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Early Warnings for All

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Global Status of Multi-Hazard Early Warning Systems

2023

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Global Status of Multi-Hazard Early Warning Systems

2023

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SENDAI FRAMEWORK
FOR DISASTER RISK REDUCTION 2015-2030

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FOREWORD

Mami Mizutori
Special Representative of the United Nations Secretary-General for Disaster Risk Reduction,

Head of the United Nations Office for Disaster Risk Reduction (UNDRR)

Petteri Taalas
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A year ago, at the twenty-seventh Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 27) held in Sharm el-Sheikh, the United Nations Secretary-General launched the Executive Action Plan of the Early Warnings for All (EW4All) initiative, stating its ambitious goal of expanding early warning systems to protect every person everywhere by the year 2027. This initiative has the potential to save millions of lives and reduce losses and damages from the growing climate crisis.

To guide our efforts under this initiative, we must have a solid understanding of where we are to chart our path forward and hold ourselves accountable. This is the value of this report, the *Global Status of Multi-Hazard Early Warning Systems 2023*. This report not only expands on many of the insights from our joint report last year, the *Global Status of Multi-Hazard Early Warning Systems: Target G*, but it also presents new ones.

Based on a more complete set of data gathered from the Sendai Framework Monitor, the report shows that 101 countries now have multi-hazard early warning systems. The number is six more than last year and double what it was in 2015. This shows still a large gap in coverage but a clear sign that the world is heading in the right direction.

Moreover, as we saw in last year's report, extra support is still needed to help the countries furthest behind to catch up. Under the detection and forecasting pillar, for example, many countries in Africa, the Pacific and South America still have significant gaps in attaining the minimum number of meteorological observations required to drive forecasting.

The good news is that this report identifies the enablers that can help countries enhance early warning and early action, especially for the most vulnerable.

One crucial enabler is the existence of a strong risk governance mechanism for early warning systems. The report shows that countries with comprehensive national disaster risk reduction strategies tend to have better coverage of multi-hazard early warning systems. This makes sense considering that early warning systems depend on strong coordination with different agencies, which is made easier by a national disaster risk reduction strategy.

Another enabler is to leverage flagship programmes and established vehicles, such as the Climate Risk and Early Warning Systems (CREWS) initiative and the Systematic Observations Financing Facility (SOFF), and to align financing frameworks to reduce fragmentation of effort.

The report also shows the potential of data, technology and connectivity to address lingering challenges to close the "last mile" of early warning and action. These areas are ripe for investment.

We are grateful to the International Telecommunication Union and the International Federation of Red Cross and Red Crescent Societies for contributing to this report and for their continued partnership under EW4All.

We hope this report serves as an accelerator of our joint efforts to ensure no one is left behind when disasters strike.

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Image Source: UNDRR


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EXECUTIVE SUMMARY

The impact of disasters continues to increase at a rapid rate, fuelled by the climate emergency. Multi-hazard early warning systems (MHEWS) are a proven measure to reduce disaster risk and adapt to a changing climate. As a result, they can save lives while averting and minimizing losses and damages. MHEWS provide a tenfold return on investment, and this report further highlights that countries with low MHEWS coverage have nearly a six times higher disaster mortality rate and five times more disaster-affected people, when compared with countries with high MHEWS coverage.

The challenge

Only half of the world (52 per cent) is covered by an early warning system. This translates to 101 countries, which is an increase of six countries from last year. While this is a doubling since 2015, only 46 per cent of LDCs and 39 per cent of SIDS have reported the existence of MHEWS. Using a compounded score, based on country reports of their progress in meeting Target G of the Sendai Framework for Disaster Risk Reduction, the report finds that the global average score of MHEWS has improved from 0.33 at the baseline period starting in 2015 to 0.47 as at end-2022, an increase of over 40 per cent. However, scores in Africa, which is home to many LDCs, remain low at 0.37 despite nearly doubling from 0.20. The lowest regional score is that of the Arab States at 0.35.

Even where early warning systems exist, **uneven progress is seen across the four MHEWS pillars**: disaster risk knowledge, observations and forecasting, dissemination and communication, and preparedness to respond. The pillar on risk knowledge has seen the least progress with significantly low scores across all the regions, especially in the Arab States. The four MHEWS elements are highly interrelated; failure in one component, or a lack of coordination across the components, could lead to the failure of the whole system.

The **increasing unpredictability, complexity and severity of hazardous events** are challenging the MHEWS capability. Limited risk knowledge, as the first MHEWS pillar, hampers early warning effectiveness, which is further aggravated by gaps in the Global Basic Observations Network (GBON) across much of the African continent and parts of the Pacific and Latin America. Less than one third of World Meteorological Organization (WMO) members have the necessary monitoring and forecasting systems for multiple hazards occurring simultaneously or cumulatively over time.

Despite advances in technology, especially connectivity, **some communities remain hard to reach and support.** Intensive action is required for community outreach and engagement. A people-centred, locally-led approach is required to effectively develop community early warning systems, to support anticipatory action in remote areas and to ensure that the design of MHEWS and related services meets local needs and preferences.

Progress and highlights

Several initiatives on MHEWS are under way to scale up early warning coverage and close the early warning–early action gap. Global efforts are ongoing to address the basic weather and climate observation data gaps, enhance capacities and build communities of practice on relevant topics. Encouraging progress has also been noted at the regional and national levels with several community-driven approaches being implemented.

Advances in science and technology, together with the increase in the availability of observation data, have led to improvements in forecasts, especially lead times. The implementation of the Common Alerting Protocol (CAP) has helped the timely flow of information from authoritative sources to the public across multiple channels. With 95 per cent of the world's population able to access a mobile broadband

network and with 4G network coverage reaching 88 per cent of the world's population, there are significant opportunities to leverage mobile networks and internet connectivity, especially in the context of hazards which can only be forecast on very short timescales (e.g. tsunami).

The report highlights the need for an overall risk governance approach to MHEWS. Out of the 101 countries reporting having MHEWS, 95 have reported the existence of a disaster risk reduction strategy. Further, countries with more comprehensive strategies tend to have higher MHEWS coverage. Countries have also reported encouraging progress in developing local plans to act on early warnings. This has improved preparedness capabilities with a steady increase in the number of people who are pre-emptively evacuated (an average of 250 million per year from 2015 to 2022). Increasing investment in anticipatory action and early action frameworks has accelerated progress on preparedness.

Increasing international cooperation in MHEWS, is enabling countries with lower capacity to generate reliable forecasts which they can then tailor to reflect the local context and local needs. Similarly, the establishment of a series of 'situation rooms' across Africa provides opportunities to strengthen the exchange and cascade of essential data, information and advice.

Outlook and opportunities

The launch of the **Early Warnings for All (EW4All) initiative,** with its vision to protect every human on Earth with an early warning system, has accelerated the momentum on MHEWS.

To realize this ambitious vision, there is a clear **need to scale up the level of investments in MHEWS.** Without large investments and technical support over a sustained period, it will be extremely difficult for a country to progress from having no early warning system to having a fully resourced and operational system capable of dealing with complex, cascading and compounding hazards. To guide global investments in MHEWS to where they are most needed, there is a need to map the investment flows, internationally and nationally.

The **data ecosystem underlying MHEWS should be strengthened and expanded.** Good data is the foundation of MHEWS and is essential for monitoring progress. Data needs to be quality assured, provided in standard formats, and georeferenced and disaggregated, where relevant. The increasing complexity of disasters demands a systematic tracking of hazardous events and disaster impacts – both to tailor MHEWS at local scales and to assess the efficacy of early warnings in building resilience.

While strengthening the technological base for MHEWS is important, **"no-tech" and "low-tech" solutions should also be considered.** Such solutions play an important part in reinforcing messages carried through other mediums, can overcome technology access limitations, and continue to function even if power and communication lines are down.

The ever-increasing magnitude and impact of the climate emergency calls for greatly **upscaling adaptation and disaster risk reduction efforts.** This in turn requires a strong policy basis for implementation, with greater synergies in planning processes across adaptation and risk reduction. As called for by the EW4All Executive Action Plan, a comprehensive risk management approach is necessary to avoid fragmentation of efforts and resources. This should be further backed by the capacity development of nations and communities. Even where plans exist, they should not go untested. Simulation exercises provide opportunities to test all aspects of the early warning system, from roles and responsibilities, data flow and warning dissemination, to testing equipment and actions.

The level of ambition behind the EW4All initiative requires leveraging global expertise and coordinating efforts across all countries, partners and funders. The adoption of a standard EW4All monitoring and evaluation framework, with commonly accepted metrics of MHEWS, will further enhance coordination in implementation.

ACRONYMS

Every effort has been made to define all acronyms on first use but this list serves as a ready-use guide. A separate glossary has not been included in this publication. However, key terms are explained, and should readers require additional information, useful guides are available online.[1]

AA	Anticipatory Action
ACMAD	African Centre of Meteorological Applications for Development
AF	Adaptation Fund
AHA	ASEAN Coordinating Centre for Humanitarian Assistance
AMHEWAS	Africa Multi-Hazard Early Warning and Early Action System
AR6	Sixth Assessment Report of the IPCC
ARC	African Risk Capacity
ASEAN	Association of Southeast Asian Nations
ASP	Adaptive Social Protection
ASW	Accelerated Support Window
AUC	African Union Commission
CAFEWS	Central Asian Flood Early Warning System
CAP	Common Alerting Protocol
CARICOM	Caribbean Community
CBEWS	Community-Based Early Warning Systems
CBO	Community-Based Organisation
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CDRFI	Climate and Disaster Risk Finance Initiatives
CEMS	Copernicus Emergency Management Service
CEWS	Community Early Warning Systems
CEPREDENAC	Centro de Coordinación para la Prevención de los Desastres en América Central y República Dominica - Coordination Center for Natural Disaster Prevention in Central America and the Dominican Republic
CERESIS	Centro Regional de Sismología para América del Sur, Regional Seismology Center for South America
CHE	Cataloguing Hazardous Event
CIEWS	Climate Information and Early Warning Systems
CIFDP	Coastal Inundation Forecasting Demonstration Project
CREWS	Climate Risk and Early Warning Systems
DAC	Development Assistance Committee
DOC	Disaster Operations Centre
DREF	Disaster Response Emergency Fund
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EAP	Early Action Protocols
ECCAS	Economic Community of Central African States
ECMWF	European Centre for Medium Range Weather Forecasting
ECOWAS	Economic Community of West African States
EENA	European Emergency Number Association
EFAS	European Flood Awareness System
EM-DAT	Emergency Event Database
EWEA	Early Warning Early Action
EWS	Early Warning Systems
EW4All	Early Warnings for All
FAO	Food and Agriculture Organization
FbF	Forecast-based Financing
FEWS NET	Famine Early Warning Systems Network
FFGS	Flash Flood Guidance System
G7	Group of Seven
GBON	Global Basic Observations Network

1 UNDRR has an online guide to Sendai Framework Terminology on Disaster Risk Reduction (as adopted by the General Assembly): www.undrr.org/terminology and a glossary of terms used in early action is available from the Risk-informed Early Action Partnership: www.early-action-reap.org/glossary-early-action-terms-2022-edition.

GCF	Green Climate Fund
GEF	Global Environment Facility
GFDRR	Global Facility for Disaster Reduction and Recovery (part of the World Bank)
GLOF	Glacier Lake Outburst Floods
GloFAS	Global Flood Awareness System
GTS	Global Telecommunications System (of the WMO)
HydroSOS	Hydrological Status and Outlooks system
(UN) IASC	(United Nations) Inter-Agency Standing Committee
IBF	Impact-Based Forecasting
IBFWS	Impact-based Forecasting and Warning Services
ICPAC	IGAD Climate Prediction and Applications Centre
ICT	Information and Communication Technology
IDMC	Internal Displacement Monitoring Centre
IFRC	International Federation of Red Cross and Red Crescent Societies
IGAD	Intergovernmental Authority on Development
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
IOM	International Organization for Migration
IOTWMS	Indian Ocean Tsunami Warning & Mitigation System
IPCC	Intergovernmental Panel on Climate Change
ITCG	Interpillar Technical Coordination Group (of the EW4All Initiative)
ITU	International Telecommunication Union
LB-SMS	Location-based Short Message Service
LDCs	Least Developed Countries (UN Country Group)
LDCF	Least Developed Countries Fund (of the GEF)
LLDCs	Landlocked Developing Countries (UN Country Group)
LTIK	Local, Traditional and Indigenous Knowledge
M&E	Monitoring and Evaluation
MENA	Middle East and North Africa
MHEWS	Multi-Hazard Early Warning Systems
MSF	Multi-Stakeholder Fora
MTR (SF)	Mid Term Review (Sendai Framework)
NDC	Nationally Determined Contributions
NDMA/O	National Disaster Management Agencies/ Authorities/ Offices/ Organizations
NGO	Non-Governmental Organization
NMHS(s)	National Meteorological and Hydrological Service(s)
NTWC	National Tsunami Warning Centres
(UN) OCHA	United Nations Office for the Coordination of Humanitarian Affairs
PDC	Pacific Disaster Center
RCCC	Red Cross Climate Centre
REAP	Risk-informed Early Action Partnership
RIMES	Regional Integrated Multi-hazard Early Warning System for Africa and Asia
RSMC	Regional Specialized Meteorological Centre
SAP	Simplified Approval Process (from the GCF)
SADC	Southern African Development Community

SCCF	Special Climate Change Fund (of the GEF)
SDG	Sustainable Development Goal
SFM	Sendai Framework Monitor
SICA	Sistema de la Integración Centroamericano, Central American Integration System
SIDS	small island developing States (UN Country Group)
SMS	Short Message Service
SOFF	Systematic Observations Financing Facility
SOP	Standard Operating Procedures
SWFP	Severe Weather Forecasting Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNHCR	United Nations Office of the High Commissioner for Refugees
USAID	United States Agency for International Development
US$	United States Dollars
USDM	United States Drought Monitor
V20	Vulnerable Twenty Group
VFDM	Volta Flood and Drought Management
W@HCA	Water at the Heart of Climate Action
WCAS	Web Content Accessibility Standards
WCM	WMO Coordination Mechanism
WFP	World Food Programme
WG-M&E	Working Group on Monitoring and Evaluation (of the EW4All Initiative)
WiA	Words into Action
WIPPS	WMO Integrated Processing and Prediction System
WISER	Weather and Climate Information Services
WMO	World Meteorological Organization

Image Source: Unsplash, Lawrence Eaton


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1 INTRODUCTION

Image Source: Shutterstock, Dwi Martono Photo

1. Introduction

The year 2023 saw disasters and extreme events in different parts of the world. The risks posed by weather- and climate-related hazards are complex and depend on the vulnerability, exposure and adaptive capacity of human and natural systems, among other contexts. Climate and extreme weather events also affect the use and distribution of natural resources across regions and within countries, and have large negative impacts on the environment (World Meteorological Organization [WMO], 2023a)

Multi-hazard early warning systems (MHEWS) are a proven, effective and feasible climate adaptation measure that saves lives and provides at least a tenfold return on investment (WMO, 2022a). It is for this reason that the Intergovernmental Panel on Climate Change's (IPCC's) Sixth Assessment Report (AR6) on impacts, adaptation and vulnerability recognized MHEWS and other disaster risk management (DRM) activities as key cross-cutting adaptation options that enhance the benefits of other adaptation measures when combined (WMO, 2022a). MHEWS also support the advancement of the 2030 Agenda for Sustainable Development and provide crossing-cutting benefits to most of the Sustainable Development Goals (SDGs).

In short, early warnings save lives and livelihoods. They are "the most effective and dignified way to prevent an extreme weather event from creating a humanitarian crisis – especially for the most vulnerable and remote communities who bear the brunt of it".[2] However, many developing countries still lack such systems. Ensuring early warnings is essential to help people prepare for extremes and is the reason why, in March 2022, United Nations Secretary-General António Guterres called for new action to ensure every person on Earth be protected by early warning systems (EWS) by the end of 2027.

This report, building on the report released in 2022,[3] analyses the global status of MHEWS and the progress that has been made under the Early Warnings for All (EW4All) initiative. It also seeks to highlight good practices through case studies and examples of both global and regional initiatives that are contributing to the achievement of the goal set by the Secretary-General.

1.1 Human and economic cost of disasters

The world is witnessing more frequent and devastating disasters, resulting in significant casualties, loss of lives and livelihoods as well as wider economic losses including of critical infrastructure. Throughout the past decade, the impacts of disasters have been felt across the globe. At the start of July 2023, the world experienced its hottest week on record, which followed the warmest June since official records began, as well as unprecedented warm sea surface temperatures, marine heatwaves and record-low sea ice extent in the Antarctic.[4] With an El Niño officially declared in July 2023, the coming months, and possibly years, will likely bring new heat records.

2 International Federation of Red Cross and Red Crescent Societies (IFRC), "Early Warnings For All Initiative scaled up into action on the ground", 21 March 2023. Available at www.undrr.org/news/early-warnings-all-initiative-scaled-action-ground.

3 United Nations Office for Disaster Risk Reduction (UNDRR), *Global Status of Multi-Hazard Early Warning Systems 2023* (Geneva, Switzerland, 2022). Available at www.undrr.org/publication/global-status-multi-hazard-early-warning-systems-target-g.

4 WMO, "Preliminary data shows hottest week on record. Unprecedented sea surface temperatures and Antarctic sea ice loss", 10 July 2023. Available at https://public.wmo.int/en/media/news/preliminary-data-shows-hottest-week-record-unprecedented-sea-surface-temperatures-and.

WMO reported that between 1970 and 2019, the number of disasters increased by a factor of 5 (WMO, 2021a). Globally, between 1970 and 2021, water-related disasters were the most prevalent disaster type, and tropical cyclones were the leading cause of reported human and economic losses worldwide (WMO, 2023b). Summarily from 1970 to 2021, there were nearly 12,000 weather-, climate- or water-related disasters recorded, causing over 2 million deaths and US$ 4.3 trillion in economic losses (WMO, 2023b).

As per official reports from governments, in the last decade (2013–2022), the global mortality rate from disasters has reduced to 1.15 persons per 100,000 population compared with 1.6 persons in the previous decade of 2005–2014. However, despite these improvements, the number of deaths resulting from disasters is still unacceptably high – from 2015 to 2022, the global annual average of disaster-related mortality was 41,789 persons (Sendai Framework Monitor [SFM], 2023).[5] In addition, over the same period, the number of people affected by disasters has been increasing, with more than 130 million people affected globally every year (SFM, 2023).[6]

In 2022, the disaster-related economic losses accounted for 0.83 per cent of global GDP (SFM, 2023). The losses also disproportionally impacted least developed countries (LDCs) and landlocked developing countries (LLDCs), exerting pressure on their already vulnerable infrastructures and capacity (SFM, 2023).[7]

In Africa from 2013 to 2022, more than 100,000 persons died or were missing because of disasters, and an additional 131 million people affected (SFM, 2023). Frequently occurring events such as droughts and floods continue to wreak havoc in different parts of the continent. In East Africa, rainfall has been "below average" for five consecutive wet seasons (since before 2022 and up to the first half of 2023), the longest such sequence in 40 years with an estimated 37 million people facing acute food insecurity across the region, under the effects of the drought and other shocks (WMO, 2023a). Flood events affected the Eastern Sahel (Chad, Niger, Nigeria, and the southern half of Sudan) from October to December 2022 (WMO, 2023a). While tropical cyclone activity was near or below average overall, the southern Indian Ocean had an active season with 12 named storms, 5 of which reached intense tropical cyclone status (WMO et al., 2022). From late January to late February 2022, Madagascar had four landfalls. Cyclones Ana and Batsirai both caused significant loss of life; Cyclone Ana also went on to have major flooding impacts in Mozambique and Malawi. In March, Cyclone Gombe brought flooding to Mozambique with significant casualties (WMO, 2023a).

In Asia, from 2013 to 2022, total disaster-related mortality reached over 146,000 persons, and over 911 million people were directly affected by disasters in the region (SFM, 2023). Economic damages were assessed at over US$ 36 billion in 2022 with more than 81 weather-, climate- and water-related disasters, of which over 83 per cent were flooding and storm events.[8] In Pakistan, record-breaking rain in July and August 2022 led to extensive flooding resulting in at least 1,700 deaths, and 33 million people were affected, while almost 8 million people displaced. Total damage and economic losses were assessed at US$ 30 billion (WMO, 2023a)..

Unprecedented heatwaves also affected China and Europe during the summer of 2022, paired with exceptionally dry conditions in some areas. Excess deaths associated with the heat in Europe exceeded 15,000 in total across France, Germany, Portugal, Spain, and the United Kingdom (WMO, 2023a).

In the Americas and the Caribbean, disasters have claimed more than 35,000 lives and affected nearly 30 million people from 2013 to 2022 (SFM, 2023). In September 2022, Hurricane Ian caused a tremendous amount of damage in Cuba, Jamaica and the United States, estimated at US$ 100 billion in total. There were also significant flooding events in Brazil in the same year, with flash flooding experienced in the city of Petropolis after significant rain events: "in the February event 250 mm of rain fell in three hours, while in March 415 mm fell in 10 hours". Further flooding events were experienced in north-east Brazil

5 Target A of the Sendai Framework, shared with SDGs 1, 11 and 13, aims to substantially reduce global disaster mortality.

6 Target B of the Sendai Framework, shared with SDGs 1, 11 and 13, aims to substantially reduce the number of affected people.

7 Target C of the Sendai Framework, shared with SDGs 1 and 11, aims to reduce direct economic loss in relation to global GDP.

8 WMO, "Climate change impacts increase in Asia", 27 July 2023. Available at https://public.wmo.int/en/media/press-release/climate-change-impacts-increase-asia.

in May and Venezuela in October and November (WMO, 2023a).

The events of 2022 followed a series of extreme events in 2021, including extreme heat in western North America, Central Europe and the Mediterranean; severe flooding in Western Europe (mid-July 2021); drought in the Greater Horn of Africa; abnormally cold conditions across central United States and northern Mexico (mid-February 2021); and unusually cold conditions in China, Japan and the Russian Federation (WMO et al., 2022).

These disasters form part of a worrying trend that is set to continue. It is projected that, by 2030, the number of medium- or large-scale disaster events will reach 560 events per year. Not only is the number of disasters likely to increase because of climate change, but climate change is also expected to "increase the difficulty, uncertainty, and complexity of emergency response efforts worldwide".[9]

The evidence and data could not be clearer: the frequency and severity of disasters are increasing, and human and economic losses persist or worsen. The global community needs to act in concord to reverse this trend of enduring disaster losses and burden, especially in developing, vulnerable countries. This requires an understanding of disaster risks as part of a multisectoral approach, which enables policymakers to integrate disaster risk reduction (DRR) policies with strategies in the climate change, biodiversity, environment, economic, finance, and socio-demographic domains. Countries need to be able to detect, observe, monitor, forecast, disseminate and communicate disaster risk information relating to hazardous events so that they can provide, in good time, appropriate guidance to the general public and policymakers in terms of what actions to take when preparing for and responding to these events. MHEWS are crucial to achieving these goals, in mitigating the adverse hazard impacts, in saving lives and reducing economic losses across the globe.

1.2 Early warning saves lives

Evidence continues to suggest that investment in MHEWS brings direct benefits in reducing the human cost of disasters. When examined alongside disaster-related mortality, data shows that **countries with limited to moderate MHEWS coverage[10] have a nearly six-times-higher disaster-related mortality ratio compared with that in the countries with substantial to comprehensive coverage (4.05 mortality per 100,000 population, compared with 0.71). Similarly, countries with limited to moderate MHEWS coverage have nearly five times more disaster-affected people than countries with substantial to comprehensive coverage (3,132 compared with 688).**

Table 1. Mortality rate and number of affected people compared with leave of MHEWS coverage

Category of countries by coverage of MHEWS	Mortality per 100,000 population, 2005–2022 (SFM Indicator A-1)	Number of affected people per 100,000 population, 2005–2022 (SFM Indicator B-1)
Limited to moderate coverage (SFM Indicator G-1 score between 0 and 0.5)	4.05	3,132
Substantial to comprehensive coverage (SFM Indicator G-1 score between 0.5 and 1)	0.71	688

Source: SFM

9 WMO, UNDRR, IFRC and the International Telecommunication Union (ITU), "Early Warnings For All Initiative scaled up into action on the ground", 21 March 2023. Available at www.undrr.org/news/early-warnings-all-initiative-scaled-action-ground.

10 Details of MHEWS coverage can be seen in Chapter 2.

1.3 Overview of Multi-Hazard Early Warning Systems

In the context of a changing climate and the increasing frequency and intensity of disasters, MHEWS have already proved to be an effective mechanism for saving lives and livelihoods.

1.3.1 Early Warning Systems

The United Nations (UN) provides the following definition for an Early Warning System (EWS) :

"An integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities systems and processes that enables individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events."[11]

This definition is expanded further to describe the key characteristics and elements of an EWS – that to be effective, EWS need to be "end-to-end" and "people-centred".

An effective EWS must be:

- Multi-Hazard: they are designed to detect different hazards that may occur alone, simultaneously, or cascade.
- End-to-end: the system covers the entire range, from hazard detection to action, which includes providing understandable and actionable warning messages.
- People-centered: this means designing the systems with people in mind, to empower them to act on time and in an appropriate manner to reduce potential harm.[12, 13]

1.3.2 Multi-Hazard Early Warning Systems

Building on the concept of an EWS, MHEWS are designed and implemented to provide warnings in more complex situations:

"Multi-hazard early warning systems address several hazards and/or impacts of similar or different type in contexts where hazardous events may occur alone, simultaneously, cascadingly or cumulatively over time, and taking into account the potential interrelated effects."[14]

Unlike a single-hazard EWS, having a system that can address multiple hazards simultaneously enables harmonized approaches for risk communication, warning dissemination and preparedness. This in turn can "minimize inefficiencies, maintenance costs, and duplication, and maximize investments in awareness, education, and preparedness" (UNDRR, 2023a).

The design, implementation, operation and success of MHEWS is necessarily a multidisciplinary endeavour involving individuals, communities and institutions at all levels of society and across all sectors. Collaboration is key to establishing, maintaining and improving each element of the system and the system overall.

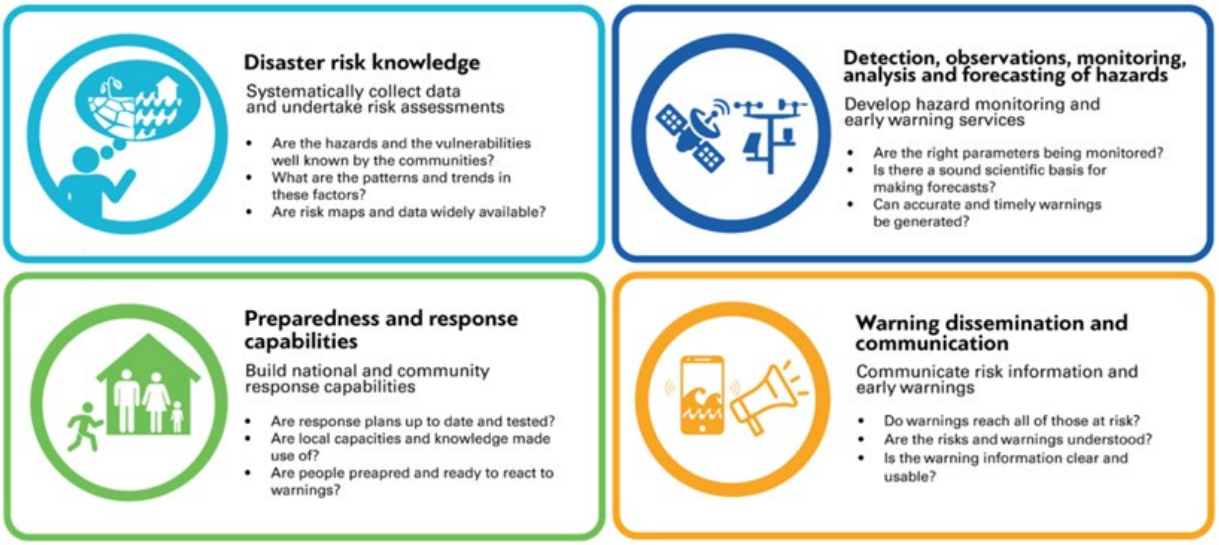
11 Sendai Framework Terminology, "Early warning system." Available at www.undrr.org/terminology/early-warning-system.

12 UNDRR, "Early warnings for all", undated. Available at www.undrr.org/early-warnings-for-all.

13 See Annex 2 for further details on people-centred MHEWS

14 Sendai Framework Terminology, "Early warning system." Available at www.undrr.org/terminology/early-warning-system.

Figure 1.1 Four elements of MHEWS.



Source: WMO (2022a, figure 2).

1.3.3 Elements of MHEWS

Four elements (or pillars) help unwrap MHEWS as seen in figure 1.1

The four MHEWS elements are highly interrelated, with linkages across all (table 3). Activities across the elements thus need to be coordinated in and across sectors and at different levels, including locally, subnationally, nationally, regionally and internationally. Effective feedback mechanisms are also essential to enabling continuous improvement across the whole system.

As with any system, failure in one component or a lack of coordination across the components could lead to the failure of the whole system. Indeed, a recent study has demonstrated that "simply improving the accuracy of weather forecasts will not result in better outcomes for vulnerable people" (Coughlan *et al.*, 2022). The authors noted that most of the deadliest and costliest hydrometeorological disasters of this century had been forecast in advance. The study identified that the largest gaps, and opportunities for improvement, lay in communication and response capability. Therefore, it is essential that the design and implementation of any MHEWS adopts an integrated approach, as promoted by the Coastal Inundation Forecasting

Table 3 Interconnections between the elements of MHEWS. After WMO (2018a, WMO-No. 1150).

	Risk knowledge	Observations & forecasting	Warning dissemination & communication	Preparedness to respond
Risk knowledge		Which hazards to monitor, where and how	Communication strategies to reach vulnerable populations Ability of communications equipment to withstand extreme events	Development of plans and protocols Testing/ optimising comms channels Public awareness/ education campaigns
Observations & forecasting	Data and information to quantify hazards and exposure to risk		Warnings as triggers for communication	Warnings provide details on impact and response
Warning dissemination & communication	Strengths / weaknesses of communication channels	Agreements on authoritative and consistent warning protocols and language		Plans include communication channels and protocols
Preparedness to respond	Feedback and lessons learnt from events and exercises used to update risk knowledge	Feedback and lessons learnt from events and exercises used to optimise monitoring, forecasting and warning	Feedback and lessons learnt from events and exercises used to optimise communication mechanisms/ channels	

MHEWS blueprint – Coastal inundation forecasting-early warning system

Coastal inundation is a multi-hazard phenomenon that occurs on the world's vulnerable coastlines and can frequently lead to major loss of life (WMO, 2022b). The urgent need for forecasting and warning in coastal regions, and especially small island developing States (SIDS), prompted the initiation of CIFPD. The aim of CIFDP was to demonstrate "cooperative work as a strategy for building improved operational forecast and warning capability for coastal inundation from combined extreme waves, surges, and river flooding events, that can be sustained by the responsible national agencies. The focus of the CIFDP was to facilitate the development of efficient forecasting and warning systems for coastal inundation based on robust science and observations."[15]

In 2022, WMO, informed by the knowledge and practical experience gained through the successful implementation of demonstration systems in four countries[16] between 2009 and 2019, published its Guidelines on Implementation of a Coastal Inundation Forecasting–Early Warning System (WMO 2022b).

The guidelines cover a range of coastal hazards, including tsunamis, as part of an MHEWS but also have wider application. The guidelines are based on four fundamental recommended actions (WMO, 2022b):

- **Technical –** including the assessment of current and historical risks.
- **Stakeholder collaboration –** including high-level interministerial and inter-agency agreement.
- **Financial, expert and volunteer support –** through the development of a costed proposal.
- **Operational readiness –** formalizing a plan for implementation.

The guidelines provide "a straightforward 10 step process with templates featuring policy, management and technical processes that countries or regions can use to build their own EWS, from vision through to 'go-live' implementation" (WMO, 2022b, p. vi). They also include "a range of ready-to-use templates to assess any country's current technical capacity, areas of risk, required project management and documentation for sponsors and other stakeholders" (WMO, 2023c). Therefore, though initially designed as a blueprint for coastal MHEWS, the guidelines are relevant to any type of weather-, water-, climate- or ocean-related MHEWS.

15 WMO. Coastal Inundation Forecasting Demonstration Project (CIFDP): https://community.wmo.int/en/activity-areas/Marine/CIFDP

16 Ibid. – CIFDP sub-projects have been completed in Bangladesh, the Caribbean, Fiji and Indonesia.

1.4 EW4All Initiative

"Early warnings and action save lives. To that end, today I announce the United Nations will spearhead new action to ensure every person on Earth is protected by early warning systems within five years."[17]

UN Secretary-General António Guterres

The EW4All initiative was launched by the United Nations Secretary-General in March 2022 to fast-track the development and implementation of life-saving MHEWS worldwide by the end of 2027. The actions required to achieve this goal have been broken down into four pillars aligned with the four components of a MHEWS. The initiative is co-led by WMO and the United Nations Office for Disaster Risk Reduction (UNDRR), with support from the International Telecommunication Union (ITU) and the International Federation of Red Cross and Red Crescent Societies (IFRC), among other partners, with each partner leading on one of the four pillars.

In November 2022, the Secretary-General launched an Executive Action Plan to implement the initiative (WMO, 2022a). The Executive Action Plan "summarizes the initial actions required to achieve the goal, and sets out the pathway to implementation. It calls for an estimated new targeted investments of US$ 3.1 Billion over the five years to advance the four Multi-Hazard Early Warning System (MHEWS) pillars from a scientific & technical, policy and financial perspective" (WMO, 2022a).

The Executive Action Plan laid out initial actions to be taken to achieve the Secretary-General's goal and set out a pathway for implementing these action points. In doing so, it has:

- Identified key areas for advancing universal disaster risk knowledge and outlined the priority actions required to achieve this.
- Prioritized the top technical actions required to enhance capacity to detect hazards, close the observations gap, and advance global forecast data processing systems and data exchange, optimizing international efforts.
- Highlighted both the infrastructure, governance and people-centred approach required to effectively disseminate and communicate warnings.
- Outlined the policies, capacities, finance and collaboration needed to improve preparedness and response capabilities over the next five years.
- Indicated how key foundational financing mechanisms will be scaled up to support the achievement of the goal, including a new framework developed by the Climate Risk and Early Warning Systems (CREWS) initiative, the Green Climate Fund (GCF), and the Systematic Observations Financing Facility (SOFF).
- Called for increased coherence and alignment of existing and planned investments from international financing institutions while recognizing existing successful bilateral funds for early warnings and calls for an acceleration of these mechanisms.

A summary of progress made to date is covered in Chapter 3 while a complementing report on progress in the initiative is being released.

17 United Nations, "Secretary-General Vows to 'Boost Power of Prediction', Extend Climate Disaster Early Warning Systems across Globe, in World Meteorological Day Message", 18 March 2022. Available at https://press.un.org/en/2022/sgsm21191.doc.htm.

1.5 Midterm Review of the Sendai Framework

The year 2022 marked the halfway point of the Sendai Framework for Disaster Risk Reduction 2015–2030. A midterm review was called for by the General Assembly.[18] The overall objective of the Midterm Review of the Sendai Framework (Midterm Review) was "to take stock of the implementation of the Sendai Framework to date, assessing progress made and challenges experienced in preventing and reducing disaster risk, identifying new and emerging issues as well as changes in context since 2015" (UNDRR, 2023b).

The key findings relating to MHEWS are reported under Target G (Increase availability and access to early warning systems and risk information) and are largely drawn from last year's Global Status of MHEWS (UNDRR and WMO, 2022).

Welcoming the progress of the Secretary-General's call to protect everyone on Earth through universal coverage of early warning systems, including through the EW4All initiative, the political declaration of the high-level meeting on the Midterm Review called for "further development of and investment in effective local, national and regional multi-hazard early warning mechanisms that lead to early action."[19]

With reference to Priority 4 of the Sendai Framework,[20] the Midterm Review reports that "Progress on the thinking around the design and implementation of multi-hazard early warning systems in different contexts is evident, yet insufficient in terms of

18 A/RES/75/216.

19 A/RES/77/289.

20 Priority 4: Enhancing disaster preparedness for effective response and to "build back better" in recovery, rehabilitation and reconstruction.

Image Source: Flickr, UNDRR

coverage and application". Several issues are recognized (UNDRR, 2023b):

- The importance of inclusion and community-based early warning systems in disaster response.
- That the effectiveness of emergency alerts depends on individuals' and businesses' ability to act upon them.
- The need for two-way communication between early warning institutions and at-risk communities.
- That MHEWS must be tailored to specific contexts by incorporating local knowledge, recognizing community vulnerabilities and including those often excluded from the decision-making process.

In relation to the acceleration of Sendai Framework implementation with respect to MHEWS, the Midterm Review reports (UNDRR, 2023b) that Member States:

- "Identify a need to further mobilize resources, technology and capacity to implement and extend the reach of inclusive MHEWS, developing guiding strategies and governance arrangements across all four phases of MHEWS implementation."
- "Are clear that MHEWS should be impact-oriented and community-based" and that "closer work with communities and across national boundaries is required to develop MHEWS that are integrated with both LTIK [local, traditional and Indigenous knowledge] and regional data on disaster risks."
- "Should develop governance arrangements and methodologies that enable the integration of vulnerability data and the needs of specific higher-risk groups into MHEWS."

2

GLOBAL STATUS OF EARLY WARNING SYSTEMS

Image Source: UNDRR


From
the People of Japan

2. Global status of early warning systems

A central instrument in the development, monitoring and strengthening of people-centred multi-hazard early warning systems (MHEWS), the Sendai Framework monitor (SFM)[21] aims to assess Member States' continuing progress on Target G: "Substantially increase the availability of and access to multi hazard early warning systems and disaster risk information and assessments to the people by 2030" through robust, timely, well-defined and internationally comparable official data.

Target G has six indicators: G1–G6. Indicators G2–G5 map to the four pillars of the Early Warnings for All (EW4All) initiative and four corresponding MHEWS key elements. Indicator G1 is a compound indicator that combines progress made in indicators G2–G5. Indicator G6 measures the effectiveness of MHEWS by considering the number of people pre-emptively evacuated compared with the exposed or at-risk populations. The definitions and mappings of these indicators can be found in table 4.

To help countries better assess and monitor the effectiveness of their MHEWS, custom indicators have also been developed (Side feature: development of MHEWS custom indicators).

In reporting on the global status of MHEWS, this report also includes an update on the progress that has been made since the launch of EW4All (in March 2022) and the publication of the associated Executive Action Plan in November 2022 (WMO, 2022a). To do this, it draws information and insights from the EW4All pillar leads[23] and other implementing partners. For example, this report includes information from the WMO relating to a rapid assessment of country capacity that was recently undertaken in support of the initiative (section 3.5). Other sources have been used to add detail about the status and progress of the initiative, for example, the latest data from ITU regarding access to mobile networks and devices, and information from the Anticipation Hub regarding the existence and activation of anticipatory action frameworks.

Table 4 Overview of Target G[22]

Sendai Framework global Target G: Substantially increase the availability of and access to MHEWS and disaster risk information and assessments to the people by 2030		
MHEWS Pillar	**Target**	**Description**
Pillars 1–4	G-1 (compound G2–G5)	Number of countries that have MHEWS
Pillar 1: Risk knowledge	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

21 See www.undrr.org/monitoring-sendai-framework.

22 Ibid.

23 Pillar 1: Disaster risk knowledge is led by UNDRR; Pillar 2: Detection, monitoring, analysis and forecasting of the hazards is led by the World Meteorological Organization (WMO); Pillar 3: Warning dissemination and communication is led by ITU; and Pillar 4: Preparedness and response capabilities is led by IFRC – see section 1.3.3.

Sendai Framework global Target G: Substantially increase the availability of and access to MHEWS and disaster risk information and assessments to the people by 2030		
MHEWS Pillar	Target	Description
Pillar 2: Observations & forecasting	G-2	Number of countries that have multi-hazard monitoring and forecasting systems
Pillar 3: Warning dissemination & communication	G-3	Number of people per 100,000 that are covered by early warning information through local governments or through national dissemination mechanisms
Pillar 4: Preparedness to respond	G-4	Percentage of local governments having a plan to act on early warnings
Pillars 1–4	G-6	Percentage of population exposed to or at risk from disasters protected through pre-emptive evacuation following early warning

Development of MHEWS custom indicators

In 2022, the global project to measure the effectiveness of MHEWS through SFM, funded by the Climate Risk and Early Warning Systems (CREWS) initiative, defined a set of 53 custom indicators to help countries better monitor and evaluate the progress of MHEWS (UNDRR *et al.*, 2022). While linked with monitoring of Target G under SFM, the MHEWS custom indicators are optional and can be used to identify aspects of MHEWS which may require targeted support and/or to identify areas where further progress can be made.

The indicators focus on the aspects of MHEWS that are common to all MHEWS and are considered critical for an effective, minimum viable MHEWS. A minimum viable MHEWS does not need to include from the outset all the hazards that occur, or have the potential to occur, in a Member State. Rather, the expectation is that an MHEWS, and the custom indicators used to measure it, will focus initially on the priority hazards that have been identified.

Available in seven languages, the custom indicators will help countries measure the effectiveness of single, cluster and multi-hazard EWS within SFM (CREWS, 2023). To support the uptake and use of these additional indicators, implementation partners have developed training packages for capacity development that have been piloted with LDCs and SIDS in different regions (UNDRR, 2023b).

2.1 Global MHEWS coverage

More than half of the world's countries have reported the existence of MHEWS. **As at March 2023, 101 countries are reporting the existence of MHEWS[24] – 52 per cent of all countries in the world** (figure 2.1). Compared with the 2022 report, six additional countries have reported the existence of MHEWS, including a mix of countries that have recently started reporting on SFM, and those that have indicated the existence of MHEWS for the first time.

These results confirm that the number of countries reporting the existence of MHEWS since 2015 has doubled, when only 50 countries reported having MHEWS. However, just under half of all countries are still not covered by MHEWS.

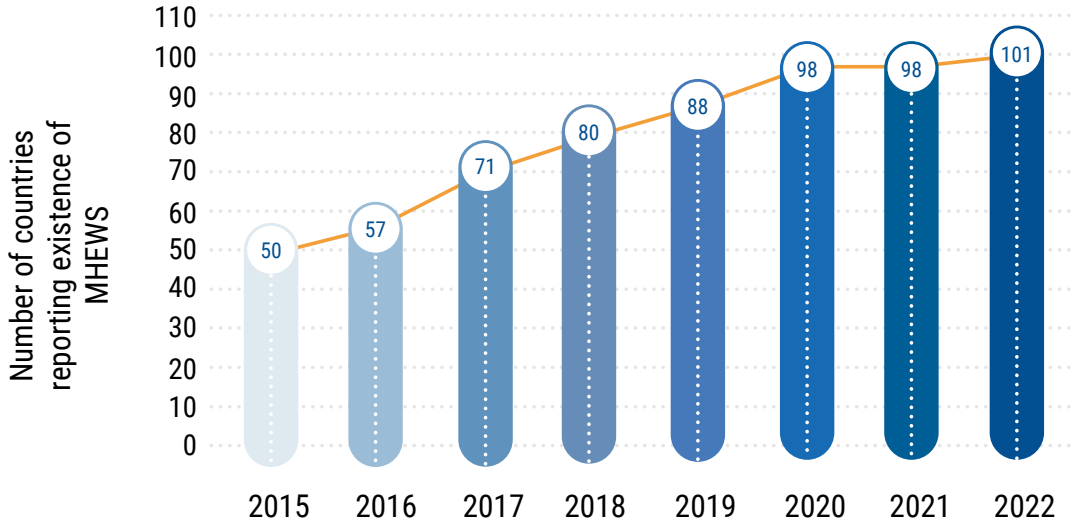
In Africa, 20 countries (or 45 per cent of countries in the region)[25] reported having MHEWS by 2022, compared with only 9 countries (20 per cent) reporting having MHEWS in 2015. On the other hand, the Americas and the Caribbean region has only 13 countries (37 per cent) reporting having MHEWS in 2022, albeit an increase from 8 countries (23 per cent) in 2015.

Other regions fare better relatively, with 67 per cent of Asia and the Pacific countries, 55 per cent of Arab States, and 55 per cent of countries in the Europe and Central Asia region reporting the existence of MHEWS as at 2022. These three regions have all witnessed more than a doubling in the number of countries reporting since 2015.

In terms of countries in special situations, 21 LDCs have reported having MHEWS (46 per cent of all LDCs), compared with 15 SIDS (39 per cent), and 19 LLDCs (59 per cent, figure 2.3). While the number of SIDS reporting the existence of MHEWS is still lagging behind the global average, this still represents a doubling or tripling of improvement since 2015, when only 11 LDCs, 5 SIDS and 9 LLDCs reported having MHEWS.

The lower coverage of MHEWS in the Americas and the Caribbean region and the Africa region suggests that efforts to implement MHEWS need to be increased in these regions. **While improved since 2022, coverage remains lower than 50 per cent in LDCs and SIDS**, confirming that expediting support for MHEWS in these countries remains a high priority.

Figure 2.1 Cumulative number of countries reporting the existence of MHEWS (i.e. a score greater than zero)

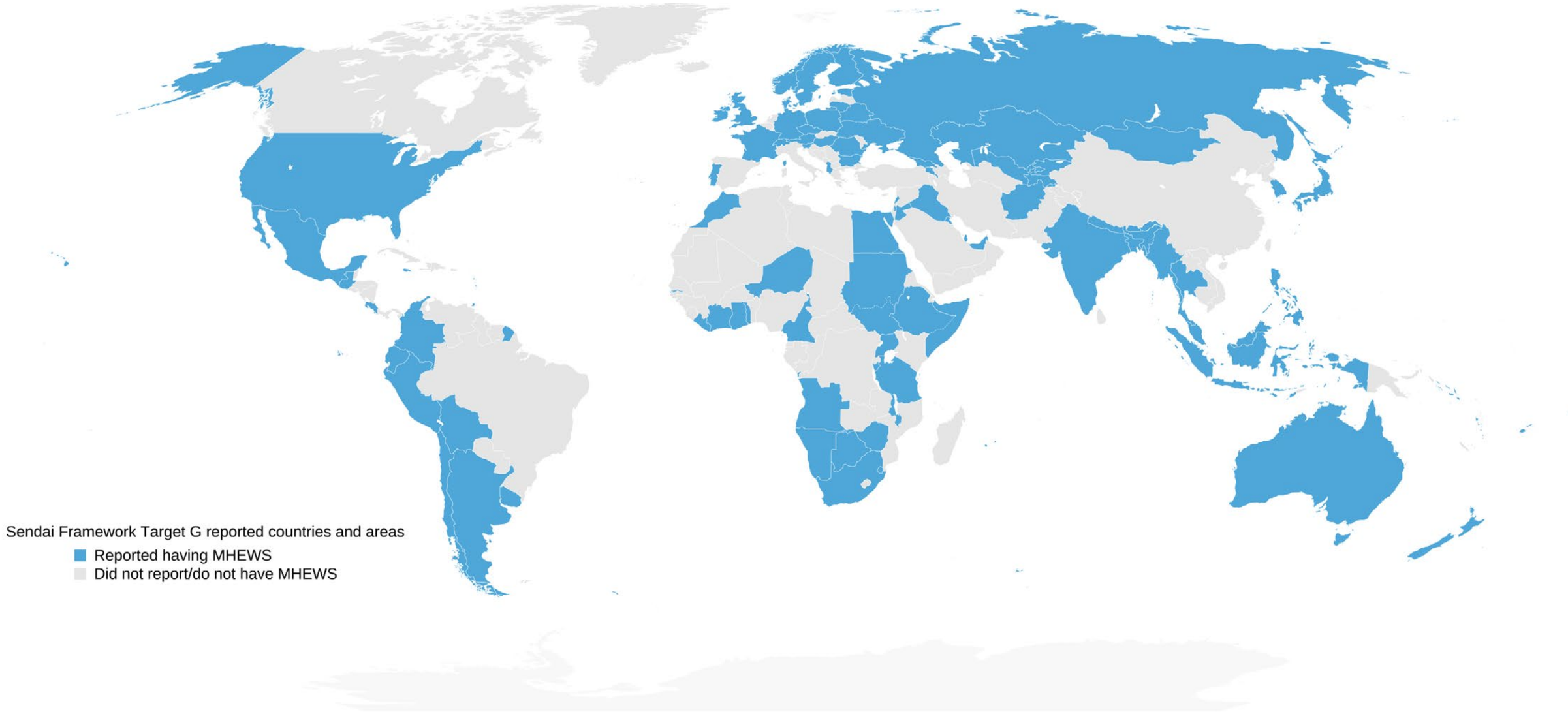


Source: SFM

24 Any score above zero is counted towards a positive report of MHEWS.

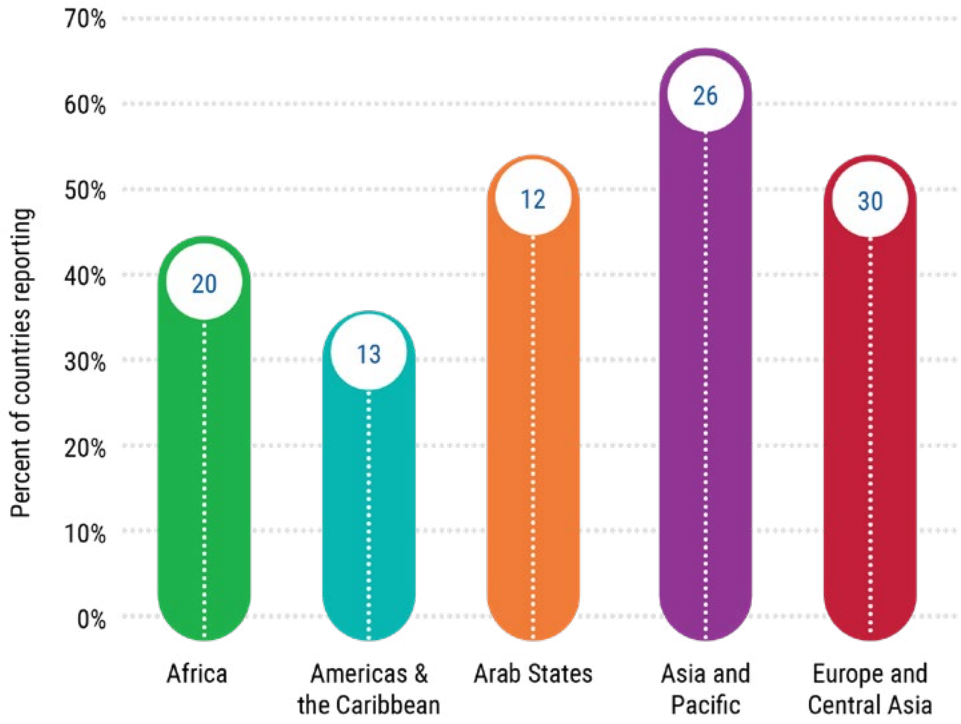
25 For SFM-related figures, the regional categories as per UNDRR regional offices have been followed. See www.undrr.org/about-undrr/where-we-work.

Image Source: UNDRR



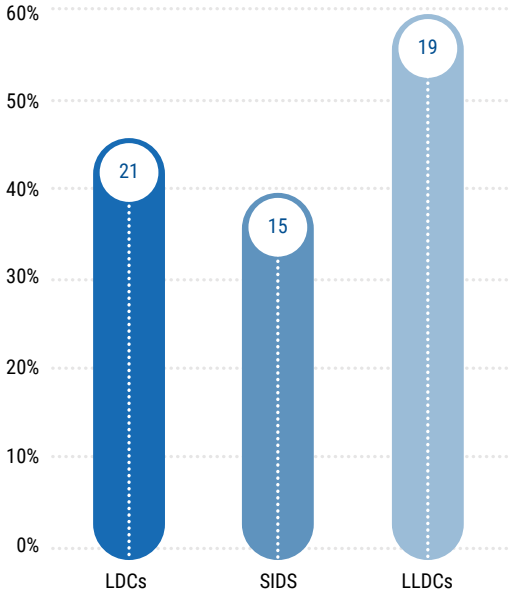
Source: Data comes from SFM, as at March 2023. The boundaries and names shown as well as the designations used on this map do not imply official endorsement or acceptance by the United Nations. The final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined. The dotted line represents approximately the Line of Control in Jammu and Kashmir agreed by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed by the parties. A dispute exists between the Governments of Argentina and the United Kingdom concerning sovereignty over the Falkland Islands (Malvinas).

Figure 2.2 Regional differences in the status of MHEWS. The bars show the percentage and the numbers inside the bars show the number of reporting countries within that region



Source: SFM

Figure 2.3 Status of MHEWS in LDCs, SIDS and LLDCs. The bars show the percentage and the numbers inside the bars show the number of reporting countries within each country group



Source: SFM

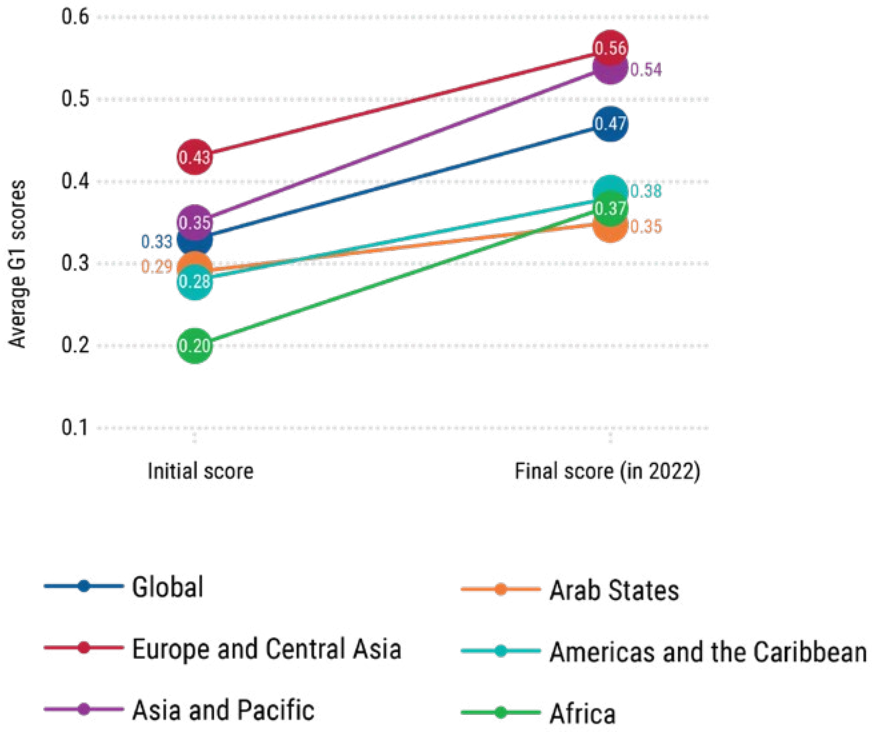
2.1.1 Progress in MHEWS coverage

An overall positive story of improving scores for G1 can be seen (figure 2.4). Globally, the average self-assessed G1 score has improved from 0.33, when first reported by countries, to 0.47 for the final reporting (as at the end of 2022).

The improvement is visible across all regions, with the highest increase seen in Africa, where scores have increased from 0.20 at initial reporting to 0.37 in the latest reporting. Yet even the latest score of the Africa region is only close to the baseline scores of the global average. The second largest improvement is seen in the Asia and Pacific region.

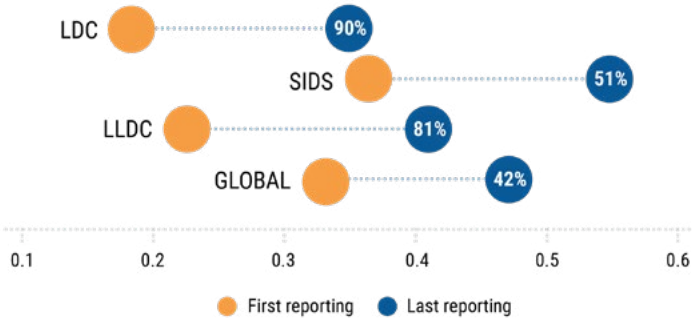
When focusing on the countries in special situations (figure 2.5, Average initial and final G1 scores by country groups), significant improvements can be seen between the first and last reported scores of the LDCs. The average baseline MHEWS score was 0.18

Figure 2.4 Average initial and final G1 scores by UNDRR region



Source: SFM

Figure 2.5 Average initial and final G1 scores by country groups. Numbers in the graph represent improvement in percentage



Source: SFM

Image Source: UNDRR

for LDCs, which has improved to 0.35, representing a 90 per cent improvement. A similar trend can also be observed for LLDCs, which witnessed an 81 per cent improvement of MHEWS scores, from 0.23 in baseline reporting to 0.41 in the latest reporting.

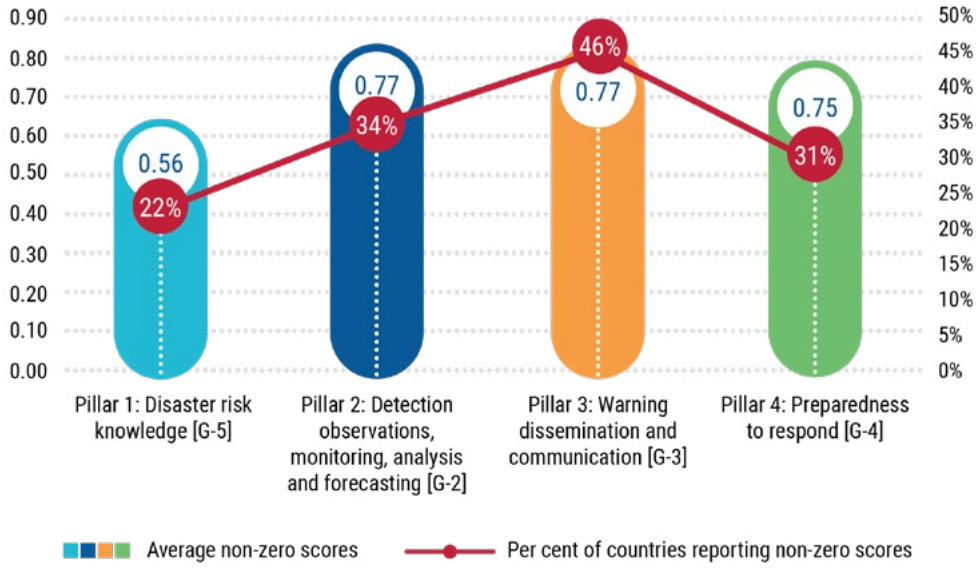
However, these country groups are progressing from lower baselines. The improvement is evidently less marked in SIDS, where the initial score was comparatively higher at 0.36 (higher than the final score of LDCs) resulting in a 51 per cent improvement. Nonetheless, all country groups show greater improvements than the global average (42 per cent), which may reflect MHEWS investments in these countries to date are making meaningful impacts to their MHEWS capacities.

2.1.2 Status of coverage: The MHEWS pillars

The comprehensiveness of MHEWS is determined by the four interconnected pillars, which serve as a value cycle and are underpinned by cross-cutting enablers of governance, coordination, advocacy, financing and monitoring. The average self-assessed scores are relatively similar for three of the four pillars and represent "substantial" progress towards comprehensive MHEWS (figure 2.6): 0.75–0.77 for MHEWS Pillars 2, 3 and 4. However, the score for Pillar 1 is significantly lower (0.56).

There is considerable discrepancy between the availability of data and capacity of the countries among the four pillars, as the maps in figure 2.7 demonstrate. The highest percentage of countries reporting by pillar was for Pillar 3: Warning dissemination & communication (G3), where 89 countries, or 46 per cent of the world, reported a positive score, indicating that their citizens were covered by early warning information through local governments or through national dissemination mechanisms. The other three pillars show evidently lower reporting rates, with the lowest for Pillar 1: Risk knowledge, where only 22 per cent of the countries in the world have reported having accessible, understandable, usable and relevant disaster risk information and assessment available to people at the national and local levels.

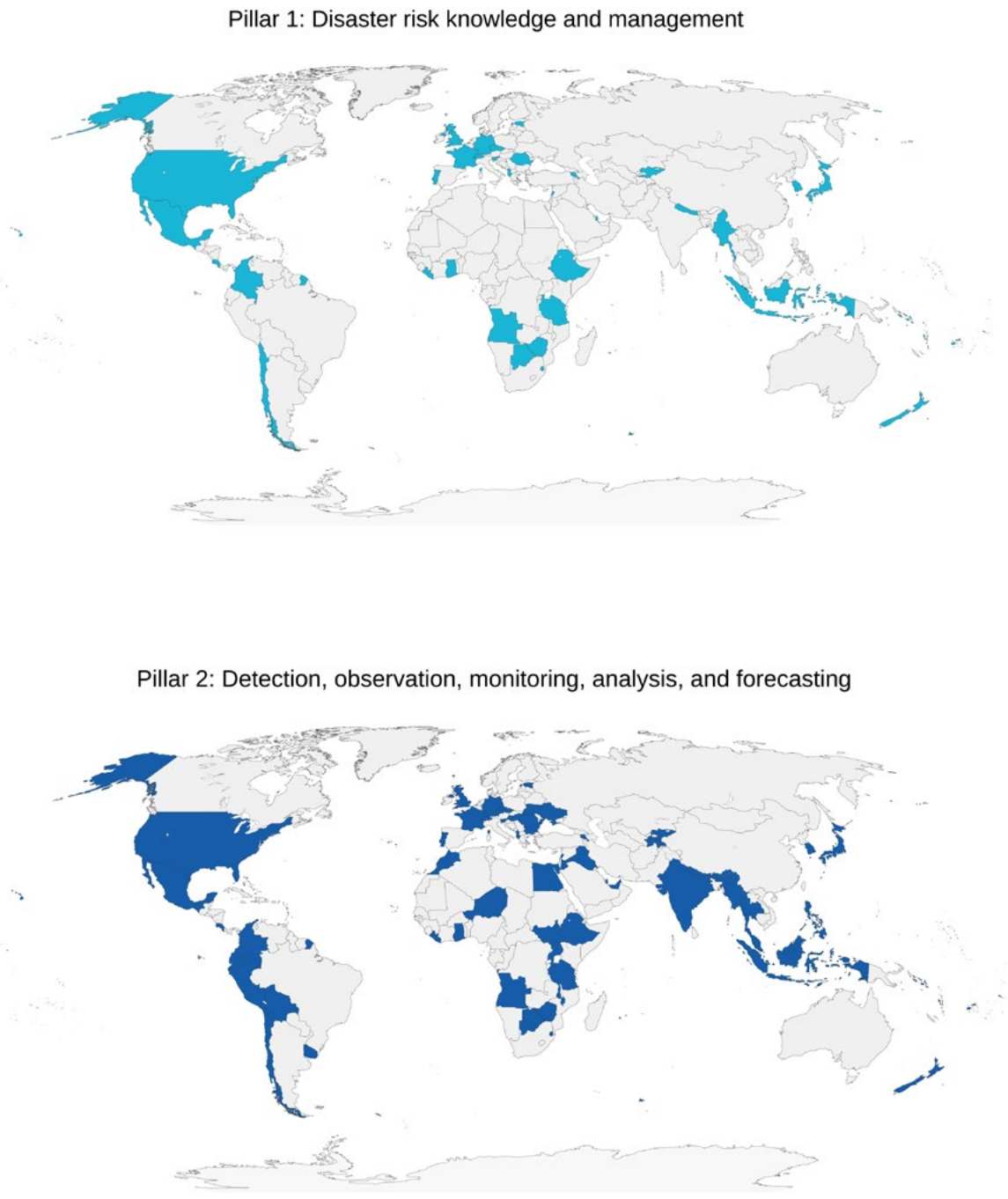
Figure 2.6 Proportion of countries reporting by pillar. The dots in the figure represents average scores by pillar (self-assessed on a scale from 0 to 1)[26]

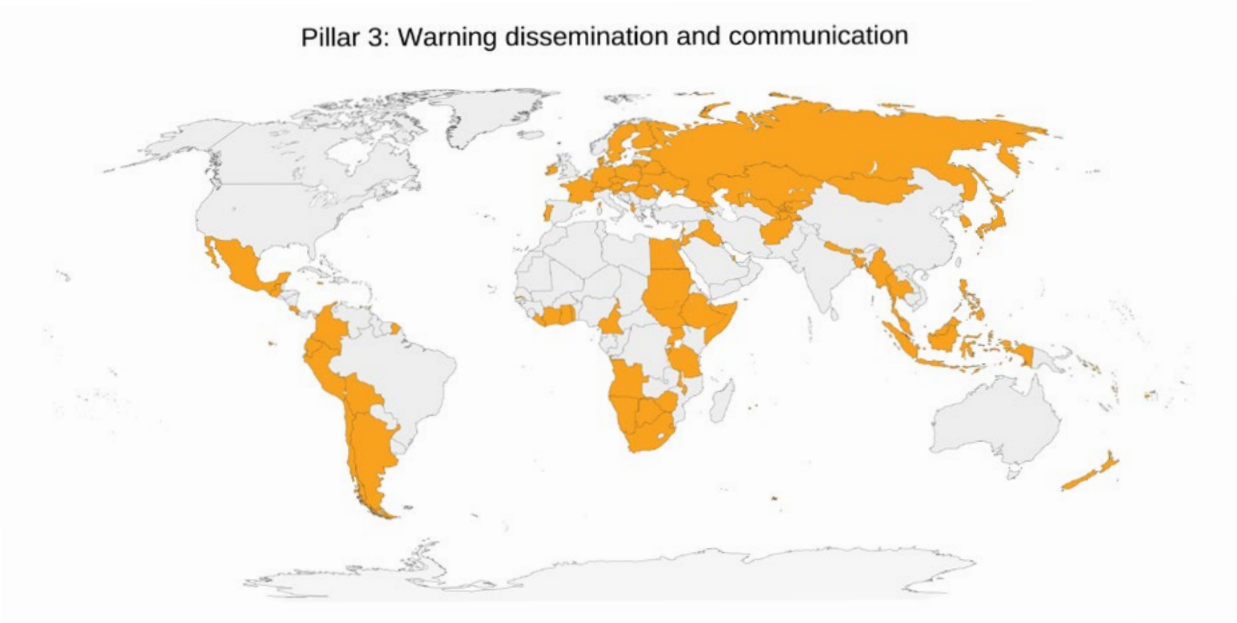


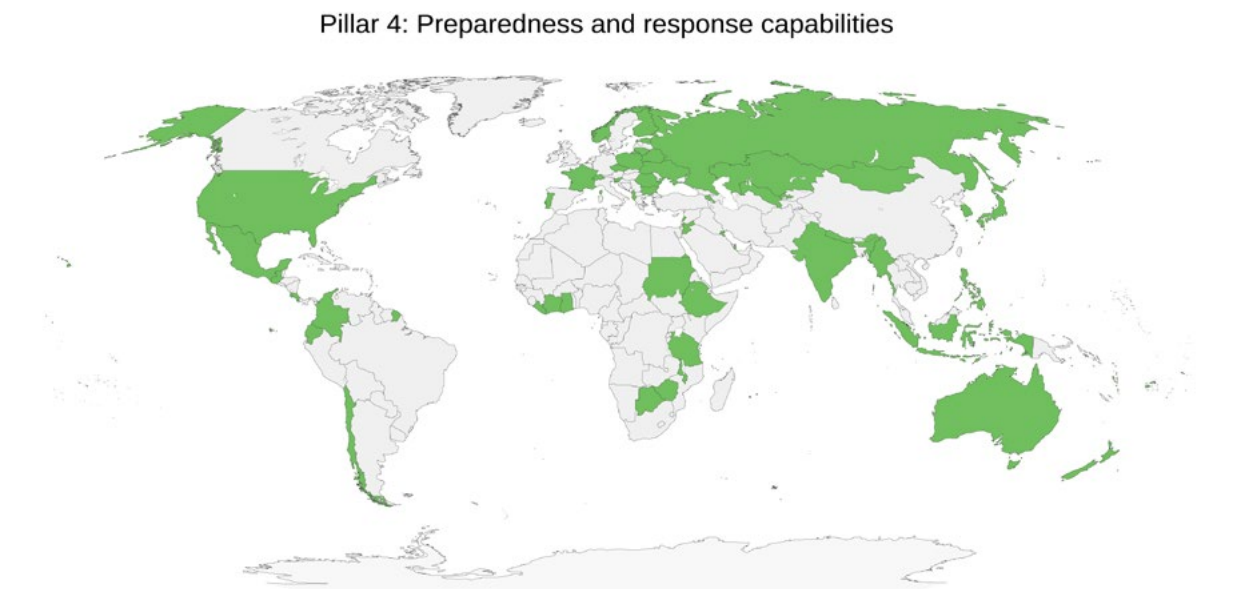
Source: SFM

26 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 where zero indicates no MHEWS, a non-zero score under 0.25 indicates "limited" MHEWS coverage, 0.25-0.50 is "moderate", 0.50-0.75 is "substantial" and 0.75 and above is "comprehensive".

Figure 2.7 Countries reporting to SFM Target G by pillar







Source: SFM

Source: Data comes from SFM, as at March 2023. The boundaries and names shown as well as the designations used on this map do not imply official endorsement or acceptance by the United Nations. The final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined. The dotted line represents approximately the Line of Control in Jammu and Kashmir agreed by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed by the parties. A dispute exists between the Governments of Argentina and the United Kingdom concerning sovereignty over the Falkland Islands (Malvinas).

While the percentages and individual pillar scores are very similar to those available last year, these statistics hide an improvement in real terms that can be seen in the raw figures. There is also regional variation in the reporting on the pillars (from G2 to G5) as shown in figure 2.8, with the Asia and Pacific region most advanced across all four pillars. Risk knowledge (G5) has the lowest percentage in every region and the figure is especially low in the Arab States (just 9 per cent).

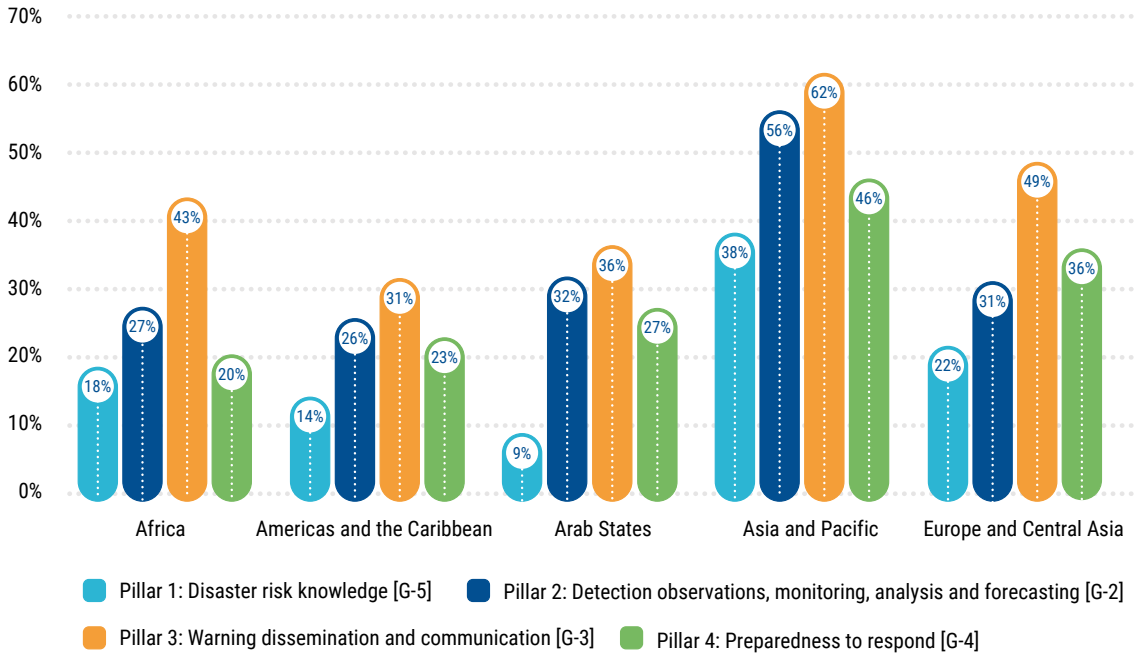
Each of the four MHEWS elements contributes differently to the overall progress of MHEWS globally (figure 2.9).

Among the four pillars, Pillar 3 (G3) has contributed the most (46 per cent) to the improvement of G1 scores. In contrast, Pillar 2 (G2) has accounted for only 12 per cent of the total score.

The baselines (initial scores) of the four pillars were also different (figure 2.10). Pillar 3 (G3) had the highest baseline among the four pillars and has also seen the greatest improvement between initial and final scores across the countries reporting on G3. The second highest improvement is in Pillar 1 (G5), which started with the lowest baseline, which is encouraging, but in the context of the low starting point and the low numbers of countries reporting on this element (figure 2.6), scaling up risk knowledge globally remains a high priority.

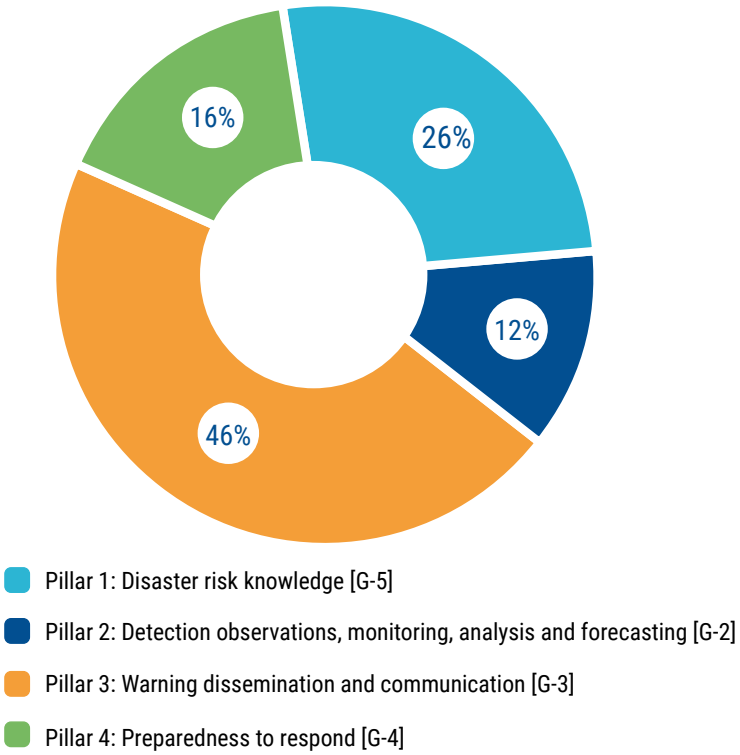
Overall, the data reveal improvement in the reporting and comprehensiveness of MHEWS in every country group and across each region. While a dramatic improvement is witnessed in the Asia and Pacific region and in Africa, significant gaps remain. Less marked improvement in the Arab States and across the Americas and the Caribbean, combined with scores that remain below the global average, suggests that there is a lot of work to be done in these parts of the world to improve access to MHEWS. Despite a marked improvement in scores since countries first reported, risk knowledge remains consistently low in terms of average score and numbers of countries reporting, suggesting that efforts to scale up global good practices in developing and managing risk information and risk assessments should remain a top priority.

Figure 2.8 Regional differences in the proportion of countries reporting by MHEWS element



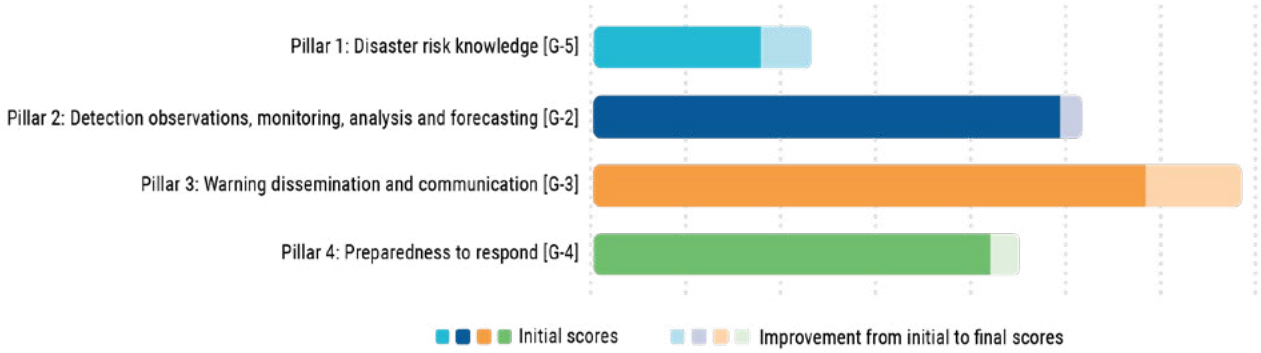
Source: SFM
Note: the global percentages (from figure 2.6) for G2 to G5 are 34 per cent (G2), 46 per cent (G3), 31 per cent (G4) and 22 per cent (G5).

Figure 2.9 Contribution of the pillars to the MHEWS improvement



Source: SFM

Figure 2.10 Baselines for the pillars to the MHEWS improvement



Source: SFM

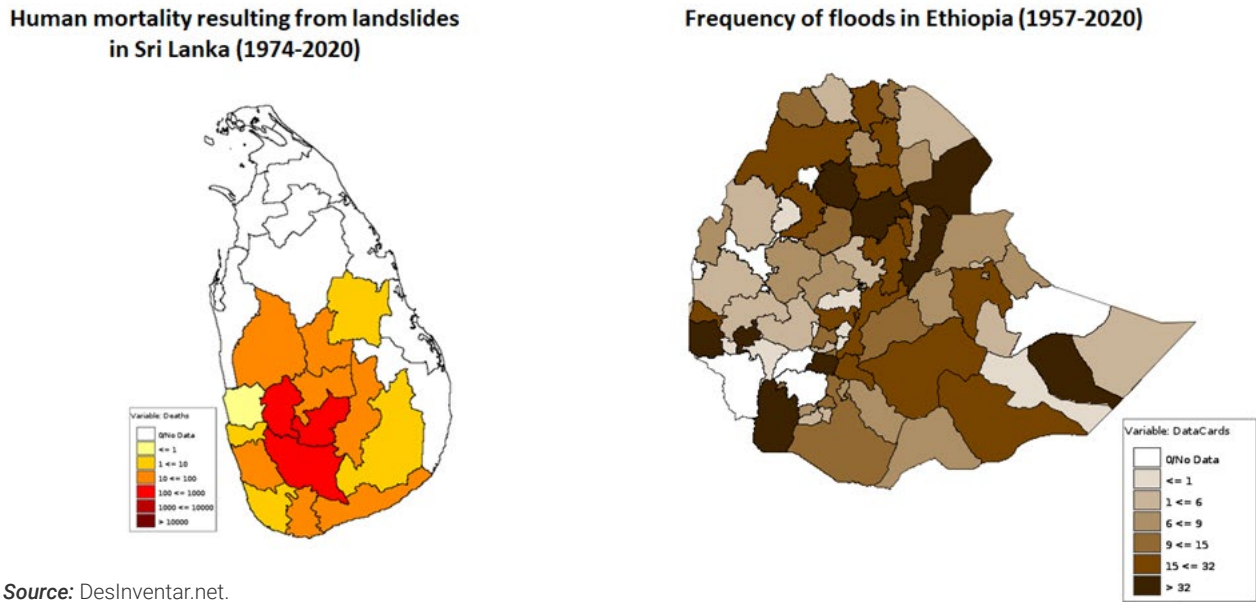
2.2 EW4All Pillar 1: Disaster risk knowledge and management

Disaster risk knowledge represents the first foundational pillar of effective MHEWS. It informs many of the actions and activities within the other pillars, from guiding which hazards need to be monitored through to planning public awareness campaigns about hazards and responses to mitigate negative impacts (see table 3).

Despite the importance of risk knowledge for MHEWS, the 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 represents the lowest of all Target G indicators (figure 2.6). There are significant gaps worldwide, and regionally, reporting on this pillar is especially low in the Arab States at just 9 per cent (figure 2.8). Indeed, less than half of the countries reporting on this pillar[27] have access to appropriate disaster risk information and even fewer have national legislation and regulatory frameworks for emergency response.[28] Although the Asia and Pacific region has the highest levels of reporting on this pillar – at 38 per cent, far exceeding the global average of 22 per cent – the scores are especially low in the south-east and south-south-west regions of Asia and among the LDCs, SIDS and LLDCs in this part of the world, suggesting that more needs to be done to translate risk analysis to national and subnational levels (United Nations Economic and Social Commission for Asia and the Pacific [ESCAP], 2023a).

There is, hence, an urgent need to improve risk knowledge in every part of the world but especially in the Arab States and in the LDCs. While inherently place-based, there are lots of good practice methodologies that guide countries as to how to create, manage and apply risk knowledge as well as advances in technology to aid the collection and analysis of this vital information.

Figure 2.11 Examples of countries maintaining and using the tracking system for losses and damages. The disaster management offices of countries collect data on impact of at all scales and for all hazards, which is helpful to understand risk at localized scales



Source: DesInventar.net.

27 Only 22 per cent of countries have reported on G5. See figure 2.6 on the proportion of countries reporting by MHEWS element pillar.

28 See www.undrr.org/early-warnings-for-all.

Spotlight: Tracking of hazardous events and losses and damages

UNDRR, WMO and the United Nations Development Programme (UNDP) are collaborating to develop a new tracking system for hazardous event and disaster losses and damages. The new system builds on the existing DesInventar,[29] developed in 1994 and currently being used by 110 countries. While preserving the data from these countries, the new tracking system will be more comprehensive and interoperable, covering hazardous events, as well as disaggregated losses and damages at localized scales.[30] Examples of countries using the existing tracking system for losses and damages can be seen in figure 2.11.

Besides tracking and recording impacts of events, the new system will build on the WMO-approved Cataloguing Hazardous Events methodology to better understand hazard-impact linkage and cascading events. The new system will be based on a stronger collaboration between and among key national agencies mandated to record hazards and their impacts such as National Disaster Management Offices (NDMOs), National Meteorological and Hydrological Services (NMHS) and other technical agencies, resulting in higher disaggregation by geography, hazards and socioeconomic variables.

The tracking system will help tailor EWS at the local level and assess its effectiveness over time through the reduction in disaster impacts. Further investments are also being made in better understanding different dimensions of losses and damages, including slow-onset events.[31]

Similarly, the International Organization for Migration and the Internal Displacement Monitoring Centre are advancing on the piloting of disaster displacement indicators linked to the Sendai Framework to build government capacity to collect, report on and analyse disaster impacts.[32] These efforts will support improved recording of disaster losses associated with displacement in the new tracking system. Efforts are also ongoing to enhance impact assessment methodologies for slow-onset events.[33]

29 See https://desinventar.net/.

30 See www.undrr.org/disaster-losses-and-damages-tracking-system.

31 UNDRR, "Workshop on assessing the impact of slow-onset events", 25 September 2023. Available at www.undrr.org/quick/80567.

32 International Organization of Migration, "Developing indicators on displacement for disaster risk reduction", undated. Available at https://environmentalmigration.iom.int/developing-indicators-displacement-disaster-risk-reduction

33 UNDRR, "Workshop on assessing the impact of slow-onset events".

Image Source: Shutterstock, joshimerbin

CASE STUDY:

PhilAWARE – Using a risk intelligence platform to minimize the impacts of disasters

The PhilAWARE system[34] is based on the DisasterAWARE platform (see 4.3.4.3), a multi-hazard early warning, hazard monitoring and risk intelligence platform[35] developed by the Pacific Disaster Center (PDC) to support disaster risk reduction and good practices throughout all phases of disaster risk management in the Philippines. The platform is designed to enhance hazard monitoring and early warning and enables information sharing between disaster managers and decision makers.[36] The system was handed over to the Philippines Office of Civil Defense (OCD) at the end of 2021 and has been put to the test several times so far.

On 10 April 2022, Tropical Storm Agaton (known internationally as Megi) made landfall, leading to flash floods in low-lying areas and rain-induced landslides. Hundreds of Philippines residents were forced to evacuate as major landslides pushed mud over villages in Leyte Province, burying more than 200 houses. Initial reports suggested that there had been 212 deaths, 132 missing and 8 injured. Despite these losses, it was reported that the outcomes of the storm could have been much worse were it not for the

34 See https://philaware.ndrrmc.gov.ph/philaware/.

35 See www.pdc.org/disasteraware/.

36 Philippines, Department of National Defense, "NDRRMC to institutionalize PhilAWARE Project in PH", 13 December 2021. Available at https://pia.gov.ph/news/2021/12/13/ndrrmc-to-institutionalize-philaware-project-in-ph.

fast and effective response of OCD, supported by the PhilAWARE system:[37]

- The OCD Operations Center used PhilAWARE to track the storm and plot the landslide-affected areas using the system's drawing tools.
- OCD leveraged the critical lifeline data collected by project partner Humanitarian OpenStreetMap for more localized response mapping.
- The PhilAWARE system supported the coordination of OCD's response, allowing stakeholders to share important hazard information in near real time, and receive hazard update notifications via the system's SmartAlert service.

The effectiveness of the PhilAWARE system was again tested in late October 2022 when Typhoon Nalgae (locally named Paeng), swept the nation. Although stronger storms had affected the Philippines during 2022, the extreme rainfall unleashed by Nalgae spurred landslides and flooding, making it among the season's deadliest and most destructive storms to hit the island nation.[38] The storm and the secondary hazards that arose from it (extreme flooding and landslides) were reported to have claimed the lives of more than 100 people and displaced nearly 200,000. Despite substantial losses, again, the impacts would have been more severe if disaster managers and decision makers had not been able to anticipate and prepare for the impacts of the typhoon.[39]

CASE STUDY:

Association for Water and Rural Development (AWARD)

In the Inkomati River Basin in South Africa, communities face health risks that are unknown to them, especially from water quality contaminants such as E. coli and arsenic, which are likely to worsen under climate change. However, vulnerable communities using this water for drinking and farming have little understanding of these risks to their health and livelihoods (Munich Re and UNDRR, 2023).

Information about these contaminants has been incorporated into a prototype decision support system (the INWARDS-DSS) as a Water-Quality Health Module which is being tested by the Inkomati-Usuthu Catchment Management Agency. The project seeks to build on this work by co-developing and testing a community risk framework through field-based engagements at key sites, exploring appropriate ways to share information on potential risks and to co-develop suitable early warning mechanisms that work for the communities. This work will be shared with water resources, disaster managers and other stakeholders and it will be incorporated into an inclusive MHEWS that is viable both for communities and managers alike (Munich Re and UNDRR, 2023). Crucially, the MHEWS is developed 'with' rather than 'for' the community and ensures that the community

37 PDC, "New early warning system aids rapid response to life-threatening landslides in Philippines", 12 May 2022. Available at www.pdc.org/new-early-warning-system-aids-rapid-response-to-life-threatening-landslides-in-philippines/.

38 NASA Earth Observatory, "Tropical Storm Nalgae Batters the Philippines", 1 November 2022. Available at https://earthobservatory.nasa.gov/images/150549/tropical-storm-nalgae-batters-the-philippines.

39 PDC, "U.S. funds major expansion of Philippines' multi-hazard risk and early warning system days ahead of Typhoon Nalgae's destruction", 4 November 2022. Available at www.pdc.org/u-s-funds-major-expansion-of-philaware/.

has a place at the table to participate fully, alongside other stakeholders, to discuss risks relating water security and safety.[40]

Ultimately, the project seeks to contribute to greater resilience, collaborative capacity and agency to expose, plan for and respond to growing climate-related risks of water insecurity for vulnerable communities through enhanced disaster preparedness, enabled by the collection, sharing and communication of risk knowledge (Munich Re and UNDRR, 2023).

The project was the winner of the 2023 RISK Award.[41]

2.3 EW4All Pillar 2: Detection, observations, monitoring, analysis and forecasting

To forecast and warn people of an imminent, high-impact hazard, it first needs to be detected and monitored. The second element to the MHEWS value cycle is forecasting: it is essential to be able to predict the areas which will be affected and to what extent. In turn this enables disaster managers and decision makers to compare the areas expected to be affected, using disaster risk knowledge on the vulnerability and exposure of people and assets (e.g. essential services and infrastructure) to determine both the likely impacts and appropriate responses. The following section lays out the overall status of hazard monitoring and forecasting capacity globally, while a further detailed assessment of the 30 initial countries of the EW4All initiative is available in section 3.5 of this report.

In the latest available data from SFM, just one third (34 per cent) of Member States reported having multi-hazard monitoring and forecasting systems (Indicator G2). These countries had an average score of 0.75 for this indicator, equivalent to "substantial progress" towards the implementation of effective MHEWS (figure 2.6).

The regional analysis of the data for observations and forecasting clearly shows that the Asia and Pacific region is the most advanced. However, more detailed examination of the data for this region reveals a large discrepancy between countries with comprehensive systems and countries with limited systems, with LDCs and LLDCs faring the worst (ESCAP, 2023a).

While the headline figures for Pillar 2 are relatively good, there remain significant gaps both in terms of monitoring and forecasting. This is perhaps most clearly visible from the latest information relating to the availability of surface and upper air meteorological observations. These data are an essential input to the computer models predicting the future state of the atmosphere, which the NMHS rely on to forecast the location, intensity and likelihood of high-impact weather, including heavy rains, strong winds and heatwaves as well as storms, tropical cyclones and related impacts. The minimum number of meteorological observations required to drive these

40 Munich Re, "2023 RISK Award Online Ceremony 'Climate resilience and early warning'", 12 July 2023. Available at www.munichre-foundation.org/en/climate-adaptation/risk-award/news/2023riskaward_ceremony.html.

41 UNDRR, 2023 RISK Award goes to an early warning system project in Africa, 12 July 2023. Available at www.undrr.org/news/2023-risk-award-goes-early-warning-system-project-africa.

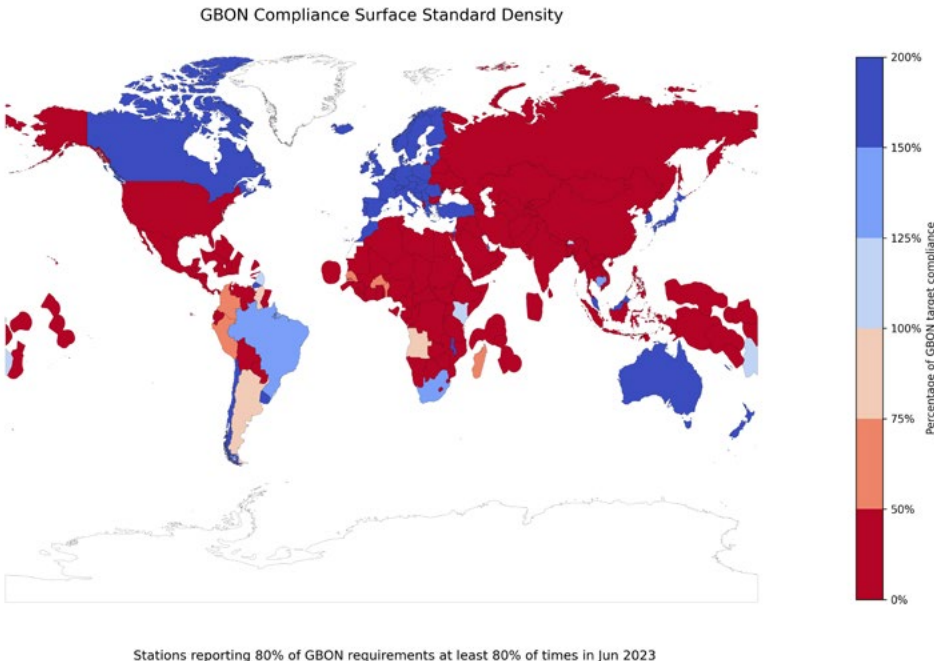
models is defined by the Global Basic Observations Network (GBON and WMO, 2020).

The global status of GBON compliance is depicted in figure 2.12, which clearly shows significant gaps across much of the African continent and parts of the Pacific and in the west of Latin America.

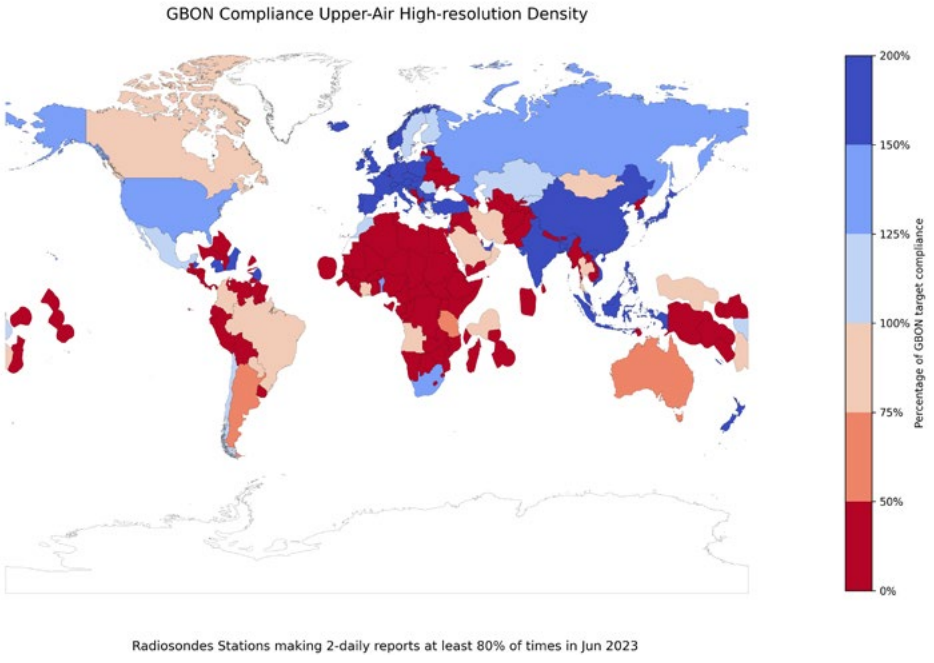
Beyond the detection and monitoring of hazards with observations, and the use of computer modelling to predict how they will develop and where they will go, the continual evolution and improvement of forecasting approaches forms another crucial part of Pillar 2. In the context of MHEWS, impact-based forecasting (IBF) represents a paradigm shift in forecasting, where forecasters also draw upon risk knowledge in order to predict not just 'what the weather will be' but 'what the weather will do'. Indeed, increasingly, the concepts of IBF and MHEWS are fully integrated, as seen in the *WMO Guidelines for Multi-hazard Impact-based Forecast and Warning Services* (WMO, 2015; WMO, 2021b) (see Spotlight: Impact-based early warnings).

Figure 2.12 a–b Global maps showing the latest status of compliance with the Global Basic Observations Network for surface (a) and upper air (b) observations. Areas in dark red are far from meeting the GBON requirements.

a)



b)



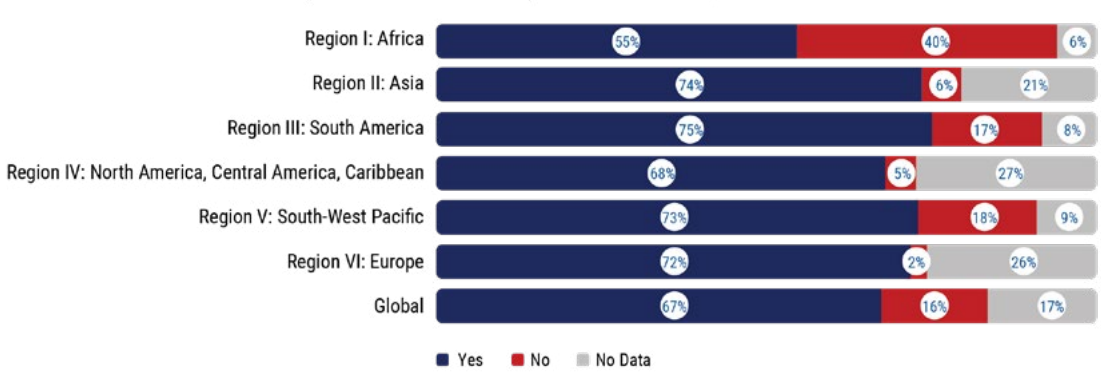
Source: SFM

Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

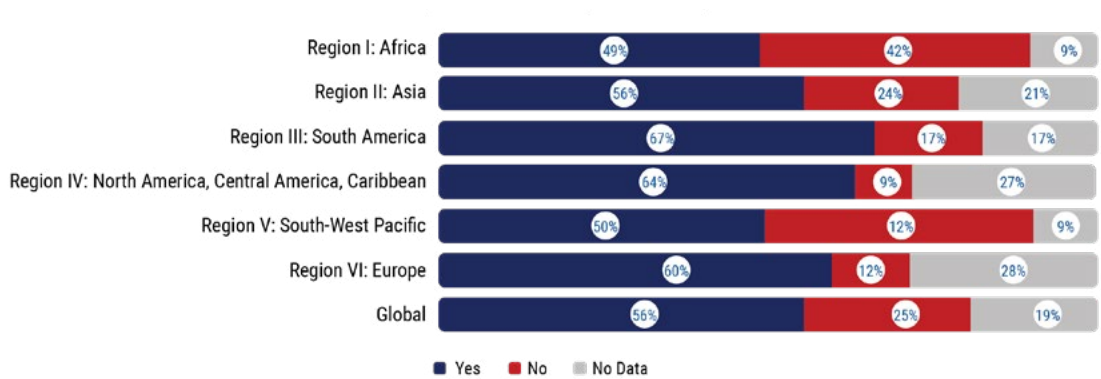
Globally, **67 per cent of WMO Members report having fully operational warning and alerting services and 56 per cent of members incorporate hazard, exposure and vulnerability information in their warning products.** However, MHEWS that can provide warnings for interrelated and cascading events are essential for an effective warning system. The latest data from WMO reveals that only 31 per cent of WMO Members have the necessary monitoring and forecasting systems for multiple hazards occurring simultaneously or cumulatively over time. Nonetheless, the foundations are being laid for MHEWS with 38 per cent of members reporting having a law, decree or similar mechanism in place for MHEWS and 78 per cent have standard operating procedures (SOPs) in place with registered authorities and stakeholders (figure 2.13 a–e).

Figure 2.13 a–e Source WMO Monitoring System (self-reported), September 2023.

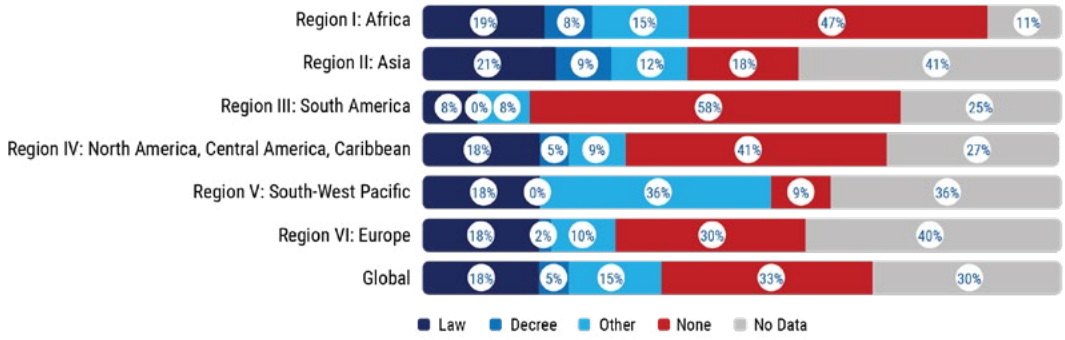
a. Availability of 24/7 year-round operation for warning and alert services standard



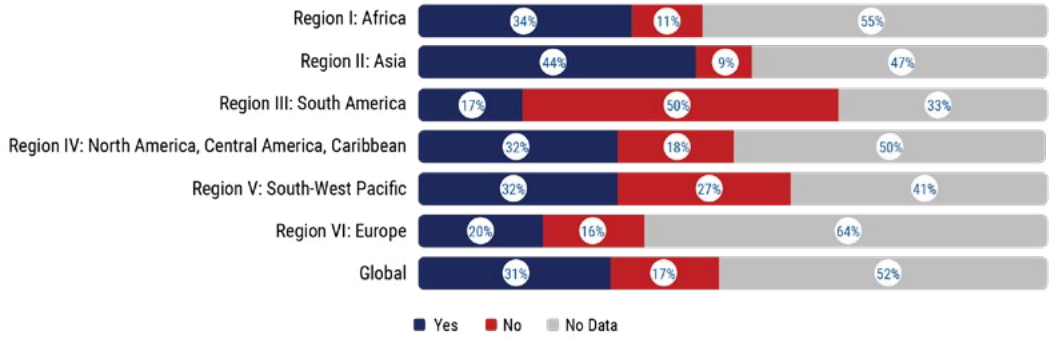
b. Incorporation of hazard, exposure and vulnerability information as input for the development of warning products by NMHS



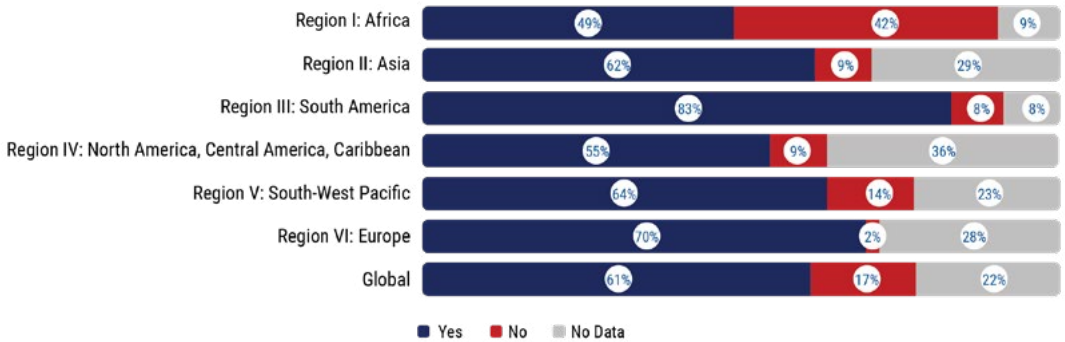
c. MHEWS regulating act



d. Existence of monitoring and forecasting systems for simultaneous or cumulative occurrence of multiple hazards – capability of MHEWS to provide warnings for possible cascading impacts



e. SOPs in place with registered authorities and stakeholders



Spotlight: Impact-based early warnings

Impact-based early warnings are based on the output of IBF. IBF sees a move away from the traditional approach of forecasting the hazards in terms of thresholds (e.g. the amount of rain falling in millimetres or the strength of wind in knots or kilometres an hour) to predicting what the impact of the hazard will be by taking account of additional information relating to the vulnerability and exposure of people, livelihoods and assets, noting that these vary in space and time. The impact also changes dynamically, especially in the context of compounding events, such as heavy rain after a long period of drought where the water will not be absorbed readily, increasing surface run-off, which could cause flash flooding; or when multiple tropical cyclones make landfall in the same location, as experienced in Mozambique in 2022 [see Case study: Deep-dive into Cyclone Freddy, 2023].

Ultimately, collaboration brings together the different types of skills, knowledge and material resources needed to collect, analyse and manage the required data, develop and interpret relevant forecast information and link these forecasts to effective early actions.[42]

A series of steps towards the implementation of IBF and IBF warning services (IBFWS) are outlined in the Words into Action (WiA) guide to MHEWS (UNDRR, 2023a): develop a risk matrix; identify events and hazards; assess vulnerabilities related to the identified hazards; develop impact tables; and implement advisory tables.

The risk matrix (figure 2.14) is a key element of IBF/IBFWS and links directly to the communication of warnings (Pillar 4). It combines an assessment of the likelihood (or probability) of an event with its impact. This enables the possibility of a high-impact event to be communicated, and advance preparations to be made, even when there remains uncertainty as to whether it will happen. Such actions may include low- or no-regret actions, which either cost little to implement (e.g. clearing blocked drains ahead of a forecast of heavy rain) or have other benefits (e.g. fixing holes in roofs), even if the rain does not arrive. Typically, the cells within the matrix are coloured and associated with different levels of awareness or action. A traffic light colour coding system has been widely adopted, especially in platforms that aggregate warnings from multiple countries (e.g. MeteoAlarm – see 4.3.5.1). However, there are some variations between countries linked to historic or cultural preferences[43] and to take account of diverse user needs.

It is important to note that thresholds still have a role to play in the IBF process, but they may not be communicated explicitly, unless specifically requested. Indeed, identifying hazard thresholds beyond which impacts are possible or the level of impact, is unacceptable, is a key piece of information that arises through the risk assessment process (under Pillar 1) (Red Cross Climate Centre *et al.*, 2020).

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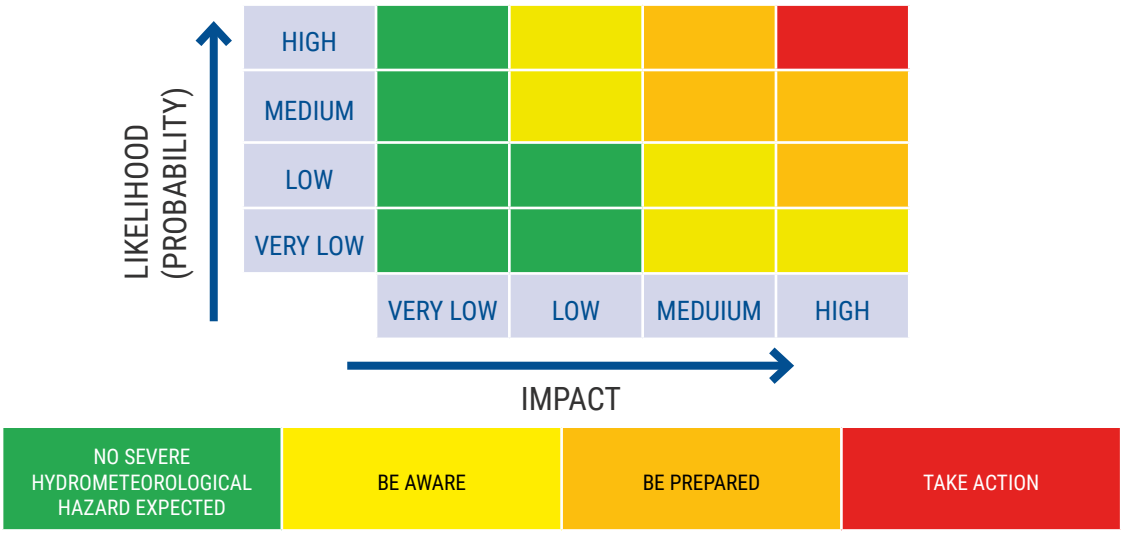
42 Anticipation Hub, "Impact-based forecasting: moving from what weather will be to what it will do for more effective disaster risk management", 3 August 2022. Available at www.anticipation-hub.org/news/impact-based-forecasting-moving-from-what-weather-will-be-to-what-it-will-do-for-more-effective-disaster-risk-management.

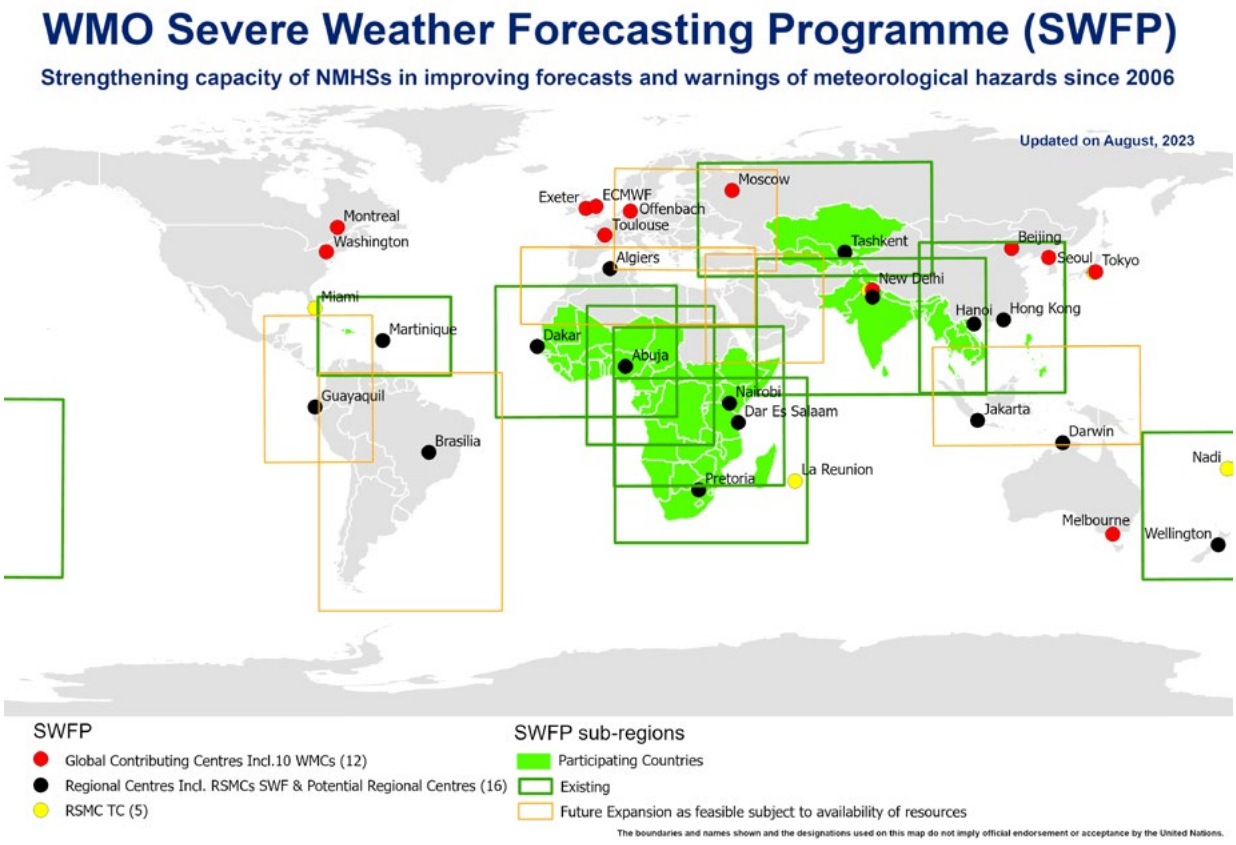
43 For examples of variations in colours used for warnings, see UNDRR (2023a).

Figure 2.14 Typical risk matrix



Source: After WMO, 2015.

Figure 2.15 Severe Weather Forecasting Programme implementation



Source: WMO, updated August 2023.

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Spotlight: Severe Weather Forecasting Programme

The Severe Weather Forecasting Programme (SWFP) started as a demonstration project with the involvement of five countries in the south-eastern Africa subregion in 2006. Since its inception, the programme has been strengthening the capacity of NMHS in participating countries to deliver improved forecasts and early warnings of severe weather[44] to save lives and livelihoods and protect property and infrastructure, with contributions from the WMO Integrated Processing and Prediction System centres and support from several development partners and donors. Through its capacity development work with NMHS, including focused work with LDCs, SIDS and LLDCs, the programme focuses on implementing IBFWS to enable effective decision-making ahead of high-impact events.

SWFP covers more than 85 developing countries in 9 subregions with contributions from WMO Integrated Processing and Prediction System centres and support from development partners and donors (figure 2.15).

Going forward, and in support of the EW4All initiative, SWFP aims to expand its geographical coverage to more countries and subregions, with the ultimate ambition of global coverage. The programme will also continue to make technical advances to improve severe weather guidance products for the NMHS in various subregions with contributions from the relevant regional centres. For example, the Regional Specialized Meteorological Centre in New Delhi has started issuing improved guidance products for squally weather in addition to heavy rainfall, strong winds, high waves and storm surge for NMHS in South Asia. Future developments will include improvements to guidance relating to existing hazards (e.g. heavy rainfall, strong winds and high waves) and may also include guidance relating to additional hazards, such as heatwaves/cold waves and forest fires/ wildfires.

44 WMO, "Severe Weather Forecasting Programme (SWFP)", undated. Available at https://community.wmo.int/en/activity-areas/severe-weather-forecasting-programme-swfp.

Image Source: Shutterstock, Sk Hasan Ali

CASE STUDY:

Cyclone Amphan and monsoon flooding in the 2020 Bangladesh floods

Bangladesh is ranked as one of the most disaster-prone countries in the world. Flooding is a recurring disaster that affects the country almost every year. The country has faced two "mega floods" in 2017 and 2019, each affecting more than 5 million people.[45]

In 2020 during the monsoon season, Bangladesh once again experienced significant flooding.[46] Prior to this, Cyclone Amphan entered Bangladesh, having already wreaked havoc over West Bengal, India. However, in both cases, it was possible to mitigate some of the impacts because of improved forecasting and through the activation of Early Action Protocols (EAPs).

In 2018, the Disaster Response Emergency Fund (DREF) approved funding for an EAP for cyclones covering 13 sea-facing coastal districts in Bangladesh (see Spotlight: The DREF Anticipatory Pillar and Early Action Protocols). On 18 May 2020, the pre-agreed trigger was met, with forecasts predicting winds of 165–175 km/hr and gusts up to 195 km/hr, exceeding the 125 km/hr threshold. The triggers were activated on 18 May 2020, 52.5 hours before Cyclone Amphan made landfall. Early actions were implemented across 10 districts, and the Bangladesh Red Crescent Society managed to reach more than 36,000 people with evacuation support, food, water and first aid services in the evacuation centres (Anticipation Hub, 2022). This was all undertaken in the context of the COVID-19 pandemic, which required plans to be adapted to meet the requirements of local restrictions, with additional costs covered by

45 OCHA. Effectiveness of Flood Early Warning System to Reduce Economic Loss at Four Communities, 31 August 2020: https://reliefweb.int/report/bangladesh/effectiveness-flood-early-warning-system-reduce-economic-loss-four-communities.

46 The monsoon season in Bangladesh typically runs from June to October.

IFRC. Despite numerous challenges, the activation of Bangladesh's EAP for cyclones unfolded smoothly, with all the early actions – and the necessary adaptations – being completed in advance of Cyclone Amphan's landfall (Anticipation Hub, 2022).

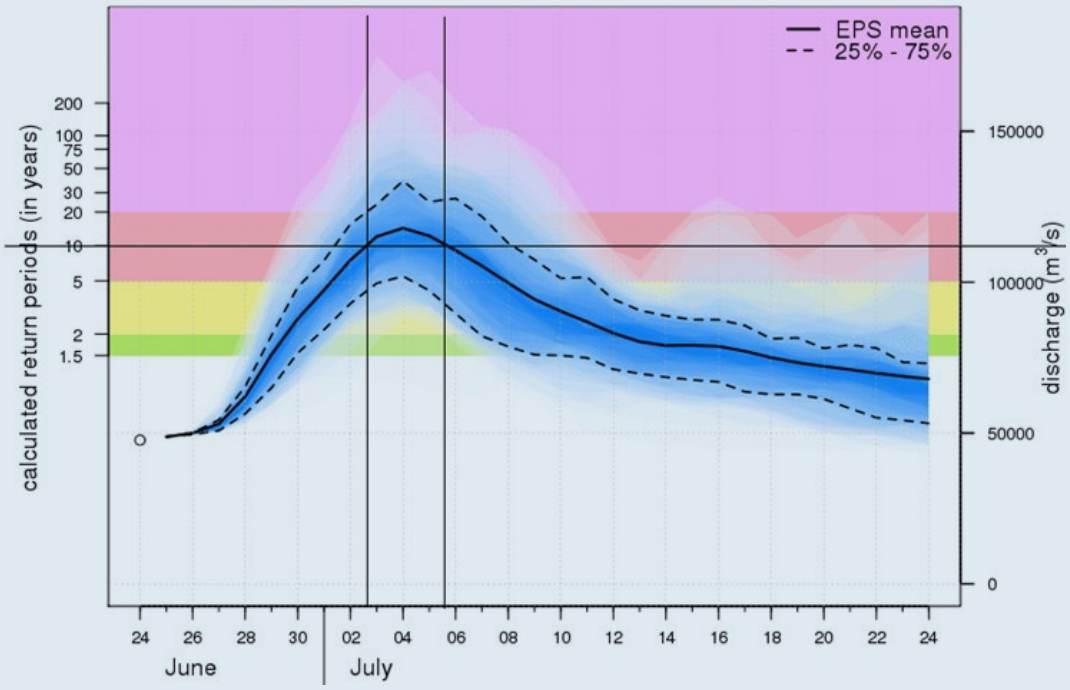
Just six weeks later, effective flood forecasting of the monsoon floods enabled early action to be taken once again.

On 25 June 2020, the Global Flood Awareness System issued a forecast predicting a more than 50 per cent probability of a severe 1-in-10 year flood event (see figure 2.16). Based on this first trigger, Bangladesh Red Crescent Society volunteers and staff were sent to the three districts most at risk (Gaibandha, Jamalpur and Kurigram) to register the families most in need and prepare for early actions. Three days later, on 28 June, the Bangladesh Flood Forecast and Warning Centre's five-day forecast confirmed there would be a severe flood. These forecasts triggered the release of more than 230,000 Swiss francs from DREF and initiated the implementation of anticipatory action.[47]

In addition, a 15-day flood forecast system successfully detected the floods 14 days ahead. The forecast, which was provided by the Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES, see 4.3.4.1), gave local communities more than five days to take early action to protect themselves and their resources.

A post-monsoon assessment carried out in the flood affected areas revealed that more than 97 per cent of the beneficiaries of its practice received forecast-based advisories, flood forecasts and warnings through its system. Examples of action taken include people moving their cattle to a safer area or stopping planting certain kinds of seeds before the flooding (ESCAP, 2023b).

Figure 2.16 10-day Global Flood Awareness System Forecast showing flooding threshold being met seven days ahead



Source: IFRC/German Red Cross.

47 IFRC and German Red Cross, "Protecting families in Bangladesh against floods: Early Action Protocol activated", 2 July 2020. Available at www.forecast-based-financing.org/2020/07/02/protecting-families-in-bangladesh-against-floods-early-action-protocol-activated/.

2.4 EW4All Pillar 3: Warning dissemination and communication

If warnings are not communicated effectively or do not reach communities at risk, people cannot act, regardless of how accurate the forecast is. Sadly, this was one of the lessons learned from the catastrophic flooding in Europe in July 2021. Forecasts on 9–10 July for the Rhine catchment, which covers Germany and Switzerland, had shown a high probability of flooding within a few days. Subsequent forecasts also showed the Meuse in Belgium would be affected. The forecasts in the following days reaffirmed that there was little doubt that a major flood was imminent. In some areas, warnings were issued through official channels and authorities took action (to evacuate people, erect temporary flood defences and move vehicles to higher ground) but this did not happen everywhere.[48] Data from an online survey in flood affected areas in Germany (n = 1,315) revealed that more than 29 per cent of the respondents did not receive any warning and that 85 per cent of those warned did not expect very severe flooding, while 46 per cent did not know what to do (Thieken *et al.*, 2022 – as cited in UNU-MERIT, 2023). Similarly, a recent study analysing some of the deadliest and costliest hydrometeorological disasters reported that a "breakdown in communicating weather information to the public" was a major problem in most of the big disasters of the twenty-first century (Coughlan de Perez *et al.*, 2022).

Notwithstanding these challenges, progress is being reported in warning dissemination and communication. The Sendai Framework Indicator G3 measures the number of people per 100,000 covered by early warning information through local governments or through national dissemination mechanisms. For this indicator, **46 per cent of Member States have reported having warning dissemination and communication systems with an average score of 0.77, indicating "substantial progress" towards the implementation of effective MHEWS** (figure 2.6).

Not all regions are at the same level when it comes to warning dissemination and communication. For example, the Asia and Pacific region is the most advanced. However, even here, a more detailed examination of the data reveals gaps in dissemination capacities, especially in the LDCs and Pacific SIDS, reported as resulting from the limitations of the communication networks in those locations (ESCAP, 2023a).

This said, in relation to warning communication and dissemination, there are significant opportunities to leverage advances and innovations in technology, especially in terms of mobile networks and Internet connectivity.

Latest figures reported by the International Telecommunication Union (ITU) reveal that an estimated 5.3 billion people of the Earth's 8 billion used the Internet in 2022, that is approximately two thirds of the world's population (ITU, 2023).

Ninety-five per cent of the world's population has access to a mobile broadband network and between 2015 and 2022, 4G network coverage doubled to reach 88 per cent of the world's population (ITU, 2023) (see figure 2.17). In addition, data show that, on average, in every region and every income group except the upper-middle-income group, the percentage of individuals owning a cell phone is higher than the percentage of Internet users, with nearly three quarters of the population aged 10 and over owning a cell phone in 2022 (ITU, 2023). However, lack of affordability continues to be a key barrier to Internet access, particularly in low-income economies (ITU, 2023).

In addition to the improvements in mobile connectivity, ongoing investment in undersea cables is bringing improved Internet coverage to many parts of the world, including the African continent. Among the 54 African countries,[49] there are 38 countries that have a seashore and 16 that are landlocked. Out of the 38 countries that have a coastline, 37 countries have at least one submarine cable landing.[50]

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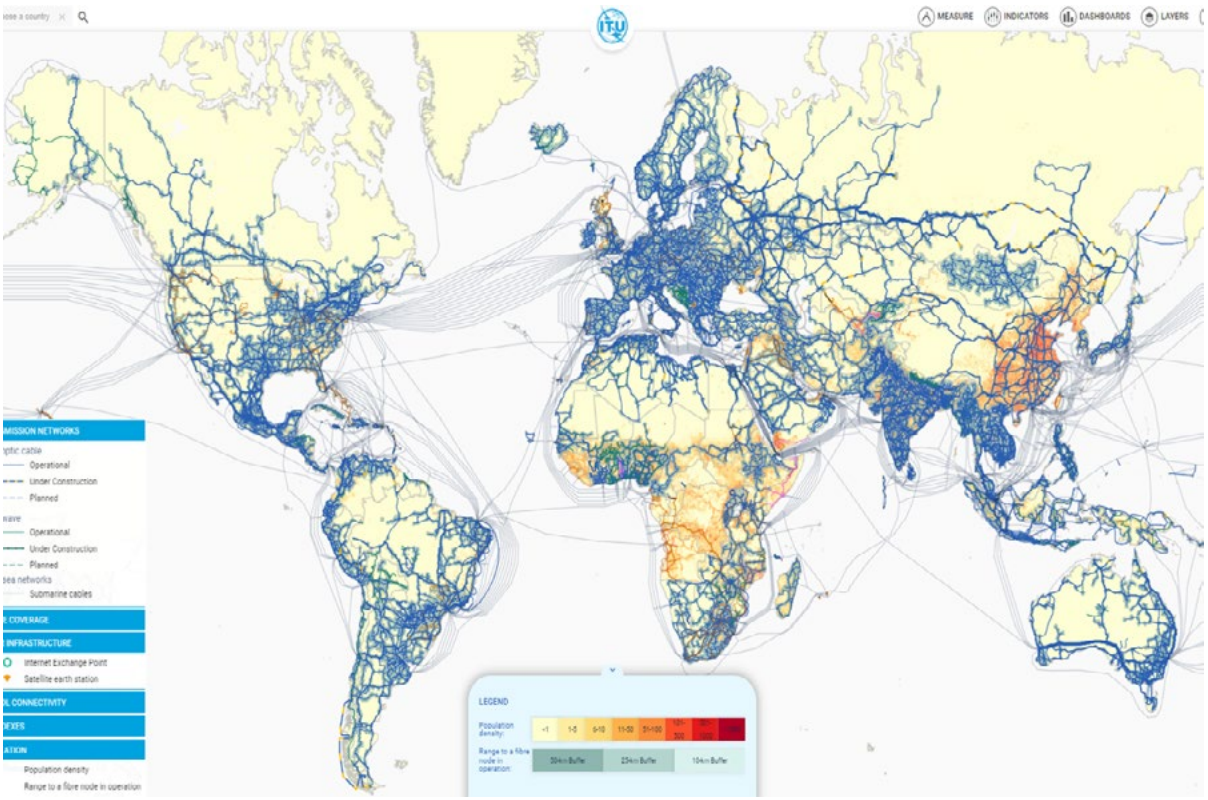
48 Hannah Cloke, "Europe's catastrophic flooding was forecast well in advance – what went so wrong?", The Conversation, 21 July 2021. Available at https://theconversation.com/europes-catastrophic-flooding-was-forecast-well-in-advance-what-went-so-wrong-164818.

49 Note that the figure "54" relates to countries on the African continent, rather than those reporting under the Africa region within SFM – in SFM, some African countries report under the region of Arab States.

50 See www.submarinenetworks.com/en/africa.

Figure 2.17 Global networks and mobile coverage



Source: ITU (2023).

Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

In addition to improvements in communications networks, there have been innovations in technologies, regulation and standards, for example:

- **Technology:** Cell broadcast or location-based SMS (short message service) warnings can be targeted to reach only people located in an at-risk area. These are proven technologies already in use in several countries, and their alerts are adaptable to specific requirements, such as a user's language.[51] (See Spotlight: Mobile EWS.)
- **Regulation:** As of June 2022, article 110 of the European Electronic Communications Code requires countries in the European Union to operate a public warning system that can send geographically targeted emergency calls to all cell phone users in the affected area during a natural or man-made disaster (ESCAP, 2023b).
- **Standards:** The Common Alerting Protocol (CAP) is a standard format for all-hazard emergency alerting across all channels (See Spotlight: Common Alerting Protocol).

Digital technologies are not just crucial for the dissemination of warnings to at-risk communities; robust communication systems are essential to MHEWS as a whole. These technologies play a critical role in disaster risk management – they are key for environmental monitoring and analysis, delivering early warnings and ensuring the timely flow of vital information in the aftermath of disasters.[52] Crucially, these communication systems must themselves be robust so that communications do not fail when they are needed the most.

51 ITU, "Early warning systems: Saving lives through mobile connection", 17 January 2023. Available at www.itu.int/hub/2023/01/early-warning-systems-mobile-connectivity/.

52 Ibid.

In addition to technology-driven communication, there are also no-tech and low-tech solutions. Examples of no-tech solutions include posters, murals, town criers and runners; low-tech communication solutions include flags, whistles and megaphones. These additional channels play an important part in reinforcing messages carried through other mediums and are especially important in less affluent areas where access to technology is limited yet communities are often exposed to the greatest risk. No-tech and low-tech solutions are also robust as they can function even if power and communication lines are down. They also play an important role in communities where literacy rates are low or multiple languages are spoken.

Spotlight: Common Alerting Protocol

A key enabler of MHEWS, CAP ensures the timely flow of consistent multichannel information from authoritative sources to the public.

CAP, an ITU recommendation, is a simple but general format[53] for exchanging all-hazard emergency alerts and public warnings over all kinds of ICT networks (figure 2.18), allowing a consistent warning message to be disseminated simultaneously over many different warning systems, thus increasing warning effectiveness while simplifying the warning task.[54]

CAP enables authorities to deliver early warnings and alerts to all people and communities at risk, and up to global scale through the use of different technologies such as mobile and landline telephones, social media, messaging services, smartphone applications, online advertising, 'Internet of things' devices (in-home smart speakers, etc.), sirens (in building or outdoor), broadcast radio and television, cable television, emergency radio, amateur radio, satellite direct broadcast, and digital signage networks (highway signs, billboards, automobile and rail traffic control), among others.[55]

In April 2021, a Call to Action on Emergency Alerting was launched to scale up efforts to ensure that, by 2025, all countries have the capability for effective, authoritative emergency alerting that leverages CAP. Latest figures show that 91 per cent of the world's population now lives in a country that is implementing CAP.[56] This is further being advanced through the Community Interest Corporation Alert-Hub.Org,[57] which offers free and open-source software tools enabling their emergency alert systems to leverage CAP.

53 CAP uses a simple digital data format (in computing Extensible Markup Language [XML]) that can be processed by software worldwide.

54 ITU, "Common Alerting Protocol and Call to Action", undated. Available at www.itu.int/en/ITU-D/Emergency-Telecommunications/Pages/Common-Alerting-Protocol-and-Call-to-Action.aspx.

55 Ibid.

56 See www.undrr.org/node/79145.

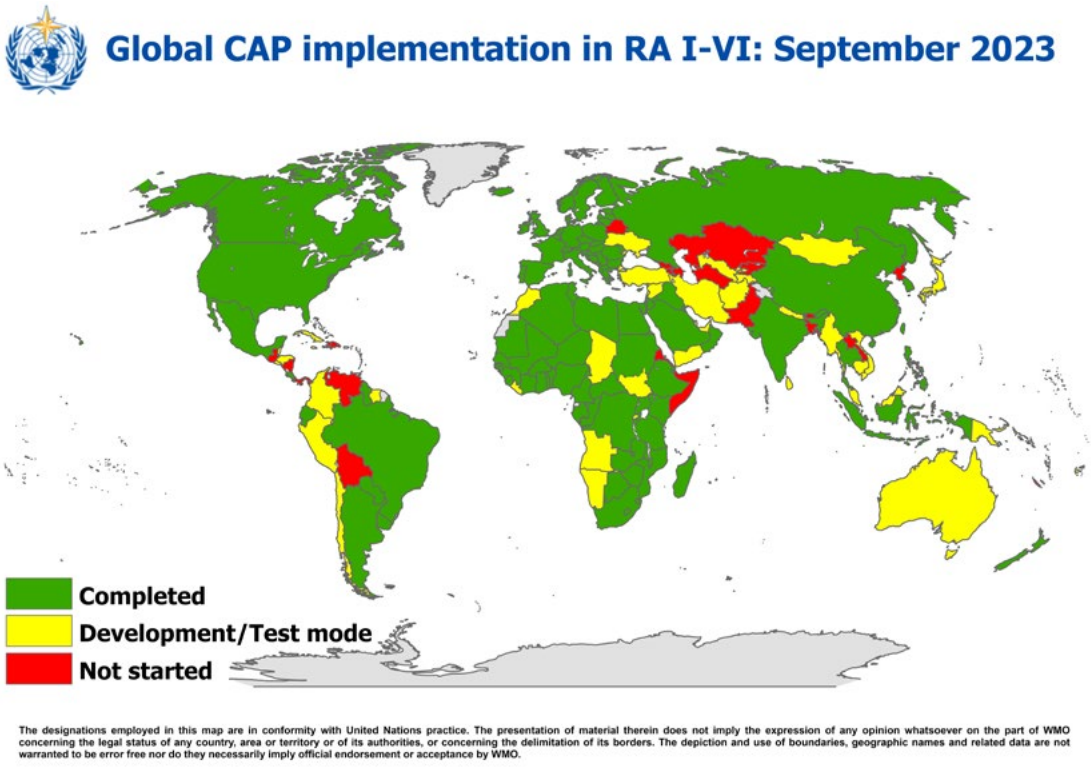
57 See www.alert-hub.org/home.html.

Figure 2.18 Graphic of the Common Alerting Protocol's role in enabling effective MHEWS

Source: ITU (see www.itu.int/en/ITU-D/Emergency-Telecommunications/Pages/Common-Alerting-Protocol-and-Call-to-Action.aspx).

Since 2006, WMO has recognized CAP as the key standard for all-hazards, all-media public warning and alerting from authoritative sources. In support of CAP implementation, WMO has issued guidelines relating to CAP (WMO, 2013) and has made freely available a set of self-paced, online training courses from its Moodle Site.[59] The latest figures from WMO reveal that more than three quarters of all Member States have either completed CAP implementation or are in the development/ test mode.[60]

Figure 2.19 Global status of CAP implementation



Source: WMO (2023).

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58 WMO Education and Training Programme: https://etrp.wmo.int/course/index.php?categoryid=54

59 Based on WMO data from July 2023, out of a total 193 Member States, 111 (57 per cent) have completed CAP implementation, 51 (26 per cent) are operating in development/test mode, with only 31 (16 per cent) yet to start.

Spotlight: Mobile EWS

The incredible growth of mobile networks has brought unprecedented opportunities and the implementation of mobile EWS will be critical in advancing the initiative's ambitious goal.

The action plan for the EW4All initiative calls for the promotion and implementation of geo-located mobile-based early warning services using cell broadcast and/or location-based SMS, as a critical element for warning dissemination and communication. These technologies are proven technologies already used in several countries, and their alerts are adaptable to specific requirements, such as a user's language.

Cell broadcast technology is a "point to N" technology: it needs only one single order to trigger the broadcasting of a specific message. The message is displayed on all mobile phones located in at-risk areas that are attached to the cells, without risk of network congestion and with a near real-time speed. Cell broadcasts allow very high precision in geographic dissemination, while being a "blind technology", meaning that it is only one way, so it provides no personal information on the user and therefore does not face any data privacy issues.

A location-based SMS is simply an SMS that is sent to a subset of all mobile devices operating under the mobile operator's network and in a particular geographical area. Since it uses standard SMS, it is compatible with all handsets and networks. Mobile network operators can be informed about the status of the SMS sent, which allows them to receive the confirmation of reception and to know the exact number of people that have been contacted and reached. However, location-based SMS carries the risk of network congestion since it must be delivered to each recipient's device separately.

A law adopted by the European Union in 2018 requires all member countries to set up systems to send alerts via mobile networks by 2022. This regulatory approach has proved an effective way to accelerate the uptake of public warning systems across Europe (EENA, 2019). In Europe, several countries equipped with MHEWS have successfully used the mobile network public warning system over the last few years. In July 2021 during the major floods in Belgium, France and Germany, Belgium sent around 2 million location-based SMS messages in 48 hours to inform and evacuate its citizens, as well as over 13,000 voice calls via its multichannel MHEWS called Be Alert. At the same time, 58 warning campaigns were sent by 37 different municipalities with access to BE-Alert.

Currently 54 countries in the world already have or are developing the mobile EWS based on cell broadcast and location-based SMS; very few of them are developing countries.

Image Source: UNDRR/Antoine Tardy

CASE STUDY:

UNESCO-IOC[60] Indian Ocean Tsunami Warning and Mitigation System exercises

Following the devastating Indian Ocean Tsunami of 26 December 2004, the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO) established the Indian Ocean Tsunami Warning and Mitigation System (IOTWMS). An Intergovernmental Coordination Group (ICG) was set up with working groups spanning all four MHEWS pillars and an interim alert system was quickly put in place in 2005. A comprehensive IOTWMS was subsequently developed and trialled in 2009, becoming fully operational in 2011.

Since 2009, tsunami exercises have been conducted across the entire Indian Ocean every two years to test and further develop the ability of the IOTWMS to support the delivery of early tsunami warnings to everyone. Called IOWave, the exercise simulates a tsunami warning situation, with national tsunami warning centres (NTWCs) issuing warnings. Disaster management offices at all levels, together with other relevant authorities (e.g. police, marine rescue, port authorities, airport authorities) and community organizations in each country activate and evaluate their national tsunami warning chains and SOPs.[61] One of the main objectives of the exercise is to ensure tsunami warnings reach everyone regardless of age, gender or whether they have disabilities.

60 UNESCO: United Nations Educational, Scientific and Cultural Organization; IOC: Intergovernmental Oceanographic Commission.

61 UNESCO-IOC, "ICG/IOTWMS Exercise Indian Ocean Wave 2023 (IOWave23)", 4 May 2023. Available at www.ioc-tsunami.org/index.php?option=com_oe&task=viewEventRecord&eventID=3916.

To help guide Member States' awareness and community preparedness, tsunami hazard and risk assessment guidelines have been developed and training has been provided in the use of specialized tools to develop tsunami hazard maps. In addition, a recent project funded by ESCAP has helped develop a probabilistic tsunami hazard assessment for the north-west Indian Ocean, with plans to extend it to the entire Indian Ocean.

To detect the generation and propagation of tsunamis, ICG/IOTWMS has coordinated a significant increase in the real-time collection and exchange of sea level and seismic data. The Ocean Decade Tsunami Programme is looking to further expand existing systems and implement new technologies by 2030 to enable more timely and accurate warnings. To provide tsunami threat information that enable NTWCs to issue sovereign national tsunami warnings for their communities, ICG/IOTWMS oversaw the implementation of Tsunami Service Providers (operated by Australia, India and Indonesia) to provide detailed tsunami threat information for the entire Indian Ocean.

To ensure national tsunami warnings reach all members of at-risk communities and they know what to do, ICG/IOTWMS assists Member States in a regular review of the effectiveness of their national tsunami warnings chains and the responsibilities of the relevant authorities. Regular training in the development of SOPs is provided for each authority and key stakeholder, including the public, to ensure each link in the chain is effective at transmitting the warnings. Exercises such as IOWave23 enable Member States to test and evaluate the effectiveness of their warning chains. Such activities may also make warning chains for other hazards more robust.

To help ensure at-risk communities are aware and prepared for a tsunami threat, the ICG/IOTWMS, with the support of the Indian Ocean Tsunami Information Centre, has developed community awareness materials and tools. They have also provided extensive capacity development and training for relevant national authorities and identified at-risk communities.

The UNESCO-IOC Tsunami Ready Recognition Programme has been developed to facilitate the direct engagement of at-risk communities to prepare themselves. Measured against 12 indicators spanning awareness, preparedness and readiness across the four pillars, the measures have been developed from good practices and lessons learned worldwide. It is being rolled out across the world's oceans. The programme is inclusive and actively encourages the involvement of at-risk communities, thereby meeting the goal of the Ocean Decade Tsunami Programme: by 2030, 100 per cent of at-risk communities are prepared and resilient to tsunami threats. This will also help strengthen preparedness for other hazards.

2.5 EW4All Pillar 4: Preparedness to respond

To be effective, an MHEWS needs to result in appropriate action being taken to avoid or minimize negative impacts on lives, livelihoods and assets, especially critical infrastructure. To be able to act when required, not only is it necessary to identify risk (Pillar 1), monitor and predict the potential impact of a hazard (Pillar 2) and for warning messages to be disseminated and understood (Pillar 3), but it is also essential to understand risk (Pillar 1) in order to underpin the actions required to prepare and respond to warnings (Pillar 4). Therefore, it is necessary for plans and procedures to be in place at the local, subnational and national levels, so that people know how to respond when warnings are received, especially communities, local government actors and national agencies as well as the NGOs and community-based organizations supporting them. Ideally, these plans should be co-produced and practised through exercises and drills, supported by training for key actors and access to the necessary resources (money, equipment, etc.) to act.

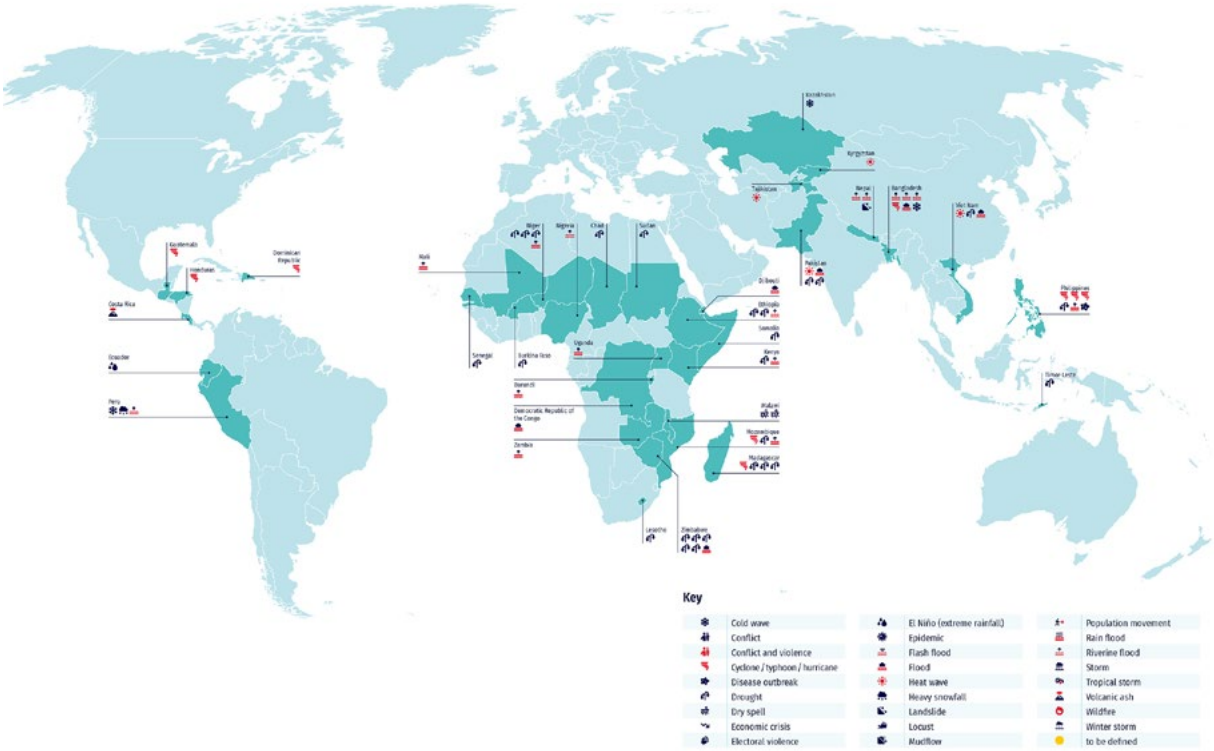
Under one third of countries globally have reported into SFM in relation to Pillar 4

Under one third of countries globally have reported into SFM in relation to Pillar 4, under Indicator G4 (percentage of local governments having a plan to act on early warnings), suggesting that more than two thirds of the world's local governments may not have these plans. Nonetheless, countries reporting the existence of such local plans report "substantial progress" towards achieving MHEWS (figure 2.6).

EAPs (Spotlight: The DREF Anticipatory Pillar and EAPs) are an example of a good practice promoted by IFRC. They enable pre-planned early actions to be triggered when a specific hazard is expected to impact communities, together with the pre-agreed funding required to implement them. In a report on anticipatory action in 2022 (Anticipation Hub, 2023), IFRC and its partners reported that across the world in 2022:

- 70 anticipatory action frameworks were in place globally, developed by IFRC, United Nations organizations and NGOs (figure 2.20)
- 7.6 million people, through these frameworks, are now better prepared to act ahead of the predictable impacts of hazards, and able to recover faster afterwards.
- The pre-agreed financing committed through these frameworks reached US$ 138 million.
- 47 anticipatory action frameworks were activated in 30 countries, reaching 3.6 million people as a minimum estimate. Funding worth US$ 53.8 million was triggered, enabling anticipatory actions by more than 56 different organizations ahead of the impacts of 15 different types of hazards. The most prevalent hazards were drought, followed by riverine flood and cyclones.

Figure 2.20 Active anticipatory action frameworks around the world



Source: Anticipation Hub (2022, figure 1.j).

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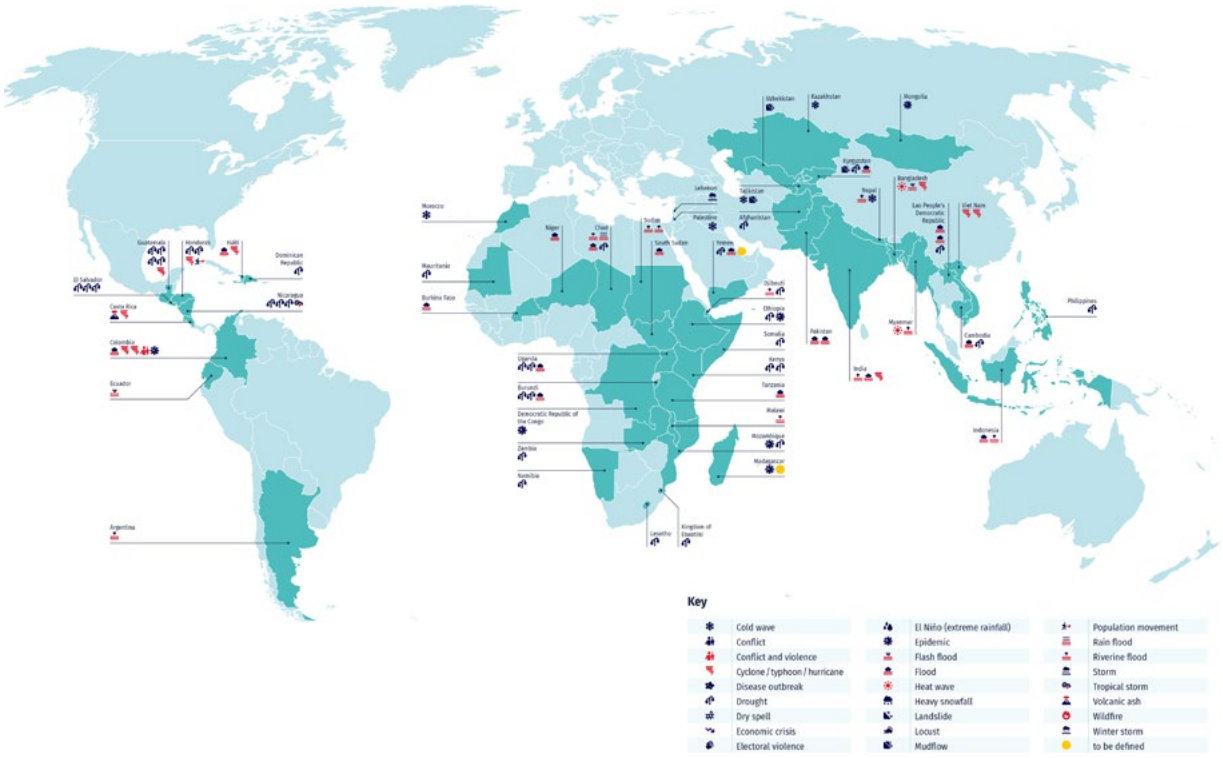
In addition to the 70 frameworks already in place, a further 97 were under development in 2022 (figure 2.21), of which 51 frameworks began this process during 2022. For 26 of the 61 countries developing anticipatory action frameworks, it is their first framework (Anticipation Hub, 2023). Although these developments are encouraging, anticipatory action is not yet being implemented at the scale required or for all the hazards that can be anticipated.

Where the risk of an impending hazard cannot be mitigated, it may become necessary to evacuate the population at greatest risk, either because of their location relating to the approaching hazard (exposure) or their vulnerability (for example, the older persons and persons with disabilities) or a combination of the two. Globally, between 2015 and 2021, 1.6 billion people have been pre-emptively evacuated.

The recent years have also seen a steady increase in the number of people pre-emptively evacuated (figure 2.22).

Figure 2.21 Anticipatory action frameworks under development in 2022



Source: Anticipation Hub (2022, figure 7).

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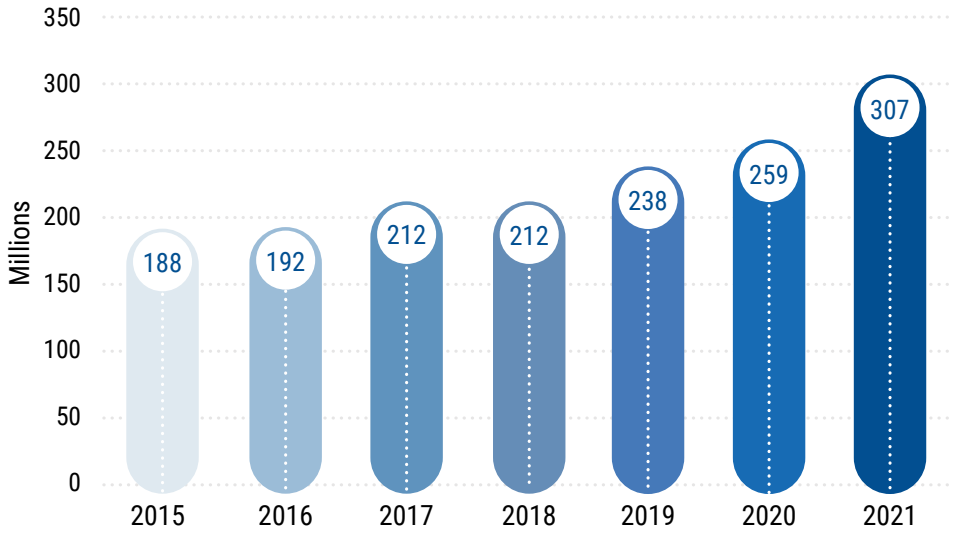
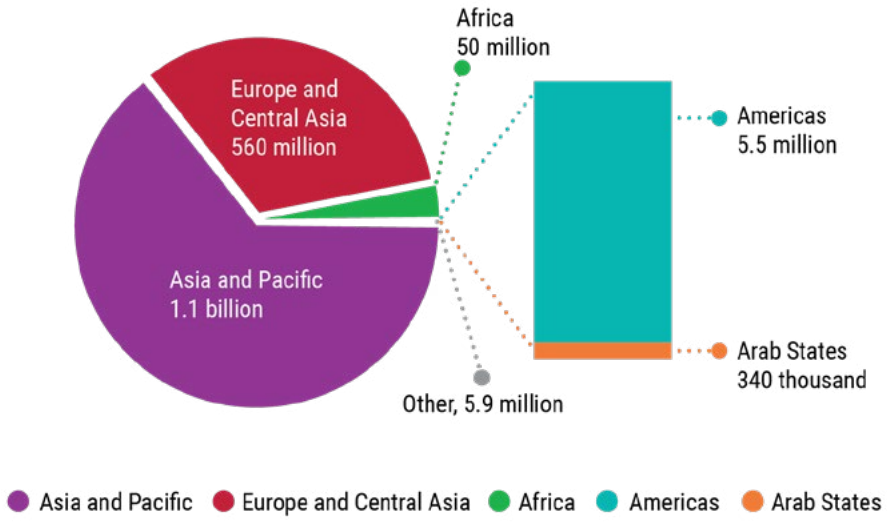
Figure 2.22 Number of people evacuated per year



Source: SFM

The pre-emptive evacuation is highly disproportional in terms of regional distribution (figure 2.23) and matches the comprehensiveness of the MHEWS captured in the data for Indicator G4 (figure 2.8): Asia and the Pacific accounted for 64 per cent of all people evacuated – a total of 1.1 billion people; Europe and Central Asia accounted for 33 per cent (560 million); and Africa for 3 per cent (50 million). Although both the Americas and the Caribbean region and the Arab States combined account for less than 1 per cent of the people evacuated, the number of people evacuated in the Americas and the Caribbean was still high at 5.5 million.

Figure 2.23 Number of people protected through evacuation, 2015–2022



Source: SFM


Image Source: UNDRR

Spotlight: The DREF Anticipatory Pillar and Early Action Protocols

DREF Anticipatory Pillar

The Anticipatory Pillar of DREF is a funding mechanism designed to provide pre-agreed financing to National Red Cross and Red Crescent Societies in advance of a hazard, enabling them to save lives and reduce – or even prevent – the damage and loss caused by disasters in vulnerable communities.

DREF builds on the forecast-based financing (FbF) approach, where money is automatically released when a pre-defined trigger is met.[62] The triggers are based on a combination of detailed risk analysis, assessment of historical impact, vulnerability data, and available forecasts for weather-related hazards or credible expert judgment for non-weather-related events. Then, based on consultation with at-risk communities and authorities, the national society implements pre-selected early action activities which will have the optimal impact within the lead time. All these aspects are captured in either formal plans called EAPs or a lighter, simplified EAP.

Early Action Protocols

Introduced in 2018, EAPs outline the early actions that will be taken when a specific hazard is forecasted to impact communities. Each EAP provides pre-approved funding for up to five years and includes the following:

- Pre-positioning of the stock needed to enable early action
- Annual readiness activities so that the national society is prepared and has the standing capacity to implement the early actions
- Pre-agreed early action activities designed to save lives and protect livelihoods once a hazard is forecast

A new funding tool, the simplified EAP, was introduced by DREF in 2022,[63] aiming to complement the full EAP. The simplified EAP has a shorter lifespan (two years), a lower maximum budget (200,000 Swiss francs) and a smaller number of target beneficiaries (2,000 people), which enables any National Red Cross and Red Crescent Society by providing the resources to act in advance of a predicted hazard.

62 IFRC, "Anticipatory Pillar of the DREF", undated. Available at www.ifrc.org/happening-now/emergencies/anticipatory-pillar-dref.

63 Anticipation Hub, "Simplified Early Action Protocols: making funding for anticipatory action more accessible", 16 August 2022. Available at www.anticipation-hub.org/news/simplified-early-action-protocols-making-funding-for-anticipatory-action-more-accessible.

Image Source: UNDRR, Mbuto Machili

CASE STUDY:

Deep-dive into Cyclone Freddy, 2023

Tropical Cyclone Freddy was an exceptionally long-lived storm that crossed the Indian Ocean, going through seven cycles of rapid intensification[64] during its lifetime of more than 35 days.

Freddy first made landfall near Mananjary, Madagascar on 21 February 2023, crossing the country from east to west. It then restrengthened as it crossed the Mozambique Channel making a second landfall just south of Vilankulos, Mozambique three days later. Despite weakening into a tropical depression as it moved slowly over land in the following days, Freddy once again intensified as it returned over the Mozambique Channel, almost making landfall in southern Madagascar on 5 March.[65] In the following days, Freddy moved north-west, making a second landfall in Mozambique (in Zambezia Province) on 11 March[66] before ending its journey in Malawi on 15 March. However, the storm's slow pace in its final days led to 20–67 centimetres of rain falling over just two days in many areas of Mozambique and Malawi, causing widespread flooding.[67]

64 NASA Earth Observatory, "Freddy Delivers Another Blow", 19 March 2023. Available at https://earthobservatory.nasa.gov/images/151111/freddy-delivers-another-blow.

65 EUMETSAT, "Record-breaking Tropical Cyclone Freddy crosses Indian Ocean", 22 February 2023. Available at www.eumetsat.int/record-breaking-tropical-cyclone-freddy-crosses-indian-ocean.

66 United Nations Office for the Coordination of Humanitarian Affairs, Mozambique: Severe Tropical Storm Freddy - Flash Update No. 9 (as of 12 March 2023) (New York, United States, and Geneva, Switzerland, 2023). Available at https://reliefweb.int/report/mozambique/mozambique-severe-tropical-storm-freddy-flash-update-no-9-12-march-2023.

67 NASA Earth Observatory, "Freddy Delivers Another Blow".

During its lifetime, Freddy caused almost 700 fatalities; nearly 1.7 million people were affected across Madagascar, Malawi, Mauritius, Mozambique, Reunion and Zimbabwe. Some Mozambique locations saw rainfall totals of up to 670 millimetres (out of which 300–400 millimetres fell in 48 hours), which caused widespread flooding and landslides across the country.[68]

First named by the Australian Bureau of Meteorology on 6 February, Freddy was tracked west across the Indian Ocean, with satellite imagery capturing its progress and phases of development.[69] The socioeconomic impacts of Freddy were immense but "the death toll was limited by accurate forecasts and early warnings, and coordinated disaster reduction action on the ground".[70]

In Madagascar, once the first warnings were issued by weather services, the Malagasy Red Cross mobilized its network of volunteers to help vulnerable communities. Working in tandem with the authorities, teams were deployed to raise awareness among inhabitants of high-risk areas, to pre-position emergency supplies and to help manage accommodation centres. The assessments carried out in the field following Cyclone Freddy's dual impact made it possible to focus emergency response on three key priorities: emergency shelter and housing, water sanitation and hygiene, and cash transfers.[71] Some of the humanitarian supplies (e.g. housing reconstruction kits, hygiene and sanitation kits, and kitchen utensil kits) were deployed in areas forecast to be impacted before the cyclone hit, and then again once needs assessments had been conducted in the field.[72]

In Mozambique, days before Cyclone Freddy first struck Mozambique on 24 February 2023, community radios, sound trucks and authorities across the country warned residents to move to shelters on higher ground. When Cyclone Freddy made landfall, thanks to the community-based MHEWS supported by Local Disaster Risk Management and Reduction Committee members, the population was prepared and relocated to safe areas with stock of food and water.[73]

Also in Mozambique, Mozambique's National Institute for Disaster Risk Management and Reduction, with technical assistance from the World Food Programme, used drones to map risk areas, assess the impact, identify safe areas and evacuation routes, and provide a source of information to search and rescue operations.[74] This built upon existing disaster knowledge, for example escape routes and safe gathering places that were identified as a result of previous mapping activities taking place along the Buzi River basin.[75]

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68 EUMETSAT, "Record-breaking Tropical Cyclone Freddy crosses Indian Ocean".

69 Ibid.

70 United Nations News, "Tropical Cyclone Freddy on track to become record-breaking storm", 7 March 2023. Available at https://news.un.org/en/story/2023/03/1134262.

71 Indian Ocean Regional Intervention Platform of the French Red Cross, "Malagasy Red Cross's humanitarian response to Cyclone FREDDY", 13 April 2023. Available at https://piroi.croix-rouge.fr/cyclone-freddy-madagascar/?lang=en.

72 Ibid.

73 UNDRR, "Cyclone Freddy puts Mozambique's early warning system to the test", 13 June 2023. Available at www.undrr.org/feature/cyclone-freddy-puts-mozambique-s-early-warning-system-to-the-test.

74 Ibid.

75 Ibid.

In Malawi, the Government's Department of Climate Change and Meteorological Services (DCCMS) issued an official warning on 7 March 2023[76] with further warnings and impact-based forecasts in the following days. To create its forecasts and warnings, the DCCMS utilized outputs from the Flash Flood Guidance System (FFGS, see 4.2.7).

The forecasts were sent to the Malawi Red Cross Society and the public through various platforms including traditional and social media.

This triggered anticipatory action (AA) by the Malawi Red Cross Society and the Danish Red Cross. In the following days, AA was taken across the southern Region of Malawi with widespread broadcast of multi-hazard warnings relating to the cyclone and potential incidence of cholera. On 12 March, with rains intensifying, the Malawi Red Cross Society district branches started to evacuate vulnerable groups (children, elderly people, and people with disabilities) ahead of Freddy making landfall on 13 March.[77]

When examining the impacts of Freddy, notable successes were the forecasting capacity of DCCMS and their guidance in the development of appropriate triggers, the deployment of search and rescue teams, improved coordination among government and humanitarian actors, strong willingness of communities to act in response to warnings, and the pre-positioning of stock. Another success was the use of different media to disseminate warnings (local radio stations, SMS, etc.).[78] These actions resulted in a lower mortality rate and more assets saved despite the magnitude of the cyclone's impacts.[79] Challenges related to unexpected secondary impacts include flooding in non-typical areas and mudslides, the fact that AA has not been fully institutionalized across all districts and providing MHEWS cover for the hardest-to-reach areas.[80]

76 See https://twitter.com/DccmsM/status/1633010320489738241.

77 Malawi Red Cross Society and 510, Extreme events/Experiences from activating AA ahead of Tropical Cyclone Freddy in Malawi, 6th Africa Dialogue Platform on Anticipatory Humanitarian Action (Johannesburg, 4–6 July 2023). Available at https://events.anticipation-hub.org/africa-2023/.

78 Ibid.

79 Ibid.

80 Ibid.

Image Source: Shutterstock, budiharjo slamet

CASE STUDY:

Early Warning and Early Action in Timor-Leste

Timor-Leste has limited climate observation infrastructure and the human resources required to generate robust climate data and information and impact-based MHEWS covering the whole country. To address the urgent need, a UNEP-GCF early warning project is under implementation: ***Enhancing Early Warning Systems to build greater resilience to hydro-meteorological hazards in Timor-Leste***.

The project will focus on the need for integrated climate information services that cover the oceans, and proactive disaster risk management approaches founded on AA informed by IBF and end-to-end MHEWS. To do this, there are activities under each of the pillars.

There is inconsistent skill and coverage of forecasting information across the hazards affecting Timor-Leste. Investments to be made under the project include a new national forecasting centre and improved observation equipment, such as automatic weather stations, Doppler radars and ocean sensors.[81]

Local monitoring equipment, megaphones and signboards will warn residents of impending disasters while the alert will also be sounded on radio and through both text messages and social media.[82]

FbF/early warning early action approaches are being implemented by the Food and Agriculture Organization of the United Nations alongside the Red Cross Climate Centre at the national level. A five-year road map is being developed to facilitate the seamless integration of AA within Timor-Leste's current disaster risk management framework. However, funding for AA remains a challenge as there are currently limited or no funds available to allocate for any pre-emptive actions but it is hoped that, through the project, this will change as the benefits of AA become visible.

81 UNEP, "An early warning system for disasters takes shape in Timor-Leste", 11 August 2023. Available at www.unep.org/news-and-stories/story/early-warning-system-disasters-takes-shape-timor-leste.

82 UNEP. An early warning system for disasters takes shape in Timor-Leste, 11 August 2023: www.unep.org/news-and-stories/story/early-warning-system-disasters-takes-shape-timor-leste.

2.6 Risk governance as a key enabler of MHEWS

MHEWS is a multidisciplinary, multisector endeavour, and so the development of strong governance structures is foundational. It is essential that roles, responsibilities, mandates and associated governance structures are established at the local, national and regional levels.

An overarching multi-hazard and multi-actor governance framework also "enables coherence, facilitates access to resources for routine operation of the system, ensures coordination and engagement among key actors and stakeholders, and reinforces integration among the four components" (UNDRR, 2023a).

At the country level, national governments "are responsible for high-level policies and frameworks that facilitate early warning and for the technical systems that predict and issue national hazard warnings" (WMO, 2018a). They also need to provide support to local communities and the institutions supporting them (including NGOs and community-based organizations) to enable them to respond effectively. National governments also need to interact with regional and international governments and agencies to strengthen early warning capacities and ensure that warnings result in related responses.

The analysis in this chapter has shown uneven progress across different pillars of MHEWS, despite that these pillars operate as a value cycle and hence need a holistic approach to their development. Therefore, to be effective, it is important that EWS are embedded in the larger risk governance approach of a country, rather than considered only from a project lens, which tend to be implemented in silos.

Target E of the Sendai Framework aims to "Substantially increase the number of countries with national and local disaster risk reduction strategies", and hence works as a good proxy indicator of the level of risk governance in a country. **Out of the 101 countries reporting having MHEWS, 95 have also reported existence of national DRR strategies.** A moderate positive correlation is also observed between the establishment of a national DRR strategy

Image Source: UNDRR

(SFM E-1 scores[83]) and the existence of MHEWS (SFM G-1 scores).

More importantly, countries with more comprehensive DRR strategies (that is, higher scores), have higher coverage of MHEWS. For instance, for countries with a low score for DRR strategies (below 0.5), only 3 out of 101 countries reported coverage of all four pillars, however, this increased to 31 countries when it came to countries with a higher score for DRR strategies (above 0.5) (table 5). The average score of comprehensiveness of DRR strategies is 0.64 for countries reporting on only one MHEWS pillar, increasing to 0.77 for countries reporting on all four pillars.

Thus, investment in risk governance serves as a key enabler to enhance the coverage of MHEWS. As outlined in the Executive Action Plan of the EW4All initiative, a comprehensive risk management approach is important to review DRM and climate change adaptation laws, policies and/or plans to ensure they reduce climate change impacts and exposure on people and the environment.

Table 5 Comparison of scores for Target E-1 (National DRR Strategy) and MHEWS implementation

	No. of MHEWS pillars reported				
Countries that reported E-1 score of	One	Two	Three	Four	Total
Low (0 to 0.5)	6	3	4	3	16
High (0.5 to 1)	16	24	8	31	79
Zero or not reporting	3	2		1	6
					101

Source: SFM

83 Countries self-assess their national DRR strategies using identified criteria and coverage of 10 key elements. UNDRR, *Technical guidance for monitoring and reporting on progress in achieving the global targets of the Sendai Framework* (Geneva, Switzerland), pp. 112–128. Available at www.undrr.org/quick/11641.

3

THE EW4ALL INITIATIVE

Image Source: UNDRR/Antoine Tardy


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3. The EW4All initiative

The EW4All Executive Action Plan (WMO, 2022a) set out a series of activities for Year One (2023), with different activities and outcomes set for each pillar. The progress that has been made within and across the pillars is highlighted in this section.

3.1 Progress in the initiative

Following up on the Executive Action Plan, and through extensive consultations, pillar implementation plans and minimum core capabilities by pillar have been developed to guide operationalization. Significant progress has also been made in the technical implementation of the EW4All initiative at the country, regional and global levels.

Led by an Interpillar Technical Coordination Group comprising representatives from the four pillar leads, and working with other implementing partners, the roll-out of EW4All has prioritized a fast-tracked approach. This approach leverages existing progress made in each country and optimizes the comparative advantages of implementing partners and national actors through strengthened partnerships.

Key accomplishments include the development of a programmatic approach, roll-out of national workshops, conducting gap analyses to inform national MHEWS road maps and the development of global guidelines on MHEWS

Key accomplishments include the development of a programmatic approach, roll-out of national workshops, conducting gap analyses to inform national MHEWS road maps and the development of global guidelines on MHEWS implementation. An implementation toolkit[84] has also been developed and is already in use by countries (see EW4All Case study: The Maldives).

Utilizing resources from the implementation toolkit, country engagement is initiated with a national consultative workshop on EW4All, bringing together government agencies, local authorities, United Nations organizations, NGOs and the private sector. These have already taken place in more than 7 of the 30 initial countries.[85] Outcomes include:

- Current state of MHEWS – with support from EW4All, undertake a preliminary gap analysis to take stock of the current state of MHEWS and promote a shared understanding of progress in implementation.
- Link and alignment – explore linkages and alignment among ongoing and upcoming initiatives to consolidate key stakeholder commitments to strengthen national and subnational MHEWS.
- Coordination mechanism – affirm or establish a national stakeholder coordination mechanism, with nominated focal points, to facilitate multi-stakeholder efforts to scale up end-to-end MHEWS, linking national and local engagement. This may leverage existing high-level and technical platforms at the national and

84 The toolkit includes a minimum core capability checklist (tool for gap analysis); template concept note and agenda for national consultation workshop; template concept note and agenda for gap analysis workshop; template for stakeholder mapping; template for national EWS road map; Terms of Reference for national stakeholder coordination mechanism; Terms of Reference for national United Nations focal point; and a workshop slide deck /comprehensive presentation / speaking points.

85 As at mid-October: Maldives, Tajikistan, Ethiopia, Madagascar, Laos, Nepal and Cambodia.

subnational level that are aligned with the aims of the EW4All initiative.

- Priority areas – agree on a process for identifying priority areas for action to address national MHEWS gaps (informed by the checklist tool).
- Addressing key challenges – identify key barriers to risk-informing, issuing, communicating and acting on early warnings effectively; recommend targeted actions to overcome these, in line with national priorities.
- National road map – leverage existing MHEWS strategy or develop a multi-year, multi-stakeholder EW4All national action plan to marshal coordinated resources, technical assistance and long-term support.

Image Source: UNDRR

Image Source: UNDRR

EW4ALL CASE STUDY:

The Maldives[86]

In July 2023, a national consultation on the EW4All initiative took place in the Maldives to boost political momentum for and the achievement of the EW4All action plan by 2027. While recognizing progress and investments made to date, the participants highlighted the need for further strengthening MHEWS as part of overall national efforts to ramp up investment in DRR and climate change adaptation for the most at-risk people, as well as highly vulnerable economic sectors (tourism and fisheries).

- ***Convening technical expertise:*** Four national organizations were confirmed as the focal points to lead the articulation of priorities and gaps to be addressed across each of the four MHEWS pillars,[87] with each organization supported by the overall EW4All pillar leads UNDRR, WMO, ITU and IFRC.
- ***Fostering multi-stakeholder collaboration:*** The need for better coordination of existing or planned MHEWS initiatives was recognized alongside the importance of taking an intersectional approach.
- ***Assessing gaps and opportunities:*** A preliminary analysis of gaps and opportunities was undertaken in relation to each pillar, including completion of the EW4All Minimum Core Capability Checklist.
- ***Setting a common agenda for MHEWS:*** Based on the outcomes of the country-led gap analysis, the EW4All Common Agenda for the Maldives summarizes national ambitions relating to MHEWS. It includes outcomes, milestones and resource requirements. Thus, it will guide multi-year and predictable investment, as well as

86 United Nations, *Early Warning for All (EW4All) in the Maldives: National Consultations and Launch*, Report of Proceedings, 4 July 2023.

87 Pillar 1 (Disaster Risk Knowledge) is led by the National Disaster Management Authority. Pillar 2 (Observations and Forecasting) is led by Maldives Meteorological Service. Pillar 3 (Warning and Dissemination) is led by the National Centre for Information Technology. Pillar 4 (Preparedness and Response) is led by the Maldives Red Crescent.

requests for technical and financial support, all aligned with national priorities to protect people, services, infrastructure and vital economic sectors in the Maldives.

Seizing immediate opportunities: Several opportunities exist for advancing MHEWS in the Maldives (United Nations Maldives, 2023), including funding from GCF for the *Toward Risk-Aware and Climate-resilienT communities* project in the Maldives;[88] funding from SOFF; and support from the ESCAP Trust Fund for Tsunami Disaster and Climate Preparedness, particularly through support from RIMES.

As a call to scale up national action, EW4All can play a crucial role in accelerating investment to address the vulnerability of the Maldives to climate change by improving MHEWS and enhancing resilience by:

Improved risk data collection and monitoring: investing in observations infrastructure, promoting open access and ensuring the sharing of accurate data in real time.

Technological advancements: facilitating the adoption and implementation of advanced technologies, such as remote sensing, satellite imagery and modelling tools.

Strengthening communication infrastructure: enhancing radio networks, mobile networks and Internet connectivity to ensure reliable communication channels are available for MHEWS.

Public awareness, education and enhanced preparedness and responses.

Capacity-building and training: delivering demand-driven technical assistance and capacity-building programmes to strengthen the skills and knowledge of government agencies, meteorological departments, disaster management organizations and local communities (United Nations Maldives, 2023).

The Maldives will also benefit more broadly from its involvement in EW4All initiative. EW4All underscores the importance of scaling up collaboration and knowledge-sharing among different stakeholders, including government agencies, international organizations, research institutions and local communities. Sharing good practices, lessons learned and experiences from other countries facing similar challenges can help the Maldives strengthen its EWS and adopt innovative approaches (United Nations Maldives, 2023).

88 Full title: "Toward Risk-Aware and Climate-resilienT communities (TRACT) – Strengthening climate services and impact-based multi-hazard early warning in Maldives".

3.2 Stakeholder engagement

The EW4All initiative stands out in terms of the vast number of partners and initiatives that it brings together across the pillars, and at different levels of scale. Only through cooperation, alignment and true partnership can multi-hazard, end-to-end and people-centred EWS be established for all countries around the globe. Inclusive multi-stakeholder engagement is a cross cutting enabler for the successful implementation of the initiative. Different partners bring different elements of focus to the initiative. Coordination, for instance through pillar meetings, aims to bring these different voices and expertise to the implementation of the EW4All initiative on the ground.

In the next months, a stakeholder mapping exercise will be carried out through a survey to map the partners engaged in the EW4All initiative, to identify their roles in the initiative and to determine what pillars and processes they are engaged in and at what level of scale. A strategy will also be developed for engaging with civil society actors, the private sector and academia. Criteria will be developed for differentiating the partners along the different tiers of engagement.

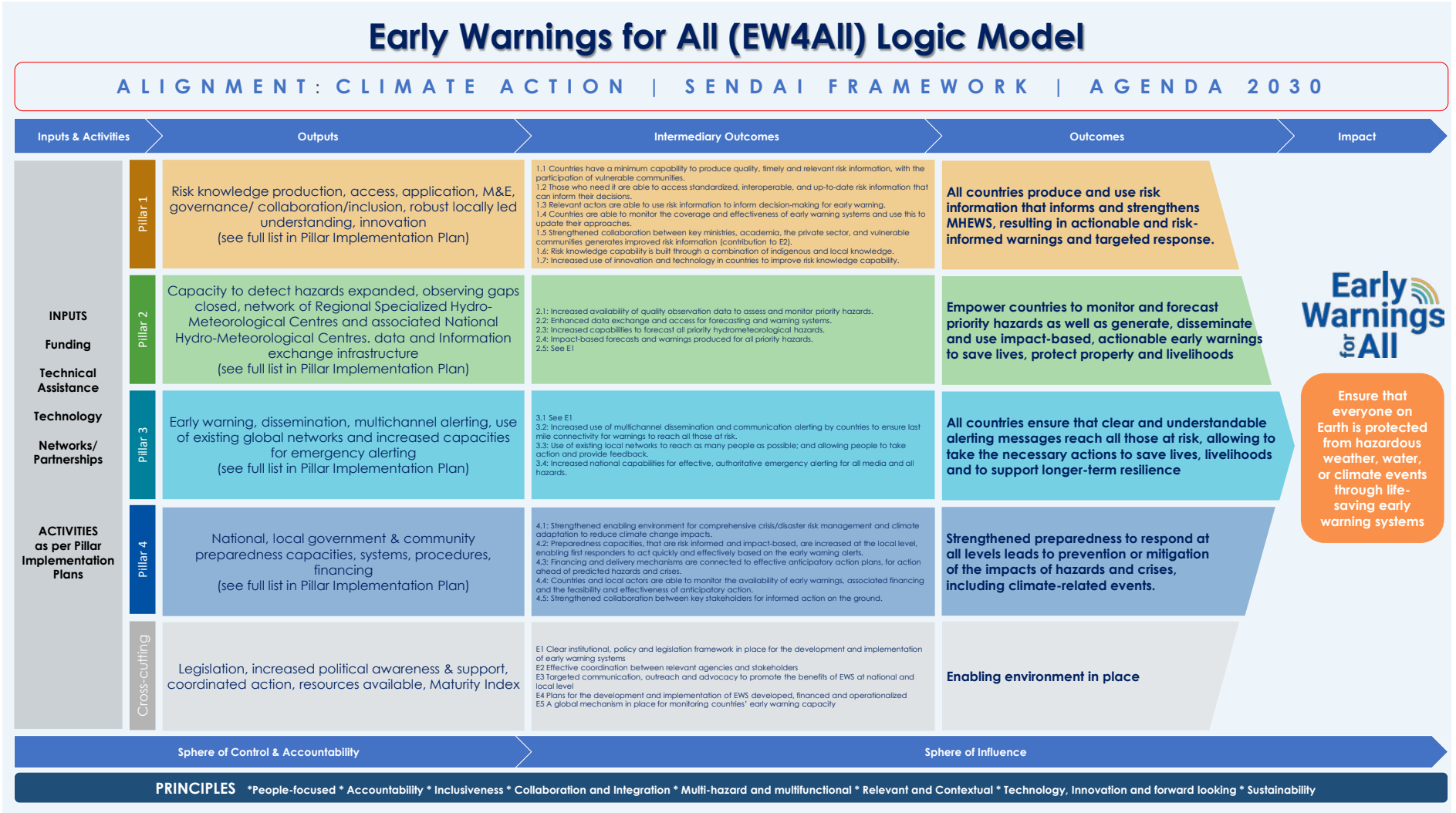
Annual multi-stakeholder forums (MSF) will be organized to ensure inclusive participation and active engagement of a wide range of partners in the EW4All initiative. The MSF will provide multiple opportunities for peer-to-peer and cross-regional learning, sharing of good practices and experiences, renewing existing and building new partnerships, and identifying ways to close remaining gaps. The MSFs will bring together global, regional, national and local actors. The first MSF will be regional, taking place alongside the regional platforms for DRR scheduled to take place in 2024. The first global MSF will take place in June 2025, alongside the Global Platform for DRR.

3.3 Monitoring and evaluation

The Secretary-General's call for global MHEWS by 2027 is an ambitious target. Effective monitoring and evaluation (M&E) is essential for tracking the progress of the initiative and enabling adjustments to be made as required, for example, to provide additional implementation support or guidance, or to prioritize the allocation of resources. To this end, a Working Group on Monitoring and Evaluation (WG-M&E) has been set up as an expert body in support of the initiative. With representatives from each of the pillar leads and other implementing partners, the purpose of WG-M&E is to ensure a coordinated, methodologically sound and uniform approach to monitoring the initiative, based on the data strengths of the partner entities and United Nations good practices and rooted in the principles of results-based management. Co-led by UNDRR and WMO, WG-M&E leads and coordinates action on the monitoring and reporting of the EW4All initiative, contributing to its transparency and accountability. It further has an important role in informing decision-making by means of reliable, timely and actionable data.

Foundational activities have already been completed. These include the development of a theory of change (or logic model, figure 3.1) for the initiative, which is supported by an M&E framework. Comprising indicators defined at the outcomes and output level, the framework is structured around the four pillars of EWS, the enabling environment and the guiding principles. The M&E framework follows a twin-track approach: monitoring the progress in implementation in the initial set of kick-off countries, and global progress monitoring to provide an overview picture of early warning coverage and effectiveness to trigger early action.

Figure 3.1 Early Warnings for All Logic Model



Source: United Nations Framework Convention on Climate Change.

In addition, the EW4All pillar leads are defining a "minimum core capability" to be achieved in all countries as a measure of success of the EW4All initiative. WG-M&E will work with the pillars to define stages of maturity, which will be measured against a set of metrics. This will result in an EW4All Maturity Index – a benchmark – which will help develop a common understanding of the basic requirements and maturity levels of early warnings and early action among Member States, implementing partners and stakeholders. An initial methodology for this has been developed in relation to Pillar 2 and applied to all 30 countries (see section 3.5).

The results of the M&E process will be shared publicly: through an EW4All dashboard that will provide regular information on the progress of the initiative based on an agreed set of indicators; and through annual EW4All reports (including the present report) that will be released at each UNFCCC Conference of the Parties.

3.4 Communication and advocacy

A coordinated approach is being taken to communication and outreach activities relating to the EW4All initiative, with inputs from each of the pillar leads as members of a communications task force. These activities aim to leverage political support for implementation, collate and promote human-interest stories to demonstrate the effectiveness of the initiative, and increase the capacity of media to report on EW4All and EWS. A key resource in this regard is the landing page for the EW4All initiative, hosted on the United Nations website.

The EW4All initiative is being promoted at all relevant events. Recent examples include the 2023 SDG Summit in New York, where EW4All was championed as a transformative strategy to address challenges linked to the SDGs. Similarly, at the Climate Ambition Summit, EW4All was promoted as a key catalyst and active player in the domain of climate action, driving progress towards the global goals, during which there was a dedicated side event showing the impact of the initiative to date.

Given that the EW4All initiative aims to ensure that everyone on Earth is protected from hazardous weather, water or climate events through life-saving EWS by the end of 2027, the importance of the initiative is also tactfully and cautiously promoted in relation to extreme weather events that capture significant media focus, such as the recent floods in Libya.

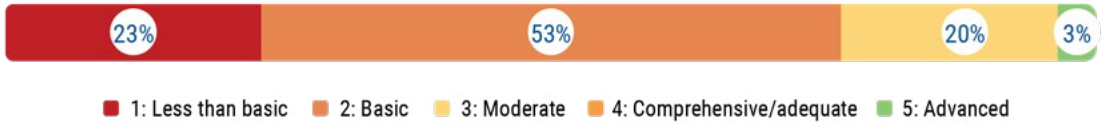
3.5 Pillar 2 zoom-in: A rapid assessment of the hazard monitoring and forecasting capacity

To inform the planning stage of the EW4All initiative and better target assistance, WMO conducted a rapid assessment of the hazard monitoring and forecasting capacity (Pillar 2) through the NMHS of the 30 countries selected for initial coordinated support.[89] The aggregate results are presented on figure 3.2 by element of the hydrometeorological value chain. Currently at an initial stage of analysis, these will be further validated during country visits and broader national consultations.

The analysis shows that over half of the NMHS rely on basic monitoring and forecasting to support their EWS. Close to a quarter operate with less-than-basic monitoring and forecasting capacity, as evident from figure 3.3.

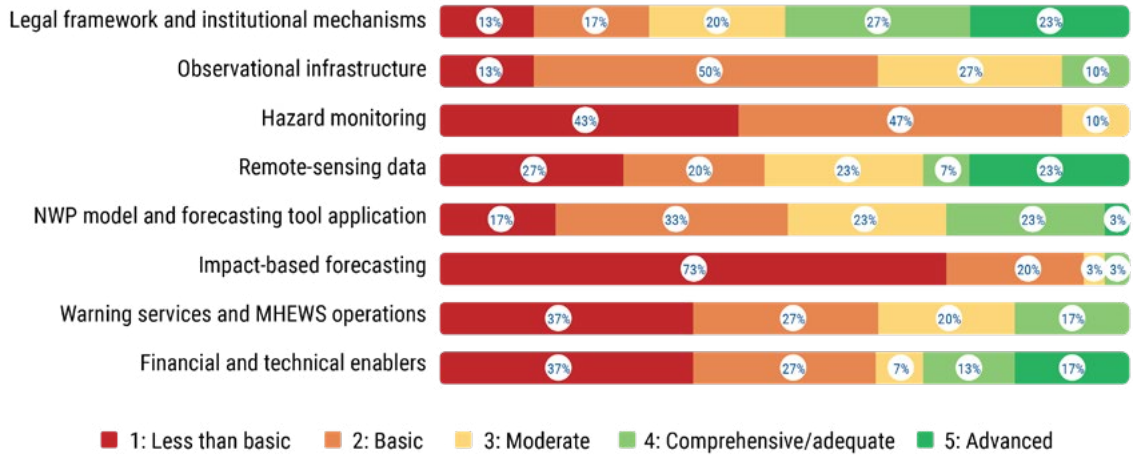
89 List of countries: Antigua & Barbuda, Bangladesh, Barbados, Cambodia, Chad, Comoros, Djibouti, Ecuador, Ethiopia, Fiji, Guatemala, Guyana, Haiti, Kiribati, Lao (People's Democratic Republic), Liberia, Madagascar, Maldives, Mauritius, Mozambique, Nepal, Niger, Samoa, Solomon Islands, Somalia, South Sudan, Sudan, Tajikistan, Tonga, Uganda. See www.undrr.org/news/early-warnings-all-initiative-scaled-action-ground.

Figure 3.2 MHEWS Pillar II overall capacity level – 30 selected countries



Source: WMO, 2023

Figure 3.3 MHEWS Pillar 2 capacity level by element – 30 selected countries



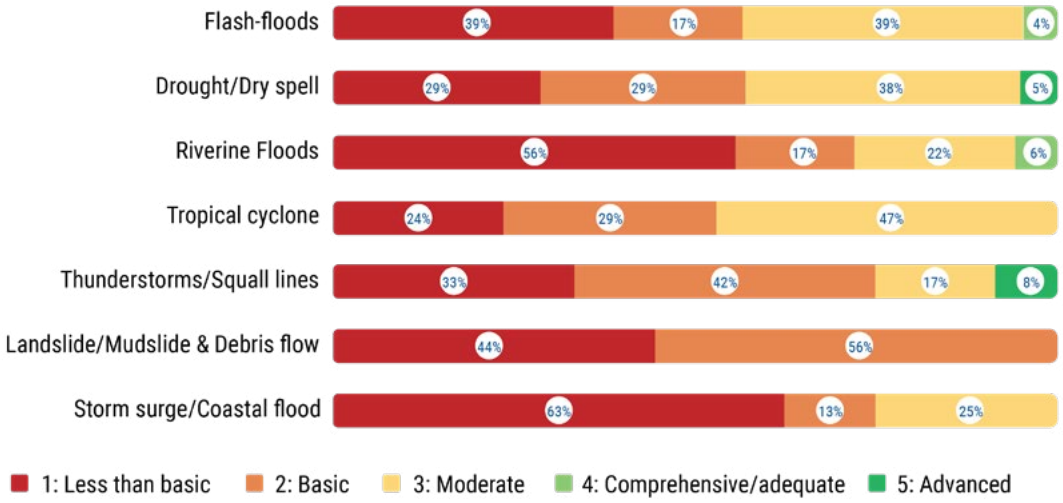
Source: WMO, 2023

Legal framework and institutional mechanisms: NMHS have general mandates to monitor, forecast and produce warnings for hydrometeorological hazards though a variety of legislative frameworks (laws, degrees, etc.). However, many fall short of establishing clear roles and responsibilities for all the organizations involved in national MHEWS and most fail to implement systematic data exchange protocols across agencies.

Observational infrastructure: Half of the 30 countries operate basic – and a small proportion (13 per cent) even less-than-basic – observational networks. All countries face challenges with observation gaps in their infrastructure. Most are further impeded by a large percentage of inoperable stations that cripple their monitoring capacity. The issue is further compounded by lack of capacity to perform appropriate maintenance, calibration and quality control of their stations and instruments leading to significant data availability and quality issues.

Hazard monitoring: The vast majority of NMHS report, on average, having basic (47 per cent) or less-than-basic (43 per cent) capacity to monitor their priority hazards, with only 10 per cent having moderate monitoring capacity.

Figure 3.4 MHEWS Pillar 2 capacity level by element – 30 selected countries



Source: WMO, 2023

Figure 3.4 presents the most commonly identified hazards among the 30 countries. The prevalent hazards require hydrological and marine observations for their monitoring as well as extensive historical observation data and ancillary information (e.g. digital elevation models, catchment boundaries, soil properties). All of these emerged as common capacity gaps for the 30 NMHS in the WMO rapid assessment process.

Remote-sensing data: While almost all NMHS use satellite imagery and data to complement their observation infrastructure, many lack the training to use these resources to monitor all their priority hazards. They are also restricted in their access by unstable, insufficient broadband connection.

Numerical weather prediction model and forecasting tool application: Most of the assessed NMHS produce forecasts entirely based on global or regional model outputs, and many are constrained in the use of the WMO Integrated Processing and Prediction System by insufficient technical resources and training.

IBF: Though essential for preventing disaster loss and damage, IBF is not applied in close to 75 per cent of the countries assessed. Their NMHS lack the human resources, training, technical solutions and necessary vulnerability and impact data required.

Warning services and MHEWS operations: Integrated MHEWS are missing in the vast majority (83 per cent) of the selected countries. There is a prevalent lack of capacity to forecast cumulative hazards and their cascading impacts. Countries are further constrained by insufficient operational inter-agency mechanisms (e.g. standard alerting procedures, warning verification processes) which are considered essential for sustaining a functional EWS.

Image Source: UNDRR

4

INITIATIVES ON EARLY WARNING - EARLY ACTION

Image Source: UNDRR/Brice Blondel

4. Initiatives on early warning – early action

The Secretary-General's call to ensure that every person on Earth is protected by MHEWS within five years will require concerted effort of individuals, communities, institutions, organizations, academia research institutions, governments, regional associations and international actors. Collaboration will be necessary at every level and across all sectors. The latest science, innovations in technology and good practices will need to be leveraged to address this grand challenge. All these actions and activities will need to be resourced appropriately, in terms of people, tools and funding, as initially set out in the EW4All Executive Action Plan.

In this section of the report, initiatives are highlighted that are already contributing to the achievement of EW4All either at the global, regional or national level. Some of the initiatives are focused primarily on one pillar (e.g. SOFF for Pillar 2), whereas others seek to improve MHEWS more holistically, with many focusing on a specific hazard e.g. flash floods. Even where an initiative is focused on a single community, there are opportunities to learn and develop good practices to inform implementation elsewhere. Therefore, while in a global status report it is necessary to focus on larger initiatives, every activity and every actor can contribute to the community of practice in terms of case studies, evaluations and lessons learned to inform good practices, approaches and the development of tools and systems to enable the implementation of effective, inclusive, people-centred MHEWS worldwide.

It is important to note that when taking a people-centred or whole-of-society approach, there is a change to the lens through which the effectiveness of MHEWS and its warnings are assessed. To ensure that action is taken in response to a warning, the warning needs not only to be deemed "useful" (as defined by scientists) but it needs to be "usable" by those receiving it. The warning message needs to be "actionable" not just "understood". To this end, an MHEWS needs to be inclusive, accessible and actionable for everyone. Special care needs to be taken in the communication and dissemination of information, for example in relation to the use of colour and language. To be truly people-centred, EWS should not just be community-based but community-driven, where communities are at the heart of the system. The importance and utility of local, traditional and Indigenous knowledge (LTIK) across each pillar should not only be recognized but embraced as fundamental to the effectiveness of MHEWS. More details on these aspects of MHEWS can be found in annex 2.

4.1 Financing for early warning systems

Funding is a critical enabler of MHEWS. However, a report commissioned by the Risk-informed Early Action Partnership (REAP) to look at finance for early action (Scott, 2022) found that funding for MHEWS, in the context of AA, is small and fragmented: "Of the US$700m future funding for early action, at least US$106m appeared to relate to early warning system development" (Scott, 2022). Furthermore, the report noted that 65 per cent of the funding was used for capacity development rather than directly financing early action or AA. The report recommended that finance for early action should be fast, government-led and sustainable; incentivize risk reduction and resilience; involve local actors; embed M&E; and link to a flexible plan (Scott, 2022).

Nonetheless, investment in MHEWS does result in progress, as shown in official statistics. For instance, a recent preliminary analysis by UNDRR and WMO

shows that over half of the global investments on MHEWS in the last decade were targeted to Africa.[90] As demonstrated in chapter 2, Africa has seen some significant improvement in its MHEWS scores, yet still remains behind the global average. Further, an analysis of Target F of the Sendai Framework[91] (substantially enhance international cooperation to developing countries) shows alignment between funding for MHEWS and increases in MHEWS scores (under Target G) for the same countries.

Recognizing such benefits, efforts are being made to increase the level of financing for EWS, both globally and regionally, to benefit the vulnerable countries. Specific funds have been set up to support the development of MHEWS (for example, the CREWS initiative) or to support specific components of MHEWS, such as SOFF, which focuses on Pillar 2. These global initiatives have been elaborated in the next section.

Other funds and mechanisms have also been established where MHEWS is either a primary focus or an integral component. These include direct support through global funds and financing instruments, as well as risk transfer and pre-arranged financing mechanisms that have early warnings as the trigger. Additional information on financing for MHEWS can be seen in annex 1.

Investments in MHEWS need to be better tracked, both in terms of international financing, as well as its delivery in countries. Tracking also needs to be improved in relation to public financing for MHEWS so as to get a comprehensive picture of the global level of investment in MHEWS.

4.2 Global initiatives

This report has highlighted some continued gaps in MHEWS coverage. The present section outlines some key ongoing initiatives that have taken major steps to address this gap.

4.2.1 The Systematic Observations Financing Facility

SOFF is a United Nations fund co-created by WMO, UNDP and the UNEP to close the basic weather and climate observation data gap in countries with the most severe shortfalls in observations, prioritizing LDCs and SIDS. Previous attempts to address this problem have not adequately resulted in a significant and sustained increase in observational data exchange. On the contrary, the data gap has been growing. Therefore, SOFF has been designed to tackle the problems identified in a systematic way.

SOFF aims to support and accelerate the sustained collection and global exchange of the most essential surface-based weather and climate observations in compliance with the internationally agreed GBON, mandatory for all countries since January 2023.[92] (See also section 2.3, figure 2.12.) Today, less than 10 per cent of the internationally mandated basic weather and climate data are available from LDCs and SIDS. The potential socioeconomic benefits directly enabled by the full implementation of GBON, primarily via its implementation in countries with the largest current data gaps, are estimated to exceed US$ 5 billion per year (Kull *et al.*, 2021). Thus, by providing long-term financial and technical assistance, SOFF contributes towards the delivery of a global public good. SOFF is also a foundational delivery vehicle of the EW4All initiative.

In total, 149 countries are eligible to access SOFF technical assistance support, with SIDS and LDCs also receiving financial support. Long-term technical assistance is provided by advanced NMHS on a peer-to-peer basis. Long-term financial assistance is provided on a grants-only basis. To deliver this

90 Preliminary analysis as part of financial tracking of EW4All.

91 Starting 2023 countries have started reporting on financing received for MHEWS.

92 WMO, "Global Basic Observing Network (Res. 2)", undated. Available at https://public.wmo.int/en/programmes/wigos/gbon

support, SOFF brings together numerous partners under one roof:

- Twenty-eight NMHS providing technical support to beneficiary countries as SOFF peer advisers
- Nine multilateral development banks and United Nations organizations act as SOFF implementing entities
- Eighteen Steering Committee members, including 12 initial funders, are the decision-making body of SOFF
- Seventeen Advisory Board members, comprising relevant actors in the hydrometeorological value chain, including major multilateral climate funds, provide recommendations to the SOFF Steering Committee

SOFF became operational in July 2022. As at September 2023, 62 countries were programmed for SOFF support, fully covering the 30 initial focus countries of the EW4All initiative. The first countries that were programmed, started receiving technical assistance for SOFF readiness work in the April of 2023 (the first out of three SOFF phases). It is expected that by the end of 2023 the first group of countries will start receiving SOFF financial support for the second phase, the SOFF Investment Phase.

Today, the biggest challenge for SOFF is responding to the high demand – as at September 2023, 39 additional countries requested SOFF support. To respond to this high demand, SOFF is accelerating resource mobilization as part of the EW4All initiative.

For 2024, SOFF is planning to programme an increased number of countries to start the Readiness Phase. Most countries programmed in 2023 are expected to move into the Investment Phase. The SOFF Steering Committee is considering a potential expansion of support to middle-income countries for all three phases of SOFF support in a phased and prioritized manner. To maximize effectiveness globally, SOFF works to ensure alignment with other funds that will utilize SOFF data to inform climate services.

Example: Bhutan

Bhutan is one of the LLDCs where the climate crisis is felt most severely. The mountainous terrain, high economic dependency on climate-sensitive sectors and small population makes the country highly vulnerable to the increasing frequency of weather- and climate-related hazards.

For its weather forecasts, Bhutan relies on global data sets as the initial input for their national forecasting. These data sets are deficient in ground station data – the only station in Bhutan contributing data internationally is not GBON compliant, while internationally mandated weather balloons are non-existent.

To become GBON compliant and share data internationally –in turn boosting local weather prediction, helping decision makers to provide timely and accurate weather and climate information – Bhutan is progressing SOFF implementation rapidly: the Bhutanese National Centre for Hydrology and Meteorology is the scientific and technical organization providing weather forecasts and early warnings for extreme weather. The Finnish Meteorological Institute is providing technical assistance as the SOFF peer adviser.

UNEP is serving as the implementing entity for Bhutan, strengthened through its partnership with RIMES which has been previously working on strengthening observational capacity in Bhutan.

4.2.2 Climate Risk and Early Warning Systems

Established in 2015, the CREWS initiative is a financing mechanism that aims to contribute to increased access and capacities of LDCs and SIDS. It leverages on the expertise and networks of partners in the countries and regions. CREWS operations are facilitated by its implementing partners UNDRR, WMO, and the World Bank and its Global Facility for Disaster Reduction and Recovery. CREWS aims to significantly increase the capacity of LDCs and SIDS to generate and communicate effective, impact-based, multi-hazard and gender-

informed early warnings and risk information within strengthened national MHEWS in order to substantially reduce disaster mortality by 2030 (UNDRR *et al.*, 2022).

CREWS is operational in more than 70 countries with investments in both country and regional projects. It provides targeted support by responding to the early warning needs of countries through country-driven, impact-based, people-centred and gender-responsive projects.

Operating across all four pillars of MHEWS,[93] CREWS is already supporting the EW4All initiative by:

- Improving risk knowledge through the identification of risks (Pillar 1)
- Modernizing hydrometeorological infrastructure and strengthening the capacity of NMHS (Pillar 2)
- Improving the dissemination and communication of actionable warnings (Pillar 3)
- Developing linkages with sectors and communities by tailoring services and products (Pillars 2 and 3)
- Strengthening the ability to prepare for and respond to warnings (Pillar 4)

CREWS has also supported EW4All by funding a global project to measure the effectiveness of MHEWS through SFM-defined custom indicators to help countries to report their progress (see Side : Development of MHEWS custom indicators). It also recently approved support to a multi-country EW4All accelerator project covering 7 of 30 initial countries.

In 2022, CREWS introduced its people-centred operational guidelines and procedures. They ensure that implementing partners will co-design, execute and monitor national and regional projects by including and integrating the input of multiple collaborators – including women, communities and local organizations – across the full spectrum of early warning.

CREWS' impact is underpinned by the expertise and collective experience of the implementing partners and the national and regional stakeholders. An external CREWS evaluation[94] found that CREWS is delivering significant impact, with regions, countries, national institutions and communities adopting and building on CREWS investments. Across Africa and the Indian Ocean, in the Asia-Pacific region and most of the Caribbean (see 4.3.2.4), the report shows that countries are advancing because of CREWS-funded interventions. Progress includes effective governance; greater forecasting, warning and dissemination capacity on hazards; increasing numbers of people benefiting from systems and services; and improved DRM. This progress was made despite the ongoing residual impacts of restrictions imposed during the COVID-19 pandemic as well as conflict, instability and sanctions that continued to impede activities to varying degrees in Afghanistan, Haiti and Mali. Highlights from 2022 include:

- 111 million more people in 15 countries globally were covered by new early warning and forecasting services (CREWS, 2023).
- In Africa, extending sand and dust forecasts to six more countries allowed 90 million more people to reduce risk.
- Hydrometeorological decrees in the Democratic Republic of the Congo, Mozambique and Togo laid legal foundations for early warning.
- Increased forecasting capacity through projects, covering 16 types of life-threatening natural hazards.
- In Central and West Africa, 15 countries have used best alerting practice to issue warnings with CREWS support, reaching 271 million people to enable timely life-saving action in response to the risks from different hazards.

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93 CREWS, "What we do", undated. Available at www.crews-initiative.org/en/about-us/what-we-do.

94 Green, E., Bennett-Bryan, Al and Harris, N., *Climate Risk and Early Warning Systems Initiative Initial Phase External Evaluation, Initial Phase External Evaluation Report* (2022, not yet publicly available]

Going forward, CREWS will continue to further expand and scale up its growing network to enable agile and dynamic project design and implementation covering all MHEWS components. CREWS will also further strengthen its collaboration with GCF in scaling up early warning financing and by providing support to monitor and evaluate progress on early warning. In collaboration with GCF, CREWS has also set up a new Accelerated Support Window to provide short-term (under 12 months), quick impact interventions to LDCs and SIDS through analyses, assessments or advisory services to monitor or deliver MHEWS, complementing multi-year CREWS projects (CREWS, 2023).

Example: Developing a user-centred integrated drought MHEWS in Papua New Guinea

In 2015, the drought induced by El Niño resulted in widespread food shortages when drought-related frosts caused subsistence crops to fail at a catastrophic scale. It was estimated that up to 2.4 million people were affected. Papua New Guinea has limited coping capacity for managing such risks, particularly drought. To address this risk, through a CREWS-funded project, the country developed an Integrated Drought Early Warning System across the country's 22 provinces.

Hazard, vulnerability and exposure indices have been developed for each province by integrating the socioeconomic, geographic and climatic indicators specific to these territories. For hazard assessment, the Standardized Precipitation Index (SPI) and the Vegetation Health Index (VHI) were selected from the WMO Spaced-based Weather and Climate Extremes Monitoring programme. Based on the selected inputs, spatial maps of the area covering the 22 provinces have been produced, representing hazard, vulnerability and exposure, as well as an overall drought risk.

The system combines satellite products (SPI and VHI) with seasonal probabilistic forecasting outputs, such as the chance of rainfall in the below average tercile for the next three months. The selected inputs are combined to produce drought warnings categorized as either "DROUGHT WATCH", "DROUGHT ALERT" or "DROUGHT CRITICAL". Drought maps and provincial status summaries are generated and used by the Papua New Guinea National Weather Service (PNGNWS), to inform improved DRM in the country by advising decision makers, including risk managers and policymakers on which provinces are a priority for resource allocation.

PNGNWS incorporates the maps into the Drought Update Bulletin, the Seasonal Climate Outlook, the Early Action Rainfall Watch and other products. Since July 2022, drought risk assessments and early warnings have been disseminated to a range of key stakeholders from the agriculture, energy, health, water and other sectors.

PNGNWS uses drought risk maps and early warnings to inform the national disaster management office and provincial disaster committees about drought status and assist with decision-making. The three–five-month lead times enable proactive drought responses with the potential for prioritized allocation of funds at the provincial level, which is crucial for enabling the reduction of economic and human losses.

4.2.3 Risk-informed Early Action Partnership

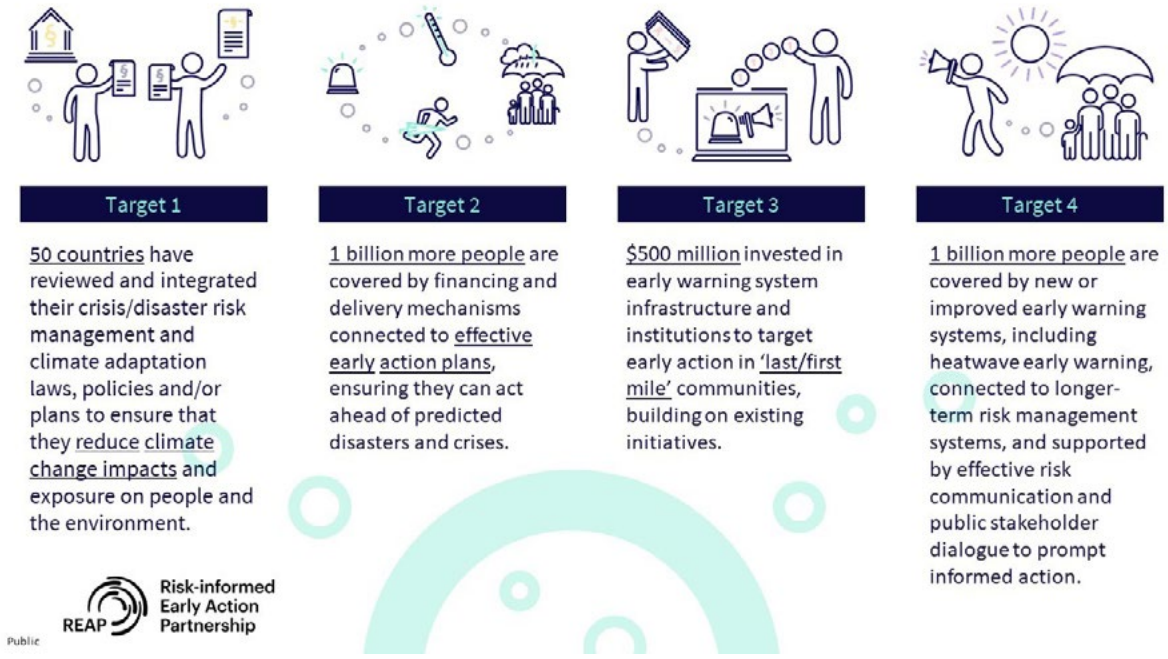
The REAP brings together an unprecedented range of stakeholders across the climate, humanitarian and development communities with the aim of making 1 billion people safer from disasters by 2025.[95] As of 2023, REAP counts over 80 partners from governments, United Nations organizations, intergovernmental organizations, networks, civil society, academia and the private sector. Lead agencies of the EW4All initiative are all partners of REAP, and REAP works closely with EW4All to assist in realizing the ambition to protect everyone with early warning systems.

REAP was launched at the United Nations Climate Action Summit in 2019, with four targets designed to drive a systemic shift towards acting earlier to reduce the impacts of disasters. The targets aim to scale up: national comprehensive risk management; financing and delivery of early action plans; investment in MHEWS that reach the most vulnerable; and coverage by early warnings that support early action.[96]

Recent publications from REAP include:

- A study looking at commitments, trends, challenges and opportunities in relation to *Finance for Early Action* in June 2022 (Scott, 2022)
- *A Glossary of Early Action Terms* in October 2022 (REAP, 2022)
- The second Early Action: *The State of Play report* for 2022 (Wagner, 2023), published in February 2023, which highlights good practices and opportunities relating to scaling up early action
- An input paper to inform the Disaster Risk Reduction Working Group of the G20 titled *Pursuing Coherence and Complementarity: Building Resilience Through Financing Early Action* and published in July 2023 (REAP, 2023)

Figure 4.1 REAP Targets



95 REAP, "Our Mission", undated. Available at www.early-action-reap.org/who-we-are.

96 Ibid.

According to the 2022 *State of Play* report, the momentum arising from the EW4All initiative is expected to have a significant positive impact on progress towards meeting REAP targets 3 and 4 in particular. However, progress on all four of REAP's targets will strengthen the full value chain of early warning and early action, and support the efforts of the EW4All initiative. The State of Play report notes that "key challenges remain to be addressed, including […] the need to attain coherence between different investments and financial instruments to effectively deliver early warnings, and the challenge of mainstreaming people-centred approaches in every element of MHEWS planning, design, implementation and evaluation" (Wagner, 2023). The need for greater integration of activities across the full value chain of early warning and early action is a key theme emerging from the 2022 *State of Play* report.

4.2.4 Water at the Heart of Climate Action

Initiated in June 2023, Water at the Heart of Climate Action is a new initiative focused on mitigating the impacts of water-related risks and disasters as well as increasing the resilience of vulnerable communities in Ethiopia, South Sudan, the Sudan and Uganda.[97] It will take an integrated climate and water approach to deal with increasing exposure to water-related risks, focusing initially on flooding and droughts. It will do this by convening multidisciplinary teams and collaborating with actors at transboundary, national and local levels. Once developed, the MHEWS for each of the targeted countries will allow the respective NMHS to deliver timely early warnings to local populations and various stakeholders across multiple sectors (including water resources, agriculture, irrigation, transport, energy, telecommunication and dam authorities).

Central to the project is the ambition to develop systemic change to accelerate and scale up water action to mitigate the impacts of water-related risks, and increase the climate resilience of affected communities. The initiative is inherently people-centred, including vulnerable groups in the design of interventions that will reduce their vulnerabilities and strengthen their capacities, thereby increasing their resilience in the long term. A particular focus is on MHEWS, drawing on the expertise of UNDRR, WMO and IFRC under the umbrella of the Centre of Excellence for Climate and Disaster Resilience,[98] and leveraging funding opportunities such as SOFF (see section 4.2.1).

The initiative is structured around five broad technical focus areas:[99]

1. Water-related risk knowledge and governance
2. Observations, monitoring and forecasting of weather and water-related hazards
3. Water-specific MHEWS, dissemination and communications
4. AA and Locally Led Adaptation
5. Cross-cutting activities, ensuring cross-fertilization of learning and efficient knowledge management

Political instability and the availability of local hydrological and meteorological observations are among the major challenges identified for the project. However, the project is already seeing improved collaboration among the project partners at global, regional and national levels and aims to build synergies with other ongoing and completed projects in the region, as well as to use all available resources to support effective early warning.

4.2.5 Famine Early Warning System Network

The Famine Early Warning Systems Network (FEWS NET) was established by the United States Agency for International Development in 1985 in response to devastating famines in East and West

97 United Nations, "Water at the Heart of Climate Action", undated. Available at https://sdgs.un.org/partnerships/water-heart-climate-action.

98 UNDRR, "Centre of Excellence for Climate and Disaster Resilience – Home", undated. Available at https://coecdr.preventionweb.net.

99 United Nations, "Water at the Heart of Climate Action", undated. Available at https://sdgs.un.org/partnerships/water-heart-climate-action.

Africa as well as a critical need for better and earlier warning of potential food security crises.[100]

FEWS NET operates in 30 countries located across Africa (22), Central Asia (2) and Latin America and the Caribbean (6), producing timely, accurate and evidence-based early warning information and analysis of the causes, severity and consequences of acute food insecurity to inform international, national and local decision-making.[101]

In April 2023, FEWS NET launched a new website, which includes interactive maps showing the number of people in urgent need of food assistance as well as easily locatable reports and alerts, in-map trend charts and both current and historical data available for download.[102]

The monthly global Food Assistance Outlook Brief is FEWS NET's most forward-looking analysis of projected emergency food assistance needs in the countries that it covers. The projected size of each country's acutely food insecure population is compared with the previous year and the recent five-year average. Countries where external emergency food assistance needs are anticipated are identified and projected lean season months are highlighted.[103]

4.2.6 WMO Coordination Mechanism

The WMO Coordination Mechanism (WCM) is a platform to leverage the collective strength of the WMO community to deliver accurate and actionable advice to the United Nations and humanitarian agencies. By enabling access to robust and authoritative weather, water and climate information, as well as expert advice from WMO members, the WCM aims to increase the effectiveness of humanitarian preparedness and response as well as to advance early action and crisis support.[104]

The core facility of the WCM is the Coordination and Briefing Team, who respond to requests from the United Nations and humanitarian agencies worldwide. The Coordination and Briefing Team is responsible for the provision of curated authoritative information, data and expert advice from WMO members and centres in the form of products and services.[105]

At the global level, the WCM supports the Inter-Agency Standing Committee (IASC) through bimonthly horizon risk scanning with the IASC's Early Warning, Early Action and Readiness group and updates for the IASC's El Niño/Southern Oscillation Cell. The WCM is also supporting the United Nations Office of the High Commissioner for Refugees with a Global HydroMet Weekly Scan for locations of forcibly displaced persons. At the regional level, the WCM is providing the United Nations Office of the High Commissioner for Refugees and the United Nations Office for the Coordination of Humanitarian Assistance to Afghanistan with Regional HydroMet Weekly Scans for the Sudan and Syria. In addition, the WCM provides "on-demand" Regional HydroMet Scans; for example, in relation to Tropical Cyclone Mocha (see below) and to support post-earthquake response in Syria.

Future developments include the provision of improved seasonal and subseasonal forecasts as key components of climate triggers for EAPs and FbF approaches.

The WCM Implementation Plan was adopted in March 2023. However, the WCM requires financial and policy support for widespread and sustainable implementation of integrated authoritative early warnings for humanitarian action.

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100 FEWS NET, "About FEWS NET", undated. Available at https://fews.net/about.

101 FEWS NET, "What We Do", undated. Available at https://fews.net/about/our-work.

102 FEWS NET, "The Next Frontier in Famine Early Warning: FEWS NET Launches New Website With Enhanced Tools, Data, and Analysis", 3 April 2023. Available at https://fews.net/next-frontier-famine-early-warning-fews-net-launches-new-website-enhanced-tools-data-and-analysis

103 FEWS Net, "Food Assistance Outlook Brief, July 2023", July 2023. Available at https://fews.net/global/food-assistance-outlook-brief/july-2023.

104 WMO, "WCM Background", undated. Available at https://community.wmo.int/en/wmo-coordination-mechanism-wcm-support-humanitarian-activities.

105 Ibid.

Example: Tropical Cyclone Mocha

Tropical Cyclone Mocha in May 2023 offered a good example of what the WCM can achieve. Millions of lives were at risk in refugee camps on the Bangladesh-Myanmar border when the cyclone made landfall, but disaster risks were mitigated through early warnings from WMO members and AA from humanitarian agencies.

Forecasting in this region is particularly challenging with high exposure and vulnerability to tropical cyclones, especially in refugee camps. Even with state-of-the-art forecasts, the risk associated with tropical cyclones for a particular location can only be updated 3–5 days before landfall.

The Regional Specialized Meteorological Centre in New Delhi provided critical information and guidance products on the formation, projected path and intensity of the tropical cyclone 3–5 days ahead of landfall. This was available to WMO members, including the national authorities in Bangladesh and Myanmar, who used it to issue forecasts and warnings. The curated authoritative information and expert advice from the WCM enabled a coordinated response across the United Nations with national and local authorities.

Tropical Cyclone Mocha made landfall on 14 May 2023 in Myanmar, near the border with Bangladesh, accompanied by sustained winds of 180–190 km/hr, violent gusts, torrential rainfall and flooding.[106] However, thanks to accurate forecasts and advance action, 500,000 people were evacuated and there were just five reported casualties; whereas in the past, there had been thousands of casualties.

4.2.7 Flash Flood Guidance System

FFGS provides operational forecasters (from meteorological and hydrological settings) and NDMOs with real-time informational guidance products pertaining to the threat of small-scale flash flooding. FFGS is a robust system designed to provide the products needed to support the development of flash flood warnings from rainfall events using surface observations, remotely-sensed precipitation (that is, radar- and satellite-based rainfall estimates) and hydrological models. The system also allows high-resolution limited area model data to be integrated into the system, enabling forecasters to address uncertainties through probabilistic FFGS capabilities, which are essential for diagnosing complex hydrometeorological conditions. The system is interactive and adjustments to the FFGS output can be made locally; for example, to take account of local conditions, include local observations or incorporate data from other models.[107]

The objectives of FFGS are to:[108]

- Enhance the capacity of NMHS to issue effective flash flood warnings and alerts.
- Enhance collaboration between NMHS and NDMO.
- Foster regional development and collaboration.
- Generate flash flood early warning products by using state-of-the-art hydrometeorological forecasting models.
- Provide extensive training, including online training, to hydrometeorological forecasters.
- Support the WMO Flood Forecasting Initiative.

106 WMO, "Extremely severe cyclonic storm Mocha hits Myanmar, Bangladesh", 12 May 2023. Available at https://reliefweb.int/report/myanmar/extremely-severe-cyclonic-storm-mocha-hits-myanmar-bangladesh#:~:text=Extremely%20Severe%20Cyclonic%20Storm%20Mocha%20made%20landfall%20on%2014%20May,gusts%2C%20torrential%20rainfall%20and%20flooding.

107 WMO, "About FFGS", undated. Available at https://etrp.wmo.int/course/view.php?id=198.

108 WMO, "Flash Flood Guidance System with Global Coverage (FFGS)", 13 September 2022. Available at https://public.wmo.int/en/projects/ffgs.

Capacity-building relating to FFGS is supported through the FFGS Portal,[109] which is free and open to anyone. FFGS also has systems in place to enable data-sharing between countries – essential for dealing with transboundary hazards – and for feedback, including guidelines and methodologies for the verification of warnings.

In addition, FFGS has a member developer community creating products and services that utilize FFGS output. For example, a group in Türkiye has produced applications that send email alerts which use FFGS data outputs to display calculations of snow water content on Google Maps to precisely pinpoint areas under threat.

By 2022, FFGS was being used in 72 countries, providing the capability of issuing flash flood early warnings to approximately 3 billion people.[110] Most recently, FFGS has aligned with the plans of the EW4All initiative: 15 new countries were added to the FFGS in 2023, including 11 across Central Africa and four in the southwest Indian Ocean, of which six are among the EW4All initial countries.

4.2.8 Hydrological Status and Outlook System

The Hydrological Status and Outlook System (HydroSOS) is the first global operational mechanism for integrating reliable, timely and accurate hydrological status assessments and outlooks from, with and for NMHS, in collaboration with producers and users of hydrological information. These products will inform water resource management and planning from the available, systematically collected, comparable and trustworthy information validated on the local scale, consistent with national, regional and global information. Moreover, the products will constitute information about vital actionable water resources, which support decision-making for stakeholders in sectors such as agricultural production, energy generation, DRR and water supply.

HydroSOS will provide a platform to access national and transboundary river basin status and outlook products, and will help integrate them into regional and global scales for use by the global community. The products that will be created and approved by the NMHS and their partners are based on agreed indicators and information products that characterize the hydrological cycle in multiple dimensions. Initially, the main variable considered is streamflow, but work is under way for assessing soil moisture, groundwater and cryosphere data (e.g. snow water equivalent). In the future, water quality variables will be included.

The pilot phase of the project completed at the end of 2021, and the project is now in its implementation phase.[111] HydroSOS is active across 27 countries,[112] with plans to extend coverage to a further 12 countries.[113] It is being implemented at several levels, including national, basin and regional, with a global platform to enable HydroSOS products to be shared and aggregated.

Sustainability of the hydrometeorological monitoring networks and availability of (near real-time) in situ data are key challenges, which several countries have identified as the reason for not developing status and outlook products. However, even if data are not fully available, pilot products can be created to showcase the viability and usability of the information that can be disseminated. This can help countries to make the case for the investment needed to implement HydroSOS.

The availability of trained staff is also a challenge. Under the initiative, several countries have received, or are receiving, training to enhance their ability to produce hydrological status assessments and outlooks, and some countries are already developing pilot streamflow products. Other countries are in the process of drafting concept notes to secure funding for their activities.

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109 WMO, "FFGS Portal", undated. Available at https://etrp.wmo.int/course/index.php?categoryid=56.

110 WMO, "About FFGS", undated. Available at https://etrp.wmo.int/course/view.php?id=198.

111 WMO, "Global Hydrological Status and Outlook System (HydroSOS)", undated. Available at https://community.wmo.int/en/activity-areas/global-hydrological-status-and-outlook-system-hydrosos.

112 HydroSOS is active in: Argentina, Belize, Brazil, Burundi, Cambodia, China, Colombia, Costa Rica, the Dominican Republic, Ecuador, El Salvador, Ghana, Guatemala, Honduras, India, Israel, Kenya, Lao People's Democratic Republic, Nicaragua, Nigeria, Panama, Peru, Rwanda, the United Republic of Tanzania, Togo, Uganda and Uruguay.

113 HydroSOS is in the pipeline in: Benin, Bhutan, the Plurinational State of Bolivia, Burkina Faso, Côte d'Ivoire, Fiji, Maldives, Mali, Paraguay, Samoa, Solomon Islands and Vanuatu.

4.3 Regional initiatives

4.3.1 Africa

4.3.1.1 Africa Multi-Hazard Early Warning and Early Action System programme and the Multi-Hazard Early Warning for All (EW4All) Action Plan for Africa (2023–2027)

In 2022, the African Union Commission (AUC) established the Africa Multi-Hazard Early Warning and Early Action System (AMHEWAS) programme to improve the availability, access and use of disaster risk information for early warning and action across the continent (AU, 2022a).

In the first year, there has been significant progress.

Framework. The African Union (AU) has adopted an Institutional and Operational Framework for Multi-Hazard Early Warning and Early Action System for Africa (AU, 2022b), which will assist decision makers and sector specialists in building capacity and directing investment in MHEWS, helping to prevent many small emergencies from developing into disasters in the future. The AMHEWAS framework proposes mechanisms to share good practices and learning to assist Member States in improving their national and subnational early warning and early action systems, as well as establishing structures for more effective transboundary data exchange and warning systems (AU, 2022b).

Interoperable situation rooms. With the inauguration of the Abuja Situation Room in June 2023,[114] the programme has now established two continental and two regional situation rooms across the continent, with technical assistance from UNDRR.[115] Similar situation rooms are also planned for Economic Community of Central African States with support from CREWS and also the Southern African Development Community (SADC), the latter in accordance with the Maputo Declaration on the Commitment by SADC to Enhance Early Warning and Early Action in the Region,[116] where it was agreed to fast-track the operationalization of the SADC Humanitarian and Operations Centre as well as support the AMHEWAS and its interoperability with regional and national systems (AU, 2022b).

The ambition is that with time, the AUC will support Member States to establish similar situation rooms at national levels to encourage a networked approach in disaster risk management and ensure their interoperability.[117] This will be enabled through the myDEWETRA platform, an open-source web-based system for real-time detection, monitoring, analysis and forecasting of natural hazards, which will be an important tool to support national MHEWS with hazard detection, monitoring and forecasting from satellite and geospatial data (ESCAP, 2023b).

Daily situation reports. The AMHEWAS situation room in Addis Ababa performs round-the-clock monitoring of flood risk and draws on real-time satellite and climatic data to model risk. The temporal, spatial and anticipated intensity of the risk is further modelled and categorized into degrees of intensity using colour coding that is easy to understand. Daily situation reports are prepared and disseminated to Member States and Regional Economic Communities, enabling them to take action to mitigate the impacts of disasters (AU, 2022a). Warnings are issued

114 UNDRR, "ECOWAS supports early warnings for all with a new disaster operations centre", 15 June 2023. Available at www.undrr.org/news/ecowas-supports-early-warnings-all-new-disaster-operations-centre.

115 The African Union Commission, "Africa Marks a Turning Point Towards Addressing Disasters Through its Multi-Hazard Early Warning and Action Systems Situation Room", 28 February 2022. Available at https://au.int/en/pressreleases/20220228/africa-marks-turning-point-towards-addressing-disasters-through-its-multi.

116 SADC, Maputo Declaration on the Commitment by SADC to enhance Early Warning and Early Action in the Region, 8 September 2022. Available at https://au.int/sites/default/files/pressreleases/42156-other-Maputo_Declaration_Final_AUC_11_Sept-2022.pdf.

117 The African Union Commission, "Africa Marks a Turning Point Towards Addressing Disasters Through its Multi-Hazard Early Warning and Action Systems Situation Room", 28 February 2022. Available at https://au.int/en/pressreleases/20220228/africa-marks-turning-point-towards-addressing-disasters-through-its-multi.

according to the severity and extent of the hazard using the MHEWAS Warning Tier Activation Criteria, ranging from Level 1 for local/subnational warnings to Level 4 for hazards with the potential for continental impacts (AU, 2022b).

Multi-Hazard Early Warning for All (EW4All) Action Plan for Africa (2023–2027). The plan aims to support the implementation of the EW4All initiative in Africa as well as strengthen the operationalization of AMHEWAS to bridge existing gaps and establish continent-wide MHEWS coverage by 2027. Drawing on priorities and catalytic actions identified in the EW4All Executive Action Plan, the Multi-Hazard Early Warning for All (EW4All) Action Plan for Africa takes into consideration Africa's specific needs as well as the existing gaps and opportunities in governance systems, capacities, technology and infrastructure. In addition, the plan leverages ongoing regional efforts and align with the AU's Climate Change and Resilient Development Strategy and Action Plan (2022–2032) (AU, 2022c) and the Integrated African Strategy on Meteorology (Weather and Climate Services) (2021–2030) (WMO, 2022c).

4.3.1.2 Volta Flood and Drought Management

The Volta Flood and Drought Management project entitled Integrating Flood and Drought Management and Early Warning for Climate Change Adaptation in the Volta Basin aims to provide the first large-scale and transboundary implementation of integrated flood and drought management strategies in the Volta Basin.[118] It will do this by empowering the NMHS and other competent authorities of the six riparian countries (Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali and Togo) with robust solutions for DRR and climate adaptation, including capacity development for green solutions and gender-sensitive participatory approaches.

The project has supported the development of a transboundary MHEWS for floods and droughts,[119] which is operationally used in the countries and at the regional level by the Volta Basin Authority. More than 200 regional and national stakeholders (NMHS, National Disaster Management Authorities and water resources institutions) have been trained in the use and upgrade of the MHEWS, which include risk maps, observations and IBF. The project has also implemented a community-based flood and drought management project in six communities within the Volta Basin to develop self-help capabilities and resilience to climate change events. For example, communities have been introduced to tools such as risk mapping, ways to monitor flood levels and channels for the dissemination of early warning. These interventions are enabling people to develop preparedness and response actions ahead of flood or drought events.

Lack of availability of local hydrological data for monitoring and modelling has been a major challenge in the countries involved in the project. Political instability has also been a challenge, especially in Burkina Faso and Mali, where frequent restructuring of national Government officials has delayed the initiation or implementation of project activities. Despite these challenges, the project has made good progress and is now testing the effectiveness of its VOLTALARM EWS at 10 pilot locations. The EWS has been developed to reach the civil protection services and other private and public stakeholders. Following testing, the project will support the review of the results and the implementation of recommendations. It will also seek ways to improve the local, national and transboundary policies, plans and guidelines on climate change adaptation and DRR.

118 Volta Flood and Drought Management, "Project Concept", undated. Available at www.floodmanagement.info/volta-basin/project-concept/.

119 MyDEWETRA, "Volta Flood and Drought Management Project (VFDM)", undated. Available at https://volta.mydewetra.world.

4.3.2 The Americas (and the Caribbean)

4.3.2.1 North America: United States Drought Monitor

The United States Drought Monitor (USDM) is a map released every Thursday, which shows where drought is and how bad it is across the United States of America and its territories – it is a snapshot of recent conditions, not a forecast. The map uses six classifications: normal conditions; abnormally dry (D0); showing areas that may be going into or are coming out of drought; and four levels of drought: moderate (D1), severe (D2), extreme (D3) and exceptional (D4).[120]

The United States Department of Agriculture uses the USDM to trigger disaster declarations and eligibility for low-interest loans, the Farm Service Agency uses it to help determine eligibility for their Livestock Forage Disaster Program and the Internal Revenue Service uses it for tax deferral on forced livestock sales due to drought. Decision makers at the state, local, tribal and basin levels use it to trigger drought responses or declare drought emergencies, ideally along with other local indicators of drought.

The USDM has also proved to be a useful resource in relation to wildfires. On 23 May 2023, conditions in Maui were relatively normal, but by the following week, it was more than half abnormally dry. By 13 June 2023, it was two-thirds either abnormally dry or in moderate drought, and by early August, about 83 per cent of the island was either abnormally dry or in moderate or severe drought. Maui experienced a flash drought with a two-category increase in drought severity in just three weeks from May to June, providing fuel to the wildfires that devasted West Maui.[121] This example demonstrates the potential of the USDM to indicate locations that may be at higher risk of wildfire, although more work needs to be done to integrate this "snapshot" of drought conditions with other parameters in order to provide guidance to stakeholders and enable preventive actions to be taken.

4.3.2.2 Central America: Coordination Centre for Natural Disaster Prevention in Central America; the Dominican Republic

The Coordination Centre for the Prevention of Natural Disasters in Central America (CEPREDENAC) is the specialized institution in charge of the coordination towards prevention, mitigation, preparation and response to disasters in Central America, and is part of the Central American Integration System (SICA).[122]

The centre promotes and coordinates international cooperation as well as the exchange of information, experiences and technical and scientific advice on disaster prevention, mitigation, care and response. Likewise, at a regional level, it systematizes and records information related to prevention, mitigation, response, impact and disaster recovery in a dynamic, interactive and accessible way.[123] It does this through its regional platform, a virtual campus and its regional simulations.[124]

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120 United States Drought Monitor, "What is the USDM?", undated. Available at https://droughtmonitor.unl.edu/About/WhatistheUSDM.aspx.

121 Claire Rush, Seth Borenstein and Jennifer McDermott, "Maui's fire became deadly fast. Climate change, flash drought, invasive grass and more fueled it", 10 August 2023. Available at https://apnews.com/article/hawaii-wildfires-climate-change-92c0930be7c28ec9ac71392a83c87582.

122 The Caribbean Catastrophe Risk Insurance Facility, "CCRIF and Central America's Regional Disaster Risk Management Agency, CEPREDENAC, Sign Memorandum of Understanding", 29 March 2023. Available at www.ccrif.org/news/ccrif-and-central-americas-regional-disaster-risk-management-agency-cepredenac-sign-memorandum?language_content_entity=en.

123 CEPREDENAC, "Disaster Displacement", undated. Available at https://campusvirtual.cepredenac.org/?lang=en.

124 CEPREDENAC. Available at www.cepredenac.org.

4.3.2.3 *South America: Regional Seismology Center for South America*

The Regional Seismology Center for South America (CERESIS)[125] carries out scientific research, monitoring of seismicity and volcanic activity, preparation of risk studies, as well as the application and transfer of knowledge to practical mitigation, education and training measures. Its goals are to reduce the number of victims and the amount of material loss, reducing the structural, environmental, social and cultural vulnerability of our societies. A lower vulnerability to a certain danger means a lower risk, that is, losses in terms of the number of victims and material goods.[126] With its headquarters in Lima, Peru, CERESIS has 12 Member States: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Spain, Paraguay, Peru, Trinidad and Tobago, and Venezuela.

4.3.2.4 *Strengthening hydrometeorological and early warning services in the Caribbean*

The CREWS Caribbean project works to strengthen and streamline regional and national systems and capacity related to weather forecasting, hydrological services, multi-hazard impact-based warnings and service delivery for enhanced decision-making.

The project addressed gaps in EWS that were identified in an assessment of the devastating 2017 Caribbean hurricane season (WMO, 2018b), which was characterized by high-powered hurricanes, such as Hurricane Irma[127] and Hurricane Maria, that left a trail of damage, devastation and casualties across 12 territories. However, it is not limited to tropical storms and hurricanes, also seeking to provide early warnings for floods, landslides, costal erosions, droughts, earthquakes and volcanic activities.

Project activities primarily focus on the 15 Caribbean Community member countries and features a people-centred approach that prioritizes the inclusion of gender and vulnerable populations such as women, children, older persons and persons living with disabilities. This requires generating early warning messages and emergency alerts that reach all these groups in an effective, timely and safe manner that meets their special needs and circumstances.[128]

Examples of activities under each of the EWS pillars include:

1. Support provided for Guyana and Trinidad and Tobago in the establishment of a living repository of open-source global, regional and national risk data and information to improve risk knowledge, literacy and analytics.

2. A newly operational integrated river flood forecasting and EWS in two river basins covering at least 160,000 people in the Dominican Republic.

3. Two CAP implementation workshops held to initiate CAP usage in Belize and the Turks and Caicos Islands, which will ultimately support a consistent standard in the dissemination of information and warnings.

4. Community-based flood management activities strengthened awareness, preparedness and early action in the flood-prone pilot communities of Antigua and Barbuda as well as Trinidad and Tobago.

To promote the harmonization and advancement of MHEWS approaches and investment, the project recognizes that strengthening and streamlining a Caribbean Community regional MHEWS requires effective collaboration across MHEWS strategies, regional and national plans. Through a country-driven

125 Centro Regional de Sismología para América del Sur (CERESIS).

126 CERESIS, "What is CERESIS", undated. Available at www.ceresis.org/articulo.php?id=46.

127 UN News, "Continued risk of catastrophic damage as Irma traverses path of destruction, warns UN", 8 September 2017. Available at https://news.un.org/en/story/2017/09/564562.

128 GFDRR CREWS Caribbean: Strengthening Hydro-Meteorological and Early Warning Services in the Caribbean", undated. Available at www.gfdrr.org/en/crews-caribbean.

and regional body-driven approach, the project will fill persisting gaps in the region. Regional efforts to establish strong and streamlined systems are underpinned by the recently adopted Strategic Roadmap for Advancing MHEWS in the Caribbean (CREWS, 2023).

It was recognized that it is critical to consolidate at national level the enabling institutional and legal conditions to ensure continuity of operations of NMHS and NDMOs, as well as long-term sustainability through adequate funding from governments. Therefore, through the project, model legislation and policies have been developed and then adapted to meet the specific needs of each of the nine countries involved. National Strategic plans and frameworks for weather, water and climate services have also been developed and endorsed in 10 countries.

In 2022, the project expanded both geographically and in scope. Cayman Islands and the Turks and Caicos Islands are also being supported on hydrometeorological and early warning strategic planning and governance (CREWS, 2023). Additional funding from CREWS is also being provided, including support for a scaled up CREWS project funded by the GCF.

4.3.3 Arab States

4.3.3.1 Weather and Climate Information Services in the Middle East and North Africa

Following the success of the Weather and Climate Information Services (WISER) programme in East Africa and in response to climate risks in other areas, the United Kingdom's Foreign, Commonwealth and Development Office asked the Met Office to expand the concept to the Middle East and North Africa (MENA) region as part of its Pioneering a Holistic approach to Energy and Nature-based Options in MENA for Long-term stability (PHENOMENAL) programme.

WISER MENA will:[129]

- Build on the transformational change delivered to date through WISER by drawing on good practices, replicating and scaling approaches to other regions.
- Support new and innovative ways of improving the uptake of weather and climate information services.

Through initial scoping in 2022, four thematic areas have been identified (Met Office, 2022):

- Build understanding of, and demand for, weather and climate information in the MENA region through collaborative and participatory approaches.
- Build resilience to extremes by supporting vulnerable communities, including support to implement forecast-based action.
- Enhance seasonal forecasting in the region through enhancing the Regional Climate Centres' capacity to produce, disseminate and assess seasonal forecasts.
- Provide support to other weather and climate service initiatives in the region through technical assistance and scientific support.

The delivery phase will adopt an integrated regional approach, and is expected to strengthen the co-production between producers, intermediaries and users. This will enhance the relevance and use of weather and climate information services, delivering to meet the priority needs identified in the scoping phase. The longer-term outcome is anticipated to be an increased use of reliable co-produced weather and climate information services to enhance policy, planning and decision-making for adaptation and resilience (Met Office, 2021).

129 Met Office, "Weather and Climate Information Services (WISER)", undated. Available at www.metoffice.gov.uk/about-us/what/working-with-other-organisations/international/projects/wiser.

4.3.4 Asia and the Pacific

4.3.4.1 Asia: Regional Integrated Multi-Hazard Early Warning System for Africa and Asia

Established in 2009, RIMES strives to address gaps in the end-to-end early warning information value chain through technical support, strategic partnership and capacity-building at all levels. RIMES assists its member countries in establishing and maintaining MHEWS according to their unique needs. It also provides expertise to build regional platforms for data-sharing, risk communication and research efforts from a multi-hazard perspective encompassing climatic, seismic, oceanic and hydrometeorological domains.[130]

While RIMES has built its own institutional capacities, it capitalizes on the surplus high-end computing facilities of India (Ministry of Earth Sciences) and the European Centre for Medium-Range Weather Forecasting. Yet, another important role that RIMES has been playing is to connect the missing links of global observations to national/local networks and vice versa, especially in low capacity developing countries, LDCs and SIDS, which are often missed out in the WMO Global Telecommunication System (ESCAP, 2023b).

Focus areas of RIMES include:[131]

- Enhancing data availability
- Improving modelling and forecasting capabilities
- Transforming data into actionable information
- Community outreach to enhance climate and disaster resilience
- Capacity-building and research and development

The value of products provided by RIMES, such as the 15-day flood forecast, are demonstrated during the floods in Bangladesh (Case study: Cyclone Amphan and monsoon flooding in the 2020 Bangladesh floods).

4.3.4.2 Southeast Asia: The Association of Southeast Asian Nations, the ASEAN Framework on Anticipatory Action in Disaster Management and the ASEAN Coordinating Centre for Humanitarian Assistance on Disaster Management

The ASEAN Coordinating Centre for Humanitarian Assistance on Disaster Management (AHA Centre) has a key role in disaster management and early warning in the region. However, a more recent development in the region is the development of the ASEAN Framework on Anticipatory Action in Disaster Management.

Officially launched in November 2011, the AHA Centre aims to facilitate cooperation and coordination among Member States of the Association of Southeast Asian Nations (ASEAN) and with the United Nations and international organizations for disaster management and emergency response in ASEAN countries (AHA Centre, 2018). Its core functions are coordination, disaster information management, knowledge and outreach, and resource

130 RIMES International, "Overview: Regional Integrated Multi-Hazard Early Warning System (RIMES) for Africa and Asia), undated. Available at www.rimes.int/aboutus/overview.

131 Ibid.

management.[132] Spanning the value chain of EWS, the AHA Centre classifies its activities into:[133]

- Disaster monitoring: risk identification, early warning and monitoring
- Preparedness and response: tools and guidance to accelerate the mobilization of resources between ASEAN Member States and its partners in times of disasters
- Capacity-building: support to National Disaster Management Authorities, including training courses and a learning hub

The AHA Centre issues Weekly Disaster Updates[134] as well as Flash Updates and Situation Updates relating to expected or ongoing disasters such as flooding events and tropical cyclones. It has also developed and published a Standard Operating Procedure for Regional Standby Arrangements and Coordination of Joint Disaster Relief and Emergency Response Operations.

ASEAN Framework on Anticipatory Action in Disaster Management

Published in June 2022, the framework aims to ensure that early warnings are reliably translated into effective AA to reduce the negative impacts of disasters across the region.[135] Specifically, it provides guidance for defining, contextualizing and streamlining AA at the regional level. It also includes some considerations for its implementation by ASEAN Member States.

4.3.4.3 The Pacific: Pacific Disaster Center

PDC is a public-private partnership and applied research centre managed by the University of Hawaii.[136] The centre's DisasterAWARE platform is used by tens of thousands of disaster management professionals. It provides global multi-hazard early warning, hazard monitoring and risk intelligence to support rapid and effective disaster response, preparedness, recovery and mitigation.[137]

DisasterAWARE includes high-resolution all-hazards impact models, advanced analytical reports and augmented information through artificial intelligence. The system features the largest scientifically vetted big data catalogue for disaster management decision-making in the world, derived in part from PDC's unique National Disaster Preparedness Baseline Assessment as well as its Global Risk and Vulnerability Assessment.[138]

Customized versions of DisasterAWARE have been deployed by PDC in locations around the world and are used operationally by national and regional agencies to support all aspects of disaster management. One such example is PhilAWARE in the Philippines (Case Study: PhilAWARE – Using a risk intelligence platform to minimize the impacts of disasters).

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132 AHA Centre, "Homepage", undated. Available at https://ahacentre.org.

133 AHA Centre, "What we do", undated. Available at https://ahacentre.org/what-we-do/.

134 AHA Centre, "Weekly Disaster Update", undated. Available at https://ahacentre.org/asean-weekly-disaster-update/.

135 ASEAN Secretariat, "ASEAN Framework on Anticipatory Action in Disaster Management", 10 June 2022. Available at https://asean.org/book/asean-framework-on-anticipatory-action-in-disaster-management-2/.

136 PDC, "About PDC", 4 June 2019. Available at www.pdc.org/about/.

137 Ibid.

138 PDC, DisasterAWARE, undated. Available at www.pdc.org/wp-content/uploads/DisasterAWARE-Fact-Sheet-English-Screen-New.pdf.

4.3.4.4 The Pacific: Weather Ready Pacific

Implemented by the Pacific Meteorological Council, the Weather Ready Pacific programme aims to reduce the human and economic cost of severe weather events across the region.[139] Through a sustainable and harmonized regional approach, the programme will help NMHS in the region to address critical gaps in observation networks, computing and communication equipment and forecasting systems.

Through a cascading mechanism enabled by the Pacific Weather Exchange, countries will have assured access to localized, accurate and timely forecasts. NMHS can use these to produce and communicate impact-based forecasts and warnings to enable communities to take AA.

4.3.5 Europe and Central Asia

4.3.5.1 Europe: MeteoAlarm

MeteoAlarm is specifically designed to visualize the current warning situation in Europe in an easily understandable way, and provides a comprehensive one-stop shop for hydrometeorological warnings to help the public and other actors to take action before natural hazards occur.[140]

The website integrates all important hazardous weather information originating from NMHS across 37 European countries and covering 12 warning parameters. This information is presented consistently to ensure coherent interpretation throughout Europe, while the NMHS remain the authoritative voice that is responsible for delivering their warnings. In this way, MeteoAlarm extends the reach of the warnings issued by individual NMHS beyond their national borders, which is especially important in the context of hydrometeorological hazards, which are often transboundary. MeteoAlarm also offers impact scenarios and advisories for the general public, enabling individuals to stay up to date with the latest weather warnings and take the necessary precautions to minimize risks.[141]

4.3.5.2 Europe: European Flood Awareness System

The Copernicus Emergency Management Service (CEMS) supports all actors involved in the management of disasters caused by natural or man-made hazards by providing geospatial data and images for informed decision-making. CEMS constantly monitors Europe and the globe for signals of an impending disaster or evidence of one happening in real time.

As part of the early warning and monitoring component of CEMS, the European Flood Awareness System (EFAS) is the first operational pan-European flood forecasting and monitoring system. The aim of EFAS is to support preparatory measures before major flood events strike, particularly in the large transnational river basins and throughout Europe in general.[142]

EFAS provides a wide range of early flood forecasting information to support national and regional authorities responsible for flood risk management, enabling them to prepare before an event strikes. In addition to forecasting where and when large riverine and flash floods will likely occur, the service also estimates and maps the potential socioeconomic impact of those events.[143]

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139 Pacific Meteorological Council, "Weather Ready Pacific", undated. Available at www.pacificmet.net/sites/default/files/inline-files/documents/WRP%20Program%20Overview.pdf.

140 MeteoAlarm, Interactive map, undated. Available at www.meteoalarm.org/en/live/.

141 Ibid.

142 Copernicus, "European Flood Awareness System – EFAS", undated. Available at www.efas.eu/en/european-flood-awareness-system-efas.

143 Copernicus, "The European Flood Awareness System (EFAS)", poster, undated. Available at www.efas.eu/sites/default/files/2021-10/CopEMS_Poster_1.0_2021_EFAS.pdf.

It provides complementary, added-value information (e.g. probabilistic, medium-range flood forecasts, flash flood indicators or impact forecasts) to the relevant national and regional authorities. Furthermore, EFAS keeps the Emergency Response Coordination Centre informed about ongoing and possibly upcoming flood events across Europe.[144]

4.3.5.3 Central Asia: Central Asian Flood Early Warning System

The Central Asian Flood Early Warning System (CAFEWS) provides a shared virtual platform for data exchange and weather and flood forecasting to better manage the transboundary risks posed by weather, climate and water.[145] The initiative is co-financed by the Central Asia Hydrometeorology Modernization Project, the Central Asia Water and Energy Program and CREWS (for Afghanistan). CAFEWS covers Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, and is designed to support future inclusion of other countries, such as Afghanistan, in relation to transboundary rivers Amu Darya and Syr Darya.

Recognizing the importance of flood warnings and that Central Asia's mountains influence weather and water across the region, CAFEWS introduces seamless data exchange among members, utilizes advanced numerical weather prediction and applies remote sensing and hydrological modelling. With a "system of systems" approach, CAFEWS leverages modern information and communication technology solutions, including cloud computing, to provide improved information and guidance on transboundary and national hydrometeorological events to forecasters in participating countries.[146]

CAFEWS supports decision-making and preparedness of disaster management and local authorities. The system's capabilities and products also benefit weather-sensitive economic sectors such as transport, energy and agriculture. Furthermore, CAFEWS strengthens regional cooperation and contributes to climate change adaptation and DRR on a regional scale.

CAFEWS has already demonstrated its potential by enabling early warnings to citizens. Most recently, the CAFEWS system was able to predict a mudslide event, enabling Tajikhydromet to provide an alert two days ahead of high precipitation and mudslides, which occurred on 27 August 2023.

4.3.5.4 Central Asia: Glacial lake outburst floods in Central Asia

One of the most significant effects of global warming in Central Asia is glacial melting and the associated formation of glacial lakes. Due to glacial melting and glacial lake formation, there is an increased danger of glacier lake outburst floods (GLOFs), which confound and exacerbate water-related threats to mountain communities, their settlements, livelihoods and infrastructure located on river floodplain areas.

The GLOFCA Project[147] is designed to strengthen adaptation to climate change in Central Asia by reducing societal risks and vulnerabilities associated with GLOFs. It will assess GLOF hazard and vulnerability, design and pilot EWS, and mainstream both DRR and climate change adaptation concepts into subnational development planning.

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144 Copernicus, "European Flood Awareness System – EFAS", undated. Available at www.efas.eu/en/european-flood-awareness-system-efas.

145 The World Bank, "Central Asian Flood Early Warning System", infographic, 10 December 2021. Available at www.worldbank.org/en/news/infographic/2021/12/10/cafews.

146 The World Bank, "Central Asian Flood Early Warning System", infographic, 10 December 2021. Available at www.worldbank.org/en/news/infographic/2021/12/10/cafews.

147 GLOFCA, "Homepage", undated. Available at https://glofca.org.

The target area of the project covers vulnerable communities across several mountain ranges in Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan, providing nearly 90,000 people with EWS and improved resilience through awareness-raising and training activities.

Working with a wide range of implementing partners, including government institutions, academia and research as well as civil society, the project is operating across all pillars.

- In relation to risk knowledge, through the project, glacial lakes and associated risks will be mapped from the regional to the local level. Already, existing knowledge of GLOF has been consolidated in a series of country-specific synthesis reports that provide essential information upon which to base a Best Practice Guidance Document covering all aspects of GLOF hazard and risk management in Central Asia.

- The project will implement a technologically advanced EWS that utilizes ground-based sensors and incorporates modern satellite-based Earth observation, providing full-system monitoring.

- Latest advances in communication technology will ensure timely and reliable transfer of data and warning services to authorities and communities. Respective EWS protocols defining roles and responsibilities will be established.

- Finally, there is a heavy emphasis on education and training of local authorities and communities to ensure long-term success and sustainability of the adaptation measures. In this context, the local communities in GLOF-prone regions will be actively involved in the project through learning exercises (training and mock drills) to ensure that they are informed about possible GLOFs and DRR measures.

5

KEY FINDINGS AND RECOMMENDATIONS TO ACHIEVE EARLY WARNINGS FOR ALL

Image Source: Shutterstock / aphichato

5. Key findings and recommendations to achieve early warnings for all

This report provides an overview of the status of MHEWS globally, identifying progress and prevailing gaps while acknowledging challenges and highlighting opportunities within and across each pillar of MHEWS and at multiple levels. Although great progress has been made in some areas (for example, in observations and communication infrastructure), there is much more to do, especially around dissemination and action, as evidenced by the floods in Europe, where lives and livelihoods were lost despite good data and even good forecasts.

In this section, key findings are outlined before presenting a series of recommendations to ensure that the world meets the challenge set by the United Nations Secretary-General to make early warnings available to everyone by 2027.

5.1 Key findings

Overall, good progress is being made, with numerous ongoing efforts to strengthen MHEWS. The EW4All initiative is catalysing and expediting progress.

Early warning protects lives

Officially reported data continue to show that countries with limited to moderate MHEWS coverage have nearly a disaster-related mortality ratio that is six times higher compared with that in the countries with substantial to comprehensive coverage (4.05 mortality per 100,000 population, compared with 0.71). Similarly, countries that have limited to moderate MHEWS coverages have nearly five times more disaster-affected people per capita than countries with substantial to comprehensive coverages (3,132 compared with 688).

"The glass remains half full"

The trend of increasing numbers of countries reporting the existence of MHEWS has continued: the number has doubled since 2015 and increased to 101 countries as of March 2023. However, this still means that just over half of all countries are covered by MHEWS. While considerable improvement has been witnessed in the regions of Africa, Asia and the Pacific, significant gaps remain. The low coverage in the Americas and the Caribbean despite progress, as well as the persistent gaps in Africa, suggest that efforts to implement MHEWS in these regions need to be expedited. Coverage remains especially low (less than 50 per cent) in LDCs and SIDS, confirming that increasing support for MHEWS in these countries remains a high priority.

Beyond the number of countries, globally, the average self-assessed MHEWS score of reporting countries has improved from 0.33 when first reported to 0.47 for the final reporting (as at the end of 2022) – an increase of 42 per cent. While this score has nearly doubled in Africa, it remains below the global average.

Risk governance: a key enabler of early warning and resilience building

To be effective, EWS need to be embedded in the larger risk governance approach of a country. Out of the 101 countries reporting having MHEWS, 95 have also reported the existence of national DRR strategies. There is also a moderate positive correlation observed between the establishment of national DRR strategy (SFM E-1 scores) and the existence of MHEWS (SFM G-1 scores).

More importantly, countries with more comprehensive DRR strategies have higher coverage of MHEWS. For instance, among countries with low scores for DRR strategies, only 3 out of 101 countries reported coverage across all four pillars. However, this number increased to 31 for countries with higher scores for DRR strategies. Conversely, the average score of comprehensive DRR strategies is 0.64 for countries reporting on only one MHEWS pillar, increasing to 0.77 for countries reporting on all four pillars.

The data reinforce the recommendation that MHEWS should be implemented as a value cycle and not approached pillar by pillar. A holistic and strategic approach to MHEWS is important. DRR and adaptation strategies provide an enabling policy environment to make this work, which in turn requires a comprehensive risk management approach to ensure a stronger policy basis for implementation, as stated in the EW4All Executive Action Plan as well as target 1 of REAP.

Limited risk knowledge hampers early warning effectiveness

Despite a marked improvement in scores since countries first reported, risk knowledge remains consistently low in terms of average score and number of countries reporting. There is an urgent need to improve risk knowledge in every part of the world, but especially in the Arab States and in LDCs. Investments are also needed to better understand historical losses and damages, trends in hazardous events and predictive capacity for hazards.

Even where it is difficult to accurately predict the occurrence of a hazard, where risk knowledge exists, is maintained and shared, then lives can be saved – as demonstrated by the case studies for Bangladesh, East Africa and the Philippines.

A particular challenge is the dynamic nature of risk information, including vulnerability and exposure, which can be affected by recent events (e.g. the impacts of other hazards, conflict, etc.). In the aftermath of Cyclone Freddy, prompt assessments were undertaken in Mozambique using drones, providing invaluable new information relating to safe areas and escape routes, even for areas that were inaccessible by foot or vehicle. This new information ensured that responses were appropriate and people were not put at greater risk during evacuation.

Significant gaps remain in observations and forecasting

Globally, two thirds of WMO members report having fully operational warning and alerting services, and more than half incorporate hazard, exposure and vulnerability information in their warning products. However, significant gaps endure in terms of monitoring and forecasting – for example, gaps in the GBON persist across much of the African continent and parts of the Pacific.

Predicting the impacts of multiple hazards occurring simultaneously or cumulatively over time is a particular challenge, and the latest data from the WMO reveal that less than a third of WMO members have the necessary monitoring and forecasting systems to do this.

SOFF, CREWS and other initiatives, including WMO flagship programmes (for example, SWFP) present opportunities to improve these figures. However, even within these initiatives, many challenges remain. For SOFF, not all countries have the capacity to initiate applications for funding, and while SOFF provides grants to support ongoing operations and maintenance, the mechanism still requires national governments to commit to funding a proportion of these costs, which many cannot afford. In the case of SWFP, country-level engagement can be limited by the availability of funds to enable participants to attend events, or institutions are unable to release staff due to lack of capacity to maintain operations, resulting in missed professional development opportunities for individuals and institutions.

Where effective monitoring is in place, accurate forecasts often follow. In the case of Cyclone Freddy, it was first detected by Australia's Bureau of Meteorology and subsequently tracked using satellites throughout its life as it travelled thousands of miles. Advanced tropical cyclone modelling was used to predict Cyclone Freddy's

track and changes in intensity, all thanks to effective international collaboration in terms of observations, data-sharing, modelling, products and expert advice.

Improved forecast lead times are saving lives

Maps showing the status of the GBON, which defines the minimum number of meteorological observations required to drive predictive models, show significant gaps across much of the African continent and parts of the Pacific as well as in the west of South America. Nonetheless, advances in science and technology together with the increase in available observations (while still below the GBON requirement) have led to improvements in forecasts, especially lead times. The provision of weekly global and regional scans/outlooks (e.g. by the WCM) are also enabling early action. Forecasts and warnings delivered days in advance gave communities time to prepare, saving lives and livelihoods in Bangladesh and in the countries where Cyclone Freddy made landfall.

There are limits to the predictability of some natural hazards

Some hazards and their impacts will always be challenging to predict in terms of timing (e.g. flash floods in Malawi and the Philippines) or location (e.g. landslides in Mozambique and the Philippines). Even with the best technology, warnings of tsunamis and earthquakes are inherently short notice, yet lives and livelihoods can be saved through preparedness and plans as well as public outreach and education relating to the risks and immediate actions to be taken.

Even in the context of hazards and impacts that can be forecast in advance, it can still take time to mobilize in response to triggers (e.g. in Bangladesh). Whether easy or hard to forecast, good practice is for the early initiation of no- or low-cost actions, which have benefits even if the expected event does not occur (for example, testing a water pump, clearing drains of rubbish, identifying safe places for evacuation or training first responders).

Data-sharing and cascading information

Data-sharing is fundamental to the provision of effective MHEWS and is regularly highlighted as a key challenge. These data are an essential input into the computer models that are used to provide advance warning of natural hazards, and which form the basis of the products and services that are produced at global, regional and national levels. This report has highlighted examples of good practice in the cascading of data and information from global and regional centres down to the national level, enabling sovereign States to issue more accurate warnings that enable local action. Examples include outputs from the SWFP, FFGS, HydroSOS and the IOTWMS, among others. These mechanisms present an efficient means by which to enable countries with lower capacity to provide reliable forecasts that they can then tailor to reflect the local context (including local impacts) and local needs (e.g. appropriate formats, language and channels). Other initiatives, such as the establishment of a series of situation rooms across the African continent, provide opportunities to strengthen the exchange and cascade of essential data, information and advice.

New opportunities with new technology

Innovations, especially in technology, present opportunities within every pillar of MHEWS – from improving the accuracy and timeliness of observations to increasing levels of connectivity across the globe. The collection and management of risk knowledge is also improved through technology, with increasing opportunities for local actors to collect data from remote locations (e.g. using drones and smartphone applications) and quickly share it nationally or internationally (e.g. over mobile Internet). In relation to warning communication and dissemination, there are significant opportunities to leverage advances and innovations in technology, especially in terms of mobile networks and Internet connectivity.

Image Source: Shutterstock / aphichato

Global connectivity and multiple channels

In the latest data, Indicator G3 (number of people per 100,000 that are covered by early warning information through local governments or through national dissemination mechanisms) has the highest scores and has also seen the greatest improvement in scores since reporting began in 2015. With 95 per cent of the world's population able to access a mobile broadband network and with 4G network coverage reaching 88 per cent of the world's population, there are significant opportunities to leverage mobile networks and Internet connectivity, especially in the context of hazards, which can only be forecast on very short timescales (e.g. tsunami). However, lack of affordability continues to be a barrier to Internet access, particularly in low-income economies and these "high-tech" solutions must be seen as part of a wider set of communication channels.

No-tech and low-tech solutions play an important part in reinforcing messages carried through other mediums and are invaluable in less affluent areas where access to technology is limited yet communities are often exposed to the greatest risk. They are also robust in the face of power failures and are essential in communities where literacy rates are low or multiple languages are spoken. In the case of Cyclone Freddy, multiple channels were used to warn communities with a combination of no-, low-, mid- and high-tech solutions being used to share data, information and knowledge with different actors, including local communities.

Sustained effort is required to support remote communities

Despite advances in technology, especially connectivity, some communities remain hard to reach and support. Intensive action is required for community outreach and engagement. A people-centred, locally led approach is required to effectively develop community EWS and support AA in remote areas and to ensure that the design of MHEWS and related services meet local needs and preferences. Local actors who people trust, such as National Red Cross and Red Crescent Societies and community-based organizations, should be engaged in collaboration to mainstream early warning and early action within and across communities.

Plans to act on warnings are not widespread

While the average score of the countries reporting on Indicator G4 (percentage of local governments having a plan to act on early warnings) indicated "substantial progress" towards achieving MHEWS, it reflects the status of just under one third of all countries. The number of countries reporting non-zero G4 scores are lowest in Africa (one fifth) and the Americas and the Caribbean (less than one quarter), whereas nearly half of the countries in Asia and the Pacific report having these plans. The scores for this indicator were also below the global average across LDCs, LLDCs and SIDS, suggesting that this should be a priority area for these highly vulnerable countries.

Developed by IFRC, United Nations organizations and NGOs in 2022, there were 70 active AA frameworks in place globally, with a further 97 under development in 2022. Although these developments are encouraging, AA is not yet being implemented at the scale required or for all of the hazards that can be anticipated. Yet, the evidence is clear – where plans, including AA frameworks, are activated, lives can be saved (e.g. Bangladesh, Cyclone Freddy).

Planned and rehearsed responses save lives

Globally, between 2015 and 2022, 1.7 billion people have been pre-emptively evacuated, 64 per cent of whom were in the regions of Asia and the Pacific. The recent years have also seen a steady increase in the number of people pre-emptively evacuated.

In the case of Cyclone Freddy, forecasts prompted mobilization of volunteers to engage in community awareness, outreach and related preparations including pre-positioning supplies and pre-emptive evacuation of people (e.g. in Malawi and Mozambique). However, evidence suggests that to be effective, plans need to be reviewed and tested regularly through simulations and drills. This is especially important for fast-onset and events that are hard to predict, and why exercises are regularly undertaken for tsunami in the Indian Ocean.

Foundations are being laid for multi-hazard early warning systems

Countries are setting the foundations for implementing MHEWS. More than a third of WMO Members report having a law, decree or similar mechanism in place for MHEWS and 78 per cent have SOPs in place with registered authorities and stakeholders. The importance of not just developing but also testing SOPs is among the good practice demonstrated by NTWCs as they come together to rehearse their responses to tsunami warnings in the regular tsunami exercises held for the Indian Ocean.

Frameworks for MHEWS are being established at regional levels (e.g. ASEAN, Africa [AMHEWAS]) and at national levels (e.g. EW4All Common Agenda for the Maldives) with associated governance structures, roles and responsibilities. Standards and codes are also being set across different disciplines (for example under Pillar 3), the implementation of CAP worldwide and the introduction of codes for the operation of public warning systems.

Collaboration, aligned initiatives and calls to action

Collaboration is key to the successful implementation of MHEWS worldwide – across all sectors, specialisms and at all levels. The pillar leads and their implementing partners, including REAP, are working hard to ensure that initiatives are aligned. Recent examples include the GCF Simplified Approval Process (SAP), which is designed to fast-track projects that scale up previously successful climate investments by CREWS. Under Pillar 3 and aligned with the EW4All initiative is the Call to Action on Emergency Alerting to scale up efforts to ensure that by 2025, all countries have the capability for effective and authoritative emergency alerting that leverages the CAP.

Global initiatives provide opportunities to leverage significant expertise. For example, SOFF draws on the expertise of advanced NMHS to provide peer-to-peer technical assistance, while CREWS is looking to further expand its growing network of partners to enable agile and dynamic project design and implementation covering all MHEWS components.

Sharing good practice through guidance and communities of practice

The publication of new guidance relating to MHEWS (e.g. UNDRR's WiA for MHEWS) ensures a shared understanding of MHEWS as a whole and its component parts. The mainstreaming of this knowledge underpins investment and adoption.

The development of communities of practice is essential to the efficient and effective scaling up of MHEWS worldwide. It is especially important at the local level, where there is the opportunity for communities in different parts of the world to share experiences and best practice, providing an entry point for the local implementation of MHEWS, from gathering risk knowledge and conducting risk assessments through to planning and practising response.

Sustainable funding for multi-hazard early warning systems is essential

The development and implementation of a MHEWS is not a small task, and requires significant investment from national actors and the global community for capital investment and ongoing operation. Sustainable funding is a challenge noted within and across each pillar – from funding forecasting products from the WCM to enabling AA – and at every level (e.g. national funding of operations and maintenance costs relating to SOFF-funded observations, credit for SMS or data on community leaders' mobile phones). A comprehensive approach is required, with sustainability built into the design of every MHEWS and related interventions.

Progress on Early Warnings for All

Foundational work to enable a full-scale implementation of the EW4All initiative has been completed. Progress has been made under each pillar and collectively, including development of road maps, plans and common agendas, and the establishment of the necessary governance structure at various levels, all of which are essential to the ongoing success of the initiative. However, now is the time for implementation and action.

5.2 Recommendations

Focus on risk knowledge, preparedness and advancing multi-hazard early warning system implementation across the regions of Africa, the Americas and the Caribbean, as well as LDCs and SIDs

Risk knowledge has the lowest scores of all the pillars, and is especially weak in the Arab States and LDCs. While inherently location-based, there are several methodologies that guide countries as to how to create, manage and apply risk knowledge as well as advances in technology to aid the collection and analysis of this vital information. The sharing of data and good practices as well as the development of communities of practice will enable the scaling up of risk knowledge at all levels. The tools and standards that are led by Pillar 1 of EW4All will greatly help accelerate the collection, analysis and application of risk data, while the forthcoming tracking system for hazardous events, losses and damages will enable localization of EWS, making it context-specific.[148]

Where preparedness and response plans exist and are activated, lives and livelihoods can be saved, even in the context of hazards that are fast-onset and hard to predict. Continued efforts to develop and agree preparedness and response plans (e.g. EAPs) must be sustained to ensure that warnings result in action being taken.

While progress has been made globally, some regions and country groups are falling behind. A renewed effort for MHEWS implementation is required in the Americas and across the Caribbean as well as in Africa. The LDC and SIDS country groups also have low levels of MHEWS and below average scores for the pillars.

Design multi-hazard early warning systems for scale

Without huge investment and technical support over a sustained period, it is extremely difficult for a country to progress from no MHEWS to a fully resourced and operational system capable of dealing with complex, multiple cascading and compounding hazards. Best practice is to start small (i.e. on the priority hazards identified locally) and to develop, test, iterate and expand the MHEWS over time. This enables the foundations to be set (e.g. governance, DRR strategies) and both technical capacity and professional relationships/partnerships to develop. However, this should not be unplanned, organic growth; rather, from the outset, the systems must be designed for scaling up in terms of geographic extent, number of hazards covered, data and systems used, implementing partners and associated resources.

Share data and knowledge

Throughout this report, data-sharing has been highlighted as an ongoing issue, yet it is the foundation for any MHEWS, whether the data is about hazards, vulnerability, exposure, risk or related information such as local traditions and languages that affect the dissemination and understanding of warnings. Good data also provide the means for monitoring progress on key indicators, compared with initial baselines.

Wherever possible, data should conform to standard formats (ideally machine-readable and where appropriate, geographically referenced) so that it can be readily ingested and used in decision-making systems (e.g. PhilAWARE). Data relating to people and communities should be disaggregated in line with key social variables (e.g. gender). Ownership should be retained by the originator and particular care taken with personal data. Quality assurance is key, with data verification and validation taking place. Regarding capacity assessments, a tiered approach can be useful with initial self-evaluation subsequently verified by regional actors before being formally validated by peer advisers (an approach used by the WMO). Equally, when taking stock of which

148 A handbook on risk knowledge for early warning systems is being prepared, which will compile different approaches and methods.

initiatives are taking place and where, it can be useful to collect data on status and progress from the perspective of the initiatives (top-down) and the countries (bottom-up).

Develop communities of practices

Data alone are not enough. To establish effective MHEWS globally, yet people-centred and adapted for local needs, it is essential to establish and grow communities of practice where knowledge and guidance can be shared and lessons learned. Rather than implement projects in silos, wherever possible, the potential for broader application should be considered. The CIFPD Project serves as a great example of where a set of guidelines have been developed primarily to address coastal issues serves as a "blueprint" for MHEWS implementation more generally, with a 10-step process supported by templates on policy, management and technical processes. This complements other reference documents, such as the guidance documents published by the WMO and UNDRR's WiA series.

Communities of practice also facilitate peer-to-peer support, mentoring and buddying, and can be a focal point for the hosting of exercises and simulations where different approaches can be tested and lessons learned. The larger these communities, the greater their potential. For example, in relation to future climate, countries can look to analogues, where their future conditions are already being experienced, to identify potential coping strategies that can be adapted to suit their local context.

Ensure local ownership and an all of society approach

Aligned with the need for MHEWS to be people-centred, it is essential that local actors are not just involved or consulted, but that they are at the heart of MHEWS design, development, implementation, evaluation, improvement and operation (e.g. AWARD). The civil sector has an important role to play in this regard, yet is often left out of the high-level discussions that focus on public-private engagement. While it may not be realistic to represent every NGO in these discussions, at a regional level, they can still be represented through larger groups (e.g. IFRC) and at a national level, by national associations of NGOs where they exist.

In the same vein, public outreach and engagement is essential to the effective functioning and adoption of MHEWS and AA. As noted in this report (including in annex 2), local communities have a wealth of risk knowledge and expertise in reducing their risks (e.g. nature-based solutions). Traditional leaders are also highly influential and can be crucial to the effective dissemination of warnings. International experts should be careful to facilitate rather than dictate solutions, instead seeking to draw out and utilize existing LTIK by ensuring that local people have a voice and agency.

Train key actors and test plans through simulations and exercises

Even where plans exist, they should not go unchecked. Simulations and exercises provide opportunities to test all aspects of MHEWS from roles and responsibilities, data flow and warning dissemination to testing equipment and practising actions (e.g. walking evacuation routes). Lessons will be learned from these activities and changes made (for example, adjustments to SOPs, introduction of additional back-up equipment and changes to governance structures). These events also provide an invaluable opportunity for different actors in the system to come together and learn from each other. Wherever possible, simulations and exercises should be part and parcel of any training for those involved in MHEWS.

Leverage flagship programmes and existing initiatives

Numerous mechanisms (e.g. SOFF), initiatives (e.g. CREWS), partnerships (e.g. REAP) and programmes (e.g. SWFP, FFGS, HydroSOS) have been showcased throughout this report. To deliver MHEWS at scale, it is essential to leverage this global expertise and proven best practices. Every opportunity should be sought to align and leverage these activities, and to ensure that time and resources are not wasted through duplication. It is essential to establish and maintain forums, mechanisms and tools

for coordination and alignment across all countries, partners and funders (including national governments, multilaterals, development donors, impact investors, philanthropists, etc.). Existing platforms (e.g. the Anticipation Hub) should also be harnessed, enhanced by increased data-sharing. However, there remains an opportunity under EW4All to create and maintain a platform to monitor activities across pillars and countries, which will provide a clear view of what is being done and where, mapped against national priorities to highlight where fundamental gaps remain. This should also enable patterns to emerge with regard to complementary activities and collaborations that have been effective in one location and have the potential to work elsewhere.

Maximize innovations in science and technology

Throughout this report, the opportunities brought by advances in technology and science have been noted. It is essential to bring these innovations to the task of EW4All. The importance of social science should also be kept in the fore – MHEWS can only be effective if warnings result in appropriate action. Thus, MHEWS can be enhanced by leveraging new understanding of how individuals and communities make decisions, experience and evaluate risk, share information and take action. To be brought into general use, the potential of new developments needs to be demonstrated. Whether centre stage or as a side event, conferences, forums and hackathons are examples of platforms for groups to showcase innovations, share best practices, build partnerships and identify new applications.

Harness sustainable and complementary funding

Sustainable funding is a key challenge for MHEWS provision worldwide. To address this, it is essential that current and potential funders (governments, donors, philanthropists, etc.) are brought into the EW4All community and its conversations to ensure shared understanding, urgency and action.

It is vital that sufficient, reliable and long-term funding is provided for public goods, such as adequate risk knowledge, hydrometeorological observations, high performance computing and significant scientific undertakings such as reanalysis work and model development.

Further, funding should not be limited to capital expenditure, but also cover operational expenses (e.g. power, communications) as well as ad hoc cash payments (for example, to ensure that community leaders have data on their phones so that they can receive warnings, implicitly valuing their important role in initiating local action).

However, the financing needs and status of MHEWS can only be assessed if there is accurate data available to understand the volume and nature of investments. Hence, tracking of investments in MHEWS, both by understanding the financial flows from donors and public finance as well as their receipt by countries, is critically important.

Fully operationalize the Monitoring and Evaluation Framework

The ambition and scale of the EW4All initiative is expanding the momentum in MHEWS implementation, both in financial flows as well as rapid advancement of MHEWS across its value cycle. Hence, accountability is a key component to sustaining this momentum. The operationalization of the EW4All Monitoring and Evaluation framework, including the accompanying tools and products, is critical to track progress, inform decision-making and measure success.

6

ANNEXES

Image Source: Shutterstock / BOULENGER Xavier


REPUBLIQUE DU TCHAD
UNITE TRAVAIL PROGRES
COMMUNE DE LA VILLE DE DOURBALI

Annex 1: Financing for multi-hazard early warning systems

A range of financial instruments exist in the field of weather, climate and early warning, including loans and grants as well as insurance.

According to the Creditor Reporting System of the Organisation for Economic Co-operation and Development's Development Assistance Committee, official development finance is provided using five main groups of instruments (Winckler *et al.*, 2019):

- **Grants:** transfers in cash and in kind where no legal debt is incurred.
- **Debt instruments:** transfers in cash and in kind where legal debt is incurred (e.g. loans, bonds and other securities) or could be incurred when certain events occur (e.g. reimbursable grants).
- **Equity:** a share in the ownership of a company or a collective investment scheme.
- **Mezzanine finance:** hybrid instruments, such as subordinated loans and preferred equity that present risk profiles between senior loans and equity.
- **Guarantees/insurance:** risk-sharing agreements under which the guarantor agrees to pay to the lender/investor part of or the entire amount due on a loan, equity or other instrument in the event of non-payment by the borrower or loss of value in case of investment.

These mechanisms operate at different levels (local, national, regional, international) and across different timescales, from short-term projects to longer-term strategic investment plans. Funds, including those led by development agencies and philanthropists, may also be structured across a set of themes and can be bilateral or multilateral. While in the past, funding may have predominantly been either public or private, increasingly, there are examples of "blended finance", which pools public (e.g. grants) and private resources (e.g. loans, equity investments, guarantees) and/or expertise (e.g. public-private partnerships) (Jung, 2020).

Specific funds have been set up to support the development of multi-hazard early warning systems (MHEWS) (for example, the CREWS initiative) or to support specific components of MHEWS, such as SOFF, which focuses on Pillar 2. These global initiatives are described in section 4.1 of this report.

In addition to these MHEWS-focused funding mechanisms, there are other funds that are increasingly supporting the development of MHEWS, as outlined below. Many of these funds have recently launched new funding or programming strategies that include a focus on MHEWS.

Alliance for Hydromet Development

Launched in 2019 and managed by the World Meteorological Organization, the Alliance for Hydromet Development pulls together major climate funds,[149] multilateral development banks[150] and United Nations organizations (UNDP, United Nations Environment Programme, World Food Programme and World Meteorological Organization) to scale up and unite efforts to close capacity gaps in hydrometeorological services. It aims to increase the effectiveness and sustainability of hydrometeorological investments by forging a collaborative partnership that recognizes and leverages the respective competencies and expertise of its members. The SOFF is a mechanism of the Alliance, which continues to serve as a coordination and knowledge exchange mechanism, and will produce the second Hydromet Gap Report in 2024.

149 The major climate funds include the Adaptation Fund, Climate Investment Fund, Global Environment Facility and Green Climate Fund

150 The multilateral development banks include the African Development Bank, Asian Development Bank, European Bank for Reconstruction and Development, Inter-American Development Bank, Islamic Development Bank and World Bank.

Green Climate Fund

GCF is the world's largest climate fund. It is mandated to support developing countries raise and realize their ambitions in relation to nationally determined contributions towards low emissions and climate-resilient pathways, with half of its resources used for mitigation and half for adaptation.[151]

To date, GCF has invested close to US$ 933 million in early warning projects. Out of 62 projects, 42 take place in least developed countries and 35 in SIDs.

To support an increased focus on MHEWS, in 2022, GCF published its *Sectoral Guide on Climate Information and Early Warning Systems* (GCF, 2022), which includes three "paradigm-shifting pathways" that guide proposal developers to the most effective projects:

- **Pathway 1:** Strengthening climate information services
- **Pathway 2:** Promoting impact-based MHEWS and early action (making robust early warning and early action services widely available)
- **Pathway 3:** Improving climate information and early warning systems for investment and financial decisions (climate information supporting systemic resilience frameworks, asset design and structuring, and innovative financial solutions)

Two new MHEWS projects were endorsed by the GCF Board in July 2023,[152] and a further six projects will be brought to the final Board meeting of 2023 in October. In total, these projects address early warning priorities across 14 countries. Once funding is approved, these countries will receive over US$ 160 million in funding (amounting to over US$ 700 million when co-financing is included).

A recent development specific to early warnings is the GCF-supported the SAP-CREWS Scaling-up Framework for Early Warning. The framework is linked to the GCF SAP and is being set up to "accelerate the deployment of climate finance towards investments in early warning systems for LDCs and SIDS", which aims to fast-track projects that scale up previously successful climate investments by CREWS. The Scaling-up Framework has been developed, and in 2023, a piloting phase with CREWS, countries and accredited entities began. The initial target is for 20 countries to access SAP funds of up to US$ 25 million for early warnings by 2027 (WMO, 2022a).

The GCF's Strategic Plan for 2024–2027[153] was successfully adopted at the thirty-sixth meeting of the GCF Board on 10 July 2023. It sets a comprehensive set of targeted results to be delivered over the 2024 to 2027 programming cycle, including ambitions around supporting developing countries to establish new or improved MHEWS. As a programming priority, GCF will expand coverage of climate information and MHEWS in line with the Early Warnings for All initiative. The 2024–2027 target is for 50–60 developing countries that particularly vulnerable to climate change to receive GCF funding for new or improved MHEWS.

Adaptation Fund

Established under the Kyoto Protocol of the United Nations Framework Convention on Climate Change, since 2010, the Adaptation Fund has committed over US$ 1 billion for climate change adaptation and resilience projects and programmes, including MHEWS.[154]

An example from West Africa is the Volta Flood and Drought Management project entitled Integrating Flood and Drought Management and Early Warning for Climate Change Adaptation in the Volta Basin. The project aims to provide the first large-scale and transboundary implementation of integrated flood and drought management strategies through the complete chain of the End-to-End Early Warning System for Flood Forecasting and Drought Prediction.[155] The project involves the NMHS and other authorities in the six riparian countries (Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali and

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151 GCF, "About GCF", 23 May 2023. Available at www.greenclimate.fund/about.

152 GCF, "GCF/B.36/21: Decisions of the Board – thirty-sixth meeting of the Board, 10–13 July 2023", 3 August 2023. Available at www.greenclimate.fund/document/gcf-b36-21.

153 GCF, "Strategic plan", 22 August 2023. Available at www.greenclimate.fund/about/strategic-plan.

154 Adaptation Fund, "About the Adaptation Fund", 29 September 2014. Available at www.adaptation-fund.org/about/.

155 Volta Flood and Drought Management, "Project Concept", undated. Available at www.floodmanagement.info/volta-basin/project-concept/.

Togo), and among other activities, is developing VOLTALARM, a MHEWS for floods and droughts in the Volta Basin.[156] For more details on Volta Flood and Drought Management, see section 4.3.1.2.

Global Environmental Facility

The Global Environment Facility is a "family of funds" dedicated to confronting biodiversity loss, climate change, pollution and strains on land and ocean health. Its combination of grants, blended financing and policy support help developing countries address their biggest environmental priorities and adhere to international environmental conventions.[157]

In July 2022, a new programming strategy was launched for the Least Developed Countries Fund and the Special Climate Change Fund, the two main channels for climate adaptation. One of the four themes in the strategy, which runs from July 2022 to June 2026, is Early Warning and Climate Information Systems. Examples of investments within this theme include: automated weather systems and their operations and maintenance; agro-hydrometeorological forecasting and information; related institutional capacity-building; and "last-mile" technologies for user groups.[158]

Risk transfer and pre-arranged financing

Funding is critical to address capacity gaps and invest in the infrastructure required to implement, operate and maintain MHEWS. With the advent of parametric insurance, payouts can be made once a predetermined trigger point, often defined by early warnings, is reached, and therefore before the full impacts materialize: "The sum of the claim pay-out will already have been decided using a predetermined method of calculating losses, rather than being based on an assessment of the actual loss and damage that has occurred".[159] This enables insurance to work alongside other mechanisms that enable AA. For example, social protection mechanisms, especially Adaptive Social Protection, which integrates social protection interventions with disaster risk management and climate change adaptation measures to better anticipate and respond to shocks.[160]

Global: Global Shield against Climate Risk

Launched at the twenty-seventh session of the Conference of Parties to the United Nations Framework Convention on Climate Change (COP 27) in November 2022, the Global Shield is a collaborative partnership of the Vulnerable Twenty Group (V20) and the Group of Seven (G7). Its aim is to provide and facilitate more and better pre-arranged protection against climate- and disaster-related risks for vulnerable people and countries.[161] It brings the design of Climate and Disaster Risk Financing and Insurance together with developments in MHEWS. The Global Shield will work across funds (including CREWS and SOFF) as well as across other financial mechanisms (e.g. insurance). For example, the Global Shield will "enable payouts even before disasters hit and support AA, e.g. by supporting forecast-based financing approaches of humanitarian actors".[162]

Regional: African Risk Capacity

The African Risk Capacity Group (ARC Group) is a specialized agency of AU established to help African governments improve their capacities to better plan, prepare and respond to extreme weather events and natural disasters. Through collaboration and innovative financing, the ARC Group enables countries to strengthen their disaster risk management systems as well as access rapid and predictable financing

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156 Zak Derler, "Early warning systems hold the key to disaster management in West Africa", 7 March 2022. Available at www.climatechangenews.com/2022/03/07/early-warning-systems-hold-the-key-to-disaster-management-in-west-africa/.

157 Global Environment Facility, "Who We Are", undated. Available at www.thegef.org/who-we-are.

158 Global Environment Facility, "Climate Change Adaptation", undated. Available at www.thegef.org/what-we-do/topics/climate-change-adaptation.

159 David Blackman, "Parametric insurance poses 'really compelling' solution to climate change driven weather events", 16 December 2022. Available at www.insurancetimes.co.uk/news-analysis/parametric-insurance-poses-really-compelling-solution-to-climate-change-driven-weather-events/1443284.article.

160 The World Bank, "Sahel Adaptive Social Protection Program", 8 November 2022. Available at www.worldbank.org/en/programs/sahel-adaptive-social-protection-program-trust-fund/overview.

161 Global Shield, "The Global Shield against Climate Risks", 21 May 2023. Available at www.globalshield.org.

162 V20, Global Shield against Climate Risks – German G7 Presidency and V20 Concept for Consultation, 21 September 2022. Available at www.v-20.org/wp-content/uploads/2022/10/2022-10-07_Global-Shield-against-Climate-Risks_Concept-_FINAL.pdf.

when disaster strikes to protect the food security and livelihoods of their vulnerable populations.[163]

The ARC Group merges traditional approaches of disaster relief and quantification with the concepts of risk pooling and risk transfer.[164] The "technical engine" of the ARC Group is Africa RiskView, "a software platform that is mainly used to estimate the number of people potentially affected by disasters and associated response costs."[165]

In operation since 2014, one of the main components of Africa RiskView is the drought model, which translates satellite-based rainfall information into near real-time impacts of drought on agricultural production and grazing for each year that data are available (1983 to the present). Insurance policy terms and conditions are based on each country's drought risk profile, and drought early warning is achieved through monitoring of the growing seasons of the main crop. In this way, the ARC Group's risk model can be used for parametric risk insurance. The ARC Group "works with in-country technical experts in emergency response and social protection to explore existing contingency funding mechanisms and response activities that could be complemented and used by ARC pay outs, and to consider supporting the scaling up of existing social protection programmes" (ESCAP, 2023b). For example, in 2019, the ARC Group's drought model detected severe drought in Senegal and estimated that more than 900,000 people were affected by severe drought conditions. The Government of Senegal received US$ 23.1 million from African Risk Capacity Insurance Company Limited to assist in providing early action to support more than the 975,000 people who were affected by drought during the 2019 agricultural season. The payouts went towards food, cash transfers and nutritional supplements for children under 5 years of age (ESCAP, 2023b). The ARC Group is modifying its existing products to pilot the concept of "anticipatory insurance", working with the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) in Malawi and Zambia, explored if its insurance payouts for drought could be made earlier by moving its trigger ahead in time (Anticipation Hub, 2022). This is now being implemented and will support AA prior to an event occurring.

In June 2023, the ARC Group launched its first flood risk insurance product in Africa. This parametric insurance product "will provide countries with predictable and rapid financing for early response to cope with emergency disaster events caused by floods." Initially developed for use in Côte d'Ivoire, Ghana, Madagascar, Malawi, Mozambique and Togo, the flood model will be extended to other countries in 2024.[166]

Regional: The Caribbean Catastrophe Risk Insurance Facility

The Caribbean Catastrophe Risk Insurance Facility (CCRIF) is a segregated portfolio company owned, operated and registered in the Caribbean, which extended its coverage to Central America in 2015. It is "the world's first regional fund utilizing parametric insurance, giving member governments the unique opportunity to purchase earthquake, hurricane and excess rainfall catastrophe coverage with lowest-possible pricing." [167]

In addition to providing parametric insurance, CCRIF also provides grants. For example, in 2021, it "provided another grant to the Government of Belize of US$43,140 to further enhance its early warning systems for extreme rainfall events", having previously provided funds for the purchase and installation of automatic weather stations.[168]

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163 ARC Group, "Homepage", undated. Available at www.arc.int.

164 ARC Group, "About ARC", undated. Available at www.arc.int/about.

165 ARC Group, Africa RiskView – Supporting early warning systems in Africa, undated. Available at www.arc.int/sites/default/files/2021-09/Africa-RiskView-Early-warning-brochure.pdf.

166 ARC Group, "African Risk Capacity launches the first Flood Risk Insurance Product in Africa", 6 June 2023. Available at www.arc.int/news/african-risk-capacity-launches-first-flood-risk-insurance-product-africa.

167 CCRIF, "Company Overview", undated. Available at www.ccrif.org/about-us.

168 CCRIF, "CCRIF Strengthens Belize's Early Warning Systems Capacity for Rainfall and Climate Forecasting with Grants Totalling US$143,000 (Belize $288,000/Eastern Caribbean $386,000)", 25 October 2021. Available at www.ccrif.org/news/ccrif-strengthens-belizes-early-warning-systems-capacity-rainfall-and-climate-forecasting?language_content_entity=en.

Annex 2: People-centred multi-hazard early warning systems

"Nearly every community has a group of people that are, for whatever intentional or unintentional reason, marginalized. It may be visitors—tourists, or seasonal and permanent immigrants to a community. Given that they do not listen to local radio stations or are unable to understand the local language and pick up cultural clues from their neighbours, they become marginalized during an imminent hazard. They must all be accounted for in early warning: identified, included, engaged or at the very least, warned. "

(IFRC, 2021).

In addition to being multi-hazard and end-to-end, to be effective, MHEWS must be people-centred (i.e. meeting the needs of all people). 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 and illness, loss of life and damage to property, assets and the environment (WMO, 2018a).

To be people-centred, a MHEWS need to be (UNDRR, 2022):

- **Inclusive** of the needs, perspectives, priorities and meaningful participation of the many different people in society, which vary according to their age, sex, disability, gender roles, sexual orientation, literacy, language, cultural practices, race, geographic location and socioeconomic position, among many others.
- **Accessible** to all, ensuring that information can reach everyone who may be impacted in a way that can be easily understood by all, regardless of their individual circumstances, including disability, literacy and language.
- **Actionable**, providing information that include potential impacts and recommended actions that people should take, which enable people to reduce their disaster risk as well as potential damages and loss. This requires that information is easily understood and relates to people's reality. For example, instead of telling people what the weather might be, explaining how the weather could affect them.

The application of a people-centred approach is perhaps most evident as an enabler of effective communication of warnings, for example, in the use of colour. If warnings are to be received, understood and acted upon, it is essential that the communication needs and preferences of the public, especially vulnerable groups, are understood and met.

The people-centred approach goes beyond the concept of the community as a receiver to one where they can also be a producer and facilitator of early warning information.[169] Communities should be

169 Global Disaster Preparedness Center, "Early Warning Systems", undated. Available at https://preparecenter.org/topic/early-warning-systems/.

actively involved in all aspects of the establishment and operation of MHEWS, aware of the hazards and potential impacts to which they are exposed, and able to take actions to minimize the threat of loss or damage. This means that MHEWS must go beyond the provision of information and advice to ensuring that communities have everything that they need to be able to take appropriate action, including knowledge, skills and resources (e.g. tools, materials, money). As noted by the International Federation of Red Cross and Red Crescent Societies (IFRC) (IFRC, 2012), MHEWS are only as good as the actions they catalyse – action is an essential part of any warning system. A community is only deemed "response capable" when they know, have practised and have the means to engage in appropriate response actions. To this end, wherever possible and practicable, communities should also take ownership of these systems (WMO, 2018a). Indeed, the IFRC distinguishes between community early warning systems (CEWS) and community-based early warning systems (CBEWS) (see Side feature: Community early warning systems and community-based early warning systems).

Communities are also the owners of essential, location-based knowledge relating to risk and how to mitigate it (see Side feature: Local, traditional and indigenous knowledge). Regular and inclusive engagement with communities from the outset is essential for successful implementation and long-term sustainability of MHEWS, with the systems embedded within the communities. Community engagement is a vital building block to ensuring the success of MHEWS initiatives as it facilitates trust and builds positive relationships between programme implementors and community members. It also ensures that the system reflects the needs and priorities of all community members, including diverse groups of women. Using community connections and networks that already exist can also enhance community cohesion (UNDRR, 2022). To this end, it is recommended (Practical Action, 2023) that practitioners primarily work as facilitators to utilize local knowledge and strengths, building people's agency and providing support when there are gaps. They should also actively recognize and work with differences within the community to ensure that MHEWS are designed to be suitable for all those at risk, not just the majority.

The importance of taking a people-centred approach is reflected in the guidance of key actors who are funding or coordinating MHEWS and risk-informed early action. For example, CREWS has developed and implemented people-centred operational guidelines and procedures (CREWS, 2023), and inclusive design is the focus of a recent report from the World Bank's Global Facility for Disaster Risk Reduction (see Side Feature: Global Facility for Disaster Risk Reduction report: Designing inclusive and accessible early warning systems). In addition, a recommendation of REAP's 2022 State of Play report was, for a change of terminology, to move towards a whole-of-society approach, which "implies, but goes beyond, 'people-centred', 'community-centred' or 'user-centred' approaches. It is not only about aiming to reach vulnerable communities and adapting existing mechanisms to a group or individual; rather, it strives to strengthen social justice and situate decision-making power within communities" (Wagner, 2023).

Use of colour in warnings

In many of the countries that have already established MHEWS, colour is used to communicate warnings. The traffic light colours of red, amber and green are increasingly used in both national and international systems, especially for impact-based warnings (see Spotlight: Impact-based early warnings). For example, in Europe, MeteoAlarm[170] uses red, amber and yellow[171] to indicate extreme weather warnings.

However, colours can be interpreted differently by users, especially those with colour vision deficiencies (e.g. colour blindness)[172] who are less able to see or distinguish between different colours. This can affect how users interpret forecasts and warnings, which use colour to indicate severity. Some people also struggle to read coloured text if it is presented over a coloured background (IFRC, 2020). There are online tools (e.g. Color Safe)[173] where colours and colour combinations can be tested. It is also important to be aware of cultural differences in the meanings and interpretations of colour.

170 MeteoAlarm, interactive map, undated. Available at www.meteoalarm.org/en/live/.

171 Green is not used – where there is no warning, no colour is shown.

172 Colour blindness typically affects 4–8 per cent of the population, with the least in Africa (IFRC, 2012).

173 "Color Safe", undated. Available at http://colorsafe.co/.

Community early warning systems and community-based early warning systems

IFRC defines a CEWS as an effort by or with, but not for, a community to systematically collect, compile and/or analyse information that enables the dissemination of warning messages that when actionable can help the community (or others "downstream") reduce harm or loss from a hazard (or threat) event (or process).[174]

In their guiding principles for CEWS, IFRC makes the distinction between community-based and community-driven MHEWS (IFRC, 2012). The latter emphasizes community empowerment and ownership of the system at every stage, putting communities at the heart of the system. They also suggest (IFRC, 2012) that CEWS are especially important in instances where:

- There is no national MHEWS
- National MHEWS are unable to provide clear and timely warnings to communities, or they are not trusted by communities
- Hazards are highly localized and would not be detected by a national MHEWS
- Disaster mitigation or communication alone may be enough to protect communities
- Communities are self-motivated to safeguard their lives and livelihoods from high exposure to risk by producing complementary or redundant monitoring products

In the case of CBEWS, there is more technical support from actors outside of the community, for example National Societies, who enable Red Cross and Red Crescent volunteers to take an active role in monitoring risks that impact their communities. This approach "provides the opportunity to both issue and respond to warnings that arise from local monitoring, especially for remote communities or where national early warning systems are undeveloped and unable to reach all at-risk areas."[175]

174 Global Disaster Preparedness Center, "Early Warning Systems", undated. Available at https://preparecenter.org/topic/early-warning-systems/.

175 IFRC, "People Centered Early Warning Systems", 10 March 2022. Available at www.ifrc.org/document/people-centred-early-warning-systems.

Local, traditional and Indigenous knowledge

LTIK is fundamental to the successful implementation of each element/pillar of MHEWS:

Risk knowledge: Communities have a good understanding of their priority risks, supported by location-based knowledge and informed by often undocumented, lived experience handed down the generations. This knowledge base can be strengthened through participatory approaches to help communities continue to monitor and learn about the risks to which they are exposed, which may in turn identify potential mitigating actions to take.

Observations, monitoring and forecasting: Using local signs to observe, monitor and forecast hazards, exposure and vulnerability, and how they change dynamically. This can involve volunteer community observers collecting and sharing data (e.g. monitoring using rain or river gauges).

Communication and dissemination: The role of traditional social networks (cooperatives, faith groups, women's groups, youth groups, schools, etc.) and related influencers (e.g. village chiefs, group leaders), especially in rural settings, in providing established and effective channels for communication that can be utilized for early warning.

Preparedness and response: Local communities are the first responders in the case of a high-impact event. They also have knowledge passed down the generations that can help to minimize impacts or aid recovery (e.g. controlled cool burning in forests), and are well-versed in the application of nature-based solutions (e.g. mangrove planting).

Global Facility for Disaster Reduction and Recovery Designing inclusive and accessible early warning systems

The 2023 report from the Global Facility for Disaster Reduction and Recovery[176] presents lessons learned, areas of good practice and entry points for inclusive and accessible MHEWS, and is structured around the four pillars. It advocates the adoption of pragmatic and contextually tailored approaches to the design and implementation of MHEWS, which ensure that everyone is included or at least represented. The report also proposes an inclusive MHEWS framework with five key actions (for example, to secure warning longevity strategies through trust and commitment). In the report, inclusivity is considered within and across each MHEWS pillar (GFDRR, 2023):

Risk knowledge: Inclusivity in MHEWS begins with community-based and participatory risk reduction approaches, including co-production of disaster management knowledge and materials that inform warning design and generate public receptiveness. The collaborative production or co-production of risk information is recommended as it enables the incorporation of local culture and knowledge.

Observations and forecasting: Communities have an important role to play in monitoring hazards and their impacts.

Warning dissemination and communication: The need for consistent messaging across multiple communication channels with contextually appropriate messaging using holistic approaches and ensuring that there is redundancy in communication infrastructure.

Preparedness and response: Importance of awareness campaigns, community training and evacuation drills to help maintain a constant level of readiness.

176 Rebekah Yore and others, "Designing inclusive, accessible early warning systems: Good practices and entry points", 2023. Available at www.preventionweb.net/publication/designing-inclusive-accessible-early-warning-systems-good-practices-and-entry-points.

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Early Warnings for All

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