funding.
Directing climate resources to local actors	Locally managed adaptation funds in Senegal and Mali[109]	Devolved grant windows allow municipalities or community-based organizations to access small grants for locally prioritized climate resilience interventions.	Simplified small-grant mechanisms demonstrate how climate finance can reach actors responsible for maintaining last-mile preparedness and response functions.

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's Climate Mobility Innovation Labs (CMIL): From displacement risk analysis to last-mile action through RICD and the Climate Catalytic Fund***

[104] 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.

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

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

[107] 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.

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

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

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 Labs (CMIL)[110] *developed the Risk Index for Climate Displacement (RICD)*[111] *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),[112] *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 barriers and enabling community-led action.*

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

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

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

(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.[113]

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.[114]

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.[115]

Partnerships can also expand access through low-bandwidth, user-centered mobile services. As illustrated earlier through the Sauti East Africa[116] 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.

Emerging financial models include social impact bonds[117] and resilience bonds[118] that link infrastructure investment to reduced disaster losses. While still evolving, such models illustrate potential pathways for mobilizing private capital toward resilience outcomes,

[113] 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.

[114] 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.

[115] 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.

[116] 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/.

[117] 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.

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

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.[119, 120] 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.[121] 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.[122] 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)[123] 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.[124] Under the Barbados Implementation Modalities (BIM),[125] 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.

Urban inclusion is also emerging as a key issue. Networks such as C40 Cities[126] 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

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

[120] 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.

[121] 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.

[122] 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.

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

[124] 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.

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

[126] 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.

functions in rapidly expanding settlements.[127]

Funding barriers are particularly pronounced in fragile and conflict-affected contexts.[128] Analysis by the International Crisis Group[129] 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.

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[127] 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.

[128] 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.

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