World Meteorological Organization (WMO)—Concerted International Efforts for Advancing Multi-hazard Early Warning Systems

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Abstract

Recent international agreements such as the Sendai Framework for Disaster Risk Reduction 2015–2030, the 2030 Agenda for Sustainable Development and the Paris Agreement have all recognized the importance of developing and operationalising multi-hazard early warning systems that integrate the specificities of single-hazard early warning systems in a holistic, systematic and coordinated manner to promote synergies and maximize efficiency. While much progress has been made in recent years towards the advancement of knowledge and practice related to early warning systems worldwide, the lack of multi-disciplinary and transboundary cooperation among and across communities of scientists, decision-makers and practitioners continues to be a key challenge for the successful establishment and operation of these systems. To address this gap, major international and national organizations have collaborated to establish the International Network for Multi-Hazard Early Warning Systems (IN-MHEWS), with the aim of facilitating knowledge sharing and capacity development for multi-hazard early warning systems around the globe. This paper presents an overview of advances and challenges in promoting a multi-hazard and systematic approach to early warning, as well as the aim, objectives and expected contributions of this newly established Network.

Keywords

Multi-hazard early warning systems • Sendai framework for disaster risk reduction 2015–2030 • Multi-stakeholder partnerships • Knowledge sharing • Disaster risk management

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Introduction

Over the past two decades, early warning systems (EWS) have received increasing local, national, regional and international attention and are now recognised as a critical and solid component of national disaster risk management (DRM) arrangements aimed at reducing risk, saving lives and minimising losses from hazard events such as floods, storm surges, earthquakes, tsunamis and epidemics (UNISDR 2015a, 2006a, b; UNEP 2012; Basher 2006; Chang Seng 2012). The importance of EWS for disaster risk reduction (DRR) has been repeatedly highlighted in major international agendas, including the Yokohama Strategy and Plan of Action for a Safer World 1994 (UN 1994), the Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities (HFA) (UNISDR 2005), major multilateral environmental agreements and action plans such as under the United Nations Framework Convention on Climate Change (UNFCCC), and the United Nations Convention to Combat Desertification (UNCCD) as well as, most recently, in the Sendai Framework for Disaster Risk Reduction 2015–2030 (UNISDR 2015b), the 2030 Agenda for Sustainable Development (UN 2015) and the Paris Agreement on Climate Change 2015 (UNFCCC 2015).

While EWS have often been developed to target specific hazards and consequences, the need to adopt a people-centred, all-hazard approach to early warning has been acknowledged based on the understanding that citizens, decision makers and practitioners are more concerned with integrated DRM strategies rather than the specificities of each individual hazard, especially when dealing with their concatenated or cascading impacts (Basher 2006). In some cases, EWS are already operated for multiple hazards, particularly in the context of hydrometeorological phenomena and increasingly in disease outbreaks and humanitarian emergencies, and to a lesser extent for geophysical hazards. However, more efforts are needed to develop and operationalise MHEWS that integrate the characteristics of single EWS through "a coordinated 'system of systems'" (Basher 2006: 2171) to build synergies and promote multi-disciplinary collaboration (UNISDR 2006a, b; UNEP 2012). Through the Sendai Framework adopted at the Third United Nations (UN) World Conference for Disaster Risk Reduction (WCDRR) in Sendai, Japan, in March 2015, UN Member States agreed on the necessity of investing in, developing, maintaining and strengthening people-centred multi-hazard early warning systems (MHEWS), including telecommunication systems for hazard monitoring and emergencies, simple and low-cost early warning equipment and facilities, and broadened release channels for warning information that is tailored to different user needs and sectors.

One of the seven global DRR targets of the Sendai Framework (target g) aims to "*substantially increase the availability of and access to "Multi-Hazard Early Warning Systems (MHEWS)" and disaster risk information and assessments to the people by 2030*". In this document States also called for the "*further development of and investment in effective, nationally compatible, regional multi-hazard early warning mechanisms, where relevant, also contributing to the Global Framework for Climate Services (GFCS)*", and the facilitation of information sharing and exchange across all countries. To a large extent, achieving this target will depend on strengthened regional and international cooperation and on developing and applying science- and community-based methodologies and tools for MHEWS.

Against this background the article presents the recently established International Network for Multi-Hazard Early Warning Systems (IN-MHEWS), a major multi-stakeholder initiative proposed at WCDRR and launched in 2016. To provide essential context, the following section looks at the evolution of the conceptual understandings of EWS and MHEWS and their key components but also at recent advances and remaining gaps and challenges with them.

Context—from Early Warning Systems to Multi-hazard Early Warning Systems

Every societal entity has its own set of threats to be concerned about and therefore an interest in early warning. Governments and many non-governmental organizations (NGOs) have a legal and ethical obligation to protect their citizens and economies by issuing early warnings. While the risks from some hazards can be reduced to a tolerable level and their impacts can be well prepared for, other risks cannot be eradicated—although one can raise the awareness of these hazards, their likelihood and the severity of their impacts. For most of these (perceived or real) threats a mix of informal or formal warning systems exists—often focussing on the same or similar hazards, but operated by several players at the same time, in any given area, and at the levels of individuals, communities, businesses, governments or international organisations. Collectively, these systems provide a first defence against a variety of hazards.

Understanding the concept and components of (MH)EWS is a key requirement to develop and strengthen such systems, to prioritize investment and international cooperation and to measure effectiveness of and progress with them. This quickly proves to be complex, and a universally accepted definition of an (MH)EWS does not—and may never—exist.

What Is a (Multi-hazard) Early Warning System?

Based on the practice across warning systems for different hazard types there is a general agreement among practitioners and decision-makers that an EWS is made up of several components rather than being the issuance of warnings alone (Fig. 1). This is reflected in the well-established definition of EWS contained in the 2009 Terminology on DRR which is based on the outcomes of three International Conferences on Early Warning in 1998, 2003 and 2006 (EWC I-III): "*The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss*" (UNISDR 2009: 12).

However, through the Sendai Framework, States tasked the United Nations Office for Disaster Risk Reduction (UNISDR) to facilitate an intergovernmental process to update this terminology, including the term EWS and the new term MHEWS. While these definitions will only become available in early 2017, EWS are being described as an interrelated set of hazard monitoring and prediction, risk assessment, communication and preparedness sub-systems and processes/activities that enable individuals, communities, governments, businesses and others to take timely action to reduce their risks in advance of hazardous events. The definition will be complemented by a annotation that essentially states that effective "end-to-end" and "people-centred" EWS are still comprised of four interrelated key elements: (1) risk knowledge based on the systematic collection of data and risk assessments; (2) detection, monitoring, analysis and forecasting of the hazards and possible consequences; (3) dissemination and communication of timely, accurate and actionable warnings and associated information on likelihood and impact; and (4) preparedness and response capabilities at different levels

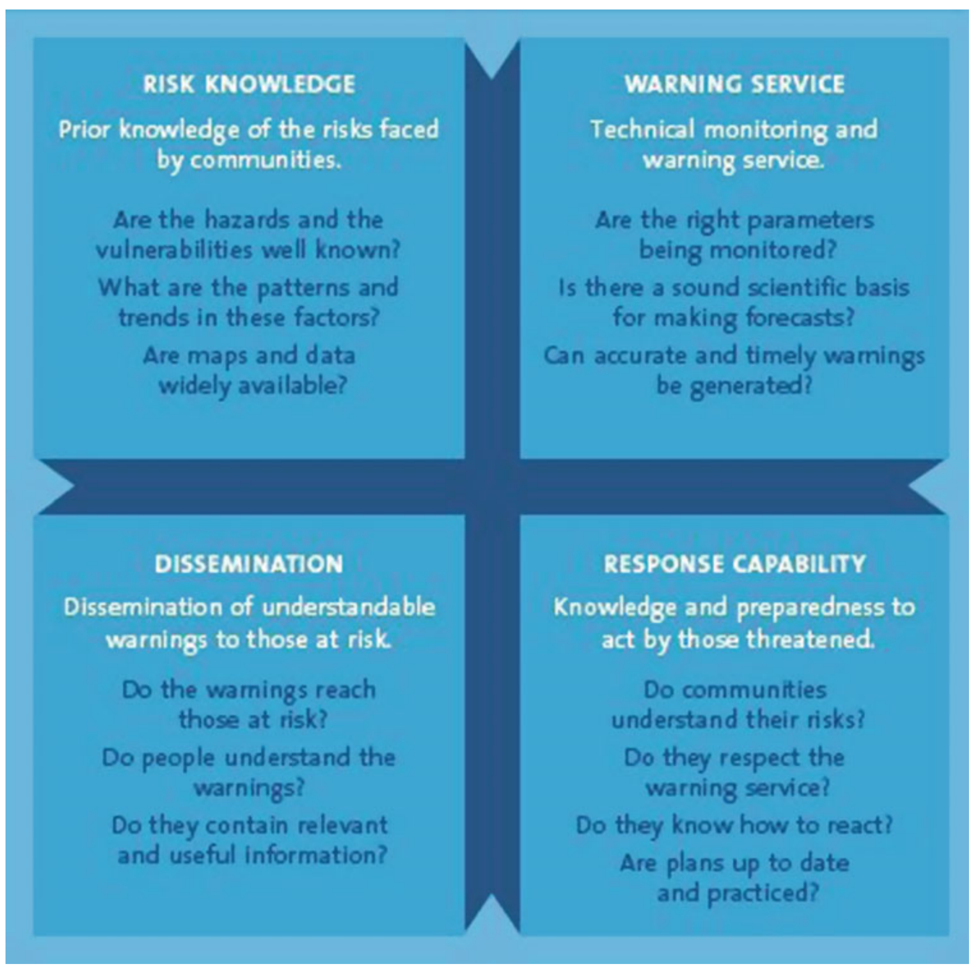

Fig. 1 The four elements of effective early warning systems [*Source* Information brochure of the International Early Warning Programme (IEWP) (http://www.unisdr.org/2006/ppew/info-resources/docs/IEWP.pdf [Last accessed: 4 November 2016])], (UNISDR 2006b)

to respond to the warnings received (UNISDR 2016b). These four interrelated elements need to be coordinated within and across sectors and multiple levels for the system to work effectively and effective feedback mechanisms need to be in place for continuous improvement. Failure in one component, or lack of coordination across them, could lead to the failure of the whole system—a critical issue since an EWS that does not warn effectively will not be trusted (Golnaraghi 2012).

EWS can be developed for specific hazards and specific consequences or for multiple hazards and a range of impacts. The latter are termed MHEWS—a concept that is relatively new—and currently defined (UNISDR 2016b) as EWS which are designed to be used in multi-hazard contexts where hazardous events may occur alone, simultaneously or cumulatively over time, and taking into account the potential interrelated effects. A MHEWS with the ability to warn of one or more hazards increases the efficiency and consistency of warnings through coordinated and compatible mechanisms and capacities, involving multiple disciplines for updated and accurate hazards identification, mapping and monitoring and dissemination of warnings from various sources with a "single authoritative voice" and through standardized formats, codes and definitions. They may also involve international cooperation to address transboundary risks, such as floods, epidemics and the release of hazardous materials into the air or water. MHEWS, therefore, build synergies for data collection, analysis and operational management, thus enhancing cooperation, efficiency and effectiveness (Basher 2006).

However, in practice and even in theory, there is no agreement what is meant by an EWS and its individual terms "early", "warning" or "system". The answers are highly contextual, depending on social settings and the hazards themselves. In general, "early" indicates that a warning is provided in advance of a potential hazard event in order to allow for sufficient time for preparatory actions Thus, the hazard-specific "lead time" becomes a crucial characteristic of the EWS. However, "early" in terms of warning of possible climatic changes could mean 100 years in advance, whereas for a flash flood it could be less than an hour in advance. In some instances, the first warnings can only be issued when the hazard has already materialised, e.g. for some tornadoes or after a potentially tsunami-generating earthquake.

A "warning" is information that supports decision-making dedicated to threats and hazards and their potential impacts based on thresholds and other, user-specific criteria. However, caution is advised since a warning can be understood as a general information category with no legal obligation or an authoritative message from a mandated national authority that triggers a specific protocol. It may also include specific actions which people or organizations should take.

A "system", from a systems thinking perspective, is made up of entities that are linked through flows and interactions, with inputs and outputs. For EWS as a "system of systems" this includes for example monitoring, forecasting, warning generation, communication, emergency response and feed-back systems as well as their legal and institutional basis, and the people involved.

EWS need to focus on vulnerabilities as part of the day-to-day lives of the people they serve who display different forms and degrees of vulnerabilities and capacities. Kelman and Glantz (2014) argue that EWS are a social process that involves technical components embedded in their social context, which contrasts with technical views that an EWS comprises only the technical equipment detecting or forecasting a hazard event and sending its parameters to a decision-making authority. This process is on-going and rooted in day-to-day and decade-to-decade functioning of society and is not only triggered when a hazard is about to strike. It is used to educate people, train them about response (e.g. through drills), gather baseline data and map risks. In fact it can be observed that there is a narrower understanding of EWS (i.e. detection, monitoring, modelling, and forecasting of the hazards as well as warning preparation and dissemination, based on risk knowledge and legal/institutional arrangements), and a wider understanding of EWS (i.e. corresponding to the 4 components) as adopted by EWC III in 2006. Both are widely in use. The problem with this wider understanding of EWS is that an EWS then becomes almost indistinguishable from DRM.

EWS also apply to long-term, "creeping" changes that can change baselines and indicate trends – often only recognised once a specific threshold is crossed and often not being hazards per se but influencing other hazards and slow-onset hazards in addition to the quick-onset ones. For example, while climate change may not be a hazard itself, the process could still be warned of, partly to address the causes and partly to deal with the consequences. In this regard the Intergovernmental Panel on Climate Change (IPCC) can be understood as an EWS for climate change by assessing and synthesising climate change science and presenting actions that are needed. In theory, the earlier a warning is available, the more time there is to prepare for and hopefully respond effectively to the potential impacts of stressors, threats and hazards. An EWS for slower and gradual changes should therefore give more time to design prevention and adaptation to new hazard regimes, plan a response and integrate that response into day-to-day life and longer-term development.

No single agency can be responsible for all EWS-related activities. While there may be an officially designated EWS for specific hazard types with authorities having a mandate for these hazard types or the warnings of them, there are many other channels through which people receive or look for warning information and advice.

Recent Advances in Early Warning Systems

In line with Priority for Action 2 of the HFA, regions and countries across the world have made significant progress over the past 10 years in strengthening end-to-end, people-centred EWS—often for multiple hazards. Progress has been evident in the development of observation and monitoring systems and the strengthening of communication and information on risks, as part of the overall efforts to strengthen disaster resilience. Today, EWS are established and operational in many countries of the world, focusing on a variety of natural and human-induced hazards and utilizing available scientific knowledge and latest technologies.

The recent decade has witnessed a significant evolution in information and communication technologies (ICT). Access to space-based data is now more open, made possible by the changes in data policies. The development of personal mobile devices, such as smart phones and tablets, and the use of geographic information systems and geo-viewers has advanced quickly. This has built the foundations for a new generation of highly sophisticated EWS making use of high-accuracy information and advanced processing techniques to provide warnings in near real-time conditions, as is the case with earthquake EWS (Meissen and Voisard 2010). In this regard, there is a need to determine and share the best ways of applying these advances in ICT to EWS operations worldwide.

With regards to EWS for hydrometeorological hazards, which remain the trigger of most disaster events, significant advances have been made in predicting weather, water, and climate extremes. On average, a five-day weather forecast of today is more reliable than a two-day weather forecast of two decades ago. There has also been consistent progress in risk assessment and hazard mapping, and the recognition of indigenous warning knowledge in enhancing the operations of such EWS.

With regards to non-hydrometeorological and non-geophysical hazards (such as biological and technological hazards, famine and other societal hazards), technical advances have been made in individual fields that have, for example, improved the detection and monitoring of epidemic-prone diseases; enhanced preparedness for potential humanitarian emergencies from various causes (e.g. lack of food availability and access can lead to food insecurity); increased safety of air, food and water quality; and reduced the risk of chemical and radiological exposures. Considerable progress has also been made on EWS for volcanic eruptions, landslides, avalanches, tsunamis, and—more recently—for earthquakes. Geophysical hazards require rigorous hazard, vulnerability and overall risk assessments in order to develop effective long-term plans and some of these systems are still relatively novel and present many theoretical and operational challenges. In general, there is a strong need to enhance the scientific, technological and operational capacities of countries, both in those that are already operating such EWS and in those that could greatly benefit from their future implementation. In this regard, international initiatives such as the establishment of the "International Platform on Earthquake Early Warning Systems" (IP-EEWS) under the United Nations Educational, Scientific and Cultural Organization's (UNESCO) lead contribute to fostering scientific knowledge on least developed EWS and enhancing collaboration between scientists and practitioners for capacity development, while at the same time promoting the integration of these systems into MHEWS. Furthermore, the increase of extreme geo-hazard events due to climate change has been subject of a large body of literature in recent years, which has investigated how global warming may trigger a broad range of geo-hazards including earthquakes and volcanic hazards (cf. McGuire 2013; Liggins et al. 2010; Deeming et al. 2010). While further research is needed to explore these interactions, their potential implications for policy and practice reinforce the need for integrated, multi-hazard systems.

EWS, together with other DRR measures, have in many regions led to a substantial reduction in the number of lives lost due to natural hazards. Moreover, in the 2011 Global Assessment Report on DRR (GAR 2011), UNISDR reported that in most parts of the world, the risk of being killed by a tropical cyclone or a major river flood is lower today than it was in 1990, also thanks to EWS. However, the economic losses from disasters are now reaching an average of US$250 billion to US$300 billion each year (UNISDR 2015a). More critically, the mortality and economic loss associated with extensive risks, i.e. the risk of low-severity, high-frequency disasters mainly associated with localised hazard events, in low and middle-income countries are trending up (UNISDR 2015a).

Gaps and Challenges Related to Early Warning Systems

Notwithstanding these advances in EWS in the past decade, many countries, in particular least developed countries (LDCs), small island developing states (SIDS), and landlocked developing countries (LLDCs), still have not benefited from them as much as they could have. Developed countries operate more EWS than developing countries, for which the sustainability of EWS is a major challenge

(UNISDR 2006a, b; UNEP 2012). Despite tremendous efforts and progress with EWS, the world has seen increasing economic losses and continued high tolls of death, injuries and illnesses from the impact of natural hazards such as storms in the USA, the Philippines, and Myanmar; floods in European countries, Thailand, India and Pakistan; the outbreak of diseases such as Ebola in West Africa; droughts in Africa; heat waves in Europe and Asia; tsunamis in the Indian Ocean and the Northwest Pacific Ocean and disastrous earthquakes in Haiti, Ecuador and China.

What has been defined as the “last mile” of EWS (Shah 2006)—i.e. reaching the most remote and vulnerable population with timely, meaningful, and actionable warning information and integrating a gender-sensitive and inclusive perspective into EWS—has been difficult. Most EWS focus on the hazard component of risk. But the necessity to promote an understanding of social vulnerability as a fundamental element of risk information and early warning to address the needs of the most vulnerable and account for the differential disaster impacts has been internationally recognised, and so has the need to tailor DRM strategies and practices to local capacities and needs (cf. UNISDR 2015b; Hewitt 1983). Thus, operational challenges exist for technical agencies, such as national geological, meteorological and hydrological services, to work together with DRM/civil protection agencies, statistical offices, and other relevant stakeholders such as NGOs, to incorporate in their warning activities relevant vulnerability and impact information (including hazard and risk maps) that is requisite to forewarn, empower and guide at-risk individuals, groups and communities to assume a more proactive role in the delivery of services for DRR.

Several gaps persist due to weak multi-disciplinary coordination and collaboration among the actors and agencies concerned, lack of standard operating procedures (SOP) and interoperable information systems, limited public awareness and participation in risk management, insufficient political commitment, and limited public/private financial support for the implementation of these systems (UNISDR 2006a, b; UNEP 2012; Clinton et al. 2016). Additional efforts are needed to institutionalize and strengthen MHEWS that provide multi-hazard risk communication messages tailored to the needs of specific individuals and communities, while following common standards such as the Common Alerting Protocol (CAP) and colour-coded warning messages based on risk matrixes. All these factors add to the scientific and technical challenges of developing some of these systems and are critical prerequisites for their operationalization (cf. e.g. Clinton et al. 2016).

Global societal changes such as rapid urbanization, increased mobility of populations and the growing exposure of people and assets to hazards are resulting in a highly dynamic, complex and globalised state of disaster risk. This is further exacerbated by global threats such as climate change, antimicrobial resistance, and other emerging and re-emerging disease threats. As proven by recent calamities, the impact of natural hazards can cascade into more serious consequences. For example, the 2010 eruptions of Iceland’s Eyjafjallajökull volcano created havoc in the airline industry, triggering many cancellations and delays in flights, and affecting economic, political and cultural activities in Europe and across the world. This and similar cascading disaster events such as the 2006 Philippines landslide, 2011 Thailand floods, and the 2013 Typhoon Haiyan in the Philippines and its storm surge manifest the need to broaden the scope of EWS to address and cope with multiple hazards and risks, at multiple spatial (including regional and even global levels) and temporal scales.

At the same time, significant gaps remain with advancing the development of EWS for specific hazards, particularly for fastest onset hazards such as earthquakes and slowest onset hazards such as droughts and eventually climate change impacts. Most EWS exist for hydrometeorological hazards while they are generally less developed for geophysical hazards (UNISDR 2006b; UNEP 2012) such as landslides which are often triggered by hydrometeorological events. This adds to the challenges of linking these systems together to establish MHEWS. In this regard, international and regional collaboration of multiple stakeholders such as internationally-agreed strategies for data sharing, together with sustainable funding for MHEWS is critically necessary, given the transboundary nature of most natural hazards.

In particular, findings from surveys (UNISDR 2006a, b; WMO 2006, 2014; UNISDR 2015a, b) highlighted further gaps and challenges in implementing EWS worldwide (Table 1). Overall, there is a present need for a prominent “voice” for early warning at the international level that could advance a coordinated agenda on MHEWS worldwide, raise their visibility and advocate the strengthening of MHEWS in global and regional platforms and among key stakeholders, such as donors, private sector partners and academia.

Tracking Progress

In 2005, at the request of the UN Secretary-General, a global survey of EWS was undertaken with a view to advancing the development of EWS for all natural hazards (UNISDR 2006b). Already this survey report concluded that while some EWS are well advanced, there are numerous gaps and shortcomings, especially in developing countries and in terms of effectively reaching and serving the needs of those at risk. After the global survey and the adoption of the HFA, UNISDR facilitated biennial government reviews of

Table 1 Main gaps and challenges with regards to early warning systems

Risk knowledge
Need for quality-controlled historical time series of extreme hazard event and disaster occurrences in terms of intensity or magnitude, location, duration, timing, impacts
Risk and impact information often not or insufficiently integrated into EWS due to e.g. lack of cooperation between technical agencies responsible for collecting hazard data and stakeholders collecting vulnerability and exposure data as well as a lack of availability or access to (reliable) loss and impact information
Even if risk knowledge is incorporated, often still an inadequate representation of all dimensions of vulnerability (e.g. in urban areas, future dynamics)
Monitoring and warning service
Many regions lack modern monitoring and communication systems such as Doppler radars
More research and development is needed to improve observations, monitoring, data processing, modelling, forecasting and prediction and related applications
Lack of policy and legal frameworks to ascertain authority and accountability
Lack of resources for sustainable operations of agencies
Insufficient transboundary information sharing
Warning dissemination and communication
Insufficient focus on the uptake and use of warning messages, including capacity to use the information for longer term interventions
Proliferation of information and communication technologies leading to loss of single authoritative voice and to warning messages from unofficial sources (also due to ineffective engagement with the media and private sector)
Warning messages sometimes not clear and incomplete, e.g. due to a lack of standardized nomenclature and non-technical, actionable language and because uncertainties are often not well specified and explained
Communication networks break down during disasters (lack of back-up systems)
New technologies and support for dissemination and communication of warnings are often not available in least developed countries
Challenges in promoting public/private partnerships, market access, and incorporation of indigenous knowledge
Response capability
Response capabilities vary between countries and depending on the hazard
Lack of education and training for response
Role of non-governmental responders not well reflected in policies and legislation, missing out on opportunities for partnerships that do not rely on the central government
Lack of participation of the public and local emergency management agencies in the development of response plans

progress in implementing the HFA at the local, national, regional and international levels, using the HFA monitor.[1]

While the surveys conducted between 2005 and 2012, including the HFA reports, provide an overview of EWS operated in many countries and regions of the world (WMO 2006), this was largely restricted to disasters triggered by natural hazards only and there has not yet been a new comprehensive, global inventory of EWS for individual hazards, let alone of MHEWS that could serve as a baseline for monitoring progress in the coming decades. In addition, at this moment in 2016 there is no official mechanism yet for detailed reporting on national, regional or global efforts on early warning, especially on advances since the 2004 Indian Ocean Tsunami.

However, as recommended in paragraph 50 of the Sendai Framework, the UN General Assembly established via resolution 69/284 (adopted on 3 June 2015) an open-ended intergovernmental expert working group (OIEWG DRR) in 2015, comprised of experts nominated by States, and supported by UNISDR and with involvement of relevant stakeholders, for the development of a set of possible indicators and an update of the 2009 UNISDR Terminology on DRR by December 2016. This is carried out in coherence with the work of the inter-agency and expert group on sustainable development indicators (IAEG-SDG) and will allow for the measurement of global progress in the

[1] http://www.preventionweb.net/english/hyogo/hfa-monitoring [Last accessed: 4 November 2016].

implementation of the Sendai Framework, including with target g), using the Sendai Monitor.

The currently proposed indicators (UNISDR 2016a) include the number of countries that have multi-hazard monitoring and forecasting systems, the number of people who are covered by and have access to MHEWS (per 100,000 persons), the number of local governments having a preparedness and/or evacuation plan with SOP, the number of countries that have multi-hazard national risk assessments/information available in an accessible, understandable and usable format and the number of local governments that have multi-hazard risk assessment/risk information available in an accessible, understandable and usable format for stakeholders and people. All these indicators combined yield the compound indicator of the number of countries that have MHEWS.

There is thus a need both for a new baseline as well as for a periodic account and review of (MH)EWS implemented and operated worldwide. Governments and stakeholders will need, however, guidance, support and good practice examples on how to strengthen MHEWS and on how to report against the respective indicators.

An International Network for Multi-hazard Early Warning Systems (IN-MHEWS)

To address these issues, key international and national agencies and organizations announced the establishment of an International Network for Multi-Hazard Early Warning Systems (IN-MHEWS) at the WCDRR Working Session on Early Warning as one of its major outcomes. This partnership under the Sendai Framework will foster coordination, cooperation, collaboration, and networking with the aim of strengthening MHEWS. Building on their respective programmes and activities and institutional mechanisms for cooperation, the IN-MHEWS partners will work together to promote a holistic and integrated multi-hazard (natural, including biological, and human-induced hazards), multi-stakeholder and multi-level approach to early warning with a common priority agenda and plan of action.

With this IN-MHEWS builds on earlier international efforts on early warning. The three International Early Warning Conferences (EWCs I-III) hosted by the Government of Germany were specifically dedicated to the scientific, operational and coordination aspects of EWS around the world, presenting innovative projects that would minimise the impact of natural hazards through the implementation of people-centred EWS. In response to the call for establishing a suitable framework for advancing early warning as an essential risk management tool, EWC II in 2003 proposed the International Early Warning Programme (IEWP). In line with the international efforts to promote early warning at the time, the World Conference for Disaster Reduction (WCDR) in 2005 Kobe, Japan, which adopted the HFA, also launched the IEWP. As an implementation mechanism for the IEWP, the Platform for the Promotion of Early Warning (PPEW) was created in 2004 in Bonn, Germany and remained operational until 2008. IN-MHEWS wants to give new momentum to these efforts under the Sendai Framework, without being a new institution nor a global operational EWS.

Objectives

As a broad-based networking initiative on early warning, IN-MHEWS will exemplify the importance of multi-stakeholder cooperation in MHEWS as a way to guide and advocate their implementation and improvement, share lessons learnt and increase the efficiency of investments in MHEWS for enhanced societal resilience. It aims at serving as the preferred source of information on MHEWS and related efforts worldwide. Responding to the calls by States in the Sendai Framework, the key objectives of IN-MHEWS are to:

(a) Promote synergies and partnerships between and among stakeholders and those directly involved in (in charge of) MHEWS at national, regional and international levels and to strengthen respective user-interface platforms;
(b) Identify effective strategies and actions to promote and strengthen MHEWS in support of the implementation of the Sendai Framework and other international agreements;
(c) Facilitate the sharing of good practice and making available to governments and key stakeholders expertise and policy-relevant guidance to enhance and sustain MHEWS and related services as an integral component of their national strategies for DRR and climate change adaptation (CCA) in their strive for a resilient and sustainable development;
(d) Provide a sound conceptual and scientific understanding of MHEWS and advocate the usefulness of a multi-hazard and systems approach to early warning in regional and international platforms and processes and among key stakeholders, including donors, from all sectors;
(e) Assess the progress made by individual EWS for specific hazards or hazard clusters, the existing relations within and between them and the potential synergies facilitating their integration into an effective, people-centred MHEWS; and,
(f) Identify new areas of, and promote further, scientific research on and technological development of EWS for

single hazards (hazard clusters) while advocating for their integration into MHEWS as well as the application of these latest scientific and technical advances.

Expected Outcomes and Initial Activities

Derived from the objectives, a first expected key outcome of IN-MHEWS is a viable and active community of institutions and practitioners working on EWS and MHEWS, including the communication tools required for such a network (a website, calendar of events and internal meetings, mailing lists, online work space, etc.), an appropriate governance mechanism, a common priority agenda on MHEWS throughout the lifetime of the Sendai Framework with a work plan for the near term, expert teams, etc. This requires federating a broad range of key international stakeholders in MHEWS, including their organizations' policy stances and attitudes on all aspects relating to MHEWS, and promote IN-MHEWS in their respective constituencies as well as multi-stakeholder fora. Activities include supporting and expanding this network of individuals, organizations and programmes working to improve early warning and related efficient response, stimulating dialogue and collaboration through further networking and partnerships (e.g. among major UN agencies concerned with early warning, such as UNESCO, WMO, the Food and Agricultural Organization (FAO), the World Food Programme (WFP), the United Nations Environment Programme (UNEP), and the UNFCCC Secretariat, amongst others).

A second key outcome is a baseline and inventory of EWS/MHEWS on different levels, based on a global review (e.g. in the form of a survey among countries and organizations). Such a survey could be conducted on a regular basis (e.g. every four years) as a benchmark that identifies gaps and emerging issues related to early warning from an international or global perspective (e.g. cascading effects of natural hazard impacts, climate change impacts, urbanization, amplification of risks at the global scale, ethical, accountability and liability issues in EWS operation, etc.). This may yield an improved conceptual understanding of MHEWS over time. It may also allow for better coordination of major programmes, funding initiatives and related projects on MHEWS that all strive to enhance the capacities of countries to generate and disseminate early warnings for multiple and/or cascading hazards and to respond to them effectively.

A third key outcome is providing policy-relevant guidance with evidence that is actually used and helpful. This requires e.g. facilitating the development of guidelines for countries to review and measure the effectiveness of and progress with EWS for single hazards/ hazard clusters and MHEWS in line with the priorities, targets and the monitoring mechanism of the Sendai Framework ("Words into Action" Sendai Implementation Guide), including how to measure the number of people with access to early warning and risk information and assessments against the number of people exposed to related risks; the potential impact of disasters, (including disaster-related mortality and morbidity) and the extent to which gender, youth and vulnerable groups' perspectives are reflected in these systems. Another set of guidelines will address multi-stakeholder partnerships for MHEWS and the mainstreaming of related goals and strategies into development processes, including legislation, policy development, institutional frameworks required and planning of development programmes and investments at international, regional, national, and community levels. These need to be based on identified user requirements, good practices and existing guidance material.

Lastly, an important expected outcome is a mechanism that is in place for sharing of good practices and expertise in relation to MHEWS across regions, countries, cities, and local communities (e.g. through lessons learnt from the use of indigenous knowledge in early warning, regional demonstration projects, etc.) and in a manner that enables countries and key stakeholders to use this information effectively. The Network will facilitate dialogue between and among stakeholders on the scientific, technological, and social issues concerning individual hazard EWS and MHEWS, and regular publications and their open access dissemination (e.g. via web portals such as PreventionWeb, media exchange, etc.) promulgating the case studies, lessons learnt and emerging issues on MHEWS, as well as related policy developments in countries, will be made available. The Network will support the conduct of regular forums, seminars and conferences to discuss current and emerging issues and to share information and knowledge, including the application of advances in science and technology to MHEWS and to provide visibility to MHEWS in established international and national discussions and platforms for DRR.

As a first major activity, encouraged by the 17th World Meteorological Congress in 2015 and as a commitment under the UN Plan of Action on DRR for Resilience, WMO and UNISDR have taken the initiative to organize an international conference on MHEWS (the earlier ones were on EWS) on 22 and 23 May 2017 in collaboration with international and national partners. Ten years after EWC-III, this conference will be the next global opportunity to merge knowledge on how to design and implement MHEWS, following the UNISDR Science & Technology Conference[2] in January 2016 that addressed early warning in one of its four main work streams. Its outcomes will directly feed into the 2017 Global Platform for DRR (in particular its Special Session on Early Warning), also in May 2017, the first one since the adoption of the Sendai Framework.

Partners, Governance and Structure

As a networking partnership IN-MHEWS is open to all stakeholders committed to sustaining the achievements of countries in implementing especially HFA Priorities 2 and 5, and to promoting a holistic, integrated, and multi-hazard approach to early warning in accordance with the Sendai Framework. Network partners can be grouped in six categories operating at three levels (global, regional, and national):

(1) National governments;
(2) UN entities and their regional bodies;
(3) Other intergovernmental organizations and their regional/national counterparts;
(4) Non-governmental organizations and civil society in the broadest sense;
(5) Academia;
(6) Private sector (including media); and,
(7) Financial institutions.

IN-MHEWS is governed by an international Steering Committee, comprised of representatives from a number global, regional and national partners. As of August 2016 these are the following 11 organizations: International Telecommunication Union (ITU), UNESCO, Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO), United Nations Economic Commission for Asia and the Pacific (UNESCAP), United Nations Development Programme (UNDP), UNISDR, United Nations Office for Outer Space Affairs (UNOOSA)/United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER), WMO, World Health Organization (WHO), as well as the International Federation of Red Cross and Red Crescent Societies (IFRC), the Helmholtz-Centre Potsdam—GFZ German Research Centre for Geosciences (GFZ), and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). Its co-chairmanship rotates on a yearly basis (July to June) basis, providing coordinating staff resources. For the first year, the IN-MHEWS Steering Committee is co-chaired by UNISDR and WMO.

Apart from these core partners predominantly from the global/international level represented in the Steering Committee, IN-MHEWS is made up of an open network of "associated partners" from around the world. IN-MHEWS will furthermore constitute multi-disciplinary Expert Groups to support the collaborative activities of IN-MHEWS in response to specific requirements/requests of countries and which would identify relevant stakeholders groups at different levels.

It is suggested that IN-MHEWS be structured in clusters, corresponding to:

(a) Interrelated hazard types which address also cascading impacts;
(b) The four functional components of MHEWS; and,
(c) Regional components of IN-MHEWS.

The most appropriate core partner could take on the lead for coordinating the members and activities related to the individual hazard and functional clusters, as well as for the regional components, of IN-MHEWS. Table 2 shows a suggestion of possible clusters with examples of IN-MHEWS partners with relevant mandates and activities in the respective field.

Implementation Approach

The underpinning strategy for IN-MHEWS is to utilize existing frameworks, partnerships and fora to complement current and emerging strategies for DRR, CCA, and sustainable development with enhanced early warning efforts. IN-MHEWS will also build on the experience, good practice, and achievements of States and the international community in this field (incl. IEWP and PPEW).

The Network will provide policy-relevant advice to countries to strengthen the linkages between national technical agencies, providing data on hydrometeorological, geophysical, and other hazards, and national DRM agencies, statistical offices and other relevant institutions providing data on vulnerability, losses and damages. This would include, for example, greater engagement of sectoral/technical agencies, such as National Meteorological and Hydrological Services (NMHSs) or National Ministries of Health, to reinforce the paradigm shift underway from current providers of hazard forecasts and early warnings to providers of impact-based forecasts and risk-informed warnings (WMO 2015) and as more proactive players in DRM.

In some regions, countries are already collaborating on early warning issues. Such Regional Networks for MHEWS

[2] http://www.preventionweb.net/events/view/45270?id=45270 [Last accessed: 4 November 2016].

Table 2 Suggested hazard-, function- and region-specific components of IN-MHEWS

Hazard (and consequence) clusters
Hydrometeorological hazards (WMO, UNESCO, etc.)
Geophysical hazards (UNESCO, IOC-UNESCO, ICL, etc.)
Technological hazards (IAEA, etc.)
Biological/infectious disease hazards (WHO, IAEA, UNEP, etc.)
Food security (FAO, WFP, etc.)
Others
Functional clusters
Risk knowledge (UNISDR, etc.)
Detection, monitoring, analysis, forecasting of the hazards and respective risk assessment and generation of warnings (WMO, UNOOSA, etc.)
Dissemination and communication of timely, accurate and actionable warnings and associated likelihood and impact information (ITU, WMO, etc.)
Preparedness and response capabilities at different levels to respond to the warnings received (IFRC, UNOCHA, etc.)
Others
Regional components
Asia (UNESCAP, RIMES, etc.)
Europe (United Nations Economic Commission for Europe (UNECE), European Commission Joint Research Centre (EC JRC) DRM Knowledge Centre (DRMKC), MeteoAlarm (developed for EUMETNET, the Network of European Meteorological Services), etc.)
Others

(RN-MHEWS) are developing in Southeast Asia [e.g. linked to the Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES)] and Europe [e.g. linked to Meteoalarm[3] and the European Commission Disaster Risk Management Knowledge Centre (DRMKC)[4]].

The ultimate beneficiary of IN-MHEWS is the population of the UN Member States, where a country's EWS/MHEWS with its respective national stakeholders, legal and institutional frameworks and fora for exchange can be considered as the national counterpart/component of IN-MHEWS. Operating these systems and issuing official warnings remains a national responsibility.

Strategic Linkages

In addition to directly contributing to achieving the seventh global target of the Sendai Framework and shaping the "Words into Action" Implementation Guide for this target g), IN-MHEWS will inform the revised United Nations Plan of Action on Disaster Risk Reduction for Resilience: Towards a Risk informed and Integrated Approach to Sustainable Development (UNISDR 2016c) and contribute to achieving the Sustainable Development Goals 3 and 13 which recommend to "*strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks*" and "*improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning*" respectively (UN 2015), as well as Articles 7-8 of the Paris Agreement (UNFCCC 2015) and the DRR Priority Area of the GFCS.[5]

IN-MHEWS will also contribute to strengthening capacity for the implementation of the International Health Regulations (IHR) (WHO 2016). The IHR are an international legal instrument that is binding on 196 countries across the globe, to help the international community prevent and respond to acute public health risks that have the potential to cross borders and threaten people worldwide.

IN-MHEWS will also be closely linked to the Climate Risk and Early Warning Systems (CREWS) initiative which was initiated by France and launched at the Paris Climate Change Conference in December 2015.[6] CREWS as a

[3]http://www.meteoalarm.eu [Last accessed: 4 November 2016].
[4]http://drmkc.jrc.ec.europa.eu [Last accessed: 4 November 2016].
[5]http://www.wmo.int/gfcs [Last accessed: 4 November 2016].
[6]http://www.cop21.gouv.fr/en/launch-of-crews-climate-risk-early-warning-systems [Last accessed: 4 November 2016].

project implementation initiative leverages IN-MHEWS as a corresponding and complementing expert forum and platform for knowledge sharing and dissemination. To this end CREWS also supports the international conference on MHEWS in 2017.

Conclusion

In conclusion, the need to promote the development and operationalization of people-centred, MHEWS has been recognized as a global target (UNISDR 2015b). While several countries have made significant progress in the establishment of EWS worldwide, in some cases even for multiple hazards, much remains to be done to successfully support the establishment of integrated and coordinated systems that work across hazards to maximize synergies and efficiencies. Moreover, the lack of multi-disciplinary and international cooperation between different players in the field of (MH)EWS has been identified as a key challenge for their implementation (UNISDR 2006a, b; UNEP 2012). The sharing of expertise and good practice on (MH)EWS will help to strengthen them around the world and make them an integral component of national strategies for DRR, CCA, and resilience building. To this end, major international and national organizations have joint efforts and established IN-MHEWS as a commitment made at WCDRR to support the implementation of the Sendai Framework. Especially achieving its global target related to MHEWS requires extensive yet coordinated action on all levels. Sound definitions of the terms, clear indicators for measuring effectiveness and progress with (MH)EWS are requirements to develop and strengthen such systems and to prioritize international cooperation. IN-MHEWS aims to provide this support. As such, IN-MHEWS welcomes the participation of the International Consortium on Landslides (ICL), while many of its core partners can also contribute to the work of the Sendai Partnerships within the framework of this partnership, with the aim of facilitating knowledge sharing and capacity development for MHEWS worldwide. Guidelines, good practices and other outcomes of the work of the Network will be shared with the international community to advocate for MHEWS and contribute to knowledge and practice advancement in this field.

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[7]http://www.wmo.int/pages/prog/drr/documents/IN-MHEWS/IN-MHEWS.html [Last accessed: 4 November 2016].

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