Global status of multi-hazard early warning systems

Target G

SENDAI FRAMEWORK
FOR DISASTER RISK REDUCTION 2015-2030

UNDRR
UN Office for Disaster Risk Reduction

WORLD METEOROLOGICAL ORGANIZATION

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FOREWORD

Mami Mizutori
Special Representative of the UN Secretary-General for Disaster Risk Reduction and Head of UNDRR

Petteri Taalas
Secretary-General World Meteorological Organization

As this report was being prepared, Pakistan was struggling with its worst climate disaster in recorded history. As we write, over 1,600 lives have been lost, over 6 million people are in need of immediate support, and over 33 million people affected. Tragically, these numbers are not final.

Despite this carnage, the death toll could have been much higher if not for early warnings through the Pakistan Meteorological Department and the National Disaster Management Authority.

Multi-hazard early warning systems are an effective disaster risk reduction and climate adaptation measure that have been demonstrated to save people's lives and reduce losses and disruptions.

They also provide a good return on investment. The 2019 Global Commission on Adaptation flagship report Adapt Now found that early warning systems provide more than a tenfold return on investment.

This is why the Sendai Framework for Disaster Risk Reduction 2015-2030 sets the expansion of multi-hazard early warning systems as a distinct target, Target G, to be achieved by 2030.

Adding to the urgency of achieving this target, is the goal set by the UN Secretary-General that every person on the planet is covered by an early warning system in the next five years.

Based on analysis from the Sendai Framework Monitor and complemented with data from surveys by the World Meteorological Organization (WMO), this report presents an overview and a baseline of the status of early warning coverage around the world.

More importantly, it identifies areas where progress can be accelerated to achieve this universal coverage, both geographically and in the four elements of early warning systems.

We hope the findings and recommendations of this report will prove useful to countries in the implementation of the upcoming executive action plan to be released by WMO at the 2022 UN Climate Change Conference, COP27, in Egypt, to achieve this life-saving campaign.

TABLE OF CONTENTS

ACRONYMS

ACE	AHA Centre Executive
AHA Centre	ASEAN Coordination Centre for Humanitarian Action
ASEAN-ERAT	ASEAN Emergency Response and Assistant Team
CAP	Common Alerting Protocol
CPP	Cyclone Preparedness Program
CREWS	Climate Risk and Early Warning Systems
CRFM	Caribbean Regional Fisheries Mechanisms
DARAJA	Developing Risk Awareness through Joint Action
ECNWF	European Centre for Medium-Range Weather Forecasts
EFAS	European Flood Awareness Systems
FBF	Forecasts-based financing
FEWER	Fisheries Early Warning and Emergency Response
GBON	Global Basic Observing Network
GFDRR	Global Facility for Disaster Reduction and Recovery
GMAS	Global Multi-Hazard Alerts System
GOOS	Global Ocean Observing Systems
GSMA	Groupe Speciale Mobile Association
ICG/IOTWMS	Indian Ocean Tsunami Warning and Mitigation System
ICT	Information, Communication and Technology
IFRC	International Federation of Red Cross and Red Crescent Societies
IOM	International Organization for Migration
IPCC	Intergovernmental Panel on Climate Change
ITU	International Telecommunication Union
LDC	Least Developed Countries
LLDC	Landlocked Developing Countries
MHEWS	Multi-Hazard Early Warning Systems
NDMO	National Disaster Management Office
NMHS	National Meteorological and Hydrological Services
PDC	Pacific Disaster Centre
RANS	Rapid Alert Notification Systems
REAP	Risk-informed Early Action Partnership
SDG	Sustainable Development Goals
SDS-WAS	Warning Advisory System for Sand and Dust Storm
SFM	Sendai Framework Monitor
SIDS	Small Island Developing States
SOFF	Systematic Observations Financing Facility
SOP	Standard Operating Procedure
TSP	Tsunami Service Providers
UNCAS	UN Climate Action Summit
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNDRR	United Nations Office for Disaster Risk Reduction
WMO	World Meteorological Organization

HEADLINE MESSAGES

1. MAKE 'EARLY WARNINGS FOR ALL' A REALITY

- Disaster risk management experiences so far show that improved multi-hazard early warning systems (MHEWS) reduce disaster mortality and number of affected people.
- The report highlights significant gaps – only half of the countries globally have reported being covered by MHEWS – underscoring that the call by the UN Secretary-General on *Early Warning for All* needs to be made a reality to further save lives, livelihoods and assets.
- Regions fare differently in their progress and effort in establishing MHEWS. Special assistance is needed for least developed countries (LDCs), small island developing States (SIDS) and Africa. More investments are needed throughout the MHEWS value cycle, with emphasis on reaching the 'last mile'.

2. ENHANCE DATA AVAILABILITY THROUGH BETTER REPORTING

- Several countries may have a MHEWS in place but may not have reported officially through the Sendai Framework Monitor. Governments need to scale up reporting to have the full understanding of all MHEWS elements, to plan ahead and target better.
- While countries have reported progress in increasing the number of people covered by MHEWS, including through national dissemination mechanisms and local preparedness efforts, significant gaps remain in coverage. Understanding of status of all MHEWS elements needs to be enhanced.
- Collection and analysis of disaggregated data is important in addressing multi-dimensional vulnerabilities.

3. IMPROVE OBSERVATION AND MONITORING

- The Systematic Observations Financing Facility (SOFF) provides technical and financial support for strengthening observational data, in particular in SIDS and LDCs. SOFF is crucial for improving the observation networks in the most vulnerable countries, especially in Africa and the Pacific.
- Impact-based forecasting minimizes the socioeconomic costs of weather and climate hazards. Improving capability to conduct vulnerability and exposure assessment and a nationwide hazards-hotspot register can support in generating impact-based information. Forecasts-based financing (FbF), anticipatory action and other instruments should be further strengthened.
- Technology for data collection, analysis (using artificial intelligence and machine learning), and dissemination (automation and linked to local knowledge) can be improved and even centralized in many situations. Optimum use of technology provides good opportunities for enhancing MHEWS through e.g., crowdsourcing data from mobile technology.

4. STRENGTHEN THE EARLY WARNING – EARLY ACTION VALUE CYCLE (A SYSTEM APPROACH)

- MHEWS should be seen in its full length of value cycle, rather than a set of disparate elements. The MHEWS cycle is as strong only as its weakest link – one break or delay in information transfer at any stage may derail the whole system.
- MHEWS governance should promote stronger inter-departmental and sectoral collaboration among hydro-meteorological institutions, national disaster risk management offices and other institutions (especially those related to non-hydrometeorological hazards).
- Effective implementation of MHEWS, hazard forecast and warning dissemination requires strong policy and institutional frameworks. Lack of policies or legislation may hinder the effective delivery of services. Therefore, creating an enabling environment through simple and well-understood legislation, and policy and institutional frameworks for implementing the MHEWS and forecast services, is necessary as part of national disaster risk management strategies, frameworks and regulations.
- All MHEWS should be multi-hazard covering relevant hazards and hazardous events taking place in a country, including at localized scales. We need to adopt a 'system approach' to MHEWS, where hazards are not monitored and predicted in silos, but their interconnectedness and cascading nature is kept at the forefront of analysis and tracking.

5. MAKE MHEWS PEOPLE-CENTRIC WITH INCREASED ACCOUNTABILITY

- Elements of MHEWS tend to be authority-driven. While progress has been made in hazard monitoring and forecasting, early warning infrastructure and dissemination, alerts and decision-support services need to reach and better support communities, in a time-sensitive manner. MHEWS need to be more people-oriented with focus on last-mile outreach, with a shift in focus from early warning dissemination to communication through impact-based forecasting and warnings.
- This can be further facilitated by harnessing the right mix of communication channels – mass media, radio, television and internet access and penetration, mobile networks, and straightened local and community communication channels. Overall, MHEWS should build on engagement with the end-users, and integrate local and traditional knowledge at different stages of MHEWS value cycle.

6. APPLY THE SENDAI FRAMEWORK METRICS AND DATA TO MONITOR EARLY WARNING COVERAGE AND EFFECTIVENESS

- Despite reporting limitations, data currently available from 95 countries shows the current and potential volume of official statistics that the Sendai Framework Monitor can generate. Importantly, the monitoring indicators are structured on the four elements of early warning, and produce a composite score of comprehensiveness of early warning across countries.
- The recently developed custom indicators to complement the Target G monitoring offer a key opportunity to assess the effectiveness of MHEWS in countries. Like the Target G indicators, these indicators also are quantified to yield a composite score.
- A combination of the global and nationally customized indicators produces quantified scores which, together with monitoring data available from WMO and other sources, can be of high relevance to the tracking of the Secretary-General's call for Early Warnings for All.

1

INTRODUCTION

1 INTRODUCTION

1.1 HUMAN AND ECONOMIC COST OF DISASTERS

Disasters continue to take a heavy toll on life and assets, rolling back the development gains of countries. While the human impact of some major disasters related to natural hazards has declined considerably – especially when measured by disaster-related mortality – the economic costs have remained high and continue to increase.

In the first seven years of Sendai Framework implementation (2015-2021), a total of around 300,000 disaster-related deaths (including missing persons) were reported by 135 countries (Target A), excluding COVID-19-related mortality. Nonetheless, in the longer term, the average annual number of dead and missing persons in the event of disaster per 100,000 people has fallen from 1.77 during 2005 to 2014 to 0.84 during 2012 to 2021.

Further, during 2015 to 2021, 145 countries reported a total of 1.05 billion people affected by disasters (Target B). The number affected by disasters per 100,000 per year has nearly doubled, from an average of 1,147 people per year during 2005 to 2014, to 2,066 during 2012 to 2021. In 2021 alone, 38 million new internally displaced people were recorded, of whom over 60 per cent were displaced due to disasters[1].

Economic losses due to disasters are high (Target C), and there is an ongoing challenge of under-reporting and underestimation of losses. During 2015 to 2021, annual reported losses average US$ 330 billion, which represents a full 1 per cent of the GDP from the countries reporting.

While it is evident that richer nations would face higher economic losses, LDCs, landlocked developing countries (LLDCs), and SIDS are bearing a disproportional burden of disaster economic losses relative to their national GDP. Combined, these countries accounted for 11.3 per cent of reported economic loss during 2012 to 2021, although only accounted for 2.2 per cent of total GDP of countries reporting.

Beyond monetized disaster-related losses, a number of countries have reported losses in housing, critical infrastructure, and other sectors. The number of critical infrastructure units and facilities destroyed or damaged by disasters (Target D) averaged over 140,000 per year between 2015 and 2021.

Governments have been making consistent efforts in addressing disaster and climate risks and building resilience. A total of 125 countries have developed national disaster risk reduction strategies (Target E). However, international cooperation and financing for disaster risk reduction remains low (Target F). Between 2010 and 2019, only 4.1 per cent of disaster-related official development assistance was allocated to ex-ante prevention and preparedness, with the majority allocated to emergency response[2].

One of the key reasons that, despite challenges, global disaster mortality levels due to natural hazards have been decreasing, is the availability of and access to MHEWS, which enables communities to take pre-emptive action to stay out of harm's way or minimize the impact. MHEWS is an effective and viable disaster risk reduction and climate adaptation measure that has been demonstrated to save people's lives, reduce losses and disruptions, and provide a good return on investments[3]. **Despite considerable advances in predictive technologies, disasters continue to claim many thousands of lives and cause irreparable damage to homes, businesses, and critical infrastructure. The accumulated and cascading human and economic cost of high-frequency, low-impact events continue to rise, a pointer to the need to advance and accelerate MHEWS at all levels.**

TARGETS OF THE SENDAI FRAMEWORK

(a) Substantially reduce global disaster mortality by 2030, aiming to lower the average per 100,000 global mortality rate in the decade 2020-2030 compared to the period 2005-2015;

(b) Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 in the decade 2020-2030 compared to the period 2005-2015

(c) Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030;

(d) Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030;

(e) Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020;

(f) Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of the present Framework by 2030;

(g) Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030.

1.2 OVERVIEW OF MULTI-HAZARD EARLY WARNING SYSTEMS

The Sendai Framework, through its Target G, aims "to substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to the people by 2030". UNDRR has been mandated to monitor the implementation of the Sendai Framework, which it does through the online Sendai Framework Monitor (SFM), also contributing to the monitoring of selected targets of SDGs 1, 11 and 13.

Progress towards Target G enables governments to assess their availability of, and access to, MHEWS, along with necessary governance arrangements for its implementation, contributing to the overall efforts in implementing the Sendai Framework. In some countries, this has led to multi-stakeholder consultations, intersectoral initiatives, and multiagency coordination. WMO's 2021 State of Climate Services[4] report provides relevant information on the progress made by countries on Target G.

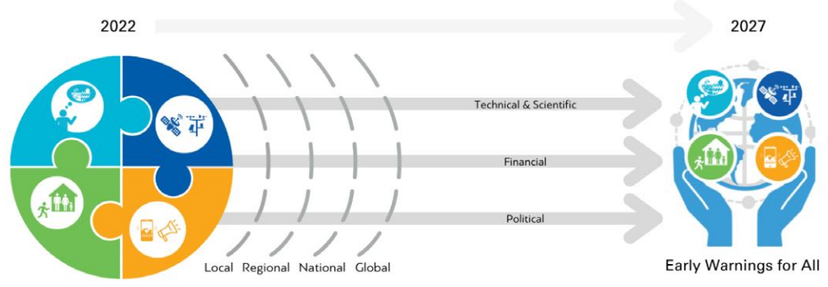


Figure 1.1: Architecture to achieve the five-year goal (Source: WMO, 2022)

1 IDMC (2022) Global Report on Internal Displacement, Internal Displacement

2 UNDRR (2021) "International Cooperation in Disaster Risk Reduction: Target F"

3 Early warning systems must protect everyone within five years | World Meteorological Organization (wmo.int)

4 2021 State of Climate Services

Recognising the importance of MHEWS in saving lives and reducing disaster impact, on 23 March 2022, the Secretary-General of the United Nations announced that "the United Nations will spearhead new action to ensure every person on Earth is protected by early warning systems within five years". WMO was given the mandate to lead this effort. To achieve this global effort, WMO, along with key partners, is developing a transformational plan of action. This report is designed to inform this action plan and its subsequent monitoring.

This report is not an assessment or evaluation of the disaster risk reduction status of the countries. Rather, it showcases the progress made in MHEWS as reported in the SFM, complemented by additional data from WMO surveys. This report can be used as a baseline for undertaking more in-depth analysis.

MHEWS is an integrated system that "addresses several hazards of similar or different type in contexts where hazardous events may occur alone, simultaneously, cascading or cumulatively over time, and taking into account the potential interrelated effects"[5]. They may include warning for hazards related to meteorological and hydrological events, geo-hazards, environmental, biological, chemical, and technological[6]. MHEWS should be resource-efficient, enable integrated disaster risk reduction, and should be easily understood by the communities. Multi-sector and multi-disciplines coordination, involvement of individuals and community at risk, having an enabling institutional and legislative environment, clear roles and responsibilities, and adequate operational capacities, are essential for effective and consistent warning through MHEWS[7].

5 Early warning system | UNDRR
6 Hazard definition and classification review (Technical Report) | UNDRR
7 Multi-hazard Early Warning Systems: A Checklist | E-Library (wmo.int)
8 Early Warning Systems – Prepare Center
9 Early warning system | UNDRR
10 Collins, L. M.; Kapucu, N.- Early warning systems and disaster preparedness and response in local government

1.2.1 End-to-end early warning systems

An end-to-end system is a "set of components that connects those who need to hear messages to others who compile and track the hazard information of which messages are composed"[8]. It works together to create a single, cohesive and robust system. An effective end-to-end early warning system includes four major interrelated elements,[9] as presented in the Figure 1.2: (i) Disaster risk knowledge, (ii) Observations, monitoring and forecasting systems, (iii) warning dissemination mechanisms, and (iv) preparedness and response capability.

Coordination within and across different sectors and at multiple levels for these interrelated elements is crucial for the effective functioning of the end-to-end MHEWS. Also, a feedback mechanism is important for continuous improvements of these elements. The failure of any of the elements will lead to the overall failure of the entire MHEWS and is likely to increase the possibility of negative impacts on lives and livelihoods. Also, it is crucial that the responsibility for warning dissemination and response is with government and local community decision-makers[10]. A well established and operational national warning centre is necessary to develop an end-to-end warning system by formulating and disseminating warnings and connecting with communities at risk to ensure that they have the capacity to act and respond.

Figure 1.2: Elements of an end-to-end early warning system
(Source: WMO, 2022)

1.2.2 People-centred MHEWS

Top-down approaches, where scientific information is passed down to the community, have been repeatedly proven to be insufficient in providing the community with appropriate information that allows them to respond and minimize risks and impacts. A people-centred MHEWS "empowers individuals and communities threatened by hazards to act in sufficient time and in an appropriate manner to reduce the possibility of personal injury, loss of life and damage to property and the environment"[11]. It has been widely acknowledged that the success of an early warning system is dependent on the community's ability to correctly understand and respond to imminent risks. This means MHEWS should be developed in collaboration with the end-users, and impacts are clearly communicated and understood. Once the community or end-user understands their likely impacts, they can communicate the information needed from a warning provider and might minimize some of these impacts.

People-centred MHEWS tend to be cost-effective, spotlight affected communities and individuals, and recognize their important role in minimizing the vulnerabilities to the hazards. Also, the community involvement in the design and implementation of MHEWS increases the trust in the system, provides ownership of the MHEWS process, empowers the communities and builds local resilience to disasters[12].

11 Multi-hazard Early Warning Systems: A Checklist , Outcome of the first Multi-hazard Early Warning Conference (wmo.int)
12 People-centered early warning systems in China: A bibliometric analysis of policy documents

2

GLOBAL STATUS OF MULTI-HAZARD EARLY WARNING SYSTEMS

2 GLOBAL STATUS OF MULTI-HAZARD EARLY WARNING SYSTEMS

One of the most effective ways to reduce disaster impact is to have an effective MHEWS in place which allows people to engage in risk reduction actions. **There is evidence suggesting that countries reporting good coverage of MHEWS have lower mortality rates compared to countries that have little or no early warning systems.** For this analysis, countries were grouped into two categories: 'Limited to moderate coverage', with Indicator G1 score higher than 0 and lower or equal to 0.5; and 'Substantial to comprehensive coverage', with G1 score higher than 0.5. As can be seen in the Table 2 1, higher MHEWS coverage corresponds to a lower reported mortality ratio – countries with limited to moderate MHEWS coverage have nearly eight times the mortality ratio compared to that in the countries with substantial to comprehensive coverage[13].

Category of countries by coverage of MHEWS (Target G)	Mortality per 100,000 population, 2005-2021 (Target A)
Limited to moderate coverage	4.62
Substantial to comprehensive coverage	0.60

Table 2 1: Mortality rate by MHEWS coverage

This section provides an overview of the global and regional progress on Target G since 2015, as officially reported by countries. Each of the indicators from G2 to G6, representing the four MHEWS elements, is crucial to the successful implementation of MHEWS, and this section provides key insights into the contribution and status of these indicators.

Sendai Framework: Target G

The Sendai Framework for Disaster Risk Reduction 2015-2030 has seven strategic targets and 38 indicators for measuring progress on reducing disaster risk and losses. These indicators align implementation of the Sendai Framework with implementation of the SDGs and the Paris Agreement on climate change.

Target G of the Sendai Framework aims to *Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030.*

UN Members States agreed to the following indicators when measuring Target G:

- **G-1** (compound G2-G5): Number of countries that have multi-hazard early warning systems.
- **G-2** Number of countries that have multi-hazard monitoring and forecasting systems. [MHEWS element: Observation & forecasting]
- **G-3** Number of people per 100,000 that are covered by early warning information through local governments or through national dissemination mechanisms. [MHEWS element: Warning & dissemination]
- **G-4** Percentage of local governments having a plan to act on early warnings. [MHEWS element: Preparedness to respond]
- **G-5** Number of countries that have accessible, understandable, usable and relevant disaster risk information and assessment available to the people at the national and local levels. [MHEWS element: Risk knowledge]
- **G-6** Percentage of population exposed to or at risk from disasters protected through pre-emptive evacuation following early warning.

(See Annex 1 for technical details)

13 The table compares data of Target G (Indicator G-1) against Target A (Indicator A-1) as reported on Sendai Framework Monitor. The data may have some gaps due to inconsistent reporting.

2.1 GLOBAL MHEWS COVERAGE [G1]

The number of countries participating in the SFM has increased iteratively and, **as of March 2022, 120 countries had provided information on their Target G status. Of those 120 countries, 95 reported the existence of MHEWS** (Figure 2.1). **While this represents a two-fold increase from the achievement reported in 2015, this represents less than half of countries in the world that have MHEWS.**

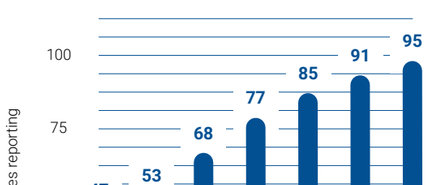


Figure 2.1: Cumulative number of countries reporting existence of MHEWS (Source: SFM)

Regions fare differently in their progress and effort in establishing MHEWS. Figure 2.2 and Figure 2.3 show the proportion of countries reporting the existence of MHEWS per region and for LDCs, LLDCs, and SIDS. There has been progress since 2015 – most regions have at least 40 per cent of countries with existing MHEWS. **However, there are regional variations. Africa, Americas and the Caribbean, and Arab State have low MHEWS coverage in their countries. Coverage is particularly low in the SIDS and LDCs – less than half of the LDCs, and only one-third of SIDS, have reported existence of MHEWS.**

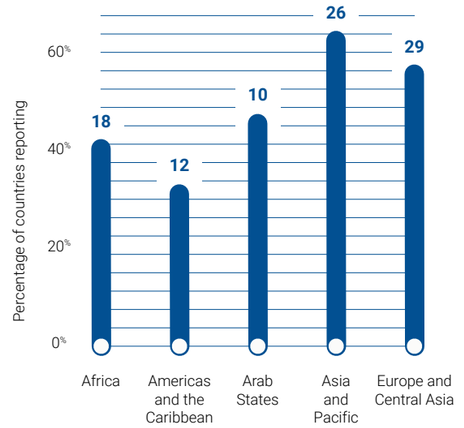


Figure 2.2: Proportion of countries per region reporting existence of MHEWS (Source: SFM). Numbers on the bars indicate the number of countries reporting

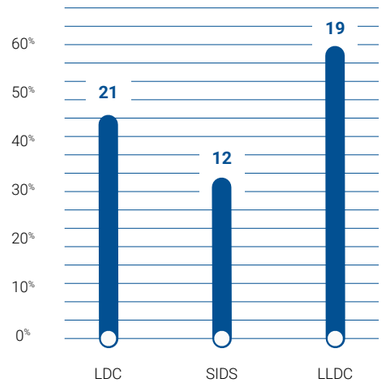
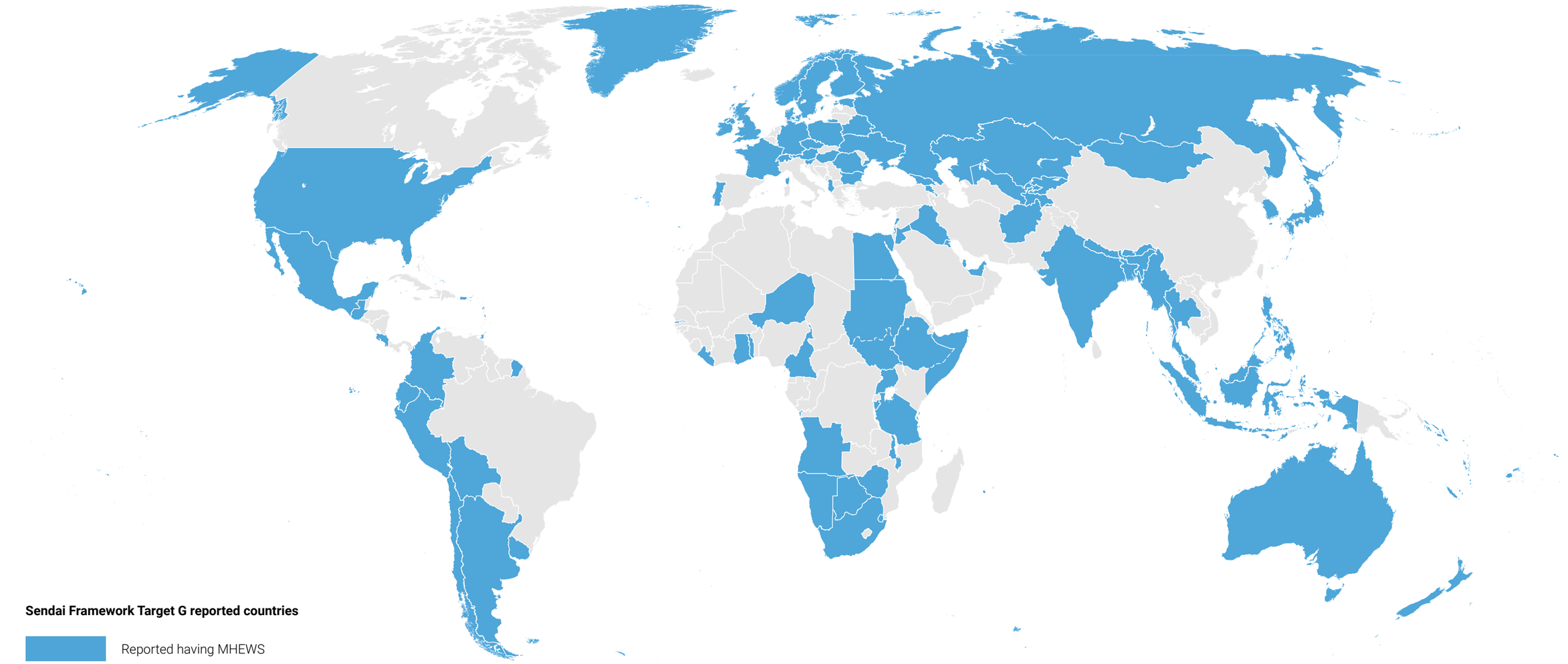


Figure 2.3: Proportion of LDCs, LLDCs, and SIDS reporting the existence of MHEWS (Source: SFM). Numbers on the bars indicate the number of countries reporting

Figure 2.4 shows the reporting status of countries, together with the average scores for the four elements of MHEWS. More countries have reported on elements on 'warning dissemination' and 'observation and forecasting' (42 per cent and 31 per cent respectively), than for elements on 'preparedness' and 'risk knowledge' (27 per cent and 20 per cent respectively). The average scores (out of maximum of one) reported by these countries have also remained very low for the 'risk knowledge' element (0.55), followed by 'preparedness' (0.73).



Sendai Framework Target G reported countries

Reported having MHEWS

Did not report having MHEWS/do not have MHEWS

Source: SFM as of March 2022

UNITED NATIONS Geospatial

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations

Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined.

A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).

Proportion of countries reporting by MHEWS elements. (Source: SFM)

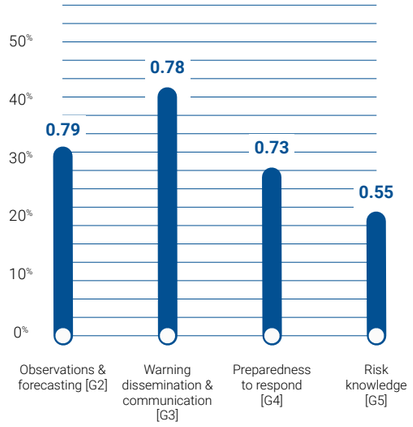


Figure 2.4: Proportion of countries reporting by MHEWS elements. (Source: SFM) Number in bars are the average scores.

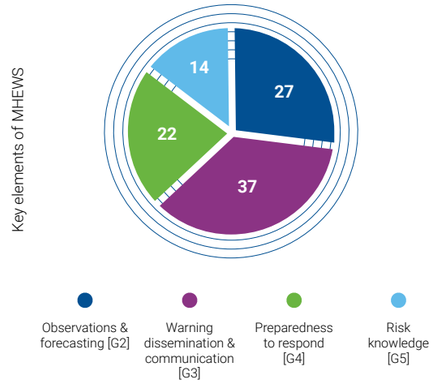


Figure 2.6: The share of contribution of Indicators G2 to G5 to the increase of G1 with respect to initial and final average scores (Source: SFM)

Many countries have demonstrated improvements in their MHEWS, as reported through an increase in scores over years (Figure 2.5). All groups of countries have seen an improvement in the average scores. However, the high increase in some categories of countries, e.g., LLDCs, LDCs and SIDS, is also a reflection of the low baseline score of these countries. Further, despite the high relative increase, countries with poor MHEWS remain behind countries in Europe and Central Asia, and Asia and the Pacific.

The four key elements of MHEWS contribute considerably differently to the progress of the early warning systems. When the increase in G-1 scores was looked at through the lens of the four key elements, it is seen that the improvement of 'warning dissemination and communication' element has contributed the most (37 per cent) to the improvement of G-1 scores (Figure 2.6). On the other hand, countries have recorded less progress in 'risk knowledge and management', which accounted for only 14 per cent of the G-1 score improvement.

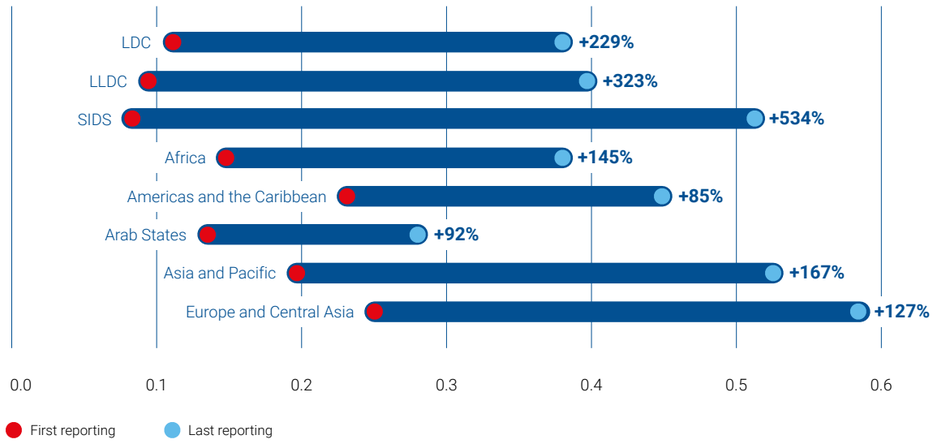


Figure 2.5: G-1 Average first and last scores and per cent increase for each region and country grouping (Source: SFM). First scores considered for countries reporting on or before 2015

While some progress has been made in all four key elements globally, to advance the MHEWS across all the countries, considerable investments are still needed in all its interrelated elements.

Effective MHEWS require systematic evaluation and improvement. As per the WMO survey, only about a third of WMO Members globally report having evaluated their performance, an important mechanism to be able to rate the effectiveness of the system. National capacities in assessing MHEWS effectiveness, especially in LDCs and SIDS, need to be enhanced.

2.2 STATUS OF MULTI-HAZARD MONITORING AND FORECASTING SYSTEMS [G2]

Multi-hazard monitoring and forecasting are critical elements of early warning systems, so improving these services can significantly reduce risk to disasters and climate extremes. These services require qualified personnel, proven science, and reliable technology for monitoring and detecting hazards in real time or near real time. This allows continuous monitoring of hazard elements so that real-time and accurate forecasts and warnings can be provided.

Of the countries reporting on this indicator on SFM, only 56 per cent reported on the availability of multi-hazard monitoring and forecasting systems.

While MHEWS for specific hazards are essential, many disasters have compounding or cascading impacts, as highlighted in the 2022 Global Assessment Report[14] and the Sixth Assessment Report of the IPCC[15]. **There is growing evidence where it was observed that MHEWS worked for the first event, but loss of lives was due to cascading and compounding impacts. These cascading impacts were not captured by MHEWS and thus this highlights the needs for risk-informed, impact-based forecasting.**

For example, during the 2018 Indonesian tsunamis in Sulawesi, the biggest and the most unexpected killer was soil liquefaction: intense tremors caused saturated sand and silt to take on the characteristics of a liquid. Similarly, the tsunami in the Sunda Strait was triggered by a huge volcanic eruption, submarine explosions, and a rapidly sliding volume of soil — a phenomenon not captured by tsunami early warning systems that were configured for seismic origins.[16] Similarly, the Titli cyclone in the Odisha state of India in 2018 is considered a rare event in its characteristics such as re-curvature after landfall and retaining its destructive potential after landfall. The track and intensity of the cyclone was well predicted but it recurved north-eastwards across Odisha, resulting in loss of 89 lives due to the cyclone and associated floods.[17]

Therefore, **MHEWS that can provide warnings for interrelated and cascading events are essential for an effective warning system. However, only 42 per cent of WMO Members confirm availability of monitoring and forecasting for multiple hazards occurring simultaneously or cumulatively over time.**

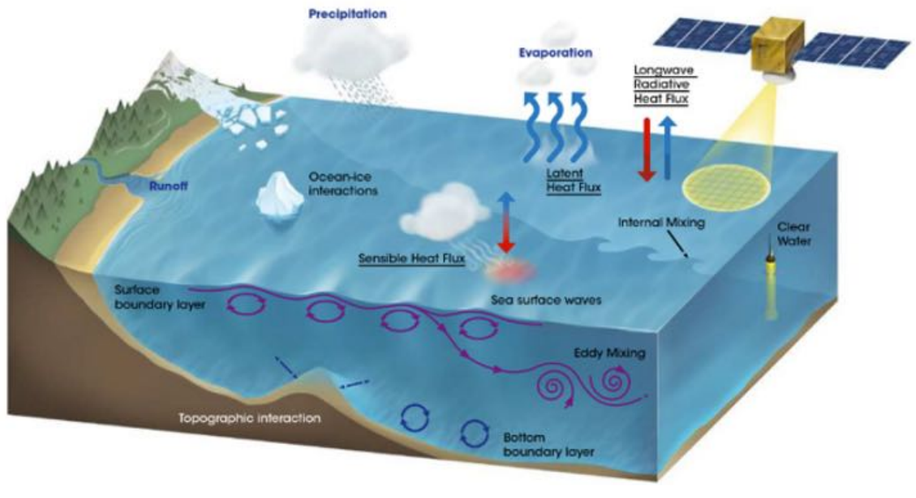
MHEWS should be available at a local scale in a timely manner, with information about the specific locations that will be affected, and the type of impacts to different exposed and vulnerable elements such as human settlements, infrastructure systems and social services. This will allow potentially affected communities to take early action. **WMO has conducted an in-depth survey of early warning systems across its Members, including whether a country's national meteorological service provides impact-based forecast and warning services. According to the latest data (April 2022), only 46 per cent of countries reported the existence of such services.**

14 UNDRR (2022), Global Assessment Report on Disaster Risk Reduction 2022
15 IPCC (2022), Climate Change 2022: Impact, Adaptation and Vulnerability, Summary for Policymakers
16 ESCAP (2019) Asia-Pacific Disaster Report
17 Indian Meteorological Department (2019), Very Severe Cyclonic Storm, TITLI over East central Bay of Bengal

Ongoing monitoring by WMO of the observational data exchanges reveals that the current data coverage falls far short of the minimum requirements to support robust weather and climate prediction, especially in SIDS and LDCs. Despite several decades of significant investments made in strengthening the meteorological services in developing countries, many areas of the globe remain far from achieving the goal of continuous, robust, real-time international exchange of surface-based observations. Figure 2.6 shows the international exchange and density of in-situ observations of surface atmospheric pressure as of June 2022 and according to the Global Basic Observing Network (GBON). The situation in countries with dark red is dire. SOFF will support SIDS and LDCs in closing these gaps (Section 3.1).

Tsunami early warning systems

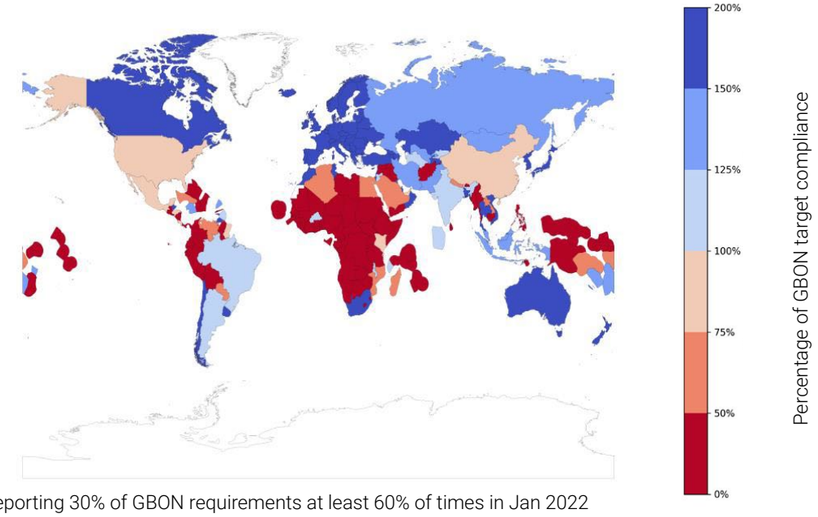
The 2004 Indian Ocean tsunami that hit the coastal areas of several South and South-east Asian countries killed more than 230,000 people, affected millions of people, and damaged critical infrastructure. The Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWMS) was formed following the tsunami, to develop an interoperable network of national and regional tsunami monitoring, warning and advisory systems. ICG/IOTWMS developed the Regional Tsunami Service in 2011 for the entire Indian Ocean with the tsunami service providers (TSPs) established by Australia, India and Indonesia. Also, national tsunami warning centres were established in all the ICG Member States, to coordinate the international tsunami warning and mitigation activities. Since the inception of IOTWMS, several tsunami warnings were issued, which led to successful evacuation of communities at risk in several countries. For example, the system alerted the communities living on Andaman and Nicobar Islands within eight minutes during the 2012 Indian Ocean earthquakes.



Representation of the ocean processes and connection with the Earth (Source: IOC-UNESCO, GOOS)

Surface reporting density

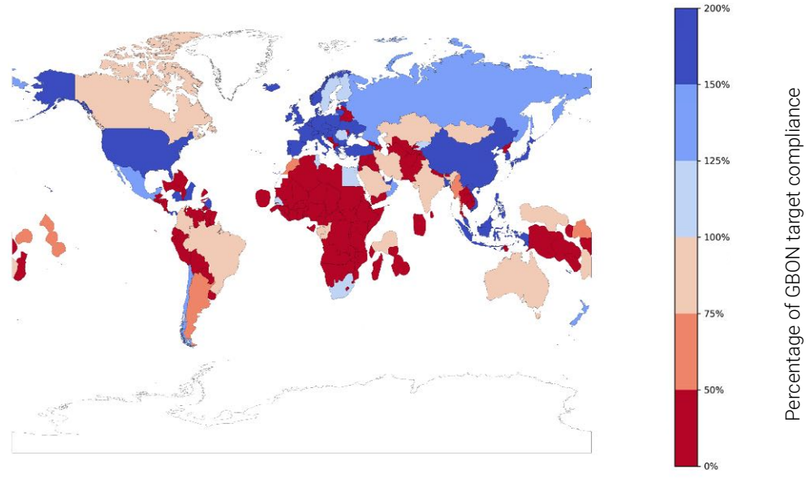
Surface Reporting Horizontal Resolution



Stations reporting 30% of GBON requirements at least 60% of times in Jan 2022

Upper-Air reporting density

Upper-Air Reporting Horizontal Resolution



Radiosondes Stations making 1-daily report at least 60% of times in Jan 2022

Figure 2.7: Gaps in Global Basic Observing Network (GBON) January 2022. Source: WMO

Map and data source: World Meteorological Organization (WMO).

Disclaimer: The boundaries and names shown and the designations used on the map do not imply official endorsement or acceptance by the United Nations.

2.3 EARLY WARNING DISSEMINATION [G3]

Dissemination and communication systems are one of the critical MHEWS elements as they ensure individuals and communities receive warnings in advance of a disaster, reduce the impact of disasters, and facilitate coordination at national and regional levels[18] . Mass media, including radio, television, website, e-mail, SMS, social media, siren, public board, mobile applications, etc., are some of the communication systems through which warnings are usually disseminated[19]. Multiple communication channels are used to enhance the outreach of early warnings, to prevent failure of any one channel, and to strengthen the communication of warning information. Indicator G3 of the Sendai Framework measures the population in each country covered by early warning information through communication, dissemination and outreach provided by local or national governments as a proxy to measure how many people might be effectively receiving messages disseminated through those channels. **Among the four MHEWS elements, countries have reported relatively good achievement (77 per cent of countries with MHEWS) in national or local dissemination mechanisms, though with varied levels of coverage**.

Globally, many steps have been taken to improve the means of communication, to ensure communities receive early warning messages or notifications to safeguard their lives and assets during emergencies. However, for efficient dissemination of warnings, a right mix of communication channels – mass media, radio, television and internet access and penetration, mobile networks, and local and community channels – is required.

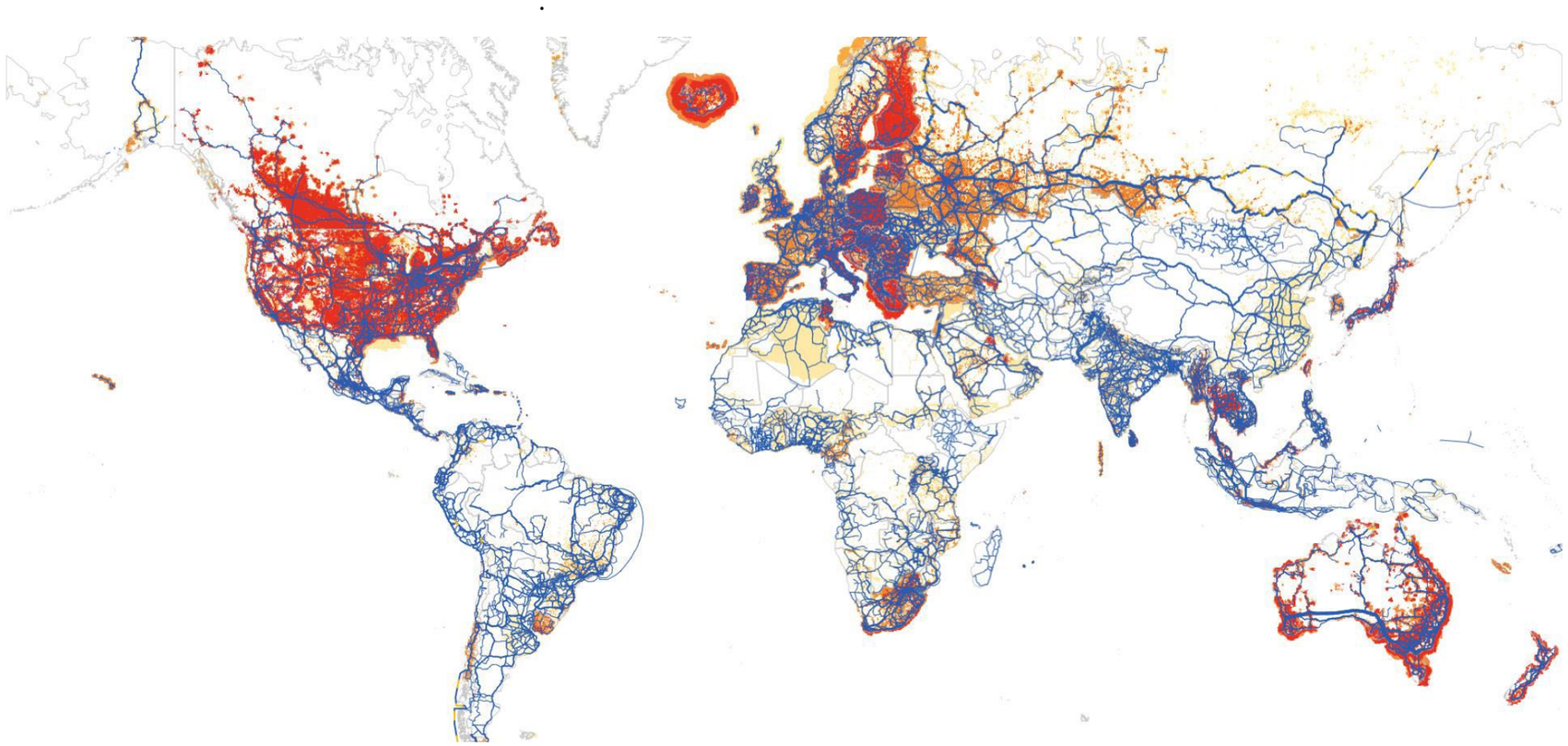


Figure 2.10: Global networks and mobile coverage.

Map and data source: International Telecommunication Union (ITU) ITU – Map

Disclaimer: The boundaries and names shown and the designations used on the map do not imply official endorsement or acceptance by the United Nations.

18 Amina Khan, Sumeet Gupta, Sachin Kumar Gupta - Multi-hazard disaster studies: Monitoring, detection, recovery, and management, based on emerging technologies and optimal techniques

19 Warning Dissemination and Communication | World Meteorological Organization (wmo.int)

In this connection, the role of mass media and mobile technology is of high significance. By the end of 2021, 5.3 billion people subscribed to mobile services, representing 67 per cent of the global population. In a growing number of markets, most adults now own a mobile phone, meaning that future growth will come from younger populations taking out a mobile subscription for the first time. Over the period to 2025, there could be an additional 400 million new mobile subscribers, most of them from Asia-Pacific and Sub-Saharan Africa, taking the total number of subscribers to 5.7 billion (70 per cent of the global population). **GSMA estimates that by the end of 2025, the total number of mobile-cellular subscribers will reach 5.7 billion, which represents 70 per cent of the global population, highlighting the potential of reaching people at risk**[20]. It should also be noted that while mobile broadband coverage and use data shows gaps and digital divides, the spread of mobile cellular networks and services is growing and providing new opportunities to reach communities at risk.

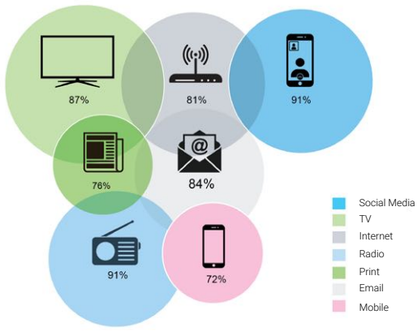


Figure 2.8: Global access to used communication channels (WMO database, 2022)

Of the WMO survey respondents, 48 per cent of the countries reported having implemented the Common Alerting Protocol (CAP) as part of their dissemination schemes. According to the WMO survey, the disaster risk management authorities and other stakeholders usually use multiple communication channels, such as television, internet, mobile, social media, email and radio for disseminating disaster risk information and assessments. The analysis suggests that the communication channels used are in line with the communications channels that are widely accessed by citizens.

Despite widespread mobile coverage, the International Telecommunication Union (ITU) indicates there are persistent internet and mobile connection gaps in many parts of the world. The coverage gap remains significant in Africa, where 18 per cent of the population still remains without any access to a mobile broadband network. Almost as many (17 per cent) lack such access in LDCs and LLDCs.[21] In 2022, an estimated 2.7 billion people – or one-third of the world's population – remain unconnected to the internet[22]. This has an implication on community outreach of early warnings. For instance, mobile applications need an internet connection, while cellular networks can be used to send SMS or broadcast messages reaching many more people.

Aside from limiting connection to receive alerts, Members are not able to upload observation data to enable the production and download of the high-quality forecasts that are critical for alerts.

20 GSMA, The Mobile Economy 2022
21 Facts and Figures 2021 | ITU
22 Internet surge slows, leaving 2.7 billion people offline in 2022 | ITU

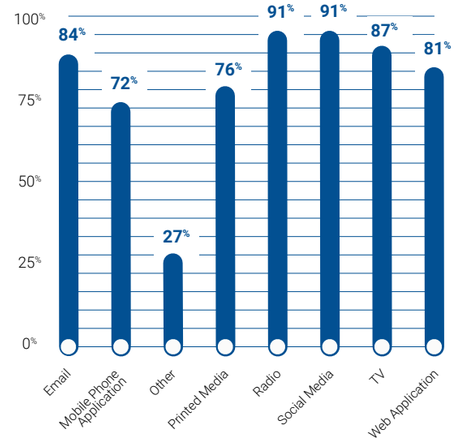


Figure 2.9: Proportion of national meteorological services that use each communication channel (Source: WMO Survey 2022)

2.4 PREPAREDNESS FOR EARLY ACTION AND RESPONSE [G4]

Regulatory, institutional and coordination frameworks (e.g., plans and policies) play a crucial role in operationalising MHEWS and including risk information while taking decisions. They define the roles and responsibilities, and steps to be taken upon receiving the warnings[25]. It is reported that several nations are developing "regulatory frameworks and technical guidelines" for MHEWS[25]. **Having plans for preparedness, evacuation, response and other relevant plans at local government level is important for responding to warnings issued by the regional or national hydro-meteorological services**. This can minimize the impacts of disasters, evacuate people to safe locations, and ensure better coordination among organizations responsible for preparedness and response[26,27]. For example, upon receiving warnings of possible floods, having an evacuation plan would direct the community toward elevated areas. **The Sendai Framework Indicator G4 measures the availability of plans to act on early warnings at local level. Countries with MHEWS have reported low progress in this element of MHEWS – only 46 per cent of such countries have reported availability of such plans to act on early warnings.**

Bushfire warning systems[23,24]

The 2009, Black Saturday bushfires in Victoria, Australia, caused widespread devastation by burning 450,000 hectares of land and 3,500 buildings, killing 173 people, injuring 414 people, and affecting millions of wild and domestic animals. To mitigate such devastating events in the future, Emergency Alert, a national telephone warning system for emergency service providers, was developed by the Australian Government to send location-specific audio messages to landlines and mobile phones of the possible or actual emergency (in a defined area). Also, the Bureau of Meteorology disseminated warnings directly to several emergency service organizations through mobile phone calls, emails, briefings and other digital channels, and to public and others via the broadcast media and the internet.

Governments and partner organizations have increasingly inclined towards anticipatory action, against conventional humanitarian response, to enhance both effectiveness and efficiency. Anticipatory action provides an important opportunity to act before a disaster strikes, or before its impact fully unfolds. Advanced risk information and forecasting mechanisms offer a big opportunity for the need to scale up anticipatory, forecast-based, and risk-informed interventions. These actions range from risk financing mechanisms, including those attached to safety net programmes, to contingent disaster financing that provides quick and flexible funding to developing countries affected by disasters until funds from other sources become available. The UN Central Emergency Response Fund has kickstarted the set-up and financing of several anticipatory action pilots to address disasters like droughts and floods[28].

23 Black Saturday bushfires | National Museum of Australia (nma.gov.au)
24 Public Information and Warnings-handbook.pdf (aidr.org.au)
25 Five approaches to build functional early warning systems | UNDP Climate Change Adaptation
26 Multi-hazard Early Warning Systems: A Checklist, Outcome of the first Multi-hazard Early Warning Conference (wmo.int)
27 Global Early Warning Systems needed: Creating Partnerships to Cope with Natural Disasters | United Nations
28 CERF Anticipatory Action

The Early Action Protocols, developed by the National Red Cross and Red Crescent Societies, are good examples of early actions they need to take when a specific hazard is forecast to affect communities. The Early Action Protocol describes the early actions selected to reduce the impact on vulnerable communities, including pre-positioning of stocks and readiness activities so the national society is prepared and on stand-by to respond, and pre-agreed early action activities designed to save lives and livelihoods once a hazardous event is forecast[29].

2.5 DISASTER RISK INFORMATION AND ASSESSMENT [G5]

Disaster risk knowledge, a key component of MHEWS, is the combination of disaster risk information and disaster risk assessments. Disaster risk information such as hazards, exposure, vulnerability and capacity of people, communities, organizations and countries and their physical assets, is important for making informed decisions[30]. Disaster risk assessments directly support the local and national authorities in identifying vulnerable groups, infrastructure and assets, to develop evacuation plans including evacuation routes and safe locations, and to improve warning messages to include potential impacts of the hazardous events[30]. To deal with the disaster risks and climate emergencies, disaster risk knowledge needs to be accessible to the authorities and public to ensure appropriate measures are in place[31].

Indicator G5 of the Sendai Framework measures the number of countries that have easily accessible, understandable, useable and relevant disaster risk information, such as climate outlook, vulnerabilities and hazards, and assessments such as risk assessment and vulnerability assessment. Fewer than half of countries with MHEWS have reported the existence of such risk information and knowledge. This is also the least area of progress among the four elements of MHEWS.

Despite the coverage and variety of communication channels, the rapid alert notification for people in high-risk areas is still challenging due to the complexity of the disasters, lack of awareness, lack of robust communication infrastructure, and unstandardized warning messages[32,33].

Enhancing risk knowledge

UNDRR, in partnership with UNDP, has been supporting countries in tracking disaster losses and damages (www.desinventar.net) since 1994. The system collects data on the human and socio-economic consequences of events of all dimensions and magnitude at national and local levels and is used by 110 UN Member States. At present, UNDRR, UNDP and WMO are partnering to reconfigure the system to align better with weather and climate observations, releasing more user-friendly customized outputs, expected to further strengthen MHEWS with a focus on LDCs and SIDS.

UNDRR further aims to improve risk understanding through increased application of climate and disaster information to support more resilient development and humanitarian planning. A new global product, the Risk Information Exchange (www.rix.undrr.org), has been launched as an open-access platform that builds on national efforts, connecting them with relevant regional and global initiatives. Climate and disaster risk information are aggregated, while adhering to global standards. UNDRR also works at global level to increase the quality and accessibility of risk data and analytics, as well as working with countries to address risk knowledge gaps to accelerate risk reduction action.

29 Practical information on Forecast based Action by the DREF
30 Disaster Risk Knowledge | World Meteorological Organization (wmo.int)
31 How can we make climate & risk knowledge accessible to those in need? | PreventionWeb
32 Communication-related vulnerability to disasters: A heuristic framework – Sten Hansson, Kati Orru, AndraSiibak, Asta Bäck, Marco Krüger, Friedrich Gabel, Claudia Morsut
33 Communication challenges during past disasters (itu.int)

While huge progress has been made in forecasting hazards, it is not always available at local level in a format that can support on-the-ground decision-making[34]. In addition to high-resolution localized information, citizens require information on the timing, duration, intensity and potential impact of the predicted hazard, to decide what actions they should take to keep their communities and livelihoods safe. If information is provided only via online sources, then it limits the accessibility to literates and people who have access to the internet or mobile services, while leaving others behind.

One way to increase the availability and use of disaster risk knowledge is to demonstrate its benefits to governments and communities. The latest WMO survey measured this by asking its Members whether their country had undertaken studies on the social and economic benefits of weather, climate and hydrological services in the last 10 years. Figures 2.11 and 2.12 show the percentage of countries that answered yes to this question. Most countries in all regions indicated that they had not undertaken this research and the percentages for Africa, SIDS, LDCs, and LLDCs were all below 30 per cent.

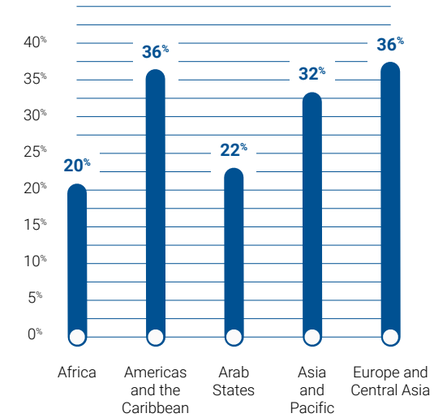


Figure 2.11: Proportion of countries that have undertaken studies on the social and economic benefits of weather, climate and water hydrological services. Source: WMO

Sand and dust-storm warning systems in Burkina Faso

Airborne dust poses significant risks for human health and has negative impacts on agriculture. The Burkina Faso Warning Advisory System for Sand and Dust Storm (SDS-WAS) has been tested and was developed with support from a CREWS initiative. Two maps are developed every day with the warning levels for the next two days (D+1 and D+2) for the 13 regions of the country, to safeguard public health, agriculture and other vulnerable sectors from the damages caused by airborne dust.

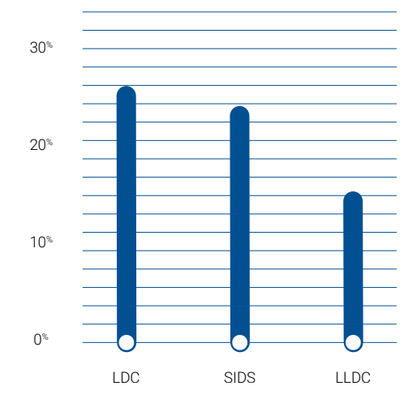


Figure 2.12: Proportion of LDCs, LLDCs and SIDS that have undertaken studies on the social and economic benefits of weather, climate and water hydrological services. Source: WMO

34 Chandni Singh, Joseph Daron, Amir Bazaz, Gina Ziervogel, Dian Spear, Jagdish Krishnaswamy, Modathir Zaroug, Evans Kituyi: The utility of weather and climate information for adaptation decision-making: current uses and future prospects in Africa and India

2.6 PRE-EMPTIVE EVACUATION FOLLOWING EARLY WARNING [G6]

Pre-emptive actions, such as evacuation, following early warnings, safeguard the population exposed to, or at risk from, the impacts of disasters. Usually standard operating procedures (SOPs)[35] along with drills (e.g., tsunami drills) are used to conduct any pre-emptive actions and direct the population to safe locations. Indicator G6 measures the percentage of population exposed to, or at risk from, disasters, protected through pre-emptive evacuation following early warning[36].

A total of 85 countries have reported so far on this indicator, reporting an average of 166 million people that have evacuated in advance of a disaster per year. Despite a decline in the number of countries reporting for this indicator, there has been a steady increase in the number of people evacuated, reaching over 200 million in 2020 (Figure 2.13).

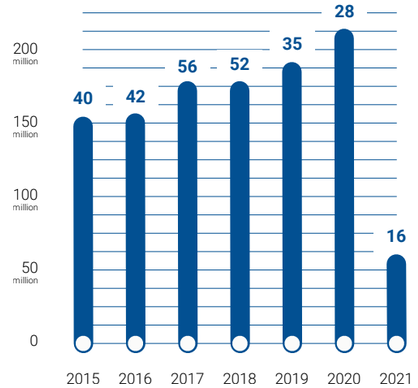


Figure 2.13: Numbers on bars indicate the number of countries that evacuated people in that year should come after (Source: SFM)

Figure 2.14 shows the number of WMO members reporting they have standard alerting procedures in place as of July 2022. While most regions report that 50 per cent or more countries do have these procedures, many African countries report to not have standard alerting procedures to support MHEWS communication and dissemination.

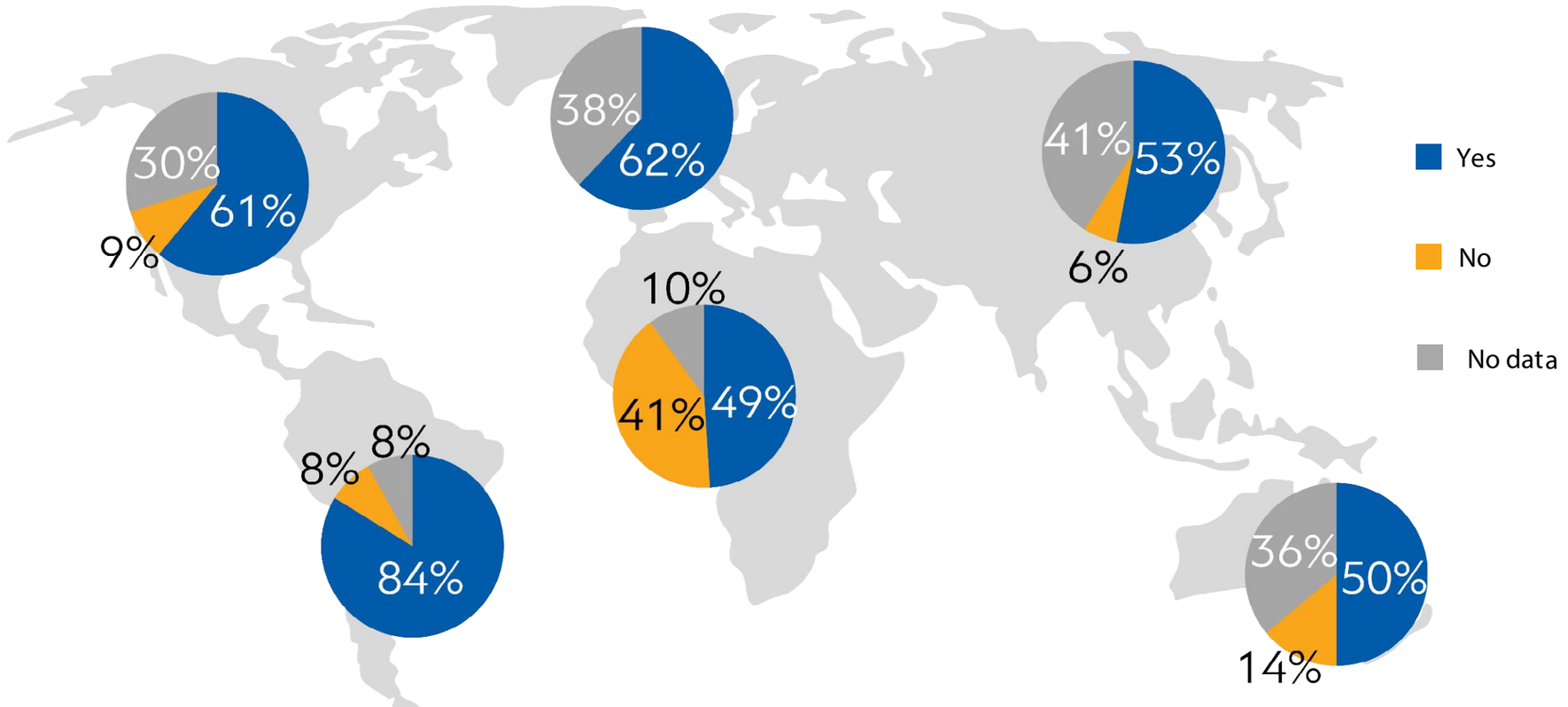


Figure 2.14: Percentage of countries reporting to have standard alerting procedures. Source: WMO

Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

35 SOPs are a set of procedures and instructions to perform during an emergency, and define the roles and responsibilities of authorities, community and other stakeholders.

36 This indicator acts as a proxy on the preparedness capabilities, but may not be the most relevant in the context of all hazards (e.g. for a drought, for a locust infestation, etc.).

3

INITIATIVES ON EARLY WARNING – EARLY ACTION

3 INITIATIVES ON EARLY WARNING – EARLY ACTION

This report has highlighted significant gaps in MHEWS globally that require a broad-based approach, with contribution by and collaboration among multiple partners. It is encouraging to note that early warning and early action has offered a common shared agenda for international organizations to come together in support of countries and communities.

3.1 THE SYSTEMATIC OBSERVATIONS FINANCING FACILITY

Early warnings can only be as good as the data underpinning them. In 2021, the Global Basic Observing Network (GBON) was established, committing all countries to generate and exchange basic weather and climate data. However, today, less than 10 per cent of these internationally agreed data are available from LDCs and SIDS. These critical data gaps hinder the provision of high-quality climate services around the globe.

For this reason, WMO, UNDP and UNEP established the Systematic Observations Financing Facility (SOFF[37]) as a UN Multi-Partner Trust Fund, with the support of an initial group of funding partners. SOFF provides long-term, technical and financial support to the countries with the largest capacity gaps, to close their GBON data gap, with a focus on LDCs and SIDS. This new mechanism contributes to achieving the adaptation and systematic observation goals of the Paris Agreement through the improved climate and weather observations essential for effective climate services and early warnings.

3.2 CLIMATE RISK AND EARLY WARNING SYSTEMS

Climate Risk and Early Warning Systems (CREWS) is an initiative that was established in 2015 at the United Nations Climate Change Conference (COP 21), to protect lives, assets, and livelihoods of people living in the LDCs and SIDS by increasing the access to early warnings on adverse weather conditions and risk information[38]. Projects by CREWS are implemented with the support of three implementing partners – WMO, UNDRR, and the World Bank/Global Facility for Disaster Reduction and Recovery (GFDRR)38. Results of CREWS country operations are measured by the global goals and targets of the SDGs and the Sendai Framework.

At present, 18 national, regional and global CREWS projects are in operation in 74 countries. CREWS projects at a national level have a focus on improving the capacity of National Meteorological and Hydrological Services (NMHS), and National Disaster Management Offices (NDMOs), while the regional level projects aim at developing the capacity of regional organizations to enhance national and regional level services. CREWS projects improve the delivery of prediction and forecasting services for hydrometeorological hazards, generate impact-based early warnings, and strengthen information and communication technology, preparedness and response plans with SOPs. CREWS facilitates implementation of WMO's Global Multi-Hazard Alerts System (GMAS) Framework, which enhances alerting capabilities of members.

The CREWS five-year operational plan (2021-2025) is well-aligned with emerging needs in relation to early warning systems and with regards to the UN Secretary General's target. The Operational Plan highlights four key features: putting people at the centre; sustainability as a cornerstone; strengthened cooperation; and

37 Find more information about SOFF at https://alliancehydromet.org/soff
38 https://www.crews-initiative.org/en

Cyclone warning systems in Bangladesh

In 1970, the Bhola Cyclone killed more than 300,000 people (some estimate between 300,000 to 500,000 people) and affected millions of people in Bangladesh (then East Pakistan). The Cyclone Preparedness Programme (CPP) was established in 1972 by the Government of Bangladesh, Bangladesh Red Crescent Society (then Bangladesh Red Cross Society) and IFRC (then League of Red Cross Societies) to mitigate the challenges of catastrophic cyclones that frequently hit the Bangladesh coast.

The Government of Bangladesh has made significant investment in improved early warning services in the last decade. At present, an Interactive Voice Response early warning service is accessible over any of the existing mobile phone operators, with a specific number 10941, which provides information on hazards, including daily weather forecast, rainfall, cyclone, floods, and landslides. In particular, the cyclone early warnings have significantly decreased the number of cyclone-related fatalities in Bangladesh. During the Cyclone Matmo-Bulbul in 2019, less than 20 lives were lost, and 2.1 million people were safely evacuated to evacuation centres.

partnerships between the public and private sector. By October 2022, CREWS received US$ 84 million in signed contributions to the CREWS Trust Fund since its inception, and US$ 71 million was allocated to projects at national, regional and global levels.

3.3 RISK-INFORMED EARLY ACTION PARTNERSHIP

The Risk-informed Early Action Partnership (REAP)[39] was launched in 2019 at the UN Climate Action Summit (UNCAS) to enhance collaboration among climate, disaster risk reduction, development and humanitarian communities, to work towards making "1 billion people safer from disasters by 2025". The Partnership currently includes 70 governments and partner organizations that collectively commit to working together on four targets. These targets emphasize the significance of "national financing, planning, and delivery mechanisms" to assist early action, investments and coverage of warning systems targeting the last-mile communities[40].

The Partnership is not a new funding mechanism or an implementing body. Instead, it ensures coherence and consistency in how different sectors approach early action, through the development of resources on

Target 1

50 countries have reviewed and integrated their crisis/disaster risk management and climate adaptation laws, policies and/or plans to ensure that they **reduce climate change impacts** and exposure on people and the environment.

Target 2

1 billion more people are covered by financing and delivery mechanisms connected to **effective early action plans**, ensuring they can act ahead of predicted disasters and crises.

Target 3

$500 million invested in early warning system infrastructure and institutionsto target early action in **'last/first mile'** communities, building on existing initiatives.

Target 4

1 billion more people are covered by new or improved early warning systems, including heatwave early warning, connected to longer-term risk management systems, and supported by effective risk communication and public stakeholder dialogueto prompt informed action.

Figure 3.1: Four targets of REAP

39 https://www.early-action-reap.org/
40 Our Mission | REAP (early-action-reap.org)

terminology, monitoring and evaluation, or the tracking of financial commitments. It brings together major stakeholders in common challenges and offers a neutral space to support existing early warning – early action initiatives and design new strategies to enable early action at scale. For instance, UNDRR co-leads the working group on comprehensive risk management focused on Target 1.

Several networks and initiatives working across the early action value chain are partners of REAP, such as the CREWS initiative, the START Network, the Anticipation Hub, the Insurance Development Forum, and the Global Network of Civil Society Organisations for Disaster Reduction.

3.4 ANTICIPATION HUB

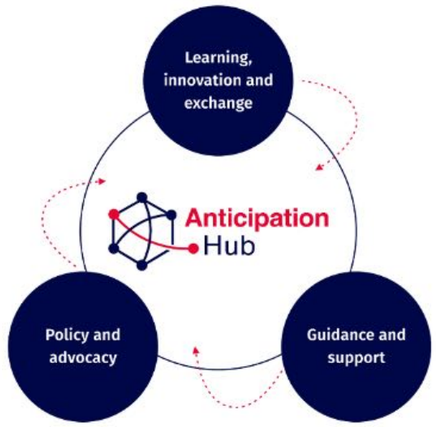


Figure 3.2: Three strategic priorities of Anticipation Hub

The Anticipation Hub is a platform to facilitate learning, guidance, exchange and advocacy on anticipatory action, hosted by the German Red Cross in cooperation with the IFRC and the Red Cross Red Crescent Climate Centre. Established to improve the ability of practitioners, scientists and policymakers to minimize the risks of predictable disasters and adapt to climate change with anticipatory action, the Hub gathers more than 100 partners from the Red Cross Red Crescent Movement, United Nations, NGOs, government, research, academia and think tanks. The three strategic priorities of Anticipation Hub are presented in Figure 3.3.

Progress in anticipatory action over the last decade has led to substantial learning based on experience, research and policies. Understanding and application of lessons and evidence is crucial to further developing anticipatory action approaches that can scientifically help predict impacts generated by hazards on vulnerable communities, and design the appropriate intervention to minimize disaster risk. The Anticipation Hub has captured and published relevant methodologies, learning resources, lessons learnt, and science and research, to learn and apply the anticipatory actions. It also has published databases such as Early Action Database, Evidence Database and Trigger Database to further improve the anticipatory actions[41]. Through thematic working groups focusing on risk financing, earth observation, conflict, health, and protection, gender and inclusion themes, the Hub partners continue to strengthen tools and approaches, as well as collaboratively develop solutions and consolidate lessons on anticipatory action.

3.5 CENTRE OF EXCELLENCE FOR CLIMATE AND DISASTER RESILIENCE

The Centre of Excellence for Climate and Disaster Resilience is jointly hosted by WMO and UNDRR, and comprises over 14 United Nations and international organizations. It aims to: i) Increase the availability, understanding and use of climate and disaster data and analysis for risk-informed development and humanitarian action; ii) Strengthen climate and disaster risk governance through integrated planning and improved access to disaster risk reduction and climate change adaptation in financing and investment mechanisms; and iii) Improve disaster preparedness and early action, including strengthening availability and access to MHEWS.

41 Learn about anticipatory action - Anticipation Hub (anticipation-hub.org)

The Centre of Excellence works by collaboratively bringing together its different organizations to consider joint and multisectoral approaches to act in advance of crises through strategic discussion and agreement. It has a primary focus of seeing expanded work in areas that are highly climate-vulnerable or fragile, to ensure that those most at risk are assisted early enough to make a long-term difference to their development trajectory. It will help to guide the outcomes of this report through its partners' programmes and policy at a strategic level.

Regional early warning initiatives

In Africa – DARAJA (Developing Risk Awareness through Joint Action), is a project that focuses on enhancing the access and the use of relevant weather and climate information for the informal settlements in Dar es Salaam, Tanzania, and Nairobi, Kenya. This initiative aims to improve the climate resilience of approximately 800,000 people (i.e., 20 per cent of population) living in informal settlements and achieve a reduction of 5-10 per cent measurable avoidable losses caused by extreme weather events using climate information services in Dar es Salaam and Nairobi.

In Americas and the Caribbean - Fisheries Early Warning and Emergency Response (FEWER) System was developed by the ICT4Fisheries Consortium in collaboration with the Caribbean Regional Fisheries Mechanism (CRFM). It is an information, communication and technology (ICT) early warning system that aims to minimize the risks posed by the impacts of the climate change on the lives and livelihood of fishermen in the Caribbean region. Mobile phone applications are used to send the early warnings of the extreme weather events and sea conditions to the fishermen. Local and traditional knowledge can be shared via mobile phone application, and can be used to improve the climate-smart fisheries planning, management and decision-making.

In Asia – AHA Centre (ASEAN Coordination Centre for Humanitarian Assistance), an intergovernmental organization, aims to support and coordinate ASEAN Member States efforts to minimize disaster losses and respond to emergency events as one, as an information and learning hub. AHA Centre supports the NDMOs across ASEAN Member States through capacity building courses such as ASEAN-Emergency Response and Assessment Team (ASEAN-ERAT) and AHA Centre Executive (ACE).

In Europe – Meteoalarm provides alerts in the Europe region to prepare for the impacts of the extreme weather events such as "heavy rain with risk of flooding, severe thunderstorms, gale-force winds, heat waves, forest fires, fog, snow or extreme cold with blizzards and avalanches, or severe coastal tides". Also, European Flood Awareness Systems (EFAS) sends out notifications to the national and regional authorities to prepare for a possible flood emergencies. Probabilistic, medium-range flood forecasts, flash-flood forecasts and impact forecasts are some of the services provided by the EFAS. More than 200 flood notifications and 500 flash-flood notifications were sent out per year by the EFAS.

In Pacific – DisasterAWARE, a mobile application developed by the Pacific Disaster Centre's (PDC), provides the global community with near real-time alerts and information on a total of 18 hazards. Scientifically verified sources automatically generate new information in the application, and where no official source of information is readily available, personnel at PDC manually update the alerts.

4

ACCELERATING ACTIONS TO ACHIEVE EARLY WARNINGS FOR ALL

- 4.1 Make Early Warnings for All a reality and forecasting systems [G2]
- 4.2 Enhance data and technology availability to enhance MHEWS
- 4.3 Apply the Sendai Framework metrics and data to monitor early warning coverage
- 4.4 Enhance observation and monitoring
- 4.5 Strengthen the early warning value cycle (a system approach)
- 4.6 Make MHEWS people-centric with increased accountability
- 4.7 Strengthen early warning communication and outreach

4 ACCELERATING ACTIONS TO ACHIEVE EARLY WARNINGS FOR ALL

The present report has outlined gaps and challenges, but also opportunities in scaling up MHEWS coverage globally and across regions. The following actions are recommended to accelerate action.

4.1 MAKE EARLY WARNINGS FOR ALL A REALITY

- **Scaling up investments**: To achieve the goal set by UN Secretary General, and to meet the Sendai Framework Target G, more investments are needed for developing and improving the MHEWS, improving MHEWS' infrastructure capacity, enhancing preparedness and building capacity for dissemination and communication of warnings globally.

- **Focus on LDCs and SIDS**: Regions fare differently in their progress and effort in establishing MHEWS. Special focus is needed on LDCs and SIDS, and Africa, as there are clear gaps in MHEWS capacity in these regions. An appropriate financing mechanism is also important to develop, sustain and strengthen MHEWS, especially for the LDCs and SIDS.

- **Working Together**: Actors and stakeholders involved in the MHEWS should work together for scaling up actions on MHEWS. Involvement of the private sector is crucial for the most cost-effective and more sustainable services. Therefore, cooperation, coordination, and engagement between actor and stakeholders should be enhanced at country and regional levels by providing platforms for engagement, establishing communication channels for stakeholder dialogue, and aligning activities of current and future work projects.

Tracking displacement to strengthen early warning systems

The changing climate is a risk multiplier that is increasingly reshaping human mobility patterns. Sea-level rise, water scarcity and declining agricultural productivity will compel millions to move in the coming decades. Displacement, if not anticipated, managed and addressed, can have devastating cascading impacts. Loss of property, livelihoods, and increased insecurity influence people's mobility decisions, shaping patterns of circular, seasonal and permanent migration. While mostly close to home and temporary, these population movements have significant, long-term demographic implications, both in areas of destination and origin.

Anticipating and addressing population movements taking place in the context of climate change will be essential to averting, minimizing and addressing losses and damages. Under Target G of the Sendai Framework, and further to the Secretary-General's call for Early Warnings for All, greater investments in early warning linked to social protection will support capacities to address vulnerability to climate impacts. The development of standard displacement-related indicators, presently a work in progress, will strengthen the ability of governments to integrate displacement in their work, are critical in this respect.

Using the potential of human mobility to adapt to the impacts of climate change is fundamental. Reliance on planned evacuations as a disaster risk management tool has significantly reduced loss of life. Pastoralism is considered a sustainable form of livelihood well suited to adapt to the impacts of climate change in the Horn of Africa. In Central Asia, transitioning from farm-based income to labour migration is a common response to water scarcity.

4.2 ENHANCE DATA AND TECHNOLOGY AVAILABILITY TO ENHANCE MHEWS

- **Strengthen risk information**: The report has highlighted specific gaps in risk knowledge across countries. Vulnerability, exposure and hazard-related data collected at national level assist in making informed decisions for developing and improving MHEWS. Development and risk reduction partners need to provide adequate support for collecting such risk information, which is also helpful for scenario-based decision making for pre-emptive and prospective actions.

- **Collect disaggregated data**: Data is often not easily disaggregated into key social variables, e.g., sex, age and disability. This is a missed opportunity for targeted social policy as part of risk reduction. For example, the lack of gender, age, disability and location-specific data will lead to failure of any pre-emptive actions. Disaggregated data collection should be promoted to enable intersectional approaches.

- **Improve data management**: Sometimes, the data needed for reporting may be used and stored in an ad hoc and fragmented way by different organizations and agencies. A centralized data ecosystem for hazard, exposure and vulnerability information is important. Development and roll-out of the Risk Information Exchange (RiX) gives a significant opportunity to understand risk. Partnerships among agencies should, wherever possible, be formalized so that critical data are always available.

- **Latest technology for data**: Technology for data collection, analysis (using artificial intelligence and machine learning), and dissemination (automation and linked to local knowledge) can be improved and even centralized in many situations. Optimum use of technology provides good opportunities for enhancing MHEWS through e.g., crowdsourcing data from mobile technology, and instant broadcast of early warnings.

4.3 APPLY THE SENDAI FRAMEWORK METRICS AND DATA TO MONITOR EARLY WARNING COVERAGE

- **Enhance the usage of Sendai Framework Monitor**: A deeper understanding of the impact of the trends and impacts of disasters is crucial for reducing disaster risks. The SFM provides an accessible tool for governments and organizations to systematically document and analyse the impact of disasters, and track progress in disaster risk reduction, including MHEWS. As many countries have MHEWS but fail to report in SFM, governments need to scale up reporting on the SFM to have the full understanding of official information to plan and target better.

- **Apply the custom indicators for Target G**: Currently, data available from 95 countries shows the current and potential volume of data that the SFM has generated and has the potential to generate. The monitoring indicators are structured on the four MHEWS elements (refer to Figure 1.1) and produce a composite score of comprehensiveness of early warning across countries. Further, the development of custom indicators to complement the Target G monitoring offers a key opportunity to assess the effectiveness of MHEWS in countries. Thus, a combination of the global and nationally customized indicators produces quantified scores which, together with monitoring data available from WMO and other sources, can be of high relevance to the tracking of the Secretary-General's call on Early Warnings for All by 2027.

- **Granularity of data for Target G**: Despite increased reporting, quality and granularity of data for MHEWS elements (G2-G5) and on pre-emptive evacuation is insufficient. Indicator G6 has a direct relationship for early actions which could provide substantive support to improve early warning and its associated early actions.

4.4 ENHANCE OBSERVATION AND MONITORING

- **Improve observation networks**: Global Basic Observing Network (GBON) and the Global Ocean Observing Systems (GOOS) are important mechanisms to improve and expand observation systems. The SOFF provides technical and financial support for the implementation of GBON, in particular in SIDS and LDCs. SOFF is crucial for improving the observation networks in the most vulnerable countries, especially in Africa and the Pacific.

- **Encourage impact-based forecasting**: Impact-based forecasting minimizes the socioeconomic costs of weather and climate hazards. Improving the capability to conduct vulnerability and exposure assessment and a nationwide hazards-hotspot register can support in generating impact-based information. A sectoral dialogue should continue to understand the main sectors' needs and how to translate hazard information into impacts. Forecasts-based financing (FbF), anticipatory action and other financial instruments should be further strengthened.

Strengthening metrics for early warning effectiveness

The Sendai Framework Target G is primarily structured on the four elements of MHEWS (Figure 1.2). While its indicators measure the availability of and access to MHEWS, they do not necessarily reflect the quality and effectiveness of early warning. To address this gap, UNDRR and WMO, with support from CREWS, have coordinated the development of custom indicators to complement the Target-G-based reporting. These indicators strengthen capacities to measure and monitor MHEWS effectiveness and incorporate feedback into the MHEWS value cycle.

A total of 53 custom indicators have been developed, structured on five themes: Governance; Disaster risk knowledge; Detection, monitoring, analysis and forecasting; Dissemination and communication; and Preparedness and response. Countries can self-assess their status on all or selected indicators on a scale of 0 to 1. The indicators can be tailored to specific situations in countries. The implementing partners have also developed training packages for capacity development that have been piloted with LDCs and SIDS in different regions.

The custom indicators have been added to the Sendai Framework Monitor and countries can select the indicators from a menu to complement reporting on Target G. Hence, the official Target G indicators and the custom indicators offer a good basis to track both coverage and effectiveness of MHEWS.

4.5 STRENGTHEN THE EARLY WARNING VALUE CYCLE (A SYSTEM APPROACH)

- **MHEWS value cycle**: MHEWS should be seen in its full length of value cycle, rather than a set of disparate elements. The MHEWS cycle is as strong only as its weakest link – one break or delay in information transfer at any stage may derail the whole system. MHEWS should consider all the hazards and hazardous events taking place in a country, including at localized scales. However, we need to adopt a systems approach to MHEWS, where hazards are not monitored in silos, but their interconnectedness and cascading nature is kept at the forefront of analysis and tracking.

- **Establish policy and institutional framework**: Effective implementation of MHEWS, hazard forecast, and warning dissemination requires strong policy and institutional frameworks. Lack of policies or law may hinder the effective delivery of services. Therefore, creating an enabling environment through simple and well-understood legislation, and policy and institutional frameworks for implementing the MHEWS and forecast services, is necessary as part of national disaster risk management strategies, frameworks or regulations. Clear responsibilities throughout should be developed to create a better flowing process from start to finish.

- **Enhance investments across the MHEWS value cycle**: Targeted development and humanitarian cooperation is necessary to improve MHEWS. All the components of MHEWS should be given equal consideration in investments, with a special focus on the 'last mile', risk-informed, people-centred early warning systems. Investments in MHEWS should be sustainable and flexible.

- **Improve coordination and partnerships**: As MHEWS involve multiple information producers, information communicators and users, it is important to coordinate and collaborate across sectors and stakeholders. National platforms or equivalent coordination mechanisms have proven to be helpful in ensuring such collaboration in countries. Developing a legal framework or policy will improve the coordination during disasters, and ensures stakeholders understand their roles and responsibilities.

- **Regularly evaluate MHEWS**: Evaluation of MHEWS following an emergency should be consistently conducted based on a standard set of indicators to understand its performance. The evaluation should not be confined to major emergencies or disasters, but should be conducted for every event where a warning was issued.

4.6 MAKE MHEWS PEOPLE-CENTRIC WITH INCREASED ACCOUNTABILITY

- **MHEWS elements tend to be 'authority-driven'**. While progress has been made in hazard monitoring, early warning infrastructure and dissemination, the flow of information back to the communities, in a time-sensitive manner, remains a challenge. Engagement of end-users needs to happen at the design stage of MHEWS. MHEWS needs to be people-oriented with focus on last mile outreach, with a shift in focus from early warning dissemination to communication, through impact-based forecasting and warning. Integrating local, traditional and indigenous knowledge in MHEWS enhances the effectiveness of early warnings.

- **From women's inclusion to transformation**: Including women in the development of MHEWS is crucial for its effectiveness. Engaging women in the MHEWS development process can support in shifting their roles and status in the wider community, which can have long-lasting impacts on gender equality. Women-led community sessions on sharing MHEWS and disaster risk reduction knowledge, lessons, updates and skills can contribute to this transformation.

- **Use existing networks for community engagement**: The establishment of the MHEWS is most effective when it is built on the existing community networks, as creating new platforms for engagement can take years to establish and are resource-intensive. Utilizing the existing networks encourages community-led information and risk identification, and is usually cost and resource-effective.

- **Encourage public-private engagement**: Establish platforms for public-private engagement, including civil society, academia and social enterprise, among others, and facilitate transparent and open discussions to improve the understanding between each other's perspectives and expectations. This can also enhance operational efficiency and quality of public services by bringing in agility and innovation.

- **Conduct training and capacity development programmes**: Capacity development and training programmes for users on warnings and services are important for improving user product development, delivery, usability, evaluation and interpretation (including data and information from new tools). Conducting training and mock drill or simulation exercises through school safety programmes or awareness-raising programmes on disaster preparedness, could be beneficial for improving a community's knowledge of disasters. Outreach material on MHEWS could guide the communities in procedures to respond to each hazard.

4.7 STRENGTHEN EARLY WARNING COMMUNICATION AND OUTREACH

- **Use multiple communication channels**: A right mix of communication channels should be utilized for effective communication – mass media, radio, television and internet access and penetration, mobile networks, and straightened local and community communication channels to ensure the warnings reach the last mile. The CAP developed by ITU provides a template for the alerting authority for generating effective warning messages and uses multiple communication channels to warn about 'any and all kinds of hazards' to the public[42].

- **Use of on-the-ground interventions and traditional channels**: Early warning outreach is often a function of participation and multi-stakeholder engagement. Training the local authorities, and sharing alerts with local NGOs and organizations, should be used to complement smartphone alerts, to ensure alert information reaches more people, especially in areas where smartphone penetration is low.

- **Improve risk communication**: COVID-19 has taught us of hesitancy towards vaccines across the globe; and this can be applicable in disaster risk reduction, where 'forecast warning hesitancy' has led to people not taking appropriate actions following warnings issued by the authorities. Limited community engagement in communication may also result in a 'false sense of security' affecting early action. Risk communication should be strengthened considering these challenges.

42 Common Alerting Protocol (oasis-open.org)

ANNEX: SENDAI FRAMEWORK TARGET G: METHODOLOGY

(Guidance and complete methodology are available online[43])

Target G of the Sendai Framework comprises six indicators that measure availability of, and access to, MHEWS (including availability of, and access to, disaster risk information and assessments) and pre-emptive evacuation based on the MHEWS. Four of the six indicators align with the four key elements of MHEWS, which are referred to as relevant in the related Target G indicators below:

G-1 NUMBER OF COUNTRIES THAT HAVE MULTI-HAZARD EARLY WARNING SYSTEMS

G-1 is a compound indicator, which measures nationally and globally, the existence and quality of MHEWS in countries, based on four global indicators, G-2 to G-5, that are aligned with MHEWS elements.

The indicators as they relate to the four elements are summarized as below:

Four interrelated key elements of MHEWS	Target G indicators
Key Element 1: Disaster risk knowledge based on the systematic collection of data and disaster risk assessments	G-5
Key Element 2: Detection, monitoring, analysis and forecasting of the hazards and possible consequences	G-2
Key Element 3: Dissemination and communication, by an official source, of authoritative, timely, accurate and actionable warnings and associated information on likelihood and impact	G-3
Key Element 4: Preparedness at all levels to respond to the warnings received	G-4

43 UNDRR (2018) Technical guidance for monitoring and reporting on progress in achieving the global targets of the Sendai Framework for Disaster Risk Reduction.

The compounded G-1 is measured as the arithmetic average of the scores of the four indicators G-2 through G-5, where each Member State reports a score from 0 to 1 for all scoring as relevant in each of the four indicators.

$Score_{G1} = (Score_{G2} + Score_{G3} + Score_{G4} + Score_{G5}) / 4$

The aggregated global score of all country reporting is considered as an average of country scores and reflects the coverage of MHEWS, measured through the four interrelated elements. Countries are categorized as below:

G-1 Score	MHEWS Coverage
Zero	No MHEWS
Below - 0.25	Limited
0.25 - 0.50	Moderate
0.50 - 0.75	Substantial
0.75 and Above	Comprehensive

(Exclusive class intervals)

If a country reports in one year and does not do so for subsequent years, the last reported score is considered as applicable until the country reports again.

G-2 NUMBER OF COUNTRIES THAT HAVE MULTI-HAZARD MONITORING AND FORECASTING SYSTEMS

Associated MHEWS Key Element 2: Detection, monitoring, analysis and forecasting of the hazards and possible consequences.

For this indicator, Member States are recommended to monitor the progress and qualitative improvement of the four elements of multi-hazard monitoring and forecasting systems, by hazard, which are as follows: (1) **Monitoring** data available through an established network served by well-trained staff; (2) **Forecasting** through data analysis and processing, modelling, and prediction based on accepted scientific and technical methodologies and disseminated within international standards and protocols; (3) **Warning messages** that include risk and impact information and trigger clear emergency preparedness and response actions are generated and disseminated in a timely, efficient and consistent manner; and (4) Standardized **processes, and roles and responsibilities** for all organizations generating and issuing warnings are established, mandated by legislation or other authoritative instruments, e.g., Memorandum of Understanding (MoU), SOPs, etc.

As a minimum data-reporting requirement, Member States are to report on existence of multi-hazard monitoring and forecasting systems per hazard type based on estimated or historical impacts, or by expert judgement, or by country priorities and objectives.

G-3 NUMBER OF PEOPLE PER 100,000 THAT ARE COVERED BY EARLY WARNING INFORMATION THROUGH LOCAL GOVERNMENTS OR THROUGH NATIONAL DISSEMINATION MECHANISMS

Associated MHEWS Key Element 3: Dissemination and communication, by an official source, of authoritative, timely, accurate and actionable warnings and associated information on likelihood and impact.

This Indicator helps to monitor the progress of early warning communication, dissemination and outreach to populations in the number of people who are covered by the MHEWS as a proportion of estimated population exposed to hazards (total population may be used a s proxy if required). Alternatively, the penetration rate of **primary media or mode** for early warning information-sharing may be used, which includes **mass media** (including radio, TV, internet, websites, e-mail, SMS, social media, and mobile phone applications); and **Local communication systems** (including siren, public boards, and landline phones). This includes national dissemination mechanisms, such as recognized authorities and local governments. However redundant coverage by different warning-dissemination channels is not recommended since the overlap of several modes would be complex.

G-4 PERCENTAGE OF LOCAL GOVERNMENTS HAVING A PLAN TO ACT ON EARLY WARNINGS

Associated MHEWS Key Element 4: Preparedness at all levels to respond to the warnings received.

Member States are expected to monitor improvements for local government plans to act on early warnings. For the purposes of this indicator, a 'plan to act on early warnings' could be a preparedness plan, an emergency plan, an action plan or any plans that describe who should, and how to, react to an early warning.

There are three quantitative sub-indicators that measure local MHEWS plans, which are as follows: (1) Are disaster **preparedness** measures, including response plans, developed and operational?; (2) Is public awareness and education conducted?; and (3) Is public **awareness** and response tested and **evaluated**? The score of each country is derived as an average of all its local governments.

Minimum data-reporting requirement: The number of local governments with a plan to act on early warnings as a proportion of all local governments (same as reported under Indicator E-2a on local disaster risk reduction strategies).

G-5 NUMBER OF COUNTRIES THAT HAVE ACCESSIBLE, UNDERSTANDABLE, USABLE AND RELEVANT DISASTER RISK INFORMATION AND ASSESSMENT AVAILABLE TO THE PEOPLE AT THE NATIONAL AND LOCAL LEVELS

Associated MHEWS Key Element 1: Disaster risk knowledge based on the systematic collection of data and disaster risk assessments.

This indicator requests Member States to report on the degree of accessibility and availability of disaster risk information, especially whether it is publicly available online. It also monitors progress and improvement in the quality of risk information and assessment over time. The Indicator G-5 does not only relate to MHEWS but also to risk assessments and information in a broader context. Risk assessment methodologies vary depending on the hazard type. Key criteria and measurements include the following three sub-indicators that have equal weighting: (1) Be based on the most **scientific** approach possible (ideally probabilistic where feasible); (2) Be the product of a national **consultation**, shared, coordinated and used by national institutions; (3) Have clear **responsibilities** for decision-making, planning, and storing data and information. Member States will reuse the hazard weighting from Indicator G-2. While this methodology for risk assessment cannot perfectly capture its quality, it can be used consistently across countries and over time to measure the progress of multi-hazard risk assessments.

G-6 PERCENTAGE OF POPULATION EXPOSED TO, OR AT RISK FROM, DISASTERS PROTECTED THROUGH PRE-EMPTIVE EVACUATION FOLLOWING EARLY WARNING

This indicator has two aspects: a) measuring the degree to which the relevant authorities have been successful in avoiding human losses by evacuating populations pre-emptively; and b) measuring the degree to which populations' lives and assets are negatively affected due to evacuation. This indicator quantifies the usefulness of early warning information, which may only be possible at local level.

Member States are encouraged to provide information on the number of evacuated people (e.g. through a proxy about who moved to official evacuation centres) as a proportion of population exposed to or at risk. If Member States are not able to produce the data of 'population exposed to or at risk', the number of people targeted by the early warning could be a proxy. This could equate to the total population in the municipalities or districts, or communities targeted by official warnings.

SENDAI FRAMEWORK
FOR DISASTER RISK REDUCTION 2015-2030

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