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| WEATHER CLIMATE WATER | **World Meteorological Organization****COMMISSION FOR WEATHER, CLIMATE, WATER AND RELATED ENVIRONMENTAL SERVICES AND APPLICATIONS****Second Session**17 to 21 October 2022, Geneva | **SERCOM-2/Doc. 5.6(6)** |
| Submitted by:Chair21.X.2022**APPROVED** |

**AGENDA ITEM 5: TECHNICAL REGULATIONS AND OTHER TECHNICAL MATTERS**

**AGENDA ITEM 5.6: Disaster risk reduction and public services**

# Concept Note on MHEWS Interoperable Environment Framework

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# GENERAL CONSIDERATIONS

**Introduction**

The Eighteenth World Meteorological Congress (2019) through its [Resolution 15 (Cg-18)](https://library.wmo.int/doc_num.php?explnum_id=9827#page=80) − Strengthening Multi-Hazard Early Warning Services in areas prone to all flooding types and severe weather, requested the technical commissions and related WMO bodies, in consultation with the regional associations, to prepare for consideration by the Executive Council a concept document that assesses the approaches, feasibility, cost and timelines of developing an interoperable Multi-Hazard Early Warning Services (MHEWS) environment, while taking into account the conclusions, findings and recommendations of the independent reviews of the Coastal Inundation Forecasting Demonstration Project (CIFDP), the Flash Flood Guidance System with Global Coverage (FFGS) and the Severe Weather Forecasting Demonstration Project (SWFDP) carried out in 2018, and the consolidated report; and requested the Executive Council to oversee the implementation of the above decision. The SERCOM-1 (2020), considering the multidisciplinary nature of work, tasked the development of a concept note on MHEWS Interoperable Environment to be led by the SC-DRR in collaboration with the other relevant SCs (SC-HYD, SC-MMO & INFCOM/SC-ESMP).

**Development of the concept note**

1. The development of a concept note on MHEWS Interoperable Environment (MIE) was initiated by SC-DRR with the establishment of an Expert Team on MHEWS Interoperable Environment (ET-MIE) in late 2020. From the outset in the development of this concept note, it was agreed to also include the Tropical Cyclone Programme (TCP) and riverine flood forecasting (in addition to Coastal Inundation Forecast Initiative (CIFI), FFGS and Severe Weather Forecasting Programme (SWFP)) as part of the consolidated MHEWS environment considering the integral role of these initiatives in disaster risk reduction activities. The concept note, prior to its finalization, was widely shared with the relevant WMO bodies including the Flood Forecasting Initiative Advisory Group (FFI-AG), Management Groups of both technical commissions and the relevant substructures of SERCOM and INFCOM and regional associations for their review.

2. The interoperability of existing programmes, systems and initiatives aims to enhance capacities of national MHEWS through regional collaboration and coordination. It should allow for the reliable and predictable transport of data, metadata, and information across system boundaries. The concept note recognizes WMO 2030 Vision as its rationale and also aims to contribute to the Action Plan on Early Warning Services for All as led by WMO in response to the UN Secretary-General’s recent call that within the next 5 years everyone on Earth should be protected by early warning systems. The concept note highlights national and local requirements and capabilities in the context of MIE as well as the regional requirements and capabilities to support national and local early warning services. It also emphasizes the importance of institutional and technical aspects as part of the national requirements. Recognizing that MIE will not start from scratch, it has been requested in the concept note that an implementation plan for MIE may be developed. The MIE implementation plan should be a ‘living document’ with enough details to carry out specific actions to sustain MIE.

**Expected action**

3. Based on the above, the Commission may wish to adopt a Recommendation along the following lines.

# DRAFT RECOMMENDATION

## Draft Recommendation 5.6(6)/1 (SERCOM-2)

### Multi-Hazard Early Warning Services Interoperable Environment

THE COMMISSION FOR WEATHER, CLIMATE, WATER AND RELATED ENVIRONMENTAL SERVICES AND APPLICATIONS,

**Recalling** [Resolution 15 (Cg-18)](https://library.wmo.int/doc_num.php?explnum_id=9827#page=80) − Strengthening Multi-Hazard Early Warning Services in areas prone to all flooding types and severe weather,

**Reaffirming** the collective efforts in the development of the Concept Note on MHEWS Interoperable Environment Framework,

**Recognizing** with appreciation that the concept note has been developed considering not only the Coastal Inundation Forecast Initiative (CIFI), the Flash Flood Guidance System (FFGS) and the Severe Weather Programme (SWFP) but also the Tropical Cyclone Programme (TCP) and riverine flooding as these are all an integral part of the disaster risk reduction activities,

**Further Recognizing** that an implementation plan on MHEWS should incorporate Impact‑Based Forecast and Warning Services (IBFWS) and local community feedback, as discussed in the WMO Strategy for Service Delivery (SERCOM-2/Doc 5.2),

**Noting** the valuable contributions of the relevant WMO bodies including the relevant substructures of technical commissions and regional associations in reviewing the concept note,

**Further Noting** the need to ensure integration among the initiatives and programme areas covered in the concept note,

**Acknowledging** a mechanism established, through extrabudgetary resources, to provide cross‑initiative and programme coordination and to strengthen, coordinate and support Members in advancing end-to-end multi-hazard early warning systems building on the guidance and technical leadership of SERCOM,

**Recommends** to the Executive Council the adoption of the Concept Note on MHEWS Interoperable Environment Framework throughthe draft resolution provided in the [annex](#_Annex_to_draft_1) to the present Recommendation;

**Requests** P/SERCOM in consultation with P/INFCOM to develop a proposal for the supporting governance mechanism for the MHEWS Interoperable Environment (MIE) framework to be presented to EC-76.

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## Annex to draft Recommendation 5.6(6)/1 (SERCOM-2)

**Draft Resolution ##/1 (EC-## )**

THE EXECUTIVE COUNCIL,

**Recalling** [Resolution 15 (Cg-18)](https://library.wmo.int/doc_num.php?explnum_id=9827#page=80),

**Having examined** Recommendation 5.6 (6)/1 (SERCOM-2),

**Having agreed** on Recommendation 5.6 (6)/1 (SERCOM-2),

**Affirming** the importance of the implementation plan for MHEWS Interoperable Environment as an essential contribution to the Action Plan on Early Warning Services for All as led by WMO in response to the UN Secretary-General’s call made on World Meteorological Day (23 March 2022) that within the next five years everyone on Earth should be protected by early warning systems,

**Noting** the need to ensure integration among the initiatives and programme areas covered in the concept note,

**Further noting** a mechanism established, through extrabudgetary resources, to provide cross‑initiative and programme coordination and to strengthen, coordinate and support Members in advancing end-to-end multi-hazard early warning systems including floods, droughts, heatwaves and storms building on the guidance and technical leadership of SERCOM,

**Acknowledging** the governance mechanism for the MHEWS Interoperable Environment (MIE) framework proposed by P/SERCOM,

**Decides** to adopt the Concept Note on the MHEWS Interoperable Environment Framework as provided in the [annex](#_Annex_to_the) to this resolution;

**Requests** SERCOM in cooperation with INFCOM and Regional Associations the Research Board and other relevant bodies and including representation from external stakeholders as appropriate, to develop an implementation plan based on the guidance provided in the concept note and report to Executive Council;

**Requests** the Secretary-General to support SERCOM in the necessary actions for developing the implementation plan for MHEWS Interoperable Environment.

## Annex to Draft Resolution ##/1 (EC-## )

**Concept Note on Multi-Hazard Early Warning Services
Interoperable Environment**

**Purpose**

The purpose of this Concept Note on Multi-Hazard Early Warning Services (MHEWS) Interoperable Environment (MIE) Framework is to provide an overview of a strategy for theinteroperability and integration of early warning initiatives, programmes, and activities as feasible into a coordinated and sustainable, multi-hazard interoperable environment, aiming enhancement of the capacities of national institutions involved in MHEWS with support from the regional level collaboration and coordination.

The proposed strategy may first focus on the existing WMO MHEWS-oriented activities with its expansion to other initiatives and additional hazards as feasible and appropriate.

**Background — Scope of work, rationale, strategic vision and objectives**

Natural hazards continue to be a major threat to the people whose lives and livelihoods depend on safety and socioeconomic development, especially, but not exclusively in low-lying and highly populated urban areas. Disasters, such as any type of flooding (flash, riverine, glacial lake outburst, rapid snow melt, etc.), landslides, coastal inundations, heat waves, and drought can be triggered by a variety of natural features, from tropical and extra-tropical cyclones, monsoon disturbances, lack of rain or various kinds of high-impact weather, including heavy rainfall, strong winds, thunderstorms and damaging waves. Combined, complex, and cascading effects can rapidly compound the risk to life, livelihood and infrastructure, and exacerbate the threat to society. This threat from many natural hazards will be exacerbated in a changing climate.

The WMO 2030 Vision and the Strategic Operating Plan foresee a world where all nations, especially the most vulnerable, are more resilient to the socioeconomic consequences of extreme weather, climate, water, and other environmental events. The Sendai Framework for DRR 2015–2030 calls for a substantial increase in availability and access to early warning systems and disaster risk reduction information. Recently (23 March 2022), the UN Secretary-General, while confirming that Multi-Hazard Early Warning Systems (MHEWS) save lives, announced a priority plan to ensure that every person on Earth is protected by early warning systems within the next 5 years.

The Concept Note on the MIE Framework has been developed in response to the request by the Eighteenth World Meteorological Congress (Cg-18, June 2019) through its [Resolution 15 (Cg-18)](https://library.wmo.int/doc_num.php?explnum_id=9827#page=80) – Strengthening Multi-Hazard Early Warning Services in areas prone to all flooding types and severe weather.Cg-18 noted the findings of independent reviews of three demonstration projects: the Flash Flood Guidance System (FFGS), the Coastal Inundation Forecast Demonstration Project (CIFDP, now the Coastal Inundation Forecast Initiative CIFI) and the Severe Weather Forecast Demonstration Project (SWFDP, now the Severe Weather Forecasting Programme SWFP) carried out in 2018 as well as the consolidated report which recommended combining the three initiatives into a sustainable MHEWS environment. Cg-18 noted that these initiatives have been very successful in their own right with all of them being relevant with highly positive results. The technical commissions and related WMO bodies were requested to prepare, in consultation with the regional associations, a concept document that assesses the approaches, feasibility, cost and timelines of developing an interoperable MHEWS environment, while taking into account the conclusions, findings and recommendations of the independent reviews of the three projects and the consolidated report.

From the outset in the development of this concept document, it was agreed to also include the Tropical Cyclone Programme (TCP) as part of the environment since it is such an integral part of disaster risk reduction in basins where they occur. At the same time, it was recognized that the Flash Flood Guidance System (FFGS) primarily deals with flash floods and that it also has the ability to address urban and riverine flooding, but that given the numerous riverine flooding activities being undertaken by NMHSs, riverine forecasting should be more fully considered in any consolidated MHEWS environment, and not just as a component of either FFGS or CIFI.

The focus of this strategic Concept Note which mainly covers hydrometeorological hazards (during its first phase) should not obscure that only a multi-disciplinary approach taking into account hydrometeorological and geophysical complex and compounding aspects, can really meet the Sendai Framework targets.

The MHEWS Interoperable Environment (MIE) builds on the foundations of each initiative (including SWFP, FFGS, TCP, CIFI) to provide a sustainable, longer-term framework without impeding the growth and development of each individual initiative or programme, although some adjustments may be taken up by each of the relevant activity areas to be able to effectively integrate into the MIE. The concept of “environment” is chosen to reflect the fact that there is not a single solution to multi-hazard events. It is rather a set of solutions which function using a common setting for information input/output stream (observations, model output, baseline data) with appropriate standards, a common communications system/Information Technology architecture, and consistent warnings and Impact-based Forecasting (IBF) output and language.



Fig: Schematic vision of the proposed MIE

MIE would take advantage and strengthen the cascading processes of weather, hydrological, oceanographic and climate analysis, forecasting, and monitoring, from global to regional, national, and local applications, from atmospheric features to hydrometeorological consequences and then concrete impacts within the IBF paradigm and increasing sectoral applications, to better meet user needs for effective decision-making.

Ideally, the MIE would consider, within different and complementary sciences and/or programmes, crosscutting capacities and needs of adequate seamless numerical weather prediction (NWP) linked to other modelling such as hydrologic, coastal marine, climatological, etc., provision from nowcasting to decadal timescales supported with Artificial Intelligence (AI)/Machine Learning (ML) technologies through big data concept, hazard and impact modelling and risk assessment, rationalized and functioning data sharing, calibration, downscaling and research and development (R&D) applications. This would provide an optimum state-of-the-art operational and IBF-oriented environment for a new MHEWS structure.

MIE would provide an optimum state-of-the-art operational and IBF-oriented environment for a new MHEWS structure, where standards, protocols, formats, and metadata are shared by the components and which should be acceptable for extensions of any forecasting systems. MIE would also point to efficient linkages of MHEWS, rather than just simultaneously operating several Early Warning Systems (EWSs) which may contain complicated and verbose procedures. Standard interfaces and linkages are indeed crucial in the smooth articulation of independent modules.

MIE should allow efficient, organic, and sustainable combinations and articulations of methodologies, hardware, software with their necessary and firm telecom means to facilitate integrated expertise and services for hydrometeorological risks, including marine risks and risks in mountainous regions.

It is recognized that interoperability might require regional-specific structures and institutional arrangements, oriented to different types of hazards, and including new approaches and means to support the sharing of data and knowledge, which varies at national and regional levels. Therefore, in this Concept Note, we provide general and desirable characteristics for operating effective systems, understanding that the final design and components of the interoperable environment should address different risks and disaster reduction strategies.

*Strategic vision:*

By 2027, interoperability allows for the reliable and predictable transport of MHEWS-related data, metadata, and information across existing and future system boundaries. And thus creating a “system-of-systems”, capable of stimulating Early Warning Systems of all Members.

*MIE Objectives:*

(1) To facilitate the integration of new systems and hazards (e.g. drought, wildfires) according to the capabilities of the National Meteorological and Hydrological Services (NMHSs) and the needs of their end-users.

(2) To harmonize future projects and activities functioning toward issuing and dissemination of forecast, including capacity development aspects of those projects and activities.

(3) To increase the effectivity and usability of all MHEWS-oriented regional projects and activities for Members, including those implemented and/or funded by various agencies. (MIE could be considered as an entry point or platform to discuss, exchange, coordinate with, from outside WMO when it is about activities in the MHEWS scope and thus to optimize complementarity and to avoid overlapping areas of work.)

**National and local requirements and capabilities in the context of MIE**

Early warning services are the purview of national and local governments, although system operation and guidance delivery may be regional or global. It is national institutions such as National Disaster Management and Civil Protection Authorities (NDMCPAs) and meteorological, hydrological, and oceanographic agencies (usually NMHSs) that shall provide early warning services to the stakeholders and the population in each country/territory. This requests a strong recognition and commitment of the governance and adequate mandates and articulations of the institutions.

Attention must also be given to transboundary natural hazards, for which regional and global networks and coordination can significantly assist in providing consistent and high-quality responses across national borders.

MHEWS does not merely refer to the forecasting system but contains four elements (cf, MHEWS Checklist): (i) disaster risk knowledge; (ii) detection, monitoring, analysis and forecasting of the hazards and possible consequences; (iii) warning dissemination and communication; and (iv) preparedness to respond. Existing Infrastructure and procedure only contain a subset of the above. All of these four elements or pillars need to build on robust operating and maintenance procedure to ensure sustainability. Even though the regional coordinated aspects are in place within the MIE, if the national institutions cannot implement and activate as necessary an effective MHEWS throughout the whole value chain at national level, the main objective of MIE, to support national MHEWS operability, cannot be achieved.

It is important that the national institutions have the minimum resources, capacities, capabilities and coordinated organizations in order for them to get the best out of the MIE and benefit from the regional commitments/provisions to ensure the success of their early warning services. Conversely, it is also essential that the MIE empowers national institutions to undertake their roles with the highest possible effectiveness. The quality of the services within MIE could be exposed to national disparities related to infrastructure, staff, professional experience, capabilities, data type and coverage, resources, and so on, but a well-designed MIE will minimize these disparities to the degree possible.

It will be crucial, based on a gap and needs analysis and strategic vision for the MIE, to develop standards and guidelines to identify concrete requirements at national level. Several tools are available for gap and needs analysis, including the MHEWS Checklist, CIF-EWS Guideline and E2E EWS for Flood Forecasting Assessment Guidelines.

The MIE guidelines and requirements for national institutions should be scalable and flexible to the needs at different spatial and temporal scales, ranging from regional to national to local. The needs should also be examined by rolling review and updated in order to be better reflected in the functional requirements for regional and global centres.

Countries, based on their needs and realities, should adapt the MIE into the design of the national MHEWS implementation. That includes three main aspects, namely institutional/ governance, technical (data, tools and technology) and staff aspects (requirements of manpower, competencies and capacity building) that should be reflected and detailed, consistent with the National Framework for Weather and Climate Services where/when implemented.

**The institutional aspect,** governance and political commitment is of the highest importance since adequate capacities, resources and coordination mechanisms within national institutions are the keys for efficient MHEWS and benefit from MIE. Cross-institutional functionalities and activities operated by several agencies or institutions, through the development of partnerships as well as data, products, and information-sharing protocols may be required in many countries.

The roles and responsibilities of agencies involved in MHEWS should be clearly identified to ensure products and warning services are effective along the whole alerting chain down to the local communities. It is crucial to reinforce the involvement and cooperation among national and local stakeholders including through the development of feedback processes. These should include complementary sciences, including social sciences, the public and private sectors, and particularly the most vulnerable communities.

The MHEWS requires consideration of national integrated Standard Operating Procedures (SOPs) and national plans, which will strengthen coordination and communication among the agencies involved. The NDMCPA represents the primary end-users for MHEWS products produced by the NMHS. Many countries already have SOPs for NDMCPAs, which, as the legal framework, must be considered in MIE implementation (as well as MHEWS implementation to NMHSs). The proper selection and functioning of the agencies should guarantee that the information and products disseminated (e.g., watches and warnings), possibly emanating from MIE, are reliable, efficient, and clearly communicated to stakeholders, media, decision-makers, and the population, allowing feedback and exchange of information, rather than one-way dissemination only.

**The technical aspect** implies interfacing, integrating, and reconciling guidance products, observing systems (real-time to long-time series), NWP, subseasonal, seasonal and decadal forecasts, pre/post processing techniques, other data, analysis tools, etc. and the needed ad-hoc systems. Data (various sources and types) availability and database(s) management will be essential to promote data sharing (as envisioned through the WMO Data Policy) and IBF paradigm, e.g. optimized observation networks, coordinated by the Global Basic Observation Network (GBON), upgraded by WIS2.0 , and wider NWP usage at different scales.

The technical aspect also covers finalized production and dissemination capacities and protocols based on national MHEWS principles. It also includes the infrastructure provided by the different agencies to host all the activities required by all the processes, including back-up procedures and continuity of service.

To facilitate integrated expertise and services at regional level for the benefit of national institutions, it is important to facilitate harmonization of national warning communication practices where appropriate (such as colour-coded warning information, Common Alerting Protocol (CAP), etc.) throughout the region, real-time coordination discussions and the possible back-up arrangements among neighbouring countries/territories, especially for the transboundary hazards.

As for **the “staff” aspect** and requirements, it will be important to ensure that the institutions involved in MHEWS through the MIE will be operated by sufficient and competent staff and/or will be supported by cooperative mechanisms and arrangements. So, the assessment of national capacities with regards to MIE will be crucial to not only define urgent actions in capacity building but also mid/long term training plans and select future hires with appropriate background. Training should be provided both for the NMHS staff and NDMCPA in charge of warning services to ensure they have the required competencies for national MHEWS for a better understanding of information needs and challenges to support decision-making processes .

**Regional requirements and capabilities to support national and local early warning services**

The detailed functions and commitments of regional centres, where identified, should be well specified based on the needs of national MHEWS and on the identification of products and services that the regional level could make efficiently available, based on standardized procedures across timescales from days to years. Several Regional Specialized Meteorological Centres (RSMCs) mandated for the provision of regional severe weather forecasting and tropical cyclone forecasting, as well as for regional climate watch advisories are already documented in the [*Manual on the Global Data-Processing and Forecasting System (GDPFS)*](https://library.wmo.int/?lvl=notice_display&id=12793#.YyCSrHbP271) (WMO-No. 485). MIE requirements for all relevant regional centres including those for hydrological services based on the Rolling Review of Requirements (RRR) should be documented in WMO regulatory documentation, including in the manual on the GDPFS. GDPFS centres are encouraged to make joint global and regional efforts in response to disasters, to give full play to its functions and operational fit-for-purpose products.

It is important to consider the roles and responsibilities of the regional centres, in their operational activities, for capacity building and training aspects, as well as for R&D transfer and continuous improvement. Cooperation among different types of regional centres is required at the early stage of the development and/or the upgrade of MIE services but also for continuous effective implementation and improvement of MIE services. Diagnosis of gaps and needs, and the identification of regional centres, if necessary, will be a useful step forward with regards to competencies, capabilities and resources based on what national MHEWS might require from a regional level in terms of support, input, and guidance.

There are two primary roles for regional contributions to MIE.

*Operational support to national level work, in data and product supply*

The relevant operational regional centres (involved in SWFP, TCP, CIFI and FFGS) actively facilitate global and national connections, providing regional harmonization/optimization, effective guidance and support for work at national levels (NMHSs) in a coordinated manner .

The regional guidance is not necessarily intended to be impact-oriented, but it must be supportive for conversion and interpretation for possible calibration/downscaling expertise ensuring that the guidance is interpreted and converted to impact-based forecasts and risk based warnings in NMHSs. Furthermore, considering the range of products issued by different regional centres, e.g., RSMC SWF and RSMC TC for the same region, coordination among different regional centres is necessary to make sure that their regional guidance products are complementarily designed, without duplication or discrepancies between them, based on needs of Members concerned. This operational support to the national level will need well-defined coordination mechanisms (especially for real-time purposes) to ensure that each centre has access to all necessary data and NWP to monitor, forecast and assess risks at a regional level to provide MHEWS guidance for the other regional centres and for national institutions, especially on those phenomena that typically take place on large spatial scales and consequently are of interest to several countries, such as hurricanes or floods in transboundary rivers. It should always be considered that satellite monitoring and application is a great global and regional resource for national disaster risk reduction activities, to complement NWP and related products.

MIE will also ensure that data and products provided by the relevant regional centres are standardized and aligned with WMO regulations and recommendations in terms of formats, protocols, conventions, etc. This promotes the enabling of national centres, not only regional centres, to implement the necessary technical tools (hardware, software, telecom) in a more harmonized and integrated manner, following clearly established requirements. Such requirement should be incorporated into the implementation of WIS 2.0, which is fundamental in realizing the standardization of data and products.

MIE will also facilitate the strengthening of crosscutting and seamless Earth system prediction across timescales, bringing together model outputs from the different timescales and disciplines needed for IBF objectives (weather, hydro, and ocean) and pertinent information of vulnerability and exposure.

*Competencies, training and outreach*

One of the key drivers for MIE success is related to sufficient and well-trained staff in the relevant operational regional centres. In this regard, MIE should facilitate collaboration and coordination between the relevant operational regional centres, Regional Training Centres (RTCs), Regional Climate Centres (RCCs), and regional NWP providers (where they exist), where each of them, in its domain of work, will contribute to training, operational and technical support and capacity building under the WMO global umbrella. RSMCs for Nowcasting and RSMCs for limited-area deterministic and ensemble NWP can also be engaged as/where appropriate and feasible.

Regional centres will be major contributors in the organization of routine training particularly to fill the gaps that have been identified at the national level with regards to MHEWS activities and efficiency.

MIE, taking advantage of regional centres’ overall capacities, will also facilitate educational and outreach programmes to be developed in coordination between operational and training centres, with a view to being adaptable (language, list of hazards, etc.,) to a maximum number of countries (e.g., UNESCO Regional Tsunami Information Centre), without re-inventing the wheel.

**Implementation and Next Steps**

MIE will not start from scratch. TCP has been successfully implemented in all basins subject to tropical storms, coordinating operational actions and capacity building. MIE can also benefit from the success, lessons learned and challenges from the three other initiatives (CIFDP, FFGS and SWFDP) and flood forecasting activities and projects .

Synergies and operational linkages have already been started in several sub-regions, which clearly showed the need for and benefit from an interoperable environment. Since each of the aforementioned WMO programmes and initiatives have been developed independently, it is important that each still works successfully as a single component. The next step is to integrate those activities to further enhance their operations in an interoperable environment.

Several countries, in different WMO Regional Associations, have implemented MHEWS incorporating all FFGS/SWFP/CIFI/TCP activity areas: Fiji, Bangladesh, Haiti/Dominican Republic, Indonesia, South Africa, Philippines, and India, the latter three with a self-developed national coastal inundation activity. Any or all of these three countries could be a suitable pilot to demonstrate the MIE concept.

The **development of an Implementation Plan**, should include measures and activities that reply to gaps and needs as provided by analysis above targeting (1) institutional, (2) technical and technological, and (3) staff aspects.

 An implementation plan should be a living document, prepared and developed in enough detail so the specific actions identified could be taken to help ensure the sustainability of the MIE for the benefit of current and future generations. The development of the MIE implementation plan should be facilitated by good coordination/input from the other SC-DRR Expert Teams (ETs) and Advisory Groups and their documents. The implementation plan could take the form of guidelines, similar to the CIF-EWS Implementation Guidelines or the SWFP Guidebook.

The guidelines should facilitate regional/sub-regional implementation, across the entire value chain, including data and product exchange, methodologies, articulations, training and competencies, R&D transfer, verification and feedback mechanisms, etc. It should be developed keeping in mind that it will need to be downscaled and adapted to specific (sub-) regions, with a wide variety of capacities and resources.

MIE would clearly be a crosscutting core component of WMO since the basic architecture, to serve DRR goals, for providing better IBF services which meet user requirements for effective decision-making, will be based on observations (WIGOS), forecasting capacities including NWP (Seamless GDPFS), climate services aspects (GFCS/CSIS), production and communication abilities (PWS) including warnings (GMAS), and telecom and exchange capacities (WIS). Input from R&D (WWRP/WCRP), for example on Artificial Intelligence use and opportunity, strengthening of interaction with social science (Societal Economic Research Applications — SERA) and more widely with the new WMO-UNDRR Centre of Excellence for Climate and Disaster Resilience, and the strong support of the education and training programme to ensure adequate competencies and resources at all levels are also crucial for MIE implementation and sustainability. Concerning the technical commissions, MIE will need and benefit from strengthened articulation with INFCOM and SERCOM, especially for the improvement of observing systems and networks, data sharing, data and product standard formats, and Research Board, when exploring emerging technologies such as Artificial Intelligence (AI)/Machine Learning (ML) technologies to contribute to the global/regional quick response to disasters.

Through their relevant subsidiary bodies and in collaboration with the technical commissions and based on MIE assessments on minimum capacities at regional and national level, Regional Associations could play detailed and substantial coordination and regional management roles since they can best identify specific requirements and priorities among Members in their regions and call for collaborative effort from GDPFS centres.

The MIE implementation plan will also provide estimated costs for implementing the activities needed to ensure MIE sustainability. Currently, activities of SWFP, FFGS and CIFI are generally implemented through extra-budgetary resources and in-kind contributions from Members.

The successful implementation will require the involvement and commitment of the WMO Technical Commissions, Research Board, the Hydrological Coordination Panel (HCP), Global Centres, Regional Centres, NMHSs, WMO Regional Associations, the WMO Secretariat and the broader community to do their part in this important strengthening process to attain sustainability of the MIE and its implemented systems.

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