Collaboration in MHEWS Through an Integrated Way

The Great Efforts Contributed by Multi-stakeholder Partnership at National, Regional and International Levels

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Abstract

In recent years, great progress has been made in the development of knowledge and practices related to the multi-hazard early warnings and in strengthening the related multi-stakeholder partnership. Global initiatives are gaining momentum to improve multi-hazard early warning systems (MHEWS) and so boost the resilience of the most vulnerable countries to extreme weather/water / geological, environment and health-related events and its impacts to the sustainability of social and economic development. However, understanding its interconnectivity and interoperability and developing impact-based and risk-informed methodologies in its integration in the all relevant hazard aspects are still needed to be strengthened. This article presents an overview of advances and challenges in multi-stakeholder partnership for improving MHEWS in an integrated way in order to better achieve the Target-G of the Sendai Framework on DRR, Paris Agreement on Climate Change and SDGs. We focus on major international cooperation and partnerships on MHEWS and its applications, but not limited to, the International Multi-Hazard Early Warning System Network (IN-MHEWS), Climate Risk and Early Warning Systems (CREWS), Regional Integrated MHEWS in Africa and Asia (RIMES); and many specific MHEWS interfaces, such as Global Disaster Alerting Coordination System (GDACS), Global Multi-hazard Alert System (GMAS), MeteoAlarm/Alert Systems, All Risk Integrated System TOwards Trans-boundary hoListic Early-warning —European Natural Hazards Scientific Partnership (ARISTOTLE-ENHSP), etc. as well as relevant multi-stakeholder partnership platforms to connect related MHEWS with its application networks between international organizations, governments, non-governmental organizations (NGOs), private sectors at regional and national levels, such as United Nations Disaster Assessment and Coordination (UNDAC), Global Water Partnership(GWP), Environment and Humanitarian Action (EHA) Network, Global network on Monitoring, Analysis, and Prediction of Air Quality (MAP-AQ), Public Health Emergency Operations Centre Network (EOC-NET), Humanitarian Networks and Partnerships Week (HNPW), and Forecast-based Financing mechanism and programme (FbF) etc. The further actions to facilitate UN Member States for improving its capacity in MHEWS partnership at national and local levels through strengthening multi-stakeholder partnership at international and regional levels are discussed and recommended in the conclusion and discussion.

Keywords

Impact-based forecasting and integrated risk management • Interactivity • Interoperability • Multi-hazard early warning systems •
Multi-stakeholder partnerships governance • Risk interconnectivity • Public and private partnership (PPP) • And public and public partnership (PUP)

Introduction

What is new in today’s increasingly interconnected society is the diversity of threats and hazards, and the complex interaction among them, which result in “an unprecedented global creation of risks” (The Global Risk Report 2020/WEF). While facing humanitarian emergencies with multiple hazards, particularly in the context of hydrometeorological, geological and environment related phenomena and increasingly in disease outbreaks, more efforts are needed to facilitate Members and Member States to improve its capacity on Multi-Hazard Early Warning Systems (MHEWS) (UN 2006; WMO 2017, 2019). The overview on MHEWS, 4th WLF 2017 illustrated the concerted international efforts for advancing MHEWSs, specifically in addressing mainly in (1) context from EWSs to MHEWSs, (2) what’s a (MH)EWSs, (3) recent advances in EWSs, (3) gaps/challenges related to EWSs, (4) tracking progress at international level and (5) introduction of IN-MHEWS while this paper mainly focus on multi-stakeholder partnership in MHEWS and its applications (Luther et al. 2017).

To “substantially increase the availability of and access to MHEWS” is one of the seven global Disaster Risk Reduction (DRR) targets of the Sendai Framework (target-G). Over the past decades, DRR was far from being the purview of a single agency or programme, as the “concept and practice of reducing disaster risks through the application of analysis to reduce causal factors of disasters” (UNDRR 2009). It consists of representatives from across areas such as government bodies, civil society, private sectors, research institutes and non-government organizations (NGOs) (UNDRR 2016).

Globally, in 2019, about 9000 people lost their lives in natural catastrophes compared with 15,000 in 2018 while the weather extremes, as an important part of natural disasters and consequence of climate change impact, are remaining at top 1 among top 5 global risks in terms of likelihood and at top 4 risks in terms of impact in 2019. This confirms the overall trend towards lower numbers of victims thanks to better DRR, including MHEWS (GRR/WEF 2020). However, increasing diseases outbreaks have shown its strong negative interconnectivity which undermines stability and sustainable development of social and economic development (Corona Virus (COVID-19) “Infodemic” and Emerging Issues through a Data Lens: The Case of China, Hua and Shaw 2020; Changing Rapid Weather Variability Increases Influenza Epidemic Risk in a Warming Climate, Liu et. al. 2020).

Despite progress in strengthening MHEWS across the world, significant gaps remain, especially in continuously building multi-stakeholder partnership among the actors and agencies concerned, lack of integrated standardized operating procedures/protocols to seamless all levels and interoperable information systems across all relevant disciplines and full chains in MHEWS, limited public awareness and participation in risk management, insufficient actionable political commitment, and limited public/private financial support for the implementation of these systems (UNDRR 2006a, b; UNEP 2012; Clinton et al. 2016). Lack of institutional harmonization of the bottom-up approach achieved at national and local levels and top-down approach facilitated to Members and Member States by international and regional organizations and its relevant programmes/projects on sharing knowledge, capacity development and early actions in the major application areas in MHEWS is a critical issue to be addressed.

There are distinct characteristics that need to be understood and addressed—aspects of the interconnectivity of disaster risks, its impacts and interoperability in implementing and delivering MHEWS—in addition to effective and acceptable multi-stakeholder governance mechanism. Answering these challenges calls for a more integrated approach to acknowledge the complexity of threats, risks and address such multiple interactive features. Current health crisis on Covid-19 is calling on that early warnings and its effective awareness for early actions are critical important to be reinforced (UNCG 2020). Best Practice has been made by the meteorological community through development and implementation of Impact based Forecasting and Warning Services (WMO No. 1150 2015) for the advisory services on hydromet hazard triggered MHEWs and its emergency response (Luther et al. 2019).

The complexity of the interaction between different spheres of the earth system that human in situated and the interconnections of the risks and impacts created from weather, water, climate, ocean and related environmental processes are increasingly challenging to the sustainability of social and economic development, especially in building a pathway on risk-informed and sustained social and economic development (UNDRR 2015). Risks generated by the interaction of complex human and natural systems, amplified by changes in the climate, are increasing the propensity for systems reverberations, setting up feedback loops with cascading consequences that are larger, more complex and more difficult to foresee—ultimately reversing efforts to achieve the 2030 Agendas (GAR 2019; Keys et al. 2019). No single government or agency has the necessary resources and capacities to address all these challenges on its own. Therefore, forging and working in partnerships with stakeholders, such as international agencies, national and local
governments (GNDR 2013), non-governmental organizations (NGOs), academia, the private sector and the media, and engaging in networks and other collaborative efforts is essential for meeting the goals/targets of SDGs, Paris Agreement on Climate Change and Sendai Framework on DRR through addressing impact-based and risk-informed integrated MHEWS at local, national, regional and international levels (UNFCC 2015).

While rapidly growing best practices on MHEWSs at national and local levels such as best practices documented in Implementing Hazard Early Warning Systems (Rogers and Tsirkunov 2011), Institutional Partnership in MHEWSs (Golnaraghi 2012), Five Approaches to Build Functional Early Warning Systems (UNDP 2018), Proceedings of MHEWC-I (INMHEWS 2017), and Proceedings of MHEWC-II (INMHEWS 2019, to be published) are gaining momentum to improve multi-hazard early warning systems and so boost the resilience of the most vulnerable countries to extreme weather and the impacts of climate change. The importance of multi-stakeholder partnership for disaster risk reduction (DRR), sustainable development, adaptation of climate change has been repeatedly highlighted in major international agendas (UN 2015).

For example, CREWS was proposed by France Governments and related international organizations especially WMO and IN-MHEWS was initiated by 11 international organizations and Member States as major outcomes of the Working Session on Early Warning at the Third United Nations World Conference on Disaster Risk Reduction (WCDRR-III) in Sendai, Japan, in 2015. “Achieving a more integrated approach to multi-hazard early warning systems requires new ways of thinking about the intergovernmental and non-governmental cross-sectoral working arrangements and partnerships to deliver end-to-end and people-centred systems” is one of the outcomes of the 2nd Multi-hazard Early Warning Conference (MHEWC-II) in 2019.

MHEWS should engage all relevant actors to increase the effectiveness, efficiency, consistency, interoperability and utilization of impact-based forecasting and risk informed warning services. Against this background, the article presents the recently established multi-stakeholder partnership at national, regional and international levels in an integrated way with recent advances and remaining gaps and challenges for discussion and consideration (UNDRR 2019a,b).

**Multi-stakeholder Partnership on MHEWS at International Level**

Efforts to strengthen multi-stakeholder partnerships have been achieved in many ways through several global initiatives, including how to improve interconnectivity through MHEWS interfaces, and how to build Interoperability across multiple international organizations. The examples include, but not limited to, United Nations Disaster Assessment and Coordination (UNDAC), Humanitarian Networks and Partnerships Week (HNPW), Climate Risk and Early Warning System (CREWS), IN-MHEWS, GWP and EHAN.

**Partnerships of Global MHEWSs Interfaces with Humanitarian and Crisis Management Networks**

The interoperability of MHEWS interfaces with response networks for actions are critical. GDACS (as a MHEW interactive information system/partnership), Global Water Partnership (GWP) (as a multi-stakeholder action network and intergovernmental collaboration Interface) and GMAS (as a MHEW integrated services framework for partnership) with the United Nations Disaster Assessment and Coordination (UNDAC), Inter-agency Steering Committee (IASC) on Humanitarian Coordination, Global Crisis Centres Network (GCCN) and HNPW, as a value-added Partnership/Network in support of services for Humanitarian activities, and with other special emergency response networks in thematic areas, such as EOC-NET, EHAN, and UN Operation and Crisis Centre (UNOCC) etc.

The United Nations Disaster Assessment and Coordination (UNDAC) is part of the international emergency response system for the first phase of a sudden-onset emergency by rapid deployment of specialized teams. UNDAC teams, consisting of experienced humanitarians and disaster management experts, can deploy at short notice (12–48 h) anywhere in the world. They are provided free of charge to the disaster-affected country, and deployed upon the request of the United Nations Resident or Humanitarian Coordinator and/or the affected Government.

The GCCN provides a community of practice for national and regional crisis centres as well as other international actors (e.g. scientific organisations, NGOs, humanitarian agencies) that deal with disaster information analysis and disaster response after major sudden-onset disasters.

The GCCN is an informal coordination mechanism to support information exchange and analysis among international actors. The GCCN has developed procedures for alerting its members, and to establish an initial coordination process. As such, the GCCN aims at leveraging the collective knowledge, expertise and experience of its members, which include (but are not limited to) disaster managers, logistics, scientists (e.g. meteorological services), humanitarian agencies, as well as specialized organisations and NGOs. The GCCN coordination process is expected to contribute to the development of a Common Operational Picture (COP) and to enable comprehensive information
analysis in support of decision making in the Affected State and among responders with regard to international assistance and international response coordination. The GCCN also provide products to the affected Member States as follow:

- **Product catalogue**: the creation of a standard product catalogue of information products that support situation analysis and decision making among international responders in the first phase after major disasters.
- **The web-based STN Knowledge Base (prototype)**, an interactive tool with comprehensive information about mechanisms and actors in international disaster and humanitarian response.
- **Impact Mapping**: the Impact Mapping is produced based on scientific modelling within a short time frame after the disaster event and made available on the GDACS website (GDACS 2020).
- **Predictability in satellite-based mapping**: feedback from Copernicus EMS (Annett Wania, EC/JRC). COPERNICUS is the European Union’s Earth Observation Programme, which provides since 2012 on-demand rapid satellite mapping products on a 24/7 basis. The products can be delivered within 24 h from the request (through the EC/ECHO-ERCC), and range from reference situation maps, the first impact estimates to detailed impact assessment maps.

The Inter-agency Steering Committee (IASC): Created by the United Nations (UN) General Assembly resolution 46/182 in 1991 IASC is the longest-standing and highest-level humanitarian coordination forum of the UN system, bringing together the executive heads of 18 UN and non-UN organizations to ensure the coherence of preparedness and response efforts, formulate policy, and agree on priorities for strengthened humanitarian action. The IASC is chaired by the Emergency Relief Coordinator (ERC) and facilitates the leadership role of the UN Secretary-General by regularly convening to ensure better preparation for, as well as a rapid and coherent response to, humanitarian crises.

The responsibilities of the IASC include: making strategic and policy decisions with system-wide implications; endorsing major operational decisions; arbitration where no consensus can be reached by other IASC structures; advocating common principles, collectively or individually on behalf of the IASC; approving the work plans of the IASC structures; bringing issues to the attention of the Secretary-General and Security Council through the ERC; and, designating Humanitarian Coordinators and selecting coordination arrangements.

The Committee is supported by subsidiary bodies; groups of decision-makers and experts who inform and carry out the priorities set by the IASC.

The IASC community extends beyond the Committee itself—it is a network of humanitarian actors and experts dedicated to delivering timely assistance to people in need. In addition to IASC-endorsed guidance, Accountability to Affected Populations, Protection from of Sexual Exploitation and Abuse, Persons with Disabilities, Gender and Age, and Mental Health and Psychosocial Support, as well as resources that draw linkages between these areas.

The cluster approach (Fig. 1), designed by IASC, is to strengthen system-wide preparedness and technical capacity to respond to humanitarian emergencies, and provide clear leadership and accountability in the main areas of humanitarian response. At country level, it aims to strengthen partnerships, and the predictability and accountability of international humanitarian action, by improving prioritization and clearly defining the roles and responsibilities of humanitarian organizations.

Clusters are groups of humanitarian organizations, both UN and non-UN, in each of the main sectors of humanitarian action, e.g. water, health and logistics. They are designated by IASC and have clear responsibilities for coordination (OCHA 2020a).

Great efforts have been taken to strengthen such inter- connectivity. One of the examples to show how such multi-stakeholder partnership has been enhanced is GDACS actively engaging in the Humanitarian Networks and Partnerships Week (HNPW) through addressing GDACS, as technical advisory platforms on MHEWS being embedded into real actions on crisis containment and mitigation through the provision of risk-informed MHEWS advisory to a large audience of the network. GDACS consultations have been regularly made through its web-based interaction and regular consultation workshops with its users from the Member States, international organizations, NGOs and private sectors. Supported by UNITAR-UNOSAT, the GDACS-Satellite Mapping Coordination System platform (SMCS) has constantly contributed by different satellite mapping groups (e.g. UNOSAT, Copernicus Emergency Management Service, Space Charter), which allows GDACS stakeholders and the wider humanitarian community to determine at real-time which satellite images are collected where and which entity is working on what type of analysis. GDACS-Satellite Mapping Coordination System platform (SMCS) (2018) has been activated and utilized in 14 major disaster events. The activation of the SMCS in the Sept 2018 Indonesia earthquake was used as a case study to demonstrate the platform.

HNPW, co-chaired by the United Nations Office for Coordination of Humanitarian Affairs (OCHA) and the Swiss Agency for Development and Cooperation (SDC), provides a unique forum for humanitarian networks and partnerships to meet and address key humanitarian issues. One of the largest humanitarian events of its kind, it gathers
participants from the UN, NGOs, Member States, the private sector, the military, academia and beyond to discuss and solve common challenges in humanitarian affairs. Among them, MHEWS related initiatives have actively engaged in.

During HNPW 2020, the technical session on tropical cyclone impact estimation for humanitarian preparedness and response has been held. This 1.5-day meeting was the first workshop jointly organized by the Joint Research Centre of the European Commission (EC-JRC) and OCHA in the context of the Global Disaster Alert and Coordination System (GDACS), and by the World Meteorological Organization (WMO). It brought together operational meteorologists and hydrologists and satellite experts with practitioners from disaster management and humanitarian agencies to discuss innovative solutions for early warning advice on tropical cyclone-related hazards and for estimating their impacts on vulnerable and exposed populations and humanitarian operations. It catalysed positive dialogue between the scientific and humanitarian communities, resulting in an increased understanding of each other’s work, challenges and constraints and showcased examples of what is already working well as well as areas where to further improve and collaborate (OCHA 2020b).

**Partnership on Funding Mechanism for MHEWS**

CREWS, initiated by French Government and relevant international organizations, such as WMO during WCDRR-III in 2015, is a mechanism that funds Least Developed Countries (LDC) and Small Island Developing States (SIDS) for risk-informed early warning services, CREWS is an excellent example for strengthening the partnership between donor countries, development agencies, international organizations and the countries to be supported for enhancing its capacity on MHEWS. CREWS works directly with countries to increase the availability of, and access to, early warning systems. CREWS focuses on ensuring that early warnings, related both to the weather and climate events are risk-informed.

Country and regional projects are implemented by the countries with the support of implementing partners who provide technical assistance and capacity development. This includes the twinning of two or more National Meteorological and Hydrological Services and by leveraging the expertise of regional and international institutions. The CREWS Steering Committee with 17 members who have committed to support CREWS, regularly reviews information on capacity gaps, demands and leveraging potential across LDCs and SIDS to prioritize its investments.
WMO and the World Bank’s Global Facility for Disaster Reduction and Recovery (GFDRR) are implementing the CREWS initiative in partnership with the UN Office for Disaster Risk Reduction (UNDRR). It is financed by Australia, France, Germany, Luxembourg, the Netherlands, Switzerland, UK and also supported by other 10 observers. A trust fund hosted by the World Bank supports the activities of implementing partners.

Many countries have already strengthened their multi-hazard early warning systems by enhancing hydro-meteorological warning services and improving emergency plans and operations. But these life-saving systems and structures are missing or inadequate in many countries. The CREWS is addressing the issue through its result-based approach to strengthen partnership with life-saving systems and structure in those countries who have implemented its CREWS Projects.

The CREWS has 42 Partners for its implementation including 13 NMHSs, 5 national government agencies, 5 international organizations, 6 regional bodies, and 13 research institutes. CREWS already launched initiatives in 18 countries and sub-regions including Mali, Burkina Faso and several Pacific islands to strengthen forecast capabilities and ensure warnings reach all who need them.

The general standards and guidelines for CREWS which include partnerships on the Disaster Risk Knowledge/Risk-informed system design, warning dissemination and communication, preparedness and response capabilities/ability to respond can be found at https://www.crews-initiative.org/en.

IN-MHEWS Partnership for Strengthening Coordination

11 international and national agencies established the International Network for Multi-Hazard Early Warning Systems (IN-MHEWS) as a major outcome of the Working Session on Early Warning at the Third United Nations World Conference on Disaster Risk Reduction (WCDRR-III) in Sendai, Japan, in 2015 and 22 international organizations have actively participated in the network until the 2nd MHEWC Conference in Geneva, May 2019.

IN-MHEWS under the Sendai Framework is to foster coordination, cooperation, collaboration, and networking to facilitate the sharing of expertise and good practice for multi-hazard early warning systems as a national strategy for disaster risk reduction, climate change adaptation, and building resilience. Besides, it aims to guide and advocate the implementation and/or improvement of multi-hazard early warning systems, share lessons learnt regarding early warning and increases the efficiency of investments in such systems for enhanced societal resilience.

The major contributions of IN-MHEWS and its members are with the following examples:

- Regular MHEW Conference organized prior to the Global Platform on DRR as its preparatory session bringing its outcomes and recommendations to the relevant higher level consultation during the GP. The MHEWC is a consultation mechanism between members of the network and the platform for sharing best practices;
- Joint Publication of the Checklist on MHEWS (WMO 2018a) and others;
- Delivering Guidelines by members of IN-MHEWS on the development of Multi-hazard impact-based forecasting and warning services (WMO), IFRC Forecast Based Financing for Early Action as examples;
- Facilitating members to implement Common Alert Protocol (CAP) to the transmission of multi-hazard warning information and promoting cataloguing and identification of hazards and utilization of Unique Identify to record and transfer data on hazards and its associated hazard clusters.

IN-MHEWS through its first and second Multi-Hazard Early Warning Conference (MHEWC-I 2017, II 2019) has addressed the importance of multi-stakeholder partnership and its major issues related are as follows:

- Partnerships between the scientific and research communities, early warning information providers and humanitarian and development practitioners are essential.
- Need for partnership with impact domain experts and data holders.
- Collaboration between Climate Risk and Early Warning Systems Initiative (CREWS) and World Bank Global Facility for Disaster Reduction and Recovery (WB-GFDRR) is important in measuring the effectiveness of MHEWS.
- Partnerships with the public and private sector are essential to creating MHEWS that usable, useful and used.

Concerning its next strategic step for IN-MHEWS, sustained multi-stakeholder partnership governance has been recognized. The critical issues should be raised for further actions as follows:

- Improvement of multi-stakeholder partnership governance model through establishing an Alliance on MHEWS to leverage current IN-MHEWS;
- Encouragement of engagement of members of IN-MHEWS through improving its rotation mechanism to manage its practical coordination between major
international organizations; Whether it should be steered by a steering committee to advise a consulted planning for collaboration/partnership for the network/alliance and co-chaired by representatives from international organizations, development agencies, academia institutes, NGOs and private sectors;

- Expert advisory teams on different thematic areas of MHEWS, such as climate extremes and public health (Rogers 2011), atmospheric emergency response for nuclear power plant accidents etc. should be established according to the features of cascading impacts of risk inter-connection between original hazard and derived hazards and the relevant authorized international organizations, associated with academia institutes, private sectors should lead these teams;

- Effective connections of the mechanism of IN-MHEWS with the frameworks for UN humanitarian assistance and emergency response, post-disaster assessment for actions and investment;

- Effective connection with national, regional and international MHEWS related networks, programmes/projects and activities, such as IN-MHEWS and CREWS, IAEA Nuclear Accident Incident and Emergency System, WHO Emergency Response Programme, IHP/UNESCO and regional flood programmes, Weather Ready Nation Project (WRN), etc.;

- Effective inter-connectivity between highly relevant centres established and authorized by inter-governmental organizations, such as European Centre for Medium-range Weather Forecast (ECMWF), International Center for El Niño Research (CIIFEN), WMO World Meteorological Centres (WMCs) and its Regional Specialized Meteorological Centres (RSMCs), UNOCHA/EU-JRC Global Disaster Alerting, Coordination Centre (GDACS) and Incidental Emergency Response Centre of IAEA, etc.;

- Strengthening PPE through the special arrangement to facilitate engagement of private sectors in IN-MHEWS;

- Taking actions to promote “no one left behind” through enhancing capacity development for LDCs and SIDS on MHEWS.

MHEWS Partnership in Thematic Areas, Such as Cascading Impact Chain Relate to Landslide

The aims of MHEWS are not only to address the interoperability issue for identifying integrated efforts contributed by multi-stakeholder through establishing capacities on scientific/technological advisories and concrete supporting facilities in support of building resilient society in a cost/effective way but also to address its interconnectivity issue to identify cascading impact processes triggered by the original hazard events. It is important for us to take a smart science-based approach in a more precise manner. Typically, landslide can be triggered by both hydrometeorological factors (e.g. heavy rainfall) and geological factors (e.g. earthquake). Overlapping with vulnerable areas, it can trigger tremendous loss and damage in a critical location. Great efforts to improve international cooperation on MHEWS for landslide have been made in recent years. At the 2nd United Nations World Conference on Disaster Reduction, which was held in Kobe, Japan, on 18–22 January 2005, the International Consortium on Landslides (ICL) co-organized a session which resulted in a global partnership and platform taking a holistic approach to research and learning on ‘Integrated Earth system risk analysis and sustainable disaster management’. This partnership was forged through a “Letter of Intent”, which was signed by UNESCO, UNDRR, WMO, FAO, UNU, ICSU, and WFEO who have committed to support MHEWS and its response for landslide (Sassa 2019).

In addition, the participating scientific and academic institutions and governmental and non-governmental organizations proposed that the Sendai Partnerships 2015–2025 for Global Promotion of Understanding and Reducing Landslide Disaster Risk in the Third UN World Conference on Disaster Risk Reduction in Sendai, Japan in March 2015. The partnership was signed by 22 global stakeholders including WMO and ICL and developed through the Fourth World Landslide Forum in Ljubljana, Slovenia in 2017. This sound global platform will be mobilized through the Fifth World Landslide Forum in Kyoto, Japan in 2020 and in the coming decade to pursue prevention, to provide practical solutions, education, communication, and public outreach to reduce landslide disaster risk.

An example at national level: National landslide early warning services operated by National Building Research Organization in Sri Lanka (Fig. 2). A landslide hazard zoning mapping programme within the 10 landslide prone districts has been developed. The maps which display the distribution of the severity of landslide hazard potential in a given area were intended to be used with associated guidelines as a decision-making tool for development of central highlands of the country. It is also used for identification of elements at landslide risk and can be utilized in relocation, rehabilitation, allocation of relief funds and insurance purposes also. Mapping is carried out at 1:50,000 scale and at 1:10,000 scale. An early warning service has been operated based on such risk mapping and impact-based forecasting.
Partnership on Environment and Humanitarian Action (EHA) Network

The Environment and Humanitarian Action (EHA) Network is an informal network aiming to avoid, minimize, or mitigate environmental impacts of humanitarian action and to promote environmentally responsible humanitarian programming through collaboration and cooperation. It was established in 2013 with the objective of mainstream environmental considerations in humanitarian action (UNEP 2020b).

The EHA network seeks to mitigate environmental impacts during humanitarian response and to promote environmentally responsible humanitarian programming. Network members jointly work to advance humanitarian policy, strengthen knowledge on EHA, conduct advocacy and provide technical support to humanitarian operations.
People can join the network on an individual or institutional basis. The network holds meetings approximately every three months as well as one annual face-to-face meeting in connection with the Humanitarian Networks and Partnerships Week of the Leading Edge Programme.

**Global Network on Monitoring, Analysis, and Prediction of Air Quality (MAP-AQ) and its Support of the Frontiers and Professional Partners**

The Global Network MAP-AQ (Fig. 3) is a specialized multi-stakeholder partnership that has been endorsed as a sponsored activity of the International Global Atmospheric Chemistry (IGAC) Project and is directly contributing to the objectives of the Global Atmosphere Watch (GAW) at WMO. The overarching goal of MAP-AQ is to constitute and develop a consortium of expert groups to coordinate and enhance research and services that will help mitigate air pollution, specifically in regions of the world where high concentrations of pollutants are observed. It aims to develop and implement a global air pollution monitoring, analysis and prediction system and alliance with downscaling capability in regions of the world that are affected by high levels of atmospheric pollutants, in particular in Asia, Latin America and Africa (NCAR 2020).

The partners of MAP-AQ network includes (1) expert groups in charge of the modelling system development and validation, space data analysis and assimilation; (2) regional and local representatives contributing to the development, dissemination and validation of the products; (3) members of international projects in support of programmes, such as the EU/ESA Copernicus programme in particular the Copernicus Atmospheric Monitoring Service (CAMS).

MAP-AQ expects to develop partnerships with other international and humanitarian frontier programs and their networks including UNEP (Climate and Clean Air (CCA) Coalition), WHO (capacity building to tackle air pollution), World Bank (WB projects for nations/regions in which MAP-AQ has initiated activities), and the EHA network etc.

**Global Water Partnership**

The Global Water Partnership (GWP) is a global action network with over 3,000 Partner organisations in 179 countries. The network has 68 accredited Country Water Partnerships and 13 Regional Water Partnerships (GWP 2018).

The network is open to all organisations involved in water resources management: developed and developing country government institutions, agencies of the United Nations, bi- and multilateral development banks, professional associations, research institutions, non-governmental organisations, and the private sector.

GWP’s action network provides knowledge and builds capacity to improve water management at all levels: global, regional, national and local. GWP does not operate alone. Its networking approach provides a mechanism for coordinated action and adds value to the work of many other key development partners.

GWP is gearing up for its continued support to countries on climate change adaptation, leading towards the implementation of the Paris Agreement. GWP activities under the Global Water, Climate, and Development Programme (WACDEP) aim to strengthen the resilience of countries to climate change.

The WACDEP Coordination Unit (CU) in Africa is strengthened through relevant strategic alliances and partnerships with Multilateral Development Banks, UN agencies, and others. The CU provides global/regional thematic leadership on strengthening regions and countries. Cross-regional technical support functions are also being established for GWP Asian regions in collaboration with established relevant strategic allies such as UNEP, UNDP, ADB, IWMI, ASEAN, and others.
Multi-Stakeholder Partnership at Regional Level

There is a growing number of regional MHEWS initiatives to actively address joint efforts on trans-boundary issues. Such as, but not limited to SSE-MHEWS-A for South-East Europe, CDEMA for Caribbean region, RIMES for Africa and Asia and GMAS-A, as well as many regional multi-hazard interfaces has been established by ARISTOTLE and GMAS etc. (WMO 2020).

ARISTOTLE in Europe and SSE-MHEWS-A in Southeast Europe

ARISTOTLE-ENHSP (also known as ARISTOTLE-2, being the continuation of the previous ARISTOTLE 2016–2018, Fig. 4) is a European Natural Hazard Scientific Partnership Project financed by the Directorate-General for European Civil Protection and Humanitarian Aid Operations (DG-ECHO) that delivers world-leading multi-hazard advice capability to the Emergency Response Coordination Centre (ERCC) (ARISTOTLE 2020).

ARISTOTLE-ENHSP has been designed to offer a flexible and scalable system that can provide new hazard-related services to the EU Emergency Response Coordination Centre (ERCC) and to create a pool of experts in the field of Meteorology and Geophysics of Europe that can support the ERCC concerning situation assessments in crises.

Within ARISTOTLE, a multi-hazard scientific partnership and its governance have been established across Europe to exploit the available scientific and technological expertise and to assure mutual learning and improved coordination based on a multi-hazard approach, including the definition and implementation of the required prevention countermeasures, enhancing the information provided to the ERCC and, through the governance structure, ensuring a collaborative dialogue with the national mandated civil protection authorities.

The 24*7 services system is set up in a way that it builds upon and adds value to existing information systems and sources, and that it fully respects national and regional responsibilities.

South-East European Multi-Hazard Early Warning Advisory System (SSE-MHEWS-A)

South-East Europe has experienced a significant number of severe meteorological and hydrological events in recent years. This will, in turn, increase demand for improved early warning for communities under threat from such natural hazard as well as a need for more preparedness in those communities to improve their resilience. WMO initiated the South-East European Multi-Hazard Early Warning Advisory System (SEE-MHEWS-A) project in 2016 to assist Members in the region to achieve these objectives (WMO 2018b). This project builds on the outcomes of several recent projects in the region related to disaster risk reduction that were implemented with funding from the European Union, United Nation agencies, the World Bank and several other international and national organizations such as U.S. Agency for International Development (USAID).

The previous projects demonstrated that there is a need to strengthen regional partnership to address gaps in forecasting and warning provision at the national and regional levels, particularly in transboundary areas. To achieve this, the development of a regional multi-hazard early warning advisory system—consisting of information and tools for forecasters at National Meteorological and Hydrological...
Services (NMHSs) and harmonized national early warning systems—is essential. The development of the SEE-MHEWS-A will support the NMHSs in fulfilling their mandate to provide timely and accurate warnings to minimize the impacts on people, infrastructure and industry of hazardous weather events and to protect the lives and livelihoods of the people.

SEE-MHEWS-A is providing operational forecasters with effective and tested tools for forecasting hazardous weather events and their possible impacts to improve the accuracy of warnings and their relevance to stakeholders and users. On a single virtual platform, the system will collect existing information, products and tools for the provision of accurate forecasts and warnings to support hazard-related decision-making by national authorities. Furthermore, the system will function as a cooperative platform where forecasters from different countries can work together on the identification of potential hazards and their impacts, especially when impending weather hazards may have potential impacts in many countries. Development, implementation and operation of the “cloud-based” Common Information (and communication) Platform (CIP) for SEE-MHEWS-A to facilitate access to-, and dissemination of model outputs, post-processing tools and post-processed products, such as nowcasting, dissemination of warnings, such as via its partnership with MeteoAlarm, and communication among forecasters to coordinate advisories and warnings especially in transboundary areas.

During the first phase of the SEE-MHEWS-A project, which was supported by the USAID in 2016–2017, a detailed Implementation Plan was developed in cooperation with the NMHSs of the region, WMO Secretariat and various stakeholders in the fields of meteorology, hydrology and disaster risk reduction. The Implementation Plan outlines the overall technical and governance structure of the SEE-MHEWS-A system to be realized until 2023. The Directors of the NMHS of Albania, Bosnia and Herzegovina, Croatia, Cyprus, Greece, Hungary, Israel, Kosovo (UNSCR 1244/99), the former Yugoslav Republic of Macedonia, Republic of Moldova, Montenegro, Romania, Slovenia, Turkey, and Ukraine declared in June 2017 their intention to collaborate towards the implementation of activities and projects leading to full operation of the SEE-MHEWS-A, within the scope broadly portrayed in the Implementation Plan.

**Regional Integrated MHEWS (RIMES) in Africa and Asia**

The Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES) is an international and intergovernmental institution aiming to provide regional warning services related to the tsunami and associated hydrometeorological hazards to its member states, which include many countries in South and Southeast Asia (RIMES 2020). RIMES evolved from the efforts of countries in Africa and Asia, in the aftermath of the 2004 Indian Ocean tsunami, to establish a regional early warning system within a multi-hazard framework for the generation and communication of early warning information and capacity building for preparedness and response to trans-boundary hazards. Tamil Nadu System for Multi-hazard potential impact assessment, Alert, emergency Response planning and Tracking (TN-SMART)—A web-GIS based Decision Support System to strengthen preparedness, response, recovery and mitigation measures during multi hazards of flood, cyclone and tsunami (Fig. 5).

RIMES has 18 core member countries, supported by 14 collaborating countries, 15 collaborating partners including WMO, ECMWF, IOC/UNESCO, 3 universities and 9 research institutes. There are 6 development partners including UNDP, UN Environment, FAO, ESCAPE, DANIDA and USAID. RIMES operates from its regional early warning centre located at the campus of the Asian Institute of Technology in Pathumthani, Thailand. In addition, RIMES partner with research organizations, such as Deltares, on projects implementing early warnings systems in-country, such as early flood warning in Bangladesh (Cumiskey et al. 2015).

**MHEWS in the Caribbean: Partnership Through Caribbean Disaster Emergency Management Agency (CDEMA) and the Application of the Early Warning Systems Checklist in the region**

In 2017, after the devastating effect that Irma and Maria left in their wake, the American, British, French and Dutch Caribbean territories, Dominica and Antigua were awaiting relief from America, Britain, France, the Netherlands and Venezuela—geographically distant countries, emphasizing the need for a region of no borders, that is, to create one singular emergency unit, specifically for the Caribbean region, equipped with the necessary resources (boats, helicopters, planes, etc.) to provide rapid relief in the event of disasters. CDEMA has established and implemented the necessary protocol in dealing with border issues (CDEMA 2020).

‘Strengthen integrated early warning systems for more effective disaster risk reduction in the Caribbean through knowledge and tool transfer’ is an initiative aimed strengthening integrated Early Warning Systems (EWS) in Antigua and Barbuda, Saint Vincent and the Grenadines (SVG), Dominica, Dominican Republic, Saint Lucia and Cuba through the effective leveraging of tools and knowledge. The Project is being implemented by UNDP in close collaboration with IFRC, CDEMA, DIPECHO partners and national counterparts.
The objective of the Project is to improve EWS for more effective Disaster Risk Reduction (DRR) in the Caribbean and to move toward the realization of a more integrated system, through concrete actions addressing existing gaps. This initiative seeks to emphasize the 4 components of EWS—and close priority gaps—at a national level, contributing to the integration of national and community EWS and addressing sustainability and national ownership of EWS through 4 following efforts:

- Increase access to existing tools and knowledge of EWS at a national and regional level;
- Provide integrated EWS solutions in five target countries through knowledge sharing;
- Increase EWS effectiveness in five target countries through concrete priority actions;
- Ensure EWS knowledge transfer, documentation and communication.

MHEWS in the Caribbean brought together representatives from CDEMA, UNDP, ECHO, national governments, governmental organizations, non-governmental organisation (NGOs), donors, and regional institutions. It created a space for sharing perspectives and promoting the harmonization of actions towards enhancing Early Warning Systems (EWS) in the Region.

Many partnerships were also formed with disaster management ministries and national disaster systems in a shared ambition to grow and strengthen the organization’s delivery capacity with stakeholder engagement, including the political directorate, and the necessary their commitment to implement DRR strategies, consider gender equality, establish mechanisms for technical and financial sustainability and build the existing capacity incorporating new productive capacities.

The policy director should enable individuals, governments and others to take timely action to reduce disaster risk in advance of hazardous events, therefore suggesting that effective EWS are really about partnerships and strengthening capabilities through cooperation and collaboration.

Looking for opportunities to establish partnerships with the private sector around closing the deficit the government has in providing adequate resources for the most vulnerable. The public/private partnerships are critical for enhancing

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*Fig. 5 TNSMART—a web-GIS based Decision Support System to strengthen partnership in preparedness, response, recovery and mitigation measures during multi hazards of flood, cyclone and tsunami. Source https://beta.tnsmart.rimes.int/index.php/login/login_form.*
preparedness through the creative financing scheme. For example, consideration of the impacts on the bottom line of the cruise ships industry to get the private sector to also invest in this broader agenda for preparing. There was also the recognition of the roles of the two consortiums facilitated through the partnership with OXFAM and IFRC. The work led by OXFAM further detailed as it relates to the gaps that were identified at the local level, for example, in Cuba work was done on the tool for the farm level looking at how that information can be shared with and managed by the national level and sharing it with the region.

In the Caribbean region, the National Risk Network launches, with Saint Lucia and Haiti, the public/private partnership action plans at country level.

**Multi-stakeholder Partnership at National Level**

The tremendous efforts have been made at the national level to strengthen national MHEWS partnership with multi-stakeholder. Successful MHEWS have been implemented in many countries such as Cuba, Bangladesh, France, Germany, Japan, China and the United States. Many examples of MHEWS span a broad spectrum of geographic and climatic conditions in both developed and developing countries and address a variety of hydrometeorological and other hazards.

The benefits have been gained for building DRR resilient society through strengthening multi-stakeholder partnership, such as the Vigilance system in France, an example of joint efforts of multi-agency collaboration for making an early warning system with a multi-Hazard approach; the Weather Ready Nation partnership in U.S. through its Weather-Ready Nation Ambassador™ (www.weather.gov/wrn/ambassadors); strategic partnership with private sectors for scaling-up multi-hazard early warning in Indonesia.

**Multi-sector and Multi-level Participation in Indonesia**

The 2004 tsunami disaster and the HFA provided the driving incentives for institutional change in disaster risk management (UNDRR 2005). A Presidential Regulation legitimized the establishment of the multi-level Disaster Management Agency (BNPB, BPBD at the national and sub-national levels) for improved links and coordination from the national to the local. Furthermore, local authorities are legitimizing the establishment and operations of Multi-level Emergency Operations Centres as another critical and important architecture component and structure for improved decision-making and governance throughout the country.

Institutionalizing and embedding the Indonesian Tsunami Early Warning System (INATEWS) within the Disaster Management Agency (BNPB) as a larger architecture is a key step towards a multi-hazard approach and improved inter-institutional coordination and performance. Furthermore, the global-regional governance framework for tsunami hazard and risks under UNESCO-IOC coordination, and the developing multi-level architectures and structures synchronized within the existing decentralization are ideal polycentric multi-layered architectures for optimum interlink between levels and improved hazard and sustainable risk governance in Indonesia.

In terms of decision-making links, the national disaster platform supporting the Hyogo Framework for Action and the new steering committee consisting of the state and professional citizens of the multi-level Disaster Management Agency gives legitimacy to multi-sector, multi-level participation and decision-making in Indonesia (Poterie and Baudoing 2015).

**MHEWS Partnership in Urban Areas**

Today, 55% of the world’s population lives in urban areas. By 2050 another 2.5 billion people will be added to urban areas, which will be 68% of the world’s population, mostly in Africa and Asia. Urban areas are inherently more vulnerable to risks and stresses, as set out in the Sendai Framework for Disaster Risk Reduction, brought about by climate change and natural hazards owing to their high concentrations of population and economic activities (Nuha et al. 2018; CEB 2019). This is exacerbated by the fact that cities are frequently located in low-lying coastal areas, with particularly vulnerable populations often living on outright hazardous land. Enormous progress has been made by integrated efforts provided by city governments, local communities, private sectors and NGOs through strengthening its partnership in MHEWS, emergency response, contamination and mitigation although its political structures varying with different assignments of roles and responsibilities in relation to disaster risk reduction. For example, the densely populated urban region of Shanghai, China has provided corresponding illustrations of the emphasis on ensuring clarity regarding stakeholders’ roles and responsibilities that is a feature of all successful MHEWS (Tang 2006, 2008).

The China Meteorological Administration (CMA) and Shanghai Municipal Government (SMG) jointly support the Shanghai Multi-Hazard Early Warning System as a WMO demonstration project with ‘Multi-agency Response’ as the core. The project integrates diversified advanced technologies into a multi-hazard warning process, advancing improved multi-agency coordination and cooperation through a multi-link communication platform with
responsible emergency response and rescue agencies. The MHEWS is organized around its “4 + 1” technical platforms and three-level standard system on multi-agency coordination and cooperation. The technical platforms are: Multi-Hazard Detection and Monitoring, Forecast and Warning Information Generation, Multi-agency Coordination and Cooperation Support, Dissemination and User Application Platforms, and the Multi-Hazard Information Database. The three-level standard systems comprise: a Multi-agency Coordination and Cooperation Standard System, Safety Community Standard System and Regional Joint Defence Standard System. The MHEWS provides technical support to the Shanghai Emergency Response Platform and has been introduced into the Emergency Response Headquarters of the SMG. It provides forecast and warning services to the SMG’s emergency response command centre, which is responsible for public emergency response actions and the delivery of emergency-related information. The network has been fully operational to provide emergency response services to Shanghai Expo2010. Following Expo2010, WMO has conducted an assessment of the MHEWS. Remarkable progress has been made. The dissemination platform has entered the testing stage; the forecast and warning information generation and multi-agency coordination and cooperation platforms are entering the development stages, with some modules already in operation. Warning subsystems for city traffic safety, heat wave and human health, power and energy security, and bacterial food poisoning are operational. There has been significant progress with grassroots level delivery of warning messages and with the integration of information into the city grid management. Breakthroughs have been made in multi-agency coordination and cooperation. “The emergency response plan of Shanghai Municipality for rain, snow and freezing weather disasters” and “The emergency response plan of Shanghai Municipality for heavy fog disasters” have been officially distributed by the general office of SMG for actions.

**Multi-stakeholder Partnership with Private Sector and NGOs**

**Scenario-Based Risk Insurance for Multi-Hazard Impacts**

Climate change risk is intensifying and is a serious threat to the insurability of communities and economies around the world. In the insurance market, the need to understand the uncertainty posed by concurrent hazards has already been recognized (e.g., Lloyd’s 2016). Insurance plays a role in reducing vulnerability to financial losses and risk sharing, either through formal insurance, micro-insurance, or crop insurance, and can be a mechanism for vulnerability reduction in the face of extreme weather events (e.g., IPCC 2012; Kunreuther 1996; Surminski and Hudson 2017).

In order to ensure an insurable, resilient and sustainable world, UNEP Finance Initiative announced a partnership with 16 of the world’s largest insurers to develop a new generation of risk assessment tools designed to enable the insurance industry to better understand the impacts of climate change through its weather/climate extremes on their business (UNEP 2020a).

To make use of the latest climate science, including some of the most advanced, forward-looking climate scenarios available. The tools and indicators were jointly developed and piloted by the Insurer Group will incorporate the latest scenario analysis to assess climate-related physical and transition risks in insurance portfolios.

The leading insurers that will work together with the UN are all signatories to UNEP FI’s Principles for Sustainable Insurance (PSI), a global best-practice sustainability framework and the largest collaborative initiative between the UN and the insurance industry.

In 2013, the Zurich Insurance Company made a monetary commitment of up to USD 22.7 million over five years to support the creation of a flood resilience model together with the International Federation of Red Cross and Red Crescent Societies. The model is based on innovative pre-event mitigation measures and targets poor communities around the world. As part of this effort, a successful activity is the implementation of the mobile application Z-alert in Indonesia. Today, Z-alert provides notifications on various hazards such as fire, typhoons, and tsunamis with the ability for private citizens to add and verify warnings.

At the regional and national level, Data necessary for catastrophe risk quantification in Asia and in SE Asia, is in general poor in terms of availability, accessibility and quality. Singapore launched the Natural Catastrophe Data Analytics Exchange (NatCatDAX) in 2016, to address the lack of holistic and good quality data for natural catastrophe risks in the region, which has led to a growing protection gap (NatCatDAX 2020). The outcome is a high resolution, objective and widely accepted data and analytics platform which would enhance the analytics and understanding of catastrophe risks. It consists of two cat risk models developed by the Institute for Catastrophe Risk Management (ICRM), specifically a Jakarta flood risk (JKT FL) and a Singapore Earthquake (SIN EQ) risk assessment model (Su et al. 2018). The models quantify the relevant hazards, assess the exposures and vulnerabilities from inputs provided by end-users, and compute the relevant loss risk metrics (ICRM 2020).

This is a Public–Private Partnership, supported by the Monetary Authority of Singapore (MAS), and led by the ICRM of the Nanyang Technological University, Singapore (NTU), in collaboration with the insurance industry. Other successful examples are the Caribbean Catastrophe Risk
Insurance Facility (CCRIF), Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) and the UK flood insurance scheme.

**Partnership with NGOs, an Example from Implementing the Early Action Protocol (EPR) for Delivering the Disaster Relief Emergency Fund (DREF) in a Forecast Based Early Action Manner**

With the new Forecast-based Financing mechanism and programme (FbF), the International Red Cross and Red Crescent Movement is reshaping the future of the global humanitarian system. Based on forecast information and risk analysis, FbF releases humanitarian funding for pre-agreed activities (German Red Cross 2020). For early actions to be performed quickly and efficiently before disaster strikes, funds through DREF are allocated automatically to be the first on the ground providing help to those in need when a specific threshold is reached. A dedicated financing mechanism (EPR) is the key for taking fast and effective action before disaster strikes. This is why Forecast-based Action (FbA) was set up. To establish FbA, experts analyse the relevant natural hazards, assess the impacts of previous disasters and look at vulnerability data.

FbF programme has supports of numerous partners in the chain of partnership, including a large network of renowned scientists to provide advisory services, business/Foundations, humanitarian agencies such as WFP, IFRC, UNOCHA and local actors with 16 Red Cross and Red Crescent national societies in Africa, the Americas and Asia–Pacific.

The German Red Cross coordinates the development of FbF with the support of the Federal Foreign Office and important institutional partners, such as the Red Cross Red Crescent Climate Centre.

With the FbF methodology, forecasts have successfully triggered early action by National Societies in Peru, Togo, Uganda, Bangladesh and Mongolia.

**Public and Private Partnership (PPP) on Delivering Warnings and Emergency Alerts**

The Common Alerting Protocol (CAP), achieved by multi-stakeholder partnership, is an international standard format for emergency alerting and public warning. It is designed for “all-hazards”, related to weather events, earthquakes, tsunamis, volcanoes, public health, power outages, and many other emergencies. Today, approximately 75% of the world’s population lives in a nation that has already implemented, or is currently in the process of implementing, a national-level, official source of CAP alerts. It is important to note that this percentage is growing steadily.

CAP has been strongly supported and adopted by multi-stakeholder partnership between International organizations (e.g. International Telecommunication Union (ITU), WMO and OASIS standard organization etc.) the emergency management community (such as the International Association of Emergency Managers (IAEM) and national emergency response agencies), humanitarian organizations (such as UNOCHA etc.) and other NGOs (e.g. IFRC etc.), and a broad range of commercial organizations (such as IBM, Google etc.).

The Wireless Emergency Alerts (WEA) system in U.S. implemented by using CAP. WEA is an essential part of national wide emergency preparedness. Since its launch in 2012, the WEA system been used more than 33,000 times to warn the public about dangerous weather, missing children, and other critical situations—all through alerts on cell phones. WEA is a public safety system that allows customers who own certain wireless phones and other enabled mobile devices to receive geographically-targeted, text-like messages alerting them of imminent threats to safety in their area. WEA enables government officials to target emergency alerts to specific geographic areas—lower Manhattan, for example.

The Google Public Alerts is implemented also based on CAP. Google Public Alerts is Google’s help platform to show relevant official weather, public safety and earthquake alerts around the world and emergency messages such as evacuation notices for hurricanes, and everyday alerts such as storm warnings. While Google Public Alerts can’t guarantee that you’ll see every alert when using Google services, the platform is doing its best to show what’s important when you need it as a useful additional source of information. Currently, the platform publishes content from its partners in some of countries, such as U.S., Australia, Canada, Colombia, Japan, Indonesia, Mexico, the Philippines, India, New Zealand, and Brazil etc.

PPP on delivering official warnings and emergency alerts is also important for the maritime safety at sea and off-shore zones. Multi-hazard, such as gust, extreme wave, storm surge, sea ice and dense fog has significant influences on maritime safety on Marine Shipping and Coastal Social and Economic Development. The Global Maritime Distress and Safety System (GMDSS), coordinated by 19 countries that invest human, material and financial resources to issue Marine Safety Information (MSI) bulletins to the entire maritime community at no charge. This IMO (International Maritime Organization)/ WMO Worldwide Met-Ocean Information and Warning Service (WWMWWS) is to undergo a significant change with a new service to support the Global Maritime Distress and Safety System (GMDSS).
in the early 2020s according to IMO approved INMAR-SAT’s ‘Fleet Safety’ solution, Iridium (May 2018) and BeiDou BDS (May 2019) (Fig. 6) Navigation Satellite Networks solutions for GMDSS services respectively.

Facing the rapidly rising costs and workload, it is hoped that such a partnership will be best to reduce the increasing burden on the 19 METAREA Issuing Services that have long shouldered the costs and responsibility for warning mariners of hazardous weather at sea. In addition, consultation process is on the way to find solution to reduce the cost through grouping users’ applications on the utilization of such new satellite communication for the IMO’s Navigation, Communications and Search and Rescue (NCSR).

PUP-PPP Multiple Disasters’ Damage and Loss Data Recording

Collecting, achieving, standardizing and processing loss and damage data are essential for multi-hazard risk mapping, integrated assessment and developing impact-based forecasting and warning services for MHEWS (EC-JRC 2015). Several best practices have been obtained through PPP.

For example, JRC/EU provided guidance for sharing loss data across organisations, among the EU Member States and with EU and international institutions, proposes a minimum set of loss indicators that should be part of any operational disaster loss database.

The cross-cutting role and utility of loss data should be discussed across government departments, including emergency management, urban planning, and government budget and across all government scales and participative governance fora (local to national). High-level requirements should be identified based on the public and private needs analyses across sectors. Implementation of the data recording should be embedded in a Public-Public Partnership (PUP) and/or Public Private Partnership (PPP) modes to ensure participation and ownership of all stakeholders.

Conclusion and Discussion

Collective experiences have been derived from the successful multi-stakeholder partnerships at all levels that have proven effective in reducing losses of life and property in the face of disasters caused by multiple natural hazards. In all
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these cases, MHEWS with an integrated approach is a critical component of comprehensive disaster risk reduction management for risk informed sustainable development. Regarding to respond the major challenges and existing gaps on strengthening multi-stakeholder partnership in MHEWSs mentioned above, greater efforts need to be reinforced in multi-stakeholder partnership to effectively harmonize the bottom-up approach achieved based on best practices at national and local levels and the top-down approach facilitated at international and regional levels for improving countries’ capacity in MHEWSs (Gaillard and Mercer 2013). Therefore, it is important to set up platform to bring them together regularly and more effectively to address the issues on MHEWS partnership.

To achieve the Sendai Framework (target-G), great efforts should still be made by multi-stakeholder MHEWS partnerships through integrated and holistic modes. There already have had different kind of partnership mechanisms with inter-governmental feature (e.g. CREWS, ARIS-TOTLE, GMAS), official authorized mandates’ feature (e.g. UNDAC, IASC, GWP), volunteer contribution feature (e.g. HNPW, IN-MHEWS) and PPP feature (e.g. UNEP FT’s Principles for Sustainable Insurance (PSI)). To strengthen and harmonize a high-level official multi-stakeholder MHEWS partnership governance is our desire and long-term goal, but currently, we need to go through a practical way based on mutual interests and commitments in the community. There are many successful experiences in building such alliances, such as GWP, HNPW, Global Alliance for Urban Crisis, International Business Alliance for Corporate Ocean Responsibility, and they have shown its strength and weakness in managing its work.

Alternatively, a joint commitment alliance is more achievable. To ensure that MHEWS multi-stakeholders’ partnership governance could be agreed by the community. The following issues should be considered:

- Initiate a partnership framework and Forum to unite all MHEWS related bodies in an open manner (e.g. similar to HNPW),
- Thereby establish an MHEWS Partnership Alliance committed to working effectively with its partners through agreed governance arrangements (e.g. Alliance Charter), which chaired by leading international organizations in the thematic areas, and co-chaired by principle research institutes, private sectors, and NGOs in a rotation base,
- Within the alliance, expert advisory teams on different thematic areas of MHEWS, such as climate extremes and public health, atmospheric emergency response for nuclear power plant accidents etc., should be established according to the features of cascading impacts of risk inter-connection between original hazard and derived hazards and the relevant authorized international organizations, associated with academia institutes, private sectors should lead these teams.
- Providing a sustainable platform to share knowledge, technologies, trainings, and even simulation exercises, for future collaboration and partnership. Specific Offices for special purpose or specific regions for the Alliance, which could also be aligned with Knowledge Centres or Portals could be considered. As an example, UN-SPIDER is a programme of the United Nations Office for Outer Space Affairs (UNOOSA), with offices in Vienna, Beijing and Bonn. The Bonn office systematically compiles relevant information on how to use Earth Observation, satellite communication and satellite navigation for disaster risk management and emergency response. This information is made available on UN-SPIDER’s Knowledge Portal. Similarly, IRDR has also an International Programme Office in Beijing. Both of them are strongly supported by the German Government and the Chinese Government through the donation of human and financial resources for establishing and maintaining the offices.
- To prioritize its activities on MHEWSs and its supporting governance mechanism on partnership through planning and developing common understanding and recognition with committed actions.
- Facilitating UN Member States in MHEWSs through scaling up its best practices of countries, international organizations and private sectors to establish a fit-for-purpose, user-oriented, and people-centred platform.
- Consultation Groups on financing, risk insurance and crisis and humanitarian management should be established under the Alliance to develop strong joint efforts with these two “End” in order to develop 3 End approach for the Alliance.

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References

All Risk Integrated System TOwards Trans-boundary hoListic Early-warning (ARISTOTLE) (2020) European natural hazard scientific partnership. https://aristotle.ingv.it/tiki-index.php. Last Accessed 22 Mar 2020

Caribbean Disaster Emergency Management Agency (CDEMA) (2020) About us, URL: https://www.cdema.org/about-us. Last Accessed 22 Mar 2020

Climate Risk and Early Warning System (CREWS), CREWS Initiatives. https://www.crews-initiative.org/en. Last Accessed 22 Mar 2020

Climate Risk and Early Warning System (CREWS). CREWS Initiative. https://www.crews-initiative.org/en. Last Accessed 22 Mar 2020

Cumiskey L, Hoang T, Suzuki S et al (2015) Youth participation at the 2015 UN world conference on disaster risk reduction. Int J Disaster Risk Sci 6:150–163. https://doi.org/10.1007/s13753-015-0054-5

De la Poterie AT, Baudoin MA (2015) From Yokohama to Sendai: approaches to participation in international disaster risk reduction frameworks. Int J Disaster Risk Sci 6(2):128–139

European Commission Joint Research Center (EC-JRC) (2015) Guidance for recording and sharing disaster damage and loss data. EC-JRC, Luxembourg

Field CB, Barros V, Stocker TF, Dahe Q (2012) Changes in climate extremes and their impacts on the natural physical environment. In: Managing the risks of extreme events and disasters to advance climate change adaptation (special report of the intergovernmental panel on climate change), pp 109–230. https://doi.org/10.1017/CBO9781139177245 (Chapter 3)

Gaillard JC, Mercer J (2013) From knowledge to action: bridging gaps in disaster risk reduction. Prog Hum Geogr 37(1):93–114

German Red Cross (2020) Manual—forecast-based financing. https://fbb.drk.de/. Last Accessed 22 Mar 2020

Global Disaster Alert and Coordination System (GDACS) (2020) GDACs overviews and partners. https://www.gdacs.org/About/overview.aspx. Last Accessed 22 Mar 2020

Global Network of Civil Society Organisations for Disaster Reduction (2013) View from the frontline: beyond 2015. https://gndr.org. Last Accessed 22 Mar 2020

Global Water Partnership (GWP) (2018) Climate insurance and water-related disaster risk management. GWP. https://www.gwp.org. Last Accessed 22 Mar 2020

Global Water Partnership (GWP) (2019) Mobilising for a water secure world. GWP, Stockholm

Golnaraghi M (ed) (2012) Institutional partnerships in multi-hazard early warning systems: a compilation of seven national good practices and guiding principles. Springer, Berlin

Hua J, Shaw R (2020) Corona virus (COVID-19) “infodemic” and emerging issues through a data lens: the case of China. Int J Environ Res Public Health 2020(17):2309

Institute of Catastrophe Risk Management (ICRM) (2020) Research projects. https://icrm.ntu.edu.sg/Research/Pages/default.aspx. Last Accessed 22 03 2020

International Network for Multi-Hazard Early Warning Systems (INMHEWS) (2019) Governance document. INMHEWS, Geneva

Keys P, Galaz V, Dyer M, Matthews N, Folke C, Nyström M, Cornell SE (2019) Anthropocene risk. https://doi.org/10.1038/s41893-019-0327-x

Liu Q, Tan ZM, Sun J, Hou Y, Fu C, Wu Z (2020) Changing rapid weather variability increases influenza epidemic risk in a warming climate. Environ Res Lett 15(4)

Luther J, Hainsworth A, Tang X, Harding J, Torres J, Fanchiotti M (2017) World meteorological organization (WMO)-concerted international efforts for advancing multi-hazard early warning systems. Adv Culture Living Landslides. WLF 2017. Springer, Cham

Luther J, Andrioli M, Honoré C, Tang X (2019) Contributing to building a weather-ready, resilient and sustainable society. World Meteorol Organ Bull Geneva 68(1)

National Center for Atmospheric Research (NCAR) (2020) Monitoring, analysis, and prediction of air quality (MAP-AQ). https://www2.acom.ucar.edu/map-aq. Last Accessed 22 Mar 2020

Natural Catastrophe Data Analytics Exchange (NatCatDAX) (2020) https://www.natcatdax.org/Aboutus.aspx. Last Accessed 22 Mar 2020

Nuha E, Charles E, Virginia M (2018) Building urban resilience for disaster risk management and disaster risk reduction. Procedia Eng 212(2018):575–582

Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES) (2020) Projects sorted by program area. https://www.rimes.int/?q=projects. Last Accessed 22 Mar 2020

Rogers D (2011) Partnering for health early warning systems. World Meteorological Organization Bulletin, Geneva, 60 (1).

Rogers D, Tsirkunov V (2011) Implementing hazard early warning systems 2011

Sassa K (2019) The Kyoto landslide commitment 2020: first signatories. Landslides 16:2053–2057

Su H, Cheung S, Lo E (2018) Multi-objective optimal design for flood risk management with resilience objectives. Stoch Env Res Risk Assess 2018:32

Tang X (2006) Managing disaster risk in a mega-city. World Meteorol Organ Bull Geneva 55(4)

Tang X (2008) New challenges for weather services in changing urban environments. World Meteorol Organ Bull Geneva 57(4)

United Nations (UN) (2006) Global survey on early warning systems. An assessment of capacities, gaps and opportunities towards building a comprehensive global early warning system for all natural hazards. UN, New York

United Nations (UN) (2015) Transforming our world: the 2030 Agenda for sustainable development. UN, New York

United Nations Communications Group (UNCG) (2020) United Nations system response to COVID-19 core messages. UNCG, Geneva

United Nations Environment Programme (UNEP) (2012) Early warning systems: state-of-art analysis and future directions. UNEP, Nairobi

United Nations Development Programme (UNDP) (2018) Five approaches to build functional early warning systems. UNDP, Geneva

United Nations Environment Programme (UNEP) (2020a) Finance Initiative. https://www.unepti.org/. Last Accessed 22 Mar 2020

United Nations Environment Programme (UNEP) (2020b) EHA platform. https://ehaplatform.org/. Last Accessed: 22 Mar 2020

United Nations Framework Convention on Climate Change (UNFCCC) (2015) Adoption of the Paris agreement. In: Conference of the parties. Twenty-first session. 30 November–11 December 2015. UNFCCC, Paris

United Nations Office for Disaster Risk Reduction (UNDRR) (2005) Hyogo framework for action 2005–2015: building the resilience of nations and communities (HFA). UNDRR, Geneva

United Nations Office for Disaster Risk Reduction (UNDRR) (2006a) Platform for the promotion of early warning. Basics of early warning. http://www.unisdr.org/2006/ppecwwats-ew/basicsew.htm. Accessed 12 Nov 2020

United Nations Office for Disaster Risk Reduction (UNDRR) (2006b) Global survey on early warning systems. An assessment of capacities, gaps and opportunities towards building a
Collaboration in MHEWS Through an Integrated Way

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comprehensive global early warning system for all natural hazards. UNISDR, Geneva
United Nations Office for Disaster Risk Reduction (UNDRR) (2009) UNDRR terminology on disaster risk reduction. UNDRR, Geneva
United Nations Office for Disaster Risk Reduction (UNDRR) (2010) German committee for disaster reduction, emerging challenges for early warning systems in context of climate change and urbanization. UNDRR, Geneva
United Nations Office for Disaster Risk Reduction (UNDRR) (2015) Making development sustainable: the future of disaster risk management. Global assessment report on disaster risk reduction. UNDRR, Geneva
United Nations Office for Disaster Risk Reduction (UNDRR) (2016) United nations plan of action on disaster risk reduction for resilience. UNDRR, Geneva
United Nations Office for Disaster Risk Reduction (UNDRR) (2019a) Global Assessment Report on Disaster Risk Reduction. UNDRR, Geneva
United Nations Office for Disaster Risk Reduction (UNDRR) (2019b) global platform for disaster risk reduction. https://www.UNDRR.org/conference/2019/globalplatform/home. Last Accessed 22 03 2020
United Nations Office for the Coordination of Humanitarian Affairs (OCHA) (2020a) What is the cluster approach?. https://www.humanitarianresponse.info/en/about-clusters/what-is-the-cluster-approach. Last Accessed 22 Mar 2020
United Nations Office for the Coordination of Humanitarian Affairs (OCHA) (2020b) Humanitarian networks and partnerships week (HNPW). https://www.unocha.org/humanitarian-networks-and-partnerships-week-hnpw. Last Accessed 22 Mar 2020
United Nations System Chief Executives Board for Coordination (CEB) (2019) United Nations system-wide strategy on sustainable urban development. CEB, Geneva
World Economic Forum (WEF) (2020) The global risks report 2020. WEF, Geneva
World Meteorological Organization (WMO) (2015) WMO Guidelines on multi-hazard impact-based forecast and warning services. WMO, Geneva
World Meteorological Organization (WMO) (2017) A disaster risk reduction roadmap for the world meteorological organization. WMO, Geneva
World Meteorological Organization (WMO) (2018a) Multi-hazard early warning systems: a checklist. WMO, Geneva
World Meteorological Organization (WMO) (2018b) South-East European multi-hazard early warning advisory system (SEE-MHEWS-A). WMO, Geneva
World Meteorological Organization (WMO) (2019) World meteorological congress abridged final report of the eighteenth session. WMO, Geneva
World Meteorological Organization (WMO) (2020) WMO pilot project to enhance the capability of meteorological disaster risk reduction in RAII (Asia) (GMAS-A). https://gmas.asia/. Last Accessed 22 Mar 2020