Strengthening Early Warning Systems for All:

Evidence and Lessons from Last-Mile Communities

Global Disaster Preparedness Center

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Acknowledgment

The Global Disaster Preparedness Center (GDPC) thanks the many individuals who contributed time, expertise, and support to develop this report.

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Research Foundation
This meta-synthesis draws on the original research studies conducted under the GDPC Research Grants Program across 14 countries between 2023 and 2024. GDPC extends sincere gratitude to the principal investigators and their research teams whose work forms the foundation of this analysis.

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This material has been funded by UK International Development from the UK government; however, the views expressed do not necessarily reflect the UK government's official policies.

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Suggested Citation
Tozier de la Poterie, A., Villatoro, C., Morinière, L., & Kavaleuski, V. (2025). *Strengthening Early Warning Systems for All: Evidence and Lessons from Last-Mile Communities*. Washington, D.C.: Global Disaster Preparedness Center. URL: https://preparecenter.org/resource/last-mile-ews-report/

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December 2025

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List of Acronyms

AA	Anticipatory Action
CHEWS	Community Heat Early Warning System
CREWS	Climate Risk Early Warnings Systems
DRR	Disaster Risk Reduction
EU	European Union
EW4All	Early Warnings for All
EWEA	Early warning and early action
EWS	Early Warning Systems
FGD	Focus Group Discussion
GDPC	The Global Disaster Preparedness Center
GSMA	Groupe Speciale Mobile Association
IFRC	International Federation of Red Cross and Red Crescent Societies
KII	Key Informant Interview
LGBTQI+	Lesbian, gay, bisexual, transgender, and intersex people
M4H	Mobile for Humanitarian Innovation
MECE	Mutually Exclusive, Collectively Exhaustive
NGO	Non-Governmental Organization
NHMS	National Hydromet Services
RCRC	Red Cross Red Crescent
REAP	Risk-informed Early Action Partnership
SLR	Systematic Literature Review
SMS	Short Message Service
SOP	Standard Operating Procedure
UNDRR	United Nations Office for Disaster Risk Reduction
WMO	World Meteorological Organization

A Red Cross volunteer checks a river-level gauge during rain-gauge verification for a community early warning system in Djoumane, Chad. © Guillaume Binet / IFRC

Executive Summary

Key Messages

1. **Inclusivity determines effectiveness.** Effective early warning systems (EWS) are built with communities, not delivered to them. Meaningful inclusive engagement in EWS development is the strongest predictor of whether warnings will be trusted, understood, and acted upon.
2. **Trust determines action.** People act on warnings from sources they trust, built through consistent accuracy, genuine partnership, and sustained engagement.
3. **Context dictates design.** Message format, language, channels, protective actions, and needed resources vary dramatically by context and can only be determined through engagement with the at-risk communities.
4. **No single communication channel reaches everyone.** Redundant, diverse dissemination strategies, combining modern technology with traditional networks and trusted messengers, are essential.
5. **Effective EWS require adequate resourcing.** Building and sustaining inclusive EWS requires dedicated funding and resources — not just for technical infrastructure and operations, but for ongoing community engagement and for providing support that enables people to act on warnings they receive.

Background

Early Warning Systems (EWS) are among the most effective tools for reducing disaster risk and saving lives, yet their effectiveness ultimately depends on whether warnings translate into protective action. To maximize impact, early warnings must be inclusive and address specific vulnerabilities and needs of the people they aim to protect, especially marginalized groups who often face the greatest risks with the least access to information and services.

To understand what enables warnings to drive action at the community level, the IFRC Global Disaster Preparedness Center (GDPC) supported 15 studies across 14 countries focusing on last-mile communities — **groups that are often geographically isolated, socially marginalized, or otherwise hard to reach**. Spanning a wide range of contexts, these studies examined the barriers and enabling factors that influence whether warnings are received, understood, and acted upon.

Drawing on these studies and complementary literature, this report identifies the **features that best support inclusive, accessible, and actionable early warning** for last-mile communities. By consolidating insights across diverse geographies and population groups, it provides an evidence base to inform policy, programming, and advocacy aimed at strengthening people-centered EWS. The **report pinpoints critical yet under-addressed system components** — elements essential to ensuring warnings reach and protect everyone but which often receive limited attention or investment. For those working to advance inclusive early warning and early action (EWEA), this report serves as both a diagnostic and a guide, **revealing where systems often falter and what can be done to make them more inclusive**, trusted, and effective.

Terminology[1]

Inclusion refers to providing equitable access to opportunities and services regardless of disability, gender, language, identity, or location. For EWS, this means the intentional process of ensuring that at-risk and last-mile populations are meaningfully involved in risk identification, monitoring, and forecasting system design and can access information, and receive clear, timely, trusted, and context-appropriate warnings and resources that enable them to act.

Accessibility means removing physical, communication, financial, digital, and institutional barriers so that all people regardless of their distinctive characteristics, can receive, perceive, and understand warning messages in a timely manner and access relevant risk information (e.g., hazard forecasts, evacuation guidance) and services (e.g., shelters, communication infrastructure, official updates) before, during, and after the hazard.

Actionability means that early warnings not only reach people, but also come with the right details, clarity, and resources so that last-mile populations understand what actions to take and are able to take those actions, before, during, and after a hazard event.

1 These definitions are a synthesis of definitions from across relevant EWS and humanitarian publications: IFRC (2018); UNDRR (2023); Mamba et al. (2024); Pertiwi et al. (2024); Obiero et al (2024); Chunga & Manda (2024); Pereira et al. (2024); ALNAP (2025)

Findings

Across the studies, breakdowns in EWS often occurred **not because warnings did not exist, but because they did not translate into clear, trusted, and actionable guidance** for diverse last-mile groups. These gaps, in turn, often stem from limited engagement of last-mile populations they intend to serve. The findings therefore reinforce that **engagement across all four pillars of EWS design and development is critical** to ensure that warning messages are delivered at the right time, in clear, appropriate language, and through trusted channels, so that people not only receive them but are also willing and able to act.

Disaster risk knowledge (Pillar 1): Risk knowledge is shaped by lived experience, cultural and Indigenous knowledge, and it directly affects willingness to act. At the same time, people recognize that patterns are shifting with climate change. When groups are not engaged in activities that help to share, build, or strengthen risk knowledge, they may underestimate risks or lack critical information.

Hazard monitoring and forecasting (Pillar 2): Forecast quality is improving, but usability for end users lags. Products are rarely localized to places and livelihoods, and formats are too technical for quick decisions. Communities have their own ways of understanding and predicting weather and environmental changes. Blending scientific outputs with community-defined indicators and plain, impact-focused phrasing makes forecasts more relevant and trusted.

Warning dissemination and communication (Pillar 3): Messages frequently arrive late, through fragile channels, or in formats people cannot access or understand. Over-generic alerts and jargon reduce comprehension. Multi-channel, multilingual, and redundant delivery, paired with simple, specific actions, consistently reaches more people and reduces confusion.

Preparedness to respond to warnings (Pillar 4): Warnings only lead to action when people have time, clear instructions, and the means to act. To respond to warnings, people must know what to do, believe action will make a difference, and have the time and financial and non-financial resources to follow through.

Inclusive planning at household, community, and government levels ensures preparedness measures are realistic for different groups and that people have sufficient time, resources, and confidence to take protective action. Pre-agreed actions, basic resources (e.g., transport, cash, assistive support), and practiced roles for local groups help translate warnings into action.

Recommendations

The recommendations build directly on the findings from the GDPC-supported studies and additional literature. Directed at practitioners, policymakers, and donors, these recommendations seek to help actors address and **overcome the barriers identified across all four pillars**, with particular attention to community engagement, trust, and the ability to act.

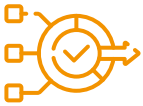
Inclusivity: Building systems with communities so they reflect the real needs, priorities, and capacities of all members.

- **Center marginalized communities as co-designers and co-owners through meaningful participation in design, implementation, and evaluation**. Centralized formal systems often fail to meet local needs because they do not reflect community realities, needs and priorities. Establish community committees with diverse representations, use participatory design and assessment methodologies, disaggregating "community" in engagement processes.
- **Integrate Indigenous and traditional knowledge with scientific forecasting through structured collaboration**. Indigenous knowledge provides hyperlocal specificity and cultural legitimacy that scientific forecasts alone cannot achieve. Establish co-management protocols where meteorological services formally recognize Indigenous forecasters as partners, and train youth as "knowledge bridges" between traditional and scientific systems.
- **Build systematic feedback mechanisms**. Establish post-event review processes that gather community input on warning effectiveness. Create two-way communication mechanisms for communities to flag gaps in real-time and use this feedback to iteratively improve systems.
- **Strengthen policy and financing frameworks that institutionalize inclusion.** Inclusion becomes sustainable when governments, donors, and policymakers hard-wire it into the mandates, incentives, and funding structures. EWS policies and frameworks should define minimum standards for participation and representation, clarify institutional roles, and prioritize funding for sustained community engagement rather than one-off consultations.

Accessibility: Removing barriers so all people can receive, understand, and benefit from warnings.

- **Implement multi-channel, redundant dissemination strategies combining modern technology with traditional networks and trusted intermediaries**. Word-of-mouth through community leaders was the most common way (see Figure 6) last-mile populations received warnings, yet formal systems rarely leverage these networks systematically. Map existing social networks, layer technological channels with human and physical channels, and conduct communication drills to test effectiveness.
- **Design clear messages in local languages and accessible formats with consistent branding**. Language barriers, technical jargon, and text-only formats consistently prevented comprehension. Develop warning templates using plain language, create visual communication products including pictographic warnings and sign language interpretation, and establish nationally consistent EWS brand identity to distinguish official warnings from misinformation.

- **Invest in last-mile infrastructure with backup power systems and community radio stations.** Infrastructure deficits physically prevent warnings from reaching remote communities regardless of message quality. Strengthen community radio powered by solar panels and provide communication equipment to volunteer networks with maintenance protocols.



Actionability: Designing warnings and supporting mechanisms that lead to protective action.

- **Include specific, context-appropriate protective action guidance, not just hazard descriptions.** Even when people receive warnings, they often do not know what to do. Co-design hazard-specific action guides that outline progressive steps linked to warning levels and tailor guidance to specific vulnerable groups.
- **Invest in public education and awareness** through community drills, school-based programs, and communication campaigns that strengthen practical preparedness skills and foster a sustained culture of risk reduction.
- **Build and maintain community trust through consistency and accountability.** Trust is foundational to EWS effectiveness yet easily eroded by false alarms, unfulfilled promises, or warnings perceived as irrelevant. Ensure accuracy in forecasting, follow through on commitments made during engagement, acknowledge when systems fail, and demonstrate how community feedback leads to tangible improvements.
- **Link warnings to anticipatory action programs providing financial and material resources**. Poverty forces people to disregard warnings, continuing dangerous work rather than losing income or being unable to afford evacuation. Develop early action protocols with pre-defined triggers, include cash transfers enabling protective actions, and provide trained volunteers to assist vulnerable individuals.
- **Ensure adequate lead time by improving forecast-to-communication speed and strengthening dissemination networks**. Delayed dissemination was pervasive, with warnings arriving too late for action. Develop standard operating procedures that define information flow, stagger warning timelines for populations needing extra preparation time, and support household and community-level planning workshops.

Conclusion

The evidence that emerged from this review underscores that last-mile challenges are not purely technical but fundamentally social and institutional. **Building inclusive EWS requires reframing last-mile populations as first-mile partners:** knowledge holders, decision-makers, and actors in their own right.

Systems become more inclusive, accessible, actionable, and ultimately effective when built on three foundations: genuine trust and sustained relationships with diverse last-mile populations, their meaningful participation across all four EWS pillars, and the resources that enable protective action when warnings arrive. Aligning investments and policies with these principles is essential for achieving universal EWS coverage and ensuring that warnings translate into action.

A community member reviews a Red Cross–supported risk map with a volunteer in a flood-prone village in Myanmar, where residents use local mapping to plan evacuation routes, identify high-risk areas, and strengthen disaster preparedness. © Brad Zerivitz / American Red Cross

1. Introduction

1.1 Background

Early Warning Systems (EWS) are universally acknowledged as essential components in disaster risk management and proactive humanitarian response. Well-designed EWS empower households, communities, and authorities to take timely action, helping save lives, protect assets, and reduce disaster-related losses by as much as one-third.[2]

However, to be effective, early warnings must be people-centered and built with at-risk communities, not delivered as a top-down, technology-first system that assumes information alone drives action.[3] The need for inclusive, people-centered EWS is emphasized across global frameworks and initiatives, including Early Warnings for All, Climate Risk and Early Warning Systems (CREWS), and the Sendai Framework for Disaster Risk Reduction, which collectively advocate a shift from purely technical approaches toward systems grounded in local knowledge and realities.[4]

A people-centered approach to early warning prioritizes active participation, empowerment, and equity. It recognizes that communities have knowledge, understanding, and capacities that are essential to the development of EWS, and require meaningful engagement throughout all four pillars of EWS[5]. These pillars are considered the building blocks of effective EWS and must be in place and integrated with each other for an EWS to operate. The purpose of each pillar in the context of this report is outlined in Figure 1.

2 World Meteorological Organization. (2024).
3 Basher, R. (2006).
4 UNDRR. (n.d.); World Meteorological Organization (WMO). (n.d.).; UNDRR & CREWS. (2020).
5 IFRC. (2009).

Figure 1: Purpose and functions of the four EWS pillars

Pillar 1:
Disaster risk knowledge

To understand hazards, exposure, vulnerability, and coping capacity of communities. This includes understanding possible threats, their likelihood, and impacts on lives, livelihoods, and assets to build EWS that meet people's needs.

Pillar 2:
Observations, monitoring, analysis and forecasting of hazards

To observe, track, and predict hazards and to provide accurate, timely information regarding when, where, and how severe impending threats will be. This can involve advanced scientific modeling or simpler methods, such as monitoring upstream water levels.

Pillar 3:
Warning dissemination and communication

To ensure that timely, clear warnings reach everyone who needs them via accessible, culturally appropriate channels.

Pillar 4:
Preparedness to respond

To ensure that people are prepared to act on warnings, including having the knowledge, resources, and time to protect themselves from hazard impacts.

To better understand what turns warnings into protective action at community level, the IFRC Global Disaster Preparedness Center (GDPC) supported 15 studies across 14 countries focused on last-mile communities — groups that are often geographically isolated, socially marginalized, or otherwise hard-to-reach. Spanning a wide range of contexts, these studies examined the barriers and enabling factors that influence whether warnings are received, understood, and acted upon.[6]

Drawing on these studies and complementary literature, this report identifies features that best support the inclusivity, accessibility, and actionability of early warning for such last-mile communities. Across the studies, breakdowns in EWS often occurred not because warnings were not issued, but due to systemic gaps that prevented people from receiving them or responding in time. This report highlights common points of failure and showcases approaches that help overcome them.

By consolidating insights across diverse geographies and population groups, the report provides an evidence base to inform policy, programming, and advocacy efforts aimed at strengthening people-centered EWS. It pinpoints under-addressed components that are essential to ensuring warnings reach and protect everyone yet often receive limited attention or investment. For those working to advance inclusive EWEA, this report serves as both a diagnostic and a guide, revealing where systems often falter and what can be done to make them more inclusive, trusted, and effective.

6 An overview of the purpose of each study is provided in Annex A.

1.2 Definition of the 'last mile'

The concept of "*last–mile*" populations in the context of EWS varies across actors, contexts, and programs.[7] In Disaster Risk Reduction (DRR) literature, the term often refers to the "delivery" of early warning messages to "end users."[8] That framing is at odds with people-centered approaches, as it implies that these communities are passive recipients, external to the development and operation of the systems, and overlooks the vital contributions they can make to the design, implementation, and response phases. In response, some scholars and practitioners use "first mile" to signal that at-risk communities should sit at the center of EWS.[9]

In contrast to the use of last-mile to connote "end users" of information, the GDPC framing emphasizes people who are harder to reach or engage due to geographic isolation, social marginalization, or other barriers. Although the studies look at different populations (Table 2), the following definition encompasses the populations considered last-mile by GDPC-supported studies:

Groups or populations systematically excluded from the production of risk information and access to timely, actionable early warning because of one or more of the following: geographic remoteness, limited infrastructure, social marginalization, and economic precarity. These communities may be rural or urban, scattered or densely populated, but all share disproportionate vulnerability to hazards and limited access to preparedness systems and resources.

Within this framing, GDPC-supported studies explore a range of last-mile populations. To identify patterns and gaps across these studies, definitions of last-mile used in each were systematically reviewed (Table 2), and then grouped into four key categories (Table 1), providing a framework for comparison and insight.

Table 1: Categories of last-mile populations

Last-mile characteristic	Definition
Geographic isolation	People living in geographically isolated areas, such as rural areas, or areas characterized by rugged terrain, inadequate transportation infrastructures and/or lack of access to critical resources during disasters.
Economic marginalization or vulnerability	People who are economically more vulnerable due to poverty, livelihood insecurity.
Social marginalization	People who are at increased risk due to aspects of their identity, such as gender or sexual identity (LGBTQI+ status), Indigenous peoples or people with minority ethnic/racial status, or age (youth, elderly). This category also includes people living in fragile or conflict-affected settings, migrants, or people who have been displaced.
Living with disabilities or chronic health conditions	People living with disabilities, chronic illnesses, or mobility limitations.

7 REAP (2025).
8 UNDRR. (2023); Thomalla, et al. (2009).
9 Kelman, I. & Glantz, M.H. (2014)

As people's experiences and vulnerability are shaped by different factors of their identity and circumstances, these categories are not mutually exclusive. For example, a woman may live in a remote area, experience poverty, and have a disability. For this meta-synthesis, however, each study was assigned a single primary last-mile characteristic based on the factor most influencing participation in EWS processes. In Table 2, the orange cell indicates the primary category assigned to each study. Figure 2 provides a visual overview of the studies' locations, the hazards they addressed, and the last-mile characteristic most prominently emphasized.

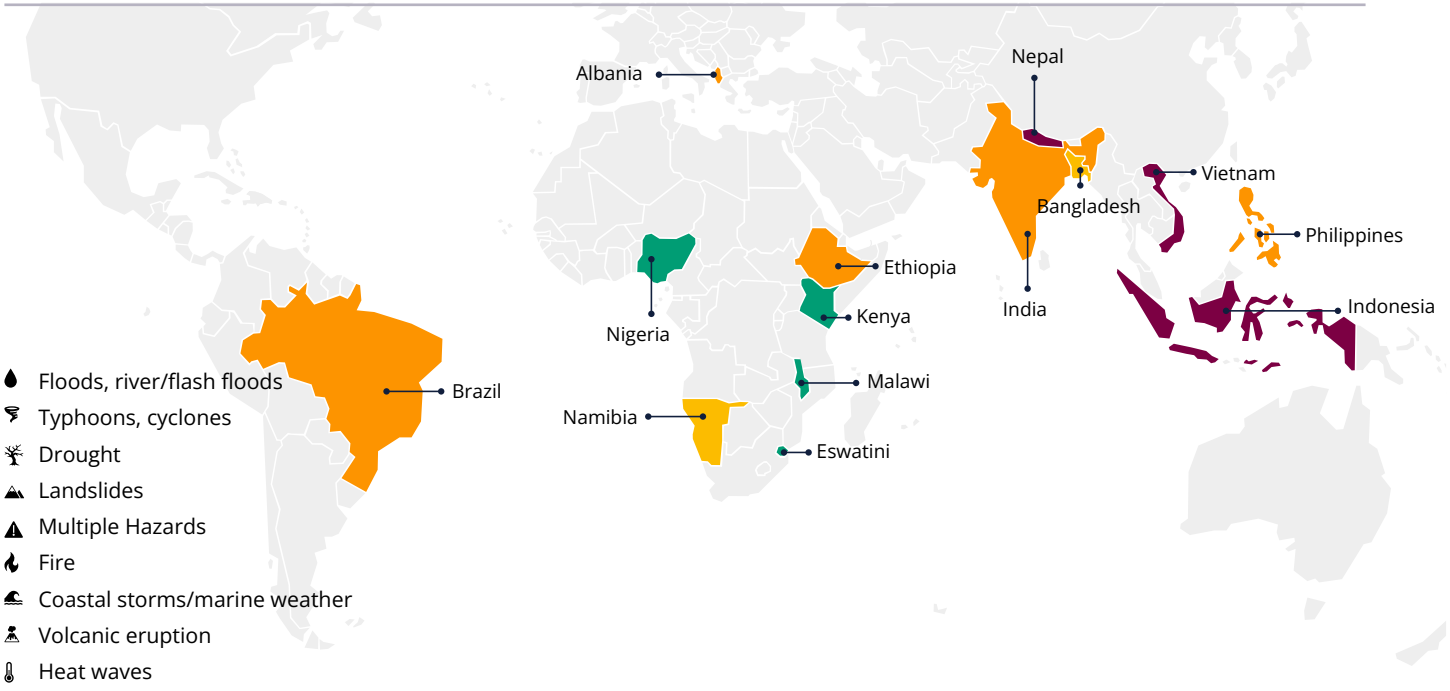
Table 2: Descriptions of 'last-mile' groups across the 15 studies

Lead author & study title (shortened)	Country	Rural & Geographically Isolated Communities	Economically Vulnerable Groups	Gender & Socially Marginalized Groups	People with Disabilities & Health-Related Vulnerabilities
Rhomir Yanquiling, Accessibility and Actionability of DRR Measures in Last Mile Communities	Philippines (PHL)	Rugged terrain; inadequate transportation infrastructures; lack of access to critical resources during disasters	—	—	—
Olumuyiwa Adegun, Utilization of Heat EW Resources Within Slum Communities	Nigeria (NGA)	—	Informal settlements, informal workers	—	—
Chinmayee Mishra, Exploring Women's Barriers to EWS in Odisha	India-women (IND-W)	—	Women from low socio-economic backgrounds	Gender: Women from low socio-economic backgrounds	—
Rafael Pereira, Enhancing People-Centred EWS in Traditional Coastal Communities	Brazil (BRA)	—	Livelihoods based on natural resources, tourism, and family labor	Traditional/ Indigenous communities	—

Lead author & study title (shortened)	Country	Rural & Geographically Isolated Communities	Economically Vulnerable Groups	Gender & Socially Marginalized Groups	People with Disabilities & Health-Related Vulnerabilities
Tirsit Sahledengle Beyene, Community-Developed Early Warning and Early Action Systems in South Omo	Ethiopia (ETH)	Geographic isolation or difficult terrain	Pastoralist livelihoods	Traditional/ Indigenous communities	—
Pradytia Putri Pertiwi, Inclusivity of Volcanic EWS for Persons with Disabilities	Indonesia (IDN)	—	—	—	People living with disabilities
Shampa, Community-Led Early Actions on Flash Floods	Bangladesh (BGD)	Geographic isolation or difficult terrain	Single-crop (paddy) farmers	—	Pregnant women, the elderly, and people with disabilities, but not these populations alone
Tara Ballav, Barriers to Early Warnings for People Living with NCDs	Nepal (NPL)	—	—	—	People diagnosed with non-communicable diseases for at least one year
Abdul Rohman, Toward Inclusive EWEA for Deaf and Hard of Hearing (DHH)	Vietnam (VNM)	—	—	—	People living with disabilities

Lead author & study title (shortened)	Country	Rural & Geographically Isolated Communities	Economically Vulnerable Groups	Gender & Socially Marginalized Groups	People with Disabilities & Health-Related Vulnerabilities
Linda Obiero, Barriers to Flood EWS in Kisumu County	Kenya (KEN)	People living furthest from services	High poverty level	—	—
Charles Chunga, Assessment of EAs for Flood Protection during Cyclone Freddy	Malawi (MWI)	—	High poverty level	—	—
Ita Bonner, Inclusive EW Strategies in Rural Lezha	Albania (ALB)	Geographic isolation or difficult terrain	—	—	—
Max Martin, Fishers on the First Mile: EWEA by Traditional Fishers	India –fishers (IND-F)	—	Livelihoods: fishers (coastal, weather-dependent)	—	—
Sipho Felix Mamba, Utilization of Early Warning Information in Drought-Prone Areas	Eswatini (ESW)	—	Farming communities in drought-prone areas	—	—
Deolfa Jose Moises, Participatory Flood EW for EA in Namibia	Namibia (NAM)	Geographic isolation or difficult terrain	—	—	—

Figure 2: Last-mile community types and study locations



Rural and geographically isolated communities

- Bangladesh
- Philippines
- Albania
- Namibia

Economically vulnerable groups

- Kenya
- Malawi
- Eswatini
- Nigeria
- India (fishers)

People with disabilities or health-related vulnerabilities

- Vietnam
- Nepal
- Indonesia

Gender and socially marginalized groups

- India (women)
- Brazil
- Ethiopia

1.3 Methodology and limitations

This research aims to answer the central question: *What features of early warning systems (EWS) best support inclusivity, accessibility, and actionability for last-mile communities?* The report draws primarily on a meta-synthesis of 15 studies supported by the GDPC's Small Research Grants Program, conducted across 14 countries.

A rapid scoping review approach was used to synthesize existing findings rather than collect new data. Studies were systematically reviewed and coded to identify patterns, gaps, and promising practices across the four EWS pillars. Additional academic and humanitarian literature was consulted to validate findings and address thematic gaps.

Given the scope of this review, it does not aim to provide an exhaustive or systematic overview of the topic. The supplementary literature search was limited to English-language sources published within the last 10 years, with a focus on promising examples and good practices. As such, the findings should be read as a focused synthesis rather than a comprehensive review. Where country names are mentioned (e.g., India, Malawi), they refer to GDPC-supported study sites, not broader national trends. For details on methodology and limitations, see Annex B.

A local radio broadcaster uses a Red Cross mobile radio station to air public health messages on hygiene and Ebola prevention in a rural community in Forecariah, Guinea, during the 2015 outbreak. © Tommy Trenchard / IFRC

2. Findings

This section synthesizes findings from 15 GDPC-funded studies and complementary literature to identify what helps or hinders people in last-mile settings to receive and act on warnings. Organized around the four pillars of EWS, the analysis highlights key features — core components that make up an EWS as observed across studies — and the enablers and barriers that determine how these features are put into practice and whether they contribute to overall system effectiveness.

Enablers and barriers are often two sides of the same coin: their presence improves EWS effectiveness, and their absence undermines it. For example, meaningful community engagement in developing risk knowledge, designing communication products and schemes, and preparing response plans consistently acts as an enabler across Pillars 1, 3, and 4. Where engagement is weak or missing, the same processes become barriers. Given this pattern, enablers and barriers are presented together throughout the analysis.

Terminology

EWS feature: A common system component, mechanism, practice, or process that contributes to the development of one or more EWS pillars, regardless of how effectively it is implemented (e.g., participatory mapping for Pillar 1, modeling tools for Pillar 2, dissemination channels for Pillar 3, and response plans for Pillar 4).

Enabler: A structural or contextual factor that facilitates the implementation or enhances the effectiveness of an EWS feature (e.g., community ownership, trust in local leaders, strong social networks).

Barrier: A factor that obstructs or limits the implementation or success of an EWS feature (e.g., language exclusion, lack of trust in alerts, perceived risk fatigue).

The findings highlight recurring barriers that limit EWS reach and effectiveness, as well as approaches and practices that enhance inclusivity and actionability. The analysis identifies where systems often fail, where they succeed, and what can be adapted across contexts. For practitioners and policymakers, it underscores persistent gaps that weaken EWS performance even where systems exist, while also pointing to practical fixes and areas for further investment to strengthen systems for underserved communities.

2.1 Disaster risk knowledge (Pillar 1)

2.1.1 Common features of risk knowledge

Four common features of risk knowledge and understanding emerged from the GDPC-supported studies:

1. **Institutional risk assessment and mapping** refer to the capacity and efforts of government agencies, NGOs, and other organizations to analyze and map hazards and vulnerabilities. This work provides the foundation for comprehensive risk knowledge at scale. Examples from the study countries include climate-informed, multi-hazard maps produced by the State Disaster Management Authority in India and hazard maps developed by the Flood Forecasting and Warning Centre in Bangladesh.
2. **Community engagement** involves unpacking and understanding individual or collective perceptions and experiences of risk and co-producing new risk knowledge through participatory exercises, mapping, or trainings led by external actors. Creating opportunities for people to reflect on locally relevant risks helps ensure that all groups are well-informed about the risks they face.
3. **Personal, traditional, Indigenous knowledge** stems from lived experience of hazards and knowledge passed through culture, tradition or customs. This personal experience shapes people's risk perceptions and is a core part of risk knowledge. As Indigenous knowledge also plays a direct role in hazard monitoring and forecasting, it is further discussed under Pillar 2.
4. **Integrating and updating risk knowledge for a changing climate** highlights the importance of maintaining a current understanding of risk by incorporating evolving hazard patterns, particularly those driven by climate change. This includes understanding whether extreme events are becoming more frequent or intense, and how these changes may impact livelihood activities and community resilience.

The findings confirm that risk perception, shaped by direct experience or general knowledge, influences people's willingness to respond to warnings (Pillar 4). Rather than repeat these connections in the Pillar 4 section, they are discussed here.

2.1.2 Enablers and barriers: what supports or hinders disaster risk knowledge

Enablers and barriers to risk knowledge were less frequently mentioned in the GDPC-supported studies than those for Pillars 3 and 4, as most studies focused on how communities receive and respond to warnings rather than on risk knowledge development. Four key themes emerged, described below.

Figure 3: Enablers and barriers to risk knowledge (Pillar 1)

Enables & Barriers	Pillar 1: Disaster risk knowledge	Rural and geographically isolated communities	Economically vulnerable groups	People with disabilities or health-related vulnerabilities	Gender and socially marginalized groups
Community engagement and training in risk knowledge		NAM	IND-F	VNM, NPL	IND-W
Experience-based and cultural risk perception		PHL, NAM, BGD	IND-F	NPL, IDN	IND-W, ETH
Integration of scientific risk information with cultural beliefs and Indigenous knowledge		BGD, NAM	ESW, KEN, IND-F		IND-W, ETH
Updating risk knowledge for a changing climate			IND-F, NGA		

Community engagement and training to include specific last-mile or vulnerable groups. Stronger community engagement leads to better understanding of risks and makes action more likely. For example, the Cyclone Preparedness Programme in Bangladesh has been engaging community members in understanding cyclone risks for decades, significantly reducing cyclone-related fatalities.[10]

By contrast, when communities — or specific groups within them — are not engaged in producing and interpreting risk knowledge, they may not be aware of the risks they face or of when or how to act. In Namibia and India[11], government agencies did not engage communities in risk knowledge–building or awareness activities, such as vulnerability assessments, evacuation route mapping, knowledge sharing, and safety training, leaving people largely unaware of their risks and unprepared to respond. In coastal India, fishermen continued to venture into hazardous ocean conditions without basic safety equipment like life jackets, illustrating how the lack of engagement can leave at-risk groups without the knowledge or tools needed to protect themselves.

10 Haque et al. (2022)

11 Throughout this report, country names (e.g., India, Namibia) refer to the specific communities and locations within GDPC-supported studies, not to national-level patterns or trends.

Good Practice Spotlight

Strengthening Citizen Collaboration with Civil Protection in Europe[12]

The EU-funded RiskPACC project shows how community engagement can close the gap between risk perception and action and inform EWS design. Using co-creation and participatory mapping, civil protection authorities and local communities jointly analyzed hazards, perceptions, and communication gaps, merging institutional data with lived experience to build a shared understanding of risk and response. The process resulted in the development of several technological tools and a new collaborative framework that strengthen authority–citizen collaboration and improve two-way communication.

Human-centered Design Approaches to EWS Design in Africa[13]

GSMA's Mobile for Humanitarian Innovation program conducted human-centered design (HCD) research in South Africa and Tanzania to improve the inclusivity and effectiveness of EWS. Through participatory methods, including persona building, journey mapping, co-creation workshops, and more, the teams worked with communities to understand how people receive, interpret, and act on warnings. The resulting report offers a practical roadmap for applying HCD methods to EWS design, showcasing how these approaches can uncover user needs, address social and cultural barriers, and inform more inclusive EW solutions.

Experience-based and cultural risk perception. Prior exposure to disasters influences both risk perception and the likelihood of taking protective action. Communities that recently experienced severe events, such as major floods in Namibia and Ethiopia, Super Typhoon Haiyan (Yolanda) in the Philippines, or rapid-onset events in South Africa[14], tend to have a lower risk tolerance and prepare more proactively for future events. These communities often develop local coping strategies, such as building physical barriers or strengthening household preparedness.

In contrast, when past experiences are limited to lower-intensity events, risk perception may remain subdued. For example, women in India who had only encountered weaker cyclones perceived less danger until a more devastating event recalibrated their understanding of risk.

Similarly, people are more likely to disregard warnings when forecasts predict conditions that are not yet visible (e.g. flooding when there is no rain in sight), as seen with fishermen in India or people in Bangladesh who disregarded warnings until ocean conditions are visibly more treacherous, or flood waters are rising.

Updating risk knowledge for a changing climate. Previously reliable signals — seasonal rains in Eswatini, storm patterns used by fishers in India, or drought and flood cycles in Kenya — are becoming increasingly unreliable. This shared perception underscores growing uncertainty about the accuracy of forecasting systems.

In the face of climate change, both scientific and Indigenous risk knowledge need to be updated to account for new 'normal' levels of risk, increased uncertainties, and extreme events that may fall outside the scope of conventional warning systems. Building complementarities between these systems can increase robustness. Hybrid approaches systematically discuss, document, and compare traditional cues alongside instrumental observations are more flexible, culturally relevant, and better suited to sustaining community trust in the face of environmental change.

12 Vollmer et al., (2025).

13 Tappendorf and Acland (2025)

14 Acland S et al., (2024)

2.2 Observations, monitoring, analysis and forecasting of hazards (Pillar 2)

2.2.1 Common features of hazard monitoring and forecasting

Across the 15 studies reviewed, Pillar 2 received limited attention and, when mentioned, mostly focused on describing national-level EWS infrastructure rather than last-mile forecast needs or community capacities. Few studies captured the specific forecast information communities find useful or the gaps in what they currently receive.

The most common Pillar 2 features described were related to **data**. The studies highlighted the importance of specific data but rarely related it to the communities they studied. Examples included flood magnitude, location, and useful lead times in Bangladesh; relative humidity in relation to extreme heat in Nigeria; and, across most cases, precipitation — most often in the form of basic rainfall measurements, such as localized, area-specific data (e.g., in Namibia).

The second most common feature was **local or Indigenous weather prediction and monitoring**. The studies, along with supporting literature, underscore the importance of identifying, understanding, and integrating traditional beliefs and risk knowledge into institutionalized EWS frameworks.

Figure 4: Enablers and barriers to monitoring and forecasting (Pillar 2)

Enables & Barriers	Pillar 2: Observations, monitoring, analysis and forecasting of hazards	Rural and geographically isolated communities	Economically vulnerable groups	People with disabilities or health-related vulnerabilities	Gender and socially marginalized groups
Gaps in monitoring infrastructure		NAM	ESW, NGA, IND-F		
Data availability and quality issues		NAM	ESW, NGA, IND-F		ETH
Environmental factors affecting monitoring		BGD	ESW, KEN, IND-F		ETH
Limited forecasting and modeling capacity		NAM			
Weak link between forecasts and local impacts		BGD		NPL	
Lack of SOPs and limited data sharing		NAM			ETH
Insufficient technical skills and human resources		NAM	ESW		
Institutional constraints		NAM, BGD	KEN, IND-F		
Challenges integrating Indigenous knowledge into forecasting		BGD	IND-F		ETH
Exclusion of people with disabilities from monitoring activities				IDN	

2.2.2 Enablers and barriers: what supports or hinders monitoring and forecasting

Data availability and quality are among the most common challenges to monitoring and forecasting (Figure 4). Many communities reported insufficient weather or gauging stations and gaps in baseline data, which limited forecast accuracy (e.g., Namibia, Eswatini, Nigeria, India-F). In some cases, inconsistencies in existing datasets further undermined confidence in forecasts (Eswatini).

Challenges also extended to data capture and analysis. Specific **environmental conditions interfered with accurate monitoring** in several contexts, such as plastics in water channels affecting measurements (Bangladesh, Ethiopia, Eswatini, India-F). The complexity of certain phenomena, such as wave patterns, made forecasting more difficult (Bangladesh, Eswatini). Additional issues included the capacity of some models and the challenge of incorporating impacts into forecasts (Bangladesh, Nepal).

Gaps in local forecasting and monitoring capacities. The most frequent barrier identified is the lack of technical skills, knowledge, and resources within local institutions to effectively operate and maintain forecasting and EW systems. Common challenges included limited expertise in hydrology, meteorology, and risk assessment, which undermines the reliability and effectiveness of monitoring and forecasting systems.

For example, in Nepal, participants mentioned a lack of technical capacity as a major barrier to delivering timely and accurate warnings. Other institutional issues include poor data sharing (e.g., Ethiopia, Namibia), too centralized system structures, limited interoperability between institutions, and insufficient resources to upgrade forecasting infrastructure and technology (e.g., Namibia, Bangladesh, Kenya and India-F).

Local and Indigenous knowledge emerged across Pillars 1 (Section 2.1.2) and 2 as a vital foundation for interpreting forecasts, strengthening trust, and tailoring early warning messages to context. Rather than being in conflict, Indigenous and scientific knowledge can complement each other, enhancing forecast accuracy, message uptake, and credibility.

In last-mile settings, where formal systems may have gaps, Indigenous knowledge adds local specificity and cultural resonance. For example, traditional fishermen in southwestern India combine generational coastal and marine knowledge — considering wind speed, wave height, currents, and boat stability — with mobile-based forecasts to decide when and where to fish. This illustrates the potential for integrating these two sources of knowledge to strengthen EWS and preparedness, with youth playing a pivotal role in bridging traditional practices and modern technologies.

A Red Cross volunteer inspects a rain gauge used for local rainfall monitoring as part of a community early warning system in Chad. © Guillaume Binet / IFRC

Faith-based beliefs and cultural practices also influence how communities interpret, validate, and act on scientific forecasts and EW messages, underscoring the need to link forecasts with cultural frameworks rather than dismissing them.[15] Communities use cues such as animal behavior (Philippines), moon phases, cloud formations, and plant flowering (Eswatini), or elders' dreams and interpretations (Ethiopia) to predict climate-related events. They also rely on traditional practices for preparedness and early action, as seen during flash floods in Bangladesh.

Nevertheless, communities are increasingly concerned that climate change has altered weather patterns to the extent that Indigenous knowledge is no longer as precise as it was decades ago (Bangladesh, Ethiopia). While some scientists question their predictive accuracy, dismissing these indicators closes off opportunities to weave culturally meaningful signals into official warnings, connecting science to local heritage and knowledge and strengthening the legitimacy of both systems.

Good Practice Spotlight

Integrating Indigenous and Scientific Droughts Forecast in Kenya[16]

In Baringo County, Kenya, Indigenous forecasters, using methods such as reading goat entrails and observing star patterns, collaborated with government meteorologists and NGOs through Participatory Scenario Planning (PSP) workshops. These sessions enabled both Indigenous and scientific forecasters to compare insights and co-produce seasonal drought forecasts, which were then used to inform planning and community advisories. The joint forecasts significantly improved community trust and engagement, making early warning messages more actionable and widely accepted. For government officials, who initially viewed Indigenous Knowledge (IK) with skepticism, the PSP workshops fostered greater respect and understanding.

Indigenous-Led Flood EWS in Ethiopia[17]

In Ethiopia's South Omo Zone, agro-pastoralist communities have developed Indigenous early warning systems that blend spiritual, ecological, and technical knowledge to anticipate and respond to floods. These include dream-based divination, environmental cues like plant blooming and rising river levels, and community-built flood barriers. Despite limited infrastructure and weak links to formal systems, these locally-led mechanisms have proven effective in mobilizing action and strengthening preparedness. Their success highlights the importance of community ownership and the need to formally integrate Indigenous knowledge into national disaster frameworks.

Revitalizing Local Knowledge in Vanuatu and Fiji[18]

Case studies from the Pacific demonstrate the value of working through existing governance structures such as village councils or traditional authorities and ensuring community elders and diverse groups are actively included in planning and implementation. Resilience certificate programs in Vanuatu and vocational training initiatives in Fiji mitigated the loss of local knowledge while strengthening modern systems by deliberately working with trusted stakeholders. These programs strengthen the legitimacy of cultural practices while also improving intergenerational knowledge transfer and integration into national disaster preparedness planning.

15 Save the Children/IRMA (2024).
16 Liang, S. (2017).
17 Sahledingle, T., & Amsalu, D. (2024)
18 UNDRR (2023).

2.3 Warning dissemination and communication (Pillar 3)

2.3.1 Common features of warning dissemination and communication

Six recurring components of warning communication and dissemination emerged from the GDPC-supported studies, each of which is briefly discussed below.

1. **Message production:** Who develops and issues early warning messages, and whether community members participate in the process.
2. **Message source:** Who conveys the message and to whom. The source of the message can significantly influence trust and the likelihood of message uptake.
3. **Communication channels:** The mediums used to disseminate messages, such as radio, television, word of mouth, printed materials, mobile platforms, or other formats.
4. **Message content:** The clarity, level of detail, language, and any labeling or branding that indicates message origin.
5. **Timing and frequency:** When initial warnings are issued and how often they are repeated.
6. **Information flow:** Whether the system is one-way (forecaster to recipient only) or incorporates two-way communication, feedback mechanisms, and opportunities for questions.

A community volunteer uses a megaphone to relay an early warning message during a disaster simulation drill in a flood- and cyclone-prone river delta village in Myanmar. © Brad Zerivitz / American Red Cross

2.3.2 Enablers and barriers: what supports or hinders warning dissemination and communication

Figure 5 summarizes the enablers and barriers to warning communication and dissemination identified in the GDPC-supported studies. Several factors originating in Pillar 3 (e.g., trust, community engagement, language) directly influence people's abilities to prepare and respond (Pillar 4). To avoid redundancy, these cross-cutting elements are discussed below in the context of their impact on preparedness and response. Except for communication frequency and clear labeling/branding, which were cited less often, all enablers and barriers were consistently mentioned across the four last-mile categories.

Figure 5: Enablers and barriers to warning dissemination and communication (Pillar 3)

Enables & Barriers	Pillar 3: Warning dissemination and communication	Rural and geographically isolated communities	Economically vulnerable groups	People with disabilities or health-related vulnerabilities	Gender and socially marginalized groups
Community engagement in message design, dissemination & feedback		BGD, ALB, NAM	NGA, KEN, IND-F	NPL, VNM	IND-W, ETH, BRA
Trust in source & messengers		ALL			
Dissemination structures and procedures		ALB, NAM, BGD	KEN, MWI, ESW, NGA	NPL	IND-W, ETH
Resources for dissemination (staff, equipment, funding)		BGD, NAM	KEN,MWI	VNM, IDN	IND-W
Dissemination methods					
	Multiple & redundant channels	BGD, PHL, ALB, NAM	MWI, ESW, NGA	NPL, IDN, VNM	BRA, IND-W, ETH
	Social networks & traditional channels	ALB	NGA	IND, NPL	IND-W, ETH
	Information flow	BGD, ALB, NAM	NGA	NPL	BRA
	Communication frequency		MWI, NGA, IND-F		ETH
Warning message content					
	Clear source identification & branding of official messages		MWI, NGA	NPL	BRA, IND-W
	Completeness & accuracy	BGD, ALB	KEN, MWI, NGA	IDN	IND-W
	Simple, jargon-free language & accessible formats		ALL		

Community engagement (*cross-cutting*[19]). Involving at-risk groups in the design and dissemination of EWS messages, especially extremely vulnerable populations like people living with disabilities, pregnant women, the elderly, and those with chronic diseases, helps ensure that advice and actions reflect real needs and constraints (Bangladesh, Ethiopia, Brazil, Namibia, India-W). Most GDPC-supported studies emphasized the importance of community engagement throughout the message production and dissemination process. External research also highlights persistent gaps in community involvement outside these study areas.[20]

When individuals or trusted representatives are part of the process, they better understand where to find information, what to expect, and how to interpret messages. Engagement reduces the risk that alerts are dismissed as spam (Brazil) or that systems overlook key needs (e.g., people living with non-communicable diseases in Nepal). Participatory approaches foster ownership and trust, enabling message producers to tailor content to local contexts, making communities more receptive to warnings and more likely to act (Bangladesh, Ethiopia, Brazil, Namibia, India-W).

Good Practice Spotlight

Community-Centered Design of Heat EWS in Nigeria[21]

In Nigeria, GDPC-supported researchers co-designed heat warning messages with residents of selected urban informal settlements. The content, formatting, and dissemination channels of these messages were directly shaped by initial focus group discussions and community surveys. These consultations provided critical insights into local needs, preferences, and barriers to accessing heat warnings, helping ensure that messages were culturally appropriate, easy to understand, and actionable. Following this formative research, the team developed and tested a Community Heat Early Warning System (CHEWS) over a 38-day pilot period. Post-implementation feedback further refined dissemination strategies, highlighting how two-way communication and community engagement can improve EWS effectiveness by building trust in and acceptance of warnings.

Beyond message content, the importance of community engagement is also reflected in decisions about dissemination channels, message frequency, use of social networks and traditional communication structures, defining what constitutes complete information, fostering understanding, and ensuring inclusivity — all of which are discussed in the sections that follow.

Trust (*cross-cutting*). Trust in information sources and messages is a critical, cross-cutting factor influencing the effectiveness of early warning.[22] Building and maintaining trust requires consistent, accurate information, meaningful community engagement, and transparent communication practices (Nepal, Kenya, India-W, Brazil, Namibia). The credibility of a message is shaped by who creates, disseminates, and delivers it. Messages from trusted sources, such as community leaders, religious figures, or well-established organizations, are more likely to be believed and acted upon than those from unfamiliar or less credible entities (Nepal, India-W, Bangladesh, Ethiopia, Brazil, Nigeria).

When trust in alerts is low, individuals may disregard warnings and instead adopt a wait-and-see approach, choosing to observe hazard conditions firsthand before taking action.[23] Repeated false alarms,

19 In this report, "cross-cutting" refers to themes or characteristics that are not confined to a single pillar. These cross-cutting themes reflect systemic issues and conditions that shape the overall functioning and inclusiveness of early warning systems.

20 Sufri et al. (2020); Macherara & Chimbari (2016)

21 Adegun et al. (2024)

22 Acland et al. (2024); Tappendorf and Acland (2025)

23 Domingos, B., & Nagamatsu, S. (2024).

inconsistent or inaccurate warnings undermine public confidence in EWS, diminishing their effectiveness (Nepal, Kenya, India-W).

As a cross-cutting theme, trust is deeply embedded in all aspects of system design and implementation. It influences two-way communication and feedback mechanisms, the use of social networks and dissemination channels, the labeling of message sources, and the language used, all of which are explored in the sections that follow.

Good Practice Spotlight

Building Trust Through Community Partnerships in Indonesia[24]

To support timely evacuations in the event of volcanic eruptions, local authorities in Indonesia implemented the 'Sister Village' initiative in areas surrounding Mt. Merapi. This approach pairs highly exposed villages with safer neighboring communities prepared to host evacuees. The program established clear procedures, designated evacuation routes, identified shelters and food supplies, and facilitated joint training exercises. By fostering trust and collaboration between paired communities, the initiative strengthens social bonds and institutional coordination, which are key to encouraging timely and organized evacuations.

Building Trust through Consistent, Endorsed Communication in Sri Lanka[25]

In Sri Lanka, public confidence in early warnings is highest when they come from government-endorsed institutions such as the Disaster Management Center, Sri Lanka Police, and verified media outlets. Mobile-based platforms are widely viewed as the most reliable and accessible means of receiving alerts, with strong trust across both urban and rural communities. Past experiences with false alarms and inconsistent messaging have weakened public trust in some cases, underscoring the importance of accurate, timely, and officially endorsed communication.

Dissemination structures and procedures. Defined communication structures are critical to ensuring early warning systems reach last-mile communities effectively. The success of risk communication depends on how smoothly information flows across different scales and social structures: from national alerting agencies to at-risk populations and back through feedback mechanisms.

Systems that rely solely on centralized, top-down messaging — without localized, trusted intermediaries — often face delays, bottlenecks, and breakdowns, leaving vulnerable groups uninformed or unprepared (Bangladesh, Kenya, Albania, Eswatini, Brazil, Namibia).

Resourcing warning dissemination. Adequate resources are essential for effective early warning dissemination, particularly in reaching last-mile communities. Sustained funding enables maintenance and upgrades of communication infrastructure, training of personnel, purchase of equipment (e.g., radios, loudspeakers, mobile phones), and community awareness campaigns. In Malawi, Village Civil Protection Committees equipped with mobile phones, bicycles, and protective gear successfully relayed timely warnings to marginalized households. Conversely, limited resources often result in poorly maintained systems, limited reach, and ineffective communication (Bangladesh, Kenya, Eswatini, Brazil, India-W, Nigeria, India-F).

24 Tupper, A., Fearnley, C.J., & Kelman, I. (2023).

25 Pitigala et al (2022).

Dissemination methods

Dissemination — multiple and redundant communication channels. Effective dissemination also relies on using multiple, redundant communication channels and strategies to reach diverse populations. (Nepal, India-W, Bangladesh, Kenya, Eswatini, Brazil, Namibia). This includes both modern technologies — such as SMS alerts, radio, television, and social media — and traditional methods like word-of-mouth, community meetings, and loudspeakers. Redundancy is especially critical during sudden-onset events, when modern systems may fail due to power outages or signal disruptions, especially in remote areas with poor infrastructure (Bangladesh, Ethiopia, Kenya, Eswatini, Brazil, India-W, Nigeria, India-F).

Dissemination — traditional channels and trusted intermediaries. Social networks — family, neighbors, community groups, and local leaders — consistently emerged as vital dissemination channels, especially where formal systems are weak or inaccessible (Indonesia, Bangladesh, Ethiopia, Brazil, India-W, Nigeria). Word of mouth and social networks were the most cited source of warnings in existing EWS for GDPC-supported studies (Figure 6).

Traditional communication methods tend to align with local cultural norms and are more trusted. This can be particularly important in overcoming language barriers or addressing cultural sensitivities related to risk communication (Ethiopia, Brazil, India-W, Nigeria). Vulnerable groups such as pregnant women, the elderly, and people with disabilities often rely on these informal networks due to physical or cultural barriers to accessing public information (India-W). In Nigeria, for example, distribution via multiple channels meant that messages were not only more likely to reach people but also to be believed and acted upon. Overall, the incorporation of local knowledge, networks, and trusted messengers play a crucial role in disseminating warnings and ensuring that they are understood and acted upon (Bangladesh, Ethiopia, Brazil, Namibia).

However, traditional channels may not be equally accessible to all, particularly those with limited mobility or disabilities (Vietnam, India-W, Nigeria). Integrating traditional and formal systems requires careful coordination to ensure messages are consistent, inclusive, and complementary (Ethiopia, Brazil, Namibia).

Good Practice Spotlight

Community-Led Cyclone EWS in Bangladesh[26]

Established in 1972 and jointly managed by the Government of Bangladesh and the Bangladesh Red Crescent Society, the Cyclone Preparedness Programme (CPP) is a long-standing, community-led early-warning model that has helped sharply reduce cyclone deaths in Bangladesh. Its strength lies in a nationwide network of 70,000+ volunteers in coastal communities, with women now comprising about 50% of the corps and taking on leadership roles. CPP teams ensure rapid dissemination of official cyclone warning signals and support evacuations and early actions. The program has also expanded to the Rohingya camps in Cox's Bazar, ensuring trusted messengers disseminate alerts within these communities.

26 Haque et al. (2022)

Information flow. Whether warnings are understood, trusted, and acted on depends on communities being able to feed back into the system. Two-way communication, where communities can ask questions, provide feedback, or seek clarification, helps tailor warnings to local needs and builds trust (Bangladesh, Albania, Namibia, Nigeria, Nepal). Two-way channels also enable authorities to adapt and tailor messages to local needs and contexts (Brazil, Nigeria).

In Nepal, people living with non-communicable diseases highlighted the need to include emergency health contacts and focal points in alerts so they could seek additional information or assistance. Even when communication did not originate from official sources, it still played a vital role. In Nigeria, households that sought clarification from family, friends, or other trusted contacts were more likely to understand and act on the warnings.

Feedback loops reveal what's unclear or impractical and enable rapid fixes to improve clarity, timeliness, and actionability (Brazil, Nigeria). Their absence can hinder alerting agencies from identifying and addressing barriers. This was evident in India, where the lack of dialogue and feedback mechanisms prevented authorities from recognizing how religious beliefs influenced residents' perception of risk (India-W).

How Communities Currently Receive Warnings: Most Common Communication Channels

Studies documented existing warning channels and, in some cases, community preferences (Figure 6).[27] Currently, traditional, low-tech methods dominate — word of mouth and social networks are most common, followed by loudspeakers, television, community institutions (churches/mosques), and radio. Digital tools such as mobile apps and social media were used far less often, though several studies noted that community members expressed interest in these channels being more widely adopted. Overall, communication relies predominantly on low-tech, locally embedded methods, underscoring the importance of strengthening traditional channels while integrating them with formal systems.

Figure 6: Existing and preferred communication channels

27 Although GDPC-supported studies did not ask systematically about preferred communication channels, many had insights regarding how people were most likely to receive messages through existing systems.

Communication frequency. It is also important to carefully consider and balance the frequency of communication. When warnings are issued too often, such as public announcements about wind and wave conditions in India or frequent heat advisories in Nigeria, people begin to ignore them (India-F, Nigeria, Ethiopia). This phenomenon, often referred to as "warning fatigue," can reduce the effectiveness of alerts. Conversely, warnings that are too infrequent may fail to capture attention or prompt action, as seen with flood alerts in Malawi.

Good Practice Spotlight

Enhancing Communication in Disaster Management in the EU[28]

Technological platforms can strengthen two-way information flows between authorities and communities. Participatory digital tools, such as the HERMES platform and the Aeolian AR Mobile App, enable citizens to receive early warnings and share reports, feedback, and real-time updates directly with authorities. These platforms integrate features like social listening, sentiment analysis, and group targeting, which help identify misinformation early, support rapid corrections, and foster continuous dialogue.

EWS Feedback Loops in Urban vs Rural Settings[29]

A global review found that two-way communication between communities and authorities is more common in urban areas, where advanced information and communication technologies (ICTs) are readily available. Urban community groups — often registered, trained, or subscribed to EW systems — use tools like mobile phones, Facebook, Google Maps, and X (formerly Twitter) to both send and receive warning messages. These exchanges typically occur before disasters to assess readiness and during emergencies to coordinate relief. In contrast, rural and remote communities often rely on one-way communication through traditional media such as radio and television, limiting their ability to interact directly with authorities.

A Salvadoran Red Cross volunteer delivers a community hazard and evacuation map to a household in Apancino, El Salvador, as part of efforts to strengthen local early warning systems. © Salvadoran Red Cross

28 Vollmer et al., (2025).

29 Sufri et al. (2020)

Warning message content

Source identification and credibility. Messages should clearly identify their source to avoid confusion and reduce the risk of misinformation. This can be achieved using logos, branding, or other visual cues that distinguish official warnings from unofficial or misleading messages (Brazil, Nigeria, India-W). In Brazil and Nepal, for example, some residents dismissed warning messages as spam, mistaking them for promotional content or telecom updates. These cases highlight the importance of establishing recognizable and trusted communication channels, especially in environments where multiple sources of information exist and credibility varies.

Completeness and accuracy. People are more likely to pay attention to warnings they perceive as reliable, relevant, and accurate. Confusion can arise when warnings are issued but the anticipated hazard does not materialize, potentially undermining trust in future alerts (Nepal). To be effective, warnings should include details about the type of hazard, its precise location (to the extent possible), its potential impact, the timing of the event, and specific instructions on what actions to take (India-W, Bangladesh, Ethiopia, Brazil, Nigeria, Kenya). In Kenya, for example, recipients expressed a desire for more localized (downscaled) flood information to better understand how the hazard would affect their immediate area.

Inclusive language choice to promote clarity and understanding. Messages presented in clear, simple terms, using the local language, and avoiding technical jargon are essential for ensuring that people understand early warning messages and can make informed decisions about how to respond (see Pillar 4) (Nepal, Kenya, Eswatini, India-W, Vietnam, Nigeria).[30] When warnings use technical language, especially in areas with language barriers or low literacy rates, they can significantly hinder comprehension and limit access to life-saving information (Nepal, Kenya, Eswatini, India-W, Vietnam, Nigeria).[31]

To effectively reach people with disabilities, communication channels and language choices should reflect the capabilities and preferences of the target communities. Standard messaging formats often fail to meet the needs of individuals who may not be able to hear, see, or interpret messages unless they are specifically adapted to their communication requirements. For example, adolescent girls with hearing impairments in India were unable to access cyclone warnings (India-W). In contrast, examples from Indonesia and Vietnam show how local actors and social networks can play a crucial role in adapting messages for last-mile households, including those with disabilities. The use of visual aids and multiple communication formats can enhance comprehension (Vietnam, Brazil, Nigeria). To ensure that people from diverse backgrounds can receive and understand warnings, messages should be translated into local languages, including sign language, and adapted to meet a range of communication needs.

Ultimately, the ability to receive and comprehend warnings directly affects preparedness and early action. If individuals cannot read, hear, or interpret messages — whether due to disability, language choice, or technical complexity — they are unable to act.

30 Domingos and Nagamatsu (2024); Kelman & Glantz (2014).

31 Tappendorf and Acland (2025)

Good Practice Spotlight

Community Networks Bridging EWS Gaps for PWDs in Indonesia[32]

In Indonesia, community networks and organizations of persons with disabilities (OPD) play a vital role in ensuring early warnings reach persons with disabilities (PWD). Word-of-mouth communication (gethok tular), especially through trusted community leaders like the Dukuh (sub-village head), and OPDs, has proven to be an effective and inclusive method of risk communication. In one village, OPDs held regular preparedness meetings with families and caregivers to raise awareness and build readiness. In another, OPDs served as liaisons, relaying warning messages from local authorities directly to member households. These low-tech, socially embedded networks bridge gaps left by formal EWS infrastructure and reinforce trust, accessibility, and community ownership, particularly when PWDs are actively engaged in DRR efforts.

2.4 Preparedness to respond to warnings (Pillar 4)

2.4.1 Common features of preparedness and capacity to respond to warnings

GDPC-supported studies identified five features that enable preparedness and capacity to respond (Pillar 4):

- **Knowledge of what to do:** People must understand which actions to take when warnings are issued. Without this knowledge, they are unable to respond effectively.
- **Physical ability to act:** This includes individual mobility (the ability to evacuate independently or with assistance), as well as broader conditions to enable such mobility, including safe evacuation routes and functional infrastructure.
- **Time to act:** Warnings must arrive with sufficient lead time for preparation or evacuation before hazard impacts are felt.
- **Resources to act:** Communities need financial and material resources to carry out protective measures, such as evacuation costs, home reinforcement, or securing livelihoods, that reduce risks to health, property, and assets.
- **Advanced planning:** Pre-established plans or standard operating procedures (SOPs) to guide early action and response at various levels. At the national level, this includes identifying and clarifying the roles and responsibilities of different actors, planning for evacuation shelters, and allocating human and financial resources to support response activities. At the community level, examples include community-based response teams and evacuation plans. At the household level, planning may involve determining how to evacuate family members requiring additional support, what to bring, and how to minimize losses.

32 Pertiwi et al. (2024)

2.4.2 Enablers and barriers: what supports or hinders preparedness and capacity to respond to warnings

Even when people receive and understand warnings, they may still be unable to act upon them. The GDPC-supported studies identified five key factors that can enable or hinder preparedness and response capacity (Figure 7). Each factor is relevant across all four last-mile groups and is elaborated below.

Figure 7: Enablers and barriers to preparedness to respond to warnings (Pillar 4)

Enables & Barriers	Pillar 4: Preparedness to respond	Rural and geographically isolated communities	Economically vulnerable groups	People with disabilities or health-related vulnerabilities	Gender and socially marginalized groups
Knowledge of what to do (clarity of actions, training, guidance)	ALB, BGD, NAM, PHL	KEN, MWI, ESW, IND-F	NPL, IDN	BRA	
Willingness to act (risk perception, trust, feasibility, beliefs, livelihood trade-offs)	PHL, NAM, ALB	NGA, IND-F, KEN, MWI, ESW	IDN, NPL	IND-W, ETH, BRA	
Resources to act (financial, material, human support, accessibility of evacuation options)	BGD, ALB, NAM	MWI, KEN, NGA, IND-F	IDN, NPL	IND-W, ETH, BRA	
Time to act (lead time, timely receipt of warnings, mobility constraints, delays)	BGD, ALB, NAM	MWI, ESW, KEN, NGA, IND-F	NPL, IDN	IND-W, ETH, BRA	
Community involvement in preparedness planning	BGD, PHL, ALB, NAM	ESW	IDN	IND-W, ETH	

Knowledge of what to do. Clear, simple, and actionable guidance is essential for helping people translate warning messages into effective preparedness and response. Even when warnings are timely, accurate, and trusted, people may be unable to act if they do not know what steps to take or what to do (Albania, Bangladesh, Namibia, Philippines, Kenya, Malawi, Eswatini, Brazil, India-F, Nepal, Indonesia). The need for warnings to be "useful" and "linked to specific actions people should take" was repeated in multiple studies (Bangladesh, Nepal, Eswatini) and other contexts.[32] In Ethiopia, Indonesia and Bangladesh, community members received information or warning from trusted or credible sources but were unsure of how to respond. By contrast, prior training, education or messages that included clear, actionable guidance helped people to take effective measures.

Good Practice Spotlight

Reducing Heat Risks with Actionable Alerts in Nigeria[34]

In informal settlements in Akure and Lagos, a pilot program sent daily heat advisories by SMS and posters with simple, actionable guidance: stay hydrated, wear light clothing, and avoid outdoor activity during peak-heat hours. Recipients reported adjusting routines to reduce heat impacts and shared tips with children, relatives, and neighbors, reinforcing trust in the alerts. Participants asked to scale the service (more languages, radio/TV) and to keep message frequency balanced to avoid alert fatigue.

33 Tappendorf and Acland (2025)

34 Adegun et al. (2024)

Willingness to act. Beyond knowing what to do, individuals must be willing to act. Willingness to act is closely linked to both trust (Section 2.3.2) and to risk perception (Section 2.1.2). People are more likely to act when they perceive the threat as real, trust the source of the warning, and believe their actions are both feasible and effective — concepts often called self-efficacy and response efficacy. In the Nigeria heatwave pilot, participants consistently reported that positive experiences with the cooling advice included in heat advisories encouraged them to adopt the recommended practices regularly.

If risks are underestimated, warnings distrusted, or trade-offs too high, even timely and clear alerts may not prompt protective action — a pattern seen across most GDPC-supported studies. Fatalistic beliefs reduced uptake in some contexts: people who believed that only divine intervention could protect them were less likely to act on warnings. (India-W, Nigeria).

In other contexts, economic and livelihoods pressures posed significant barriers. Workers in Nigeria and fishermen in India often chose not to heed heat or wind warnings because doing so would result in immediate income loss, while the risks of continuing work might not materialize. For those with precarious livelihoods, the need for daily earnings outweighed potential hazard considerations, even when forecasts were available. Similarly, fear of losing property or assets to looting or vandalism led some individuals in Kenya, India, and Bangladesh to remain behind during evacuation orders, prioritizing asset protection over personal safety.

Resources to act. GDPC-supported studies consistently highlighted that last-mile populations often lacked the resources necessary to act upon early warnings — whether financial, material, or human support (Albania, Bangladesh, Ethiopia, Kenya, Brazil, India-F, India-W, Nigeria, Nepal, Malawi).

Financial resources are essential for covering evacuation costs, reinforcing homes, or taking time off work during hazard periods — costs often beyond the reach of economically, geographically, or socially marginalized households. In Malawi, for example, 70% of surveyed households said that financial support would help them better prepare their homes and evacuate during floods.

Beyond individual needs, financial resources are also critical for building and sustaining systems that enable long-term engagement with last-mile communities. Effective EWS requires ongoing investment, not one-off events or short-term project funding. When EWS activities are project-based, they often lose momentum and institutional support once funding ends. This happened in Namibia, where response drills and evacuation training were discontinued when funding stopped.

Non-financial resources, such as human resources and targeted support for individuals with specific needs, are equally important. Even when individuals have the knowledge and willingness to act, they may be unable to do so if recommended actions are inaccessible or evacuation centers are unsuitable for their needs. Elderly individuals, people with disabilities, and those with non-communicable diseases often require mobility assistance or transportation to evacuate safely (Bangladesh, Brazil, Ethiopia, Indonesia, Nepal).

Informants in several contexts emphasized the importance of trained volunteers to assist vulnerable groups, such as helping people with disabilities pack and move (Bangladesh, India-W), or and supporting pregnant women, who often cannot act independently of their husbands, to reach health facilities (India-W). Support for family-level preparedness plans for families with members with special needs (Indonesia) can also facilitate action.

Even when evacuation is physically possible, highly vulnerable populations may still hesitate due to concerns about the conditions of evacuation centers. These include overcrowding and insufficient supplies (Malawi, Ethiopia, Bangladesh, Indonesia), insecurity (Bangladesh, Kenya), long distances to shelters (Bangladesh, Brazil, Ethiopia), cultural taboos against being housed with certain groups (Kenya), and facilities that are not equipped to accommodate people with disabilities or special medical needs (Indonesia, Ethiopia).

"When the sirens go off, I know I have to move quickly, but it's hard without proper tools or assistance. My family and I have made sure we know the evacuation route, but I worry about whether I can make it in time, especially if my caregiver is not around"

– Person with a disability, on volcano EWS in Indonesia[35]

35 Pertiwi et al. (2024)

Good Practice Spotlight

Pairing Early Warnings with Resources to Act

Anticipatory action (AA) programs aim to remove barriers that prevent people from acting on early warnings. When forecast thresholds signal likely impacts, these AA programs deliver financial and non-financial assistance so households can prepare, protect livelihoods, and evacuate if needed. For example, distributing cash ahead of a flood has been shown to increase evacuation rates,[36] and generate additional benefits, such as reducing livestock losses[37] and improving food security.[38] The mix of actions and support should be co-designed with affected communities and tailored to the hazard and context. Providing resources alongside early warnings is relatively new but promising practice to ensure that warnings lead to action.

Time to act. Adequate lead time is essential for enabling preparedness and action in response to early warnings. Knowledge, willingness, plans, and resources are of limited value if warnings arrive too late for people to act. In several GDPC-supported studies, messages were often delayed (Albania, Brazil, Malawi, Nepal, Nigeria, Indonesia, and Eswatini), arriving after the window for meaningful action had passed. In other cases, warnings failed to reach communities altogether (Bangladesh, Brazil, and among women in India). These delays are often linked to vulnerabilities such as geographic isolation, limited access to communication technologies, slower mobility among certain populations (Indonesia), or, at times, failures to issue alerts.

Community involvement in planning (*cross-cutting*): To ensure that people have the knowledge, willingness, resources, and time to act, meaningful engagement with communities must be central to preparedness and early action planning. Meaningful engagement with last-mile groups helps other EWS stakeholders understand what enables specific groups to act and ensures systems and facilities accommodate their needs. Yet research showed that last-mile communities in many places remain excluded from EWS and disaster planning efforts, resulting in limited understanding of how these systems work or what actions to take (India-F, Indonesia, Kenya, Nepal). This was the case even where disaster management officials claimed that communities had been engaged and community-based disaster preparedness organizations existed (Kenya). This disconnect highlights the need for more inclusive approaches that actively involve groups often left out of traditional engagement processes.

Good Practice Spotlight

Community-Driven Triggers for Timely Action in the Philippines[39]

Anticipatory action works best when communities co-own the "trigger" (i.e. the forecast threshold at which organizations provide support for early actions) that moves warnings into action. On Catanduanes, local DRR offices, civil society, and residents co-designed a two-step trigger. The readiness step activates when the national meteorological agency issues official advisories, cascading immediately to local government and community channels. The second, "activation," blends updated forecasts with structured local observations, such as rainfall, river levels, and crop conditions, gathered by local leaders, farmers, and volunteer committees. Local leaders, farmers, or volunteer committees make real-time assessments such as rainfall, river levels, or crop conditions that complement meteorological thresholds. This hybrid model connects technical data to lived realities, linking warnings to pre-agreed actions like opening shelters or moving livestock. It enables faster, clearer decisions and builds trust across all levels.

36 Pople et al. 2021; Gros et al. 2023
37 Gros et al. 2023
38 WFP 2025
39 Schneider, S. (2024).

A Mozambique Red Cross volunteer uses a megaphone during an early warning drill in a rural flood-prone community in Mozambique. © Damien Schumann / IFRC

3. Conclusions

Across diverse contexts, the research consistently found that EWS often falter not for lack of warnings, but because of systematic barriers that limit people's ability to receive, understand, or act on them. This reinforces that the effectiveness of EWS depends not only on technology and scientific infrastructure, but on people-centered design and operation processes that account for the lived realities and diverse needs and priorities of the communities they aim to protect. Success requires addressing systemic barriers across all four EWS pillars through intentional inclusion, accessible design, and support for action.

Several cross-cutting themes emerged consistently. **Community engagement** must extend beyond token consultation to meaningful co-design and ongoing participation. **Trust in message sources and content** determines whether warnings are heeded. **Resource constraints** (financial, material, temporal) often prevent action even when knowledge and willingness exist. **Traditional and Indigenous knowledge** remains underutilized despite its proven complementarity with scientific systems.

Critically, the research reaffirms that last-mile populations are not homogeneous. Vulnerabilities are shaped by intersecting factors, such as geography, poverty, gender, disability, age, ethnicity, language, and social status, which compound to create distinct barriers for different groups. Systems designed for an "average" community member inevitably exclude those who deviate from that imagined norm. Effective EWS must therefore be designed with this complexity in mind, actively seeking out and addressing the specific needs of the most marginalized.

Findings across the four EWS pillars reveal both persistent challenges and pathways forward:

Pillar 1: Disaster Risk Knowledge. Last-mile populations build risk knowledge not only from scientific data, but also through lived experience, culture, tradition, and engagement with external actors. As climate patterns shift, communities are increasingly aware that traditional indicators are changing. Mapping emerging risks and integrating scientific and Indigenous knowledge is becoming essential.

Pillar 2: Hazard Monitoring and Forecasting. This pillar remains the most technically centered and least participatory pillar, often disconnected from last-mile realities. Forecasting remains primarily centralized at the national level, with limited examples of community participation or culturally contextualized forecast products.[40] However, when Indigenous indicators are systematically recorded, compared with instrumental data, and incorporated into forecast discussions, both systems strengthen and community trust increases. Local observations can validate formal scientific forecasts, identify monitoring gaps, and provide hyperlocal specificity that improves accuracy and uptake.

Pillar 3: Warning Dissemination and Communication. Effective dissemination requires predefined procedures, adequate human and financial resources, and critically, the use of multiple, diverse, redundant communication channels. The research confirmed that no single channel reaches everyone. Modern technologies fail during disasters due to power outages and network disruptions, while traditional channels may exclude people with disabilities or those outside dominant social networks. The most successful approaches layered technological channels (e.g., SMS, radio, social media) with human channels (e.g., community volunteers, religious leaders, neighbor networks) and physical channels (e.g., sirens, loudspeakers, visual signals).

Message characteristics proved equally important as dissemination channels. Warnings are more likely to be trusted and acted upon when clearly labeled with recognizable sources, translated into local languages using plain terms, culturally appropriate, specific about timing and severity, and accompanied by actionable guidance. Two-way communication and feedback loops consistently enhanced outcomes by enabling clarification, building trust through responsiveness, and providing information for continuous system improvement.

Pillar 4: Preparedness to respond to warnings. Even when people received timely, accurate, trusted, and comprehensible warnings, many could not act. Barriers include lack of knowledge about protective actions, insufficient lead time, absence of financial resources and materials to implement preparedness actions, and physical inability to act independently. These barriers were compounded by inadequate evacuation infrastructure, shelters inhospitable to vulnerable groups, and fear of property loss or inhospitable shelter conditions that deterred evacuation even when physically and financially possible.

Willingness to act is closely tied to risk perception, which is shaped by lived experience. Communities that recently faced severe events are more proactive, while those experiencing only minor impacts show lower risk tolerance and are more likely to disregard warnings. Economic precarity created impossible tradeoffs, such as fishers braving dangerous seas rather than losing income and informal workers laboring through heat waves because they couldn't afford unpaid time off.

Many of the enablers and barriers identified in this synthesis have long been recognized by the EWS community[41], but their recurrence across contexts underscores the ongoing gap between recognition and practice. Closing this gap requires fundamentally reframing last-mile communities as the starting point — the "first mile" — for building effective systems. This means beginning EWS design not with available technology or institutional mandates, but with understanding how specific communities experience risk, access information, make decisions, and mobilize resources.

40 Šakić Trogrlić et al. (2021)

41 UNDRR (2023).

Volunteers disseminate early warning messages door-to-door in Cox's Bazar, Bangladesh, to support timely evacuation and community preparedness during emergencies. © IFRC

4. Recommendations

Building on these findings, the following recommendations are offered to strengthen the inclusivity, accessibility, and actionability of EWS for last-mile communities. Their intended audiences include governments and policymakers, donors, humanitarian and non-governmental organizations, and forecasting and technical agencies. While many recommendations reinforce global best practices, their continued relevance underscores the urgency of more meaningful integration of these approaches into EWS design and implementation.

The recommendations are organized around three core principles: inclusivity, accessibility, and actionability. In practice, these principles are interconnected and mutually reinforcing: ensuring inclusivity in EWS design is foundational to achieving accessibility and actionability later when warnings are shared. Each recommendation includes rationale and implementation strategies drawn from lessons and good practices documented across the analyzed literature.

Inclusivity

Inclusivity refers to intentionally designing and implementing systems that enable all last-mile populations, regardless of identity, ability, language, location, or other sources of marginalization, to meaningfully participate in all four pillars of EWS. Without deliberate inclusion, systems inevitably reflect the priorities and assumptions of those who design them, systematically overlooking the needs, knowledge, and constraints of at-risk populations.

Recommendation 1.1: Center marginalized subgroups as co-designers and co-owners of EWS through meaningful participation in design, implementation, and evaluation.

Why it matters: Top-down systems often consistently fail to meet the needs of marginalized populations because they do not reflect local realities, priorities, or knowledge systems. When last-mile communities participate only as "end users" rather than co-designers, systems miss critical insights about access barriers, communication preferences, cultural beliefs, and resource constraints. Meaningful participation builds ownership, increases trust, and ensures warnings are relevant and actionable for those most at risk.

Implementation strategies:

- Establish community committees with diverse representation (people with disabilities, women, elderly, indigenous communities) to guide EWS design and implementation, using participatory methodologies to structure engagement and co-design solutions. See IFRC Community Early Warning Systems guide for additional guidance on community-driven EWS development.
- Disaggregate "community" in engagement processes to ensure marginalized subgroups are directly included through targeted recruitment, separate consultations where needed, and accommodations such as sign language interpretation, transportation assistance, flexible meeting times, or home-based consultations.
- Involve community members in monitoring EWS performance and in iterative decision-making. Establish feedback mechanisms, such as community reporting platforms, hotlines, or post-event review sessions that enable communities to flag problems, suggest improvements, and validate whether warnings met their needs.
- Recruit and train diverse volunteer bases for last-mile dissemination, ensuring gender balance and representation of marginalized groups. Leverage existing networks (disability advocacy groups, indigenous associations, women's cooperatives) to co-host EWS training, amplify warnings through their established channels, and serve as trusted intermediaries.

Recommendation 1.2: Integrate Indigenous and traditional knowledge with scientific forecasting through structured collaboration, treating both as complementary and equally legitimate sources.

Why it matters: Indigenous knowledge provides hyperlocal specificity, cultural resonance, and community legitimacy that scientific forecasts alone cannot achieve. Communities demonstrated sophisticated understanding of environmental cues, including animal behavior, plant phenology, and celestial patterns, which complement instrumental observations. Dismissing this knowledge undermines trust, misses opportunities to strengthen forecast accuracy, and fails to connect warnings to cultural frameworks that shape interpretation and response.

Implementation strategies:

- Establish co-management protocols where meteorological services formally recognize Indigenous forecasters as partners through participatory scenario planning sessions where both compare predictions, discuss how climate change affects each system, and develop combined warnings.
- Document traditional indicators systematically through community-led research, creating visual guides or databases linking observable environmental cues to hazard probabilities, validating correlations over time and updating them to reflect climate change impacts.
- Train youth as "knowledge bridges" who learn traditional forecasting from elders while understanding scientific methods, enabling intergenerational knowledge transfer and translation between systems to prevent loss of traditional knowledge while strengthening modern systems.
- Support community-science partnerships by training local volunteers to use simple monitoring tools (e.g., rain gauges, river level markers) and validating their observations against official data, creating hybrid monitoring network.

Recommendation 1.3: Strengthen policy and financing frameworks that make inclusion a standard requirement across national and local EWS operations.

Why it matters: Across the studies, inclusion was strongest where national or local authorities had clear mandates and established processes for engaging marginalized groups. Where inclusion depended on individual, time-bound projects, it was often inconsistent, temporary, or deprioritized once funding ended. Policy, governance and financing frameworks are therefore key to sustaining inclusive EWS, so that participation, accessibility, and representation are treated as core system functions rather than optional add-ons.

Implementation strategies:

- Integrate inclusion requirements into national EWS policies, SOPs, and DRR frameworks, defining minimum standards for participation, representation, accessibility, and community feedback mechanisms.
- Clarify institutional roles and responsibilities for inclusion across meteorological services, disaster management authorities, and local government through inter-ministerial coordination mechanisms, reducing fragmentation and ensuring accountability.
- Link EWS performance assessments to inclusion indicators, including percentage of last-mile populations reached, community satisfaction, demographic breakdown of recipients, and post-event community evaluation.
- For donors, government agencies, and other EWS funders, integrate inclusion criteria, incentive structures, and dedicated budget lines that prioritize sustained engagement over one-off consultations.

Accessibility

Accessibility means removing physical, communication, institutional, and other barriers so that all people, regardless of their distinctive characteristics, can receive, understand, and benefit from warning messages and associated services when needed. Accessible systems recognize that different populations access information and services differently and offer multiple pathways to ensure no one is left uninformed.

Recommendation 2.1: Implement multi-channel, redundant dissemination strategies that combine modern technology with traditional communication networks and trusted community intermediaries.

Why it matters: No single communication channel reaches everyone, and modern technologies often fail during the disasters they're meant to warn about due to power outages, network disruptions, or device limitations. Word-of-mouth through family, neighbors, and community leaders was the most common way last-mile populations received warnings, yet formal systems rarely leverage these networks systematically. Redundancy ensures warnings reach even the most isolated households when primary channels fail.

Implementation strategies:

- Map existing social networks and information flow before designing dissemination plans. Identify trusted intermediaries (religious leaders, health workers, teachers, shopkeepers) and formalize these channels by equipping them with communication tools (e.g., mobile phones, loudspeakers, radios) and clear protocols.
- Layer technological channels (e.g., SMS, social media, mobile apps, radio, TV) with human channels (e.g., door-to-door visits, mosque/church announcements, market-day briefings) and physical channels (e.g., sirens, drums, bells, flags) to maximize reach and ensure multiple pathways for message delivery.
- Partner with organizations serving vulnerable groups (e.g., organizations of persons with disabilities, community health networks) to act as conduits for warnings, establishing neighborhood "buddy" systems where people with special needs are paired with volunteers who ensure they receive warnings and assistance.
- Conduct communication drills testing whether messages successfully reach last-mile households through intended channels, using feedback to identify gaps and adjust strategies. Create standard operating procedures with specifying at least three dissemination methods for each warning.

Recommendation 2.2: Design clear warning messages in local languages and accessible formats, with consistent branding to distinguish official warnings from misinformation.

Why it matters: Language and literacy barriers consistently prevented comprehension, with technical meteorological terms, foreign languages, and text-only formats excluding large population segments. People reported receiving warnings they couldn't understand, rendering forecasts useless, regardless of accuracy. Simultaneously, people dismissed legitimate warnings as spam because messages lacked clear source identification, and wariness of misinformation led them to ignore potentially life-saving alerts.

Implementation strategies:

- Develop warning message templates in partnership with community members using plain language (e.g., "dangerous flooding expected tomorrow morning" rather than "75% probability of >100mm precipitation in 24-hour period"), avoiding technical jargon, testing drafts with representative groups including those with limited literacy, and translating into predominant local languages.
- Create visual communication products — pictographic warnings, color-coded risk levels, illustrated action guides, video/audio messages — for distribution via multiple channels, ensuring accessibility for non-readers and providing sign language interpretation for all video content.
- Customize messages to local contexts by allowing community disaster committees to add locally relevant information (e.g., referencing familiar landmarks, past events, or trusted local voices) while maintaining consistency in core forecasting information and safety guidance.
- Develop nationally consistent EWS brand identity including logos, color schemes, message headers/footers, and audio signatures that become immediately recognizable.

Recommendation 2.3: Invest in last-mile communication infrastructure with backup power systems, community radio stations, and equipment for volunteer communicators in remote areas.

Why it matters: Infrastructure deficits — insufficient weather stations, unreliable electricity, poor mobile coverage, lack of communication devices — physically prevent warnings from reaching remote and marginalized communities regardless of message quality. Without sustained investment in last-mile connectivity and backup systems that function during disasters, inclusive EWS remain aspirational.

Implementation strategies:

- Establish or strengthen community radio stations powered by solar panels or generators, as these often remain operational when internet and mobile networks fail.
- Provide communication equipment (e.g., solar-powered radios, mobile phones with pre-paid credit, megaphones, two-way radios) to village civil protection committees and volunteer networks, with maintenance and replacement protocols ensuring long-term functionality.
- Install multi-hazard alert infrastructure (e.g., sirens, public address systems) in last-mile settings with redundant power sources (e.g., solar, battery backup) and regular testing schedules, designing systems to function when grid power fails.

Actionability

Actionability means that early warnings not only reach people but come with sufficient detail, clarity, lead time, and resources so that last-mile populations understand what actions to take and are able to take those actions before, during, and after hazard events. Actionable warnings connect information to specific protective behaviors appropriate for local contexts and capacities. Without actionability, warnings become mere notifications rather than tools for risk reduction.

Recommendation 3.1: Ensure warnings include specific, context-appropriate protective action guidance, not just hazard descriptions.

Why it matters: Even when people received and understood warnings, they often did not know what to do with the information. Forecasts describing "heavy rainfall" or "dangerous heat" without protective action guidance leave households paralyzed or guessing, particularly when facing unfamiliar or intensifying hazards. Actionability requires connecting hazard information directly to protective behaviors appropriate for local contexts, vulnerabilities, and available resources.

Implementation strategies:

- Develop hazard-specific action guides with communities, outlining progressive steps linked to warning levels (e.g., "Yellow Alert: Secure outdoor items and review evacuation plan; Orange Alert: Pack emergency supplies; Red Alert: Evacuate immediately to [specific shelter location]") and ensuring advice matches local capacity, and includes brief rationale (e.g., "move to higher ground because flash floods come fast").
- Tailor guidance to specific vulnerable groups through targeted messaging, reminding people with disabilities to charge assistive devices, advising pregnant women to pre-position at health facilities, or informing informal workers about cooling centers during heatwaves. See the IFRC DRR messages compendium for global safety action guidance across different hazards.
- Invest in public awareness and education through community drills, school programs, and information campaigns that prepare people to act on warnings and build a culture of risk awareness and preparedness. See IFRC Public Awareness and Public Education (PAPE) guide for additional resources on DRR awareness and education.

Recommendation 3.2: Link warnings to anticipatory action programs that provide financial and other resources enabling last-mile communities to take protective actions they otherwise could not afford.

Why it matters: Knowledge and willingness mean nothing if people lack resources to act. Poverty, economic precarity, and resource constraints forced people to disregard warnings — fishers continuing to fish in dangerous conditions rather than lose income, workers laboring through heatwaves without paid time off, households unable to evacuate due to transportation costs. Anticipatory action addresses this by providing resources alongside warnings, removing financial or other barriers to protective behavior.

Implementation strategies:

- Develop hazard-specific early action protocols with pre-defined triggers blending meteorological forecasts with local community assessments, securing funding ahead of time through contingency funds or donor agreements so action begins immediately when thresholds are met. See this Pre-Financing Anticipatory Action guide to learn more about possible pre-financing strategies.
- Include cash transfers or vouchers to at-risk households as one of the pre-agreed early actions[42] enabling them to purchase supplies, cover evacuation costs, take time off work, or reinforce homes without depleting savings.
- Provide trained volunteer teams to help elderly or disabled community members evacuate, pack belongings, secure property, and transport to shelters, recognizing many vulnerable individuals cannot act independently even when willing and informed.

Recommendation 3.3: Ensure adequate lead time by improving forecast-to-communication speed, strengthening last-mile dissemination networks, and pre-developing response plans.

Why it matters: Warnings arriving too late for action are essentially useless, yet delayed dissemination was pervasive: bottlenecks between national forecasting agencies and local communities, slow cascade through hierarchies, or communications reaching some neighborhoods hours after others. People with mobility limitations, caregiving responsibilities, or limited transportation need more time to act than systems typically provide.

Implementation strategies:

- Develop institutional standard operating procedures that define how warning information flows across levels (e.g., who informs whom, in what format, and how to avoid duplication or contradicting messages) and specify the roles and responsibilities of all actors at each stage to prevent overlaps and gaps.
- Stagger warning timelines to account for differential response capacity, issuing early "watch" notifications when hazards first become probable to alert populations needing extra preparation time (people with disabilities, remote communities), followed by escalating urgency as threats materialize.
- Facilitate household-level planning workshops where families develop personalized evacuation plans identifying who evacuates with whom, where they go, how they travel, what they bring, how they communicate if separated, and what specific steps members with disabilities or health conditions require, documenting plans on simple cards posted in homes.
- Support community-level planning through participatory mapping of hazards, safe zones, evacuation routes, assembly points, and shelter locations, combined with scenario simulations where communities practice coordinated response to different warning levels, identifying gaps and refining protocols iteratively.

42 For further examples of early actions, see the Anticipation Hub's Early Action Database: https://www.anticipation-hub.org/experience/early-action/early-action-database/ea-list

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Annexes

Annex A: Overview of GDPC-supported studies

The tables below summarize the 15 GDPC-supported studies, grouped by the topics outlined in the call for proposals. Each entry provides a brief overview of the study and its purpose.

Topic 1: Accessibility, inclusivity, and actionability of early warning messages among last-mile communities

Lead author & affiliation	Study Title	Focus Country/ Region	Primary hazard(s) studied	Study purpose
Rhomir Yanquiling, University of Melbourne	Factors Influencing Accessibility and Actionability of Risk Reduction Measures in Last Mile Communities: Insights from the Northern Philippines	Philippines, Pangasinan Province (Mapita and Cabalitian communities)	Typhoons, landslides, storm surges	Identify what influences communities' abilities to access and act on EWS; analyze behavior using Protection Motivation Theory.
Olumuyiwa Adegun, Federal University of Technology Akure	Utilization of Heat Early Warning Resources Within Slum Communities in Nigeria	Nigeria, Akure & Lagos	Heatwaves / extreme heat	Assess awareness, access, and actions related to heat warnings; pilot and evaluate a Community Heat Early Warning System
Chinmayee Mishra, Utkal University	'Disasters can't happen here. Lord Jagannath will save Us': Exploring women's experience of barriers to Early warning system in Odisha, India	India – Puri District, Odisha state	Cyclones (Cyclone Fani)	Explore socio-cultural and gender-based barriers affecting women's access to early warnings and preparedness.
Rafael Pereira, University College Cork	Enhancing People-Centred Early Warning Systems in Traditional Coastal Communities of Brazil: An Intersectional Approach to Inclusive Risk Communication	Brazil, São Paulo coast (Ubatuba and Paraty municipalities)	Coastal storms, floods	Examine how Traditional and Local Communities (TLCs) perceive and use EWS. Develop and propose a community-based communication prototype for risk communication.

Lead author & affiliation	Study Title	Focus Country/ Region	Primary hazard(s) studied	Study purpose
Pradytia Putri Pertiwi, Universitas Gadjah Mada	Inclusivity and Actionability of Volcanic Hazard Early Warning System in Indonesia: Perspectives of Persons with Disabilities	Indonesia, Mount Merapi region	Volcanic eruptions	Assess how people with disabilities access and act on volcanic EWS; explore inclusive design requirements and OPD participation.
Tara Ballav Adhikari, Aarhus University	Understanding Barriers to Access Early Warning Messages During Disasters Among People Living with Non-Communicable Diseases in Nepal	Nepal, Kanchanpur & Kailali Districts	Floods and health-related emergencies	Identify barriers that people living with NCDs face in accessing early warnings and propose strategies to enhance inclusive EWS.
Linda Obiero, University of Nairobi	Barriers to accessing early warning messages and factors impeding their comprehension and inclusivity in Kolwa East Ward, Kisumu County, Kenya	Kenya, Kisumu	Floods	Identify barriers to comprehension and inclusivity of flood early warning messages; recommend improvements for local governance.
Max Martin, University of Sussex	Fishers on the First Mile: Early Warning Early Action by Traditional Fishers of Southwestern India	India, Thiruvananthapuram District, Kerala	Marine storms, cyclones	Investigate how traditional fishers perceive and act on marine weather warnings; propose improvements for localized EWS.
Sipho Felix Mamba, University of Eswatini	Utilization of Early Warning Information and the Factors Influencing Actionability of Early Warning Messages Among Last Mile Communities in Drought-Prone Areas in Eswatini	Eswatini, Lubombo and Shiselweni regions	Drought	Investigate how marginalized farming communities in drought-prone areas use EWS and the factors affecting their ability to take preventive actions based on received messages.

Topic 2: Strategies to improve accessibility and actionability of early warning messages among last-mile communities

Lead author & affiliation	Study Title	Focus Country/ Region	Primary hazard(s) studied	Study purpose
Tirsit Sahledengle Beyene, Addis Ababa University	Community-Developed Early Warning and Early Action Systems: The Case of South Omo Communities in Ethiopia	Ethiopia, South Omo	Floods and droughts	Analyze Indigenous early warning systems in South Omo communities, particularly for floods, evaluating their strengths, weaknesses, and integration potential into formal EWS.
Shampa, University of Engineering and Technology	Community-Led Early Actions on Rapid-Onset Flash Flood Events in North-Eastern Bangladesh	Bangladesh, Tahirpur and Sunamganj	Flash floods	Examine how communities access, interpret, and act on flash flood early warnings; identify enabling and limiting factors for early action
Abdul Rohman, RMIT University Vietnam	Breaking the Circuit of Information Poverty: Early Warning Messages and Deaf and Hard of Hearing (DHH) Communities in Vietnam	Vietnam, multiple locations	Multi-hazard (typhoons, floods, landslides	Explore how information poverty limits access to EWS and disaster preparedness among Deaf and Hard of Hearing (DHH) communities and suggest inclusive design approaches.
Ita Bonner, Agricultural University of Tirana	Bridging the Gap: Investigating Barriers and Enhancing Resilience in Last Mile Communities Through Inclusive Early Warning Strategies in Rural Lezha, Albania	Albania, Lezha County	Multi-hazard (flood, landslide, fire)	Assess barriers preventing rural communities from accessing, understanding, and acting on early warning information.
Deolfa Jose Moises, University of the Free State	Towards Participatory Flood Early Warning for Early Action: A Situational Analysis of Flood Risk Communication in the Zambezi Region, Namibia	Namibia, Zambezi Region	Floods	Assess the efficacy of existing flood risk communication, to identify operational gaps in the EWS and opportunities to improve last-mile communication and action

Topic 3: Resource accessibility in facilitating early action among last-mile communities

Lead author & affiliation	Study Title	Focus Country/ Region	Primary hazard(s) studied	Study purpose
Charles Chunga, Mzuzu University	Early Action for Flood Protection in Makhuwira: Understanding Last-Mile Community Response to Flood Warning in Malawi	Malawi, Chikwawa District, Makhuwira	Floods (Cyclone Freddy)	Assess household-level early actions before Cyclone Freddy, focusing on types of actions, EWS communication effectiveness, and their impact on flood risk reduction.

Annex B: Methodology and limitations

Research Questions

This rapid scoping review addresses the primary research question: "What EWS features best support the inclusivity, accessibility, and actionability of early warning systems (EWS) for last-mile communities?" Each of these terms is defined in the box in the executive summary. The study's sub-questions and corresponding deliverables are presented in Table 3.

Table 3: Study sub-questions & deliverables

Key study question	Product
1. What EWS features visibly support the inclusivity, accessibility, and actionability of early warning systems (EWS) for last-mile communities?	Inventory of EWS features
2. What barriers or enabling factors influence the implementation of inclusive, accessible, and actionable EWS?	Summary of key enablers and barriers for each pillar of EWS
3. What missing information is revealed by the literature?	Listing of gaps in knowledge from the 15 GDPC-supported studies

Methodology Overview

This study is a rapid scoping review — a streamlined, structured approach for mapping literature, screening, and extracting key insights. More efficient than a systematic literature review, it applies practical constraints while maintaining methodological rigor. Table 4 outlines the methods employed and their objectives.

Table 4: Methods and objectives of this study

Method	Objective
Analysis and synthesis of 15 research reports from the GDPC Small Research Grants Program	To identify key trends, commonalities, and context-specific variations, including barriers and enablers
Targeted desk review of additional literature on last-mile early warning early action delivery	To further develop and validate GDPC findings, fill gaps in the research, and contextualize findings within global best practices
Compilation of findings and practical, evidence-based recommendations	To inform advocacy efforts and guide future programming on inclusive EWEA

This study relies exclusively on existing secondary data sources; no primary data was collected. The meta-synthesis focuses on 15 Small Research Grant program studies conducted in 14 countries.

Data Analysis Process

The research team conducted a structured coding and synthesis process using MaxQDA, following the steps below:

Step 1: Pre-coding

Large segments of text (e.g., full paragraphs or sections) relevant to the meta-synthesis were pre-coded. Content not directly related to the local EWS contexts, such as general literature reviews or global background, was excluded.

Step 2: Lexical search

Lexical searches were conducted on the pre-coded segments to highlight key terms, particularly those that correspond to the four EWS pillars, organized using the MECE (Mutually Exclusive, Collectively Exhaustive) principle. These lexical searches supported structured, manual coding.

Step 3: Manual coding

Analytical categories are distinct groups or themes used to organize and interpret data systematically during analysis. The research team coded the following analytical categories within each relevant segment to enable consistent classification and comparison across studies:

- Last-mile qualifiers (main target group and subgroups identified as most marginalized or vulnerable)
- Hazards addressed
- Study methodologies used
- Early Warning System (EWS) features implemented
- Stakeholders involved
- Identified barriers, enablers, and gaps, including inclusivity.

These categories helped structure the data and highlight key aspects of each study for meaningful synthesis. These categories were explicitly linked to specific EWS pillars (with a focus on Pillars 3 and 4).

Step 4: Preliminary synthesis

The research team then analyzed the coded the 15 studies by EWS pillar, examining commonalities and differences across the studies for how to make EWS more inclusive, accessible, and actionable. This synthesis was presented to an advisory committee, who provided feedback on the preliminary findings and identified the most critical themes and gaps to supplement additional literature and examples.

Step 5: Additional literature recruitment and synthesis

The team performed a rapid, purposive search of academic and grey literature (Relief Web or Prevention Web), and selected examples and cases to supplement the findings in those critical areas.

Study Limitations

As this research is a rapid scoping review, it does not aim to achieve the rigor and depth of a systematic literature review (SLR). Given the time available, additional literature search was limited to articles published in the last 10 years, in English, with a focus on extracting promising examples and good practices. The findings and recommendations outlined in this report, therefore, represent a comprehensive review of the literature and lessons around study themes and gaps. Given the limited scope of this review, where the findings refer to countries by name (e.g., India, Malawi) we are referring to findings related to specific GDPC-supported studies and sites, not to broader national trends.

A broader review of the literature was also conducted to assess whether certain last-mile categories were underrepresented in GDPC-supported studies. Treatment of all the factors listed in Table 3 varied considerably across the GDPC-supported studies and complementary literature reviewed. Most research focused on disability, Indigenous identity, poverty, and geographic isolation, while other factors were largely absent. Notably underrepresented were LGBTQI+ status, age diversity beyond older adults, and the distinct challenges facing populations in fragile or conflict-affected settings. These gaps should be considered when interpreting the findings and highlight priority areas for future research.

The Global Disaster Preparedness Center (GDPC) is a global reference center hosted by the International Federation of Red Cross and Red Crescent Societies and the American Red Cross. It works to strengthen the disaster preparedness and risk reduction capacities of Red Cross and Red Crescent National Societies and the wider humanitarian community by improving access to research, tools, learning, and innovation. The GDPC provides services in three main areas — knowledge management, research, and technical assistance — to help build preparedness at national and community levels.

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