World Meteorological Congress

Abridged Final Report of the Extraordinary Session

Virtual session

11–21 October 2021

WEATHER CLIMATE WATER

WORLD METEOROLOGICAL ORGANIZATION

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GENERAL SUMMARY OF THE WORK OF THE SESSION

1. The extraordinary session of the World Meteorological Congress in 2021 (Cg-Ext(2021)) was opened by videoconference on Monday 11 October 2021 at 1100 UTC/GMT by the WMO President, Professor G. Adrian. The President welcomed the Congress and the other participants, recalling the challenging conditions under which the session was organized due to the COVID-19 emergency. The WMO Secretary-General, Professor P. Taalas, also welcomed the Congress. A high-level segment followed the opening of the session.

2. Mr Alain Berset, Head of the Federal Department of Home Affairs of the Swiss Confederation, welcomed all the delegates on behalf of Switzerland. Quoting Winston Churchill ("You must look at facts, because they look at you"), he emphasized the importance of reliable scientific data in supporting sound decision-making and improved risk management in the areas of weather, climate and water. In this regard, he underlined the institutional role of WMO in facilitating international cooperation in observation, research and services and its strengthening through the constituent body reform. Finally, he called on the spirit of international collaboration and emphasized the taking of a long-term perspective to face, with courage, the challenges experienced by humanity because of climate change and extreme weather events.

3. Ms Tatiana Valovaya, United Nations Under-Secretary-General, Director-General of the United Nations Office at Geneva (UNOG), through a video statement, highlighted the importance of climate change as the defining and most urgent global challenge. She called for immediate action and ambition to ensure climate change adaptation and mitigation through coordinated efforts at the international level. In this regard, she noted that the proposed unified WMO Data Policy will be an essential tool to support sound decisions and essential services needed by all sectors of society to face climate change and its impacts. In addition, the Water and Climate Coalition will provide an important mechanism to address the nexus between water and climate.

4. The WMO Secretary-General underlined the key achievements of the WMO reform during 2019–2021: rationalization of the technical commissions, wider engagement of the private and academic sectors, restructuring and modernization of the Secretariat, raising awareness of climate science, streamlined and more action-oriented meetings, active partnerships with United Nations system organizations, record mobilization of extrabudgetary resources for capacity development and strengthened support to and an enhanced role of the regional associations. He emphasized the importance of the meteorological value chain, from observations and data to research and custom-oriented operational services, to generate economic benefits, and the need to support it through a modernized observation infrastructure, a unified data policy and financial mechanisms.

5. Ms Mami Mizutori, United Nations Assistant Secretary-General and Special Representative of the Secretary-General for Disaster Risk Reduction, United Nations Office for Disaster Risk Reduction (UNDRR), underscored the critical impacts of climate change and disasters on economic development. Recalling the long-standing collaboration between WMO and UNDRR, she announced the forthcoming establishment of a joint Centre of Excellence for Climate and Disaster Resilience. She also emphasized that WMO and UNDRR are collaborating to enhance the role of multi-hazard early warning systems in support of disaster risk reduction and humanitarian action in developing countries. Such collaborative efforts will be considered by both the forthcoming twenty-sixth Conference of the Parties of the United Nations Framework Convention on Climate Change (UNFCCC) and the seventh session of the Global Platform for Disaster Risk Reduction (DRR).

6. In concluding the high-level event, the WMO President expressed appreciation to all the members of the WMO community for their contribution to advancing the mission of the Organization at such a critical moment. While taking stock of the important accomplishments since the eighteenth session of Congress, he highlighted the opportunity for Members to strengthen the ability of WMO to address present and future challenges by considering and

adopting critical proposals regarding the international exchange of Earth system data and supporting financial mechanisms, hydrology and water resources, the enhancement of regional mechanisms, and the updated General and Technical Regulations.

7. The agenda approved by Congress is provided in Appendix 1.

8. The session adopted 12 resolutions, given in Appendix 2.

9. The World Meteorological Congress recalled the official languages of the Organization and the working languages of WMO bodies defined in the General Regulations and recommended that, in addition to decision documents, information documents and other materials pertaining to sessions should be translated into the working languages of WMO to the extent possible. Congress commended the commitment of the Secretariat to providing the broadest range of linguistic support possible to Members taking into account existing resources and noted with appreciation that the Secretariat is currently investing in new technologies (machine translation, computer-assisted translation tools and similar) that will allow for the provision of session information documents and other supporting documentation in the working languages of the session beyond what has been possible so far. The pilot project is well advanced and should yield concrete results for Members in the constituent body sessions in 2022.

10. The World Meteorological Congress thanked Mr David Grimes, laureate of the sixty-fifth International Meteorological Organization (IMO) Prize, for his lecture and requested the Secretary-General to arrange for the appropriate publication in the WMO Bulletin series.

11. The list of participants is given in Appendix 3. Out of a total of 760 participants, the ratio of female to male participants was 253:507, that is 33:67%.

12. The session was closed by the President on Thursday, 21 October 2021 at 1400 UTC/GMT.

APPENDIX 1. AGENDA

1. Agenda and organizational matters

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APPENDIX 2. RESOLUTIONS ADOPTED BY THE SESSION

Resolution 1 (Cg-Ext(2021))

WMO Unified Policy for the International Exchange of Earth System Data

THE WORLD METEOROLOGICAL CONGRESS,

Recalling:

(1) Article 2 of the WMO Convention (*Basic Documents No. 1* (WMO-No. 15)), which commits Members to facilitating worldwide cooperation in the establishment of observing networks and to promoting the exchange of meteorological, hydrological and other geophysical observations,

(2) Resolution 40 (Cg-XII) – WMO policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities, which, inter alia, reminds Members of the need to ensure a stable ongoing commitment of resources in order to meet their obligations under Article 2 of the WMO Convention in the common interest of all nations,

(3) Resolution 25 (Cg-XIII) – Exchange of hydrological data and products,

(4) Resolution 60 (Cg-17) – WMO policy for the international exchange of climate data and products to support the implementation of the Global Framework for Climate Services,

(5) Resolution 80 (Cg-18) – Geneva Declaration – 2019: Building Community for Weather, Climate and Water Actions, which presents the WMO high-level policy for partnership and engagement among stakeholders from the public, private, academic and civil sectors,

(6) The long-term goals and strategic objectives of the Organization as laid out in the *WMO Strategic Plan 2020–2023* (WMO-No. 1225) and Vision 2030, which require more data from an ever-broadening range of disciplines and sources to be exchanged,

Recalling further:

(1) Resolution 55 (Cg-18) – Emerging data issues, in which the Executive Council was required to consider the recommendations of the Commission for Basic Systems-led Review of Emerging Data Issues and to continue the evaluation of the emerging data issues and their implications on Members and the weather enterprise as a whole,

(2) Resolution 56 (Cg-18) – Data policies and practices, in which the Executive Council was required to establish a process for the review of the WMO data policies and practices expressed in Resolution 40 (Cg-XII), Resolution 25 (Cg-XIII) and Resolution 60 (Cg-17),

(3) Decision 39 (EC-70) – Outcomes of the fourteenth session of the WMO Consultative Meeting on High-level Policy on Satellite Matters, in which the Executive Council, by recognizing that space-based observations are now playing and will continue to play a critical role in the ability of all Members to deliver vital services to help save lives, protect property and foster economic growth, required that these observations be addressed under policies for international data exchange,

(4) Resolution 34 (Cg-18) – Global Basic Observing Network, which initiated the design of a Global Basic Observing Network to better meet the current and future observational requirements for global numerical weather prediction and climate reanalysis,

Commending those Members and international organizations that have supported the implementation of these data policies by providing access to – and by broadening the volume of – essential data (as defined in Resolution 40 (Cg-XII)), available on a free and unrestricted basis, and by providing additional data under fair and transparent conditions,

Recognizing:

(1) The key role of access to timely and reliable weather, climate, water and related environmental data[1] as a basis for informed decision-making at all levels to underpin essential public services that help save lives, protect property and foster economic prosperity,

(2) That the overall economic benefits of weather, climate, water and related environmental services have grown by orders of magnitude over the last 25 years, enabled by WMO's data policies,

(3) That the growing impact of and reliance on these services continues to increase our dependence on weather, climate, water and related environmental data,

(4) The critical role played by the output of global numerical prediction systems in underpinning all weather, climate, water and related environmental products and services and thus, the importance of broadening and enhancing the free and unrestricted access to such output for all Members,

(5) That these global prediction systems in turn depend on a continuous, robust and reliable supply of observational input from all areas of the globe provided by both surface-based observing systems[2] and space-based observing systems,

(6) The need to take an integrated Earth system approach to monitoring and prediction and the critical dependence such an approach places on data spanning all relevant components of the Earth system and the interactions between them,[3]

(7) The experience and lessons gained by WMO in the development and implementation of Resolution 40 (Cg-XII) and Resolution 25 (Cg-XIII) and Resolution 60 (Cg-17),

Noting:

(1) The United Nations Secretary-General Data Strategy for Action by Everyone, Everywhere, which aims at delivering better data-driven support to people and the planet,

(2) The contribution of weather, climate, water and related environmental data and services to the implementation of the United Nations Sustainable Development Goals (SDGs),

(3) The Paris Agreement under the United Nations Framework Convention on Climate Change, which aims to strengthen the global response to the threat of climate change,

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[1] "Environmental data" here refers to data (observed and modelled variables) beyond those directly pertaining to weather, climate or hydrology, in particular atmospheric composition, properties of the marine environment, the land surface and the exosphere.

[2] The term "surface-based observing systems" is taken to encompass all systems not deployed in space.

[3] Earth system data here encompass data pertaining to weather, climate, hydrology, atmospheric composition, oceans, the cryosphere, and space weather. For further details on these domains and disciplines, see Annex 1 to the present resolution. For a precise definition of Earth system data, see Annex 4 to the present resolution.

(4) The Sendai Declaration and Framework for Disaster Risk Reduction 2015–2030, with its four priority areas: Understanding disaster risk; Strengthening disaster risk governance to manage disaster risk; Investing in disaster risk reduction for resilience; and Increasing disaster preparedness for effective response,

(5) The endorsement by the World Meteorological Congress, through Resolution 80 (Cg-18), of an inclusive and collaborative approach among the public, private, academic and civil sectors to promote, inter alia, innovative approaches and incentives to enable fair and equitable access to data,

(6) The increased significance of data and digital technologies in informing socioeconomic policy development and decision-making,

(7) Prevailing data policy trends under which many governments and international organizations have already decided to provide access to all publicly funded data on a full, open and free basis having seen that the open provision of data tends to maximize their net contribution to the overall economy,

(8) The need for WMO to help advance the ability of all Members to benefit from the free and unrestricted access to data, emerging technology, and the global trend towards a digital economy, with the aim of enhancing shared benefits between Members and stakeholders,

(9) The activities undertaken by the Coordination Group for Meteorological Satellites (CGMS) and the Committee on Earth Observation Satellites (CEOS) to ensure that there is a robust and continued supply of critical satellite data for the benefit of all WMO Members,

Acknowledging:

(1) The WMO long-term goal of closing the capacity gap on weather, climate, hydrological and related environmental services among Members, including their ability to acquire and benefit from the model data and derived products which are essential for the critical mission of saving lives and protecting property,

(2) The need for all Members to contribute to maximizing the benefits of global modelling products by participating more fully in the exchange of observational data on which these products are based,

(3) The importance of efficient investment in systems used for acquiring and exchanging weather, climate, water and related environmental data and of maximizing the contribution of these data to supporting economic development, climate resilience and environmental sustainability,

(4) The significant expansion that has taken place since the adoption of Resolution 40 (Cg-XII) in the number and diversity of providers of observations and other data products including, in particular, the growing role played by private sector entities,

(5) The critical role of research in fostering the continuous improvement and innovation of observing systems, products and services and the importance of ensuring the free and unrestricted exchange of data between the research and the operational communities,

(6) The crucial function of the Permanent Representatives with WMO and the role of Hydrological Advisers in helping to maximize the societal impact of Earth system monitoring and prediction efforts, both by coordinating with all stakeholders from the public, private and academic sectors in their States and Territories, and by promoting relevant WMO activities, policies and standards,[4]

[4] For guidance to Members regarding coordination of the implementation of the present resolution, see Annex 2 to the present resolution. Guidelines for public-private sector engagement on Earth system data are provided in Annex 3 to the present resolution.

(7) The continued disparity with respect to the available technical and institutional capacities and the financial and human resources that the individual Members have at their disposal for their implementation of the WMO Data Policy,

(8) The need for the WMO Data Policy, and the national implementations thereof, to be consistent with other policies based on international law, including, in particular, the rules governing marine scientific research in the United Nations Convention on the Law of the Sea (UNCLOS),

(9) The right of governments, having done their utmost to implement the decisions of the World Meteorological Congress, to, based on their national laws and policies, choose the manner by, and the extent to which, they make data available domestically or for international exchange, while still understanding that without reciprocity, international data exchange cannot be sustained,

Having examined Recommendation 3 (EC-73) – WMO Unified Policy for the International Exchange of Earth System Data,

Agrees to have one unified data policy for all WMO domains and disciplines;

Decides that the scope of the data policy shall cover Earth system data exchanged among Members under the auspices of the WMO Convention and the decisions of the World Meteorological Congress, as described in Annex 1 and Annex 4 to the present resolution and as specified in detail in the WMO Technical Regulations;

Adopts the following policy on the international exchange of Earth system data:

> *As a fundamental principle of WMO and in consonance with the expanding requirements for its scientific and technical expertise, WMO commits itself to broadening and enhancing the free and unrestricted*[5] *international exchange of Earth system data*;

Also agrees to maintain a two-tiered approach to the international provision and exchange of Earth system data via the following practice:[6]

(1) Members shall provide on a free and unrestricted basis the ***core*** data that are necessary for the provision of services in support of the protection of life and property and for the well-being of all nations, at a minimum those data described in Annex 1 to the present resolution, which are required to monitor and predict seamlessly and accurately weather, climate, water and related environmental conditions;

(2) Members should also provide the ***recommended*** data that are required to support Earth system monitoring and prediction activities at the global, regional and national levels and to further assist other Members with the provision of weather, climate, water and related environmental services in their States and Territories. Conditions may be placed on the use of recommended data;[7]

Further agrees that Members should provide without charge access to all recommended data exchanged under the auspices of WMO to public research and education communities for their non-commercial activities;

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[5] "Free and unrestricted" is defined in Annex 4 to the present resolution.

[6] The basis for this practice is that Earth system data required to fulfil Members' commitments under the WMO Convention and WMO strategic objectives are encompassed by the combination of core and recommended data exchanged by Members and relevant international organizations.

[7] "Conditions" may be applied by licensing agreements or other appropriate arrangements.

Encourages all users of Earth system data to honour reasonable requests for the attribution of input data wherever possible;

Urges Members:

(1) To undertake the necessary actions to promote the alignment of national policies and regulations concerning Earth system data sharing and exchange, nationally and internationally, with the policy promulgated through the present resolution;

(2) To provide full transparency on conditions of use and re-use when such conditions apply to exchanges of recommended data;

(3) To accommodate the need for users of recommended data to respect the conditions of use set by the owners of the data, as this will help to facilitate access to the data;

(4) To facilitate the exchange of data from all stakeholders and sectors at the international level when emergencies and natural disasters occur;

(5) To build partnerships to enhance the exchange of Earth system data among national and regional stakeholders in order to improve the integration of data across disciplines and domains, thereby helping to strengthen them all;

Requests the Executive Council:

(1) To oversee the implementation of the present resolution via appropriate mechanisms for continual monitoring of compliance;

(2) To keep the definitions of core and recommended data provided in Annex 1 to the present resolution under regular review and to propose updates as necessary;

Requests the presidents of the regional associations to support and monitor the implementation of the present resolution within their regions;

Requests the president of the Commission for Observation, Infrastructure and Information Systems (INFCOM), in coordination with the president of the Commission for Weather, Climate, Water and Related Environmental Services and Applications (SERCOM) and the Chair of the Research Board:

(1) To provide draft technical regulations to support the implementation of the present resolution, to be submitted to the World Meteorological Congress in 2023;

(2) In light of the commitment to the free and unrestricted exchange of data and the requirements of Members for access to high-quality numerical weather prediction and analysis products, to initiate a process for amending the *Manual on the Global Data-Processing and Forecasting System* (WMO-No. 485), to be submitted to the World Meteorological Congress in 2023;

(3) To develop a process for the systematic and regular review of the types or domains of data that fall within the established practice and categories of Earth system data, as described in Annex 1 to the present resolution, in order to meet the changing needs of Members, the changing availability of data, and the continued development of modelling capabilities;

(4) To ensure that the regional associations are kept informed of initiatives related to the implementation of the present resolution and consulted on developments as necessary;

(5) To take the necessary steps to ensure that WMO technical systems and guidelines will develop and evolve to accommodate the exchange and interoperability of Earth system data envisaged in this policy;

Requests the president of SERCOM, in coordination with the president of INFCOM, the Chair of the Research Board, and other relevant bodies:

(1) To initiate a process to review the emerging data requirements for risk- and impact-based warning and decision support systems;

(2) To seek the engagement of concerned partners, that is, international organizations/agencies that are reliant on the provision of weather, climate, water and related environmental services by Members in order to further apply and implement WMO's unified data policy;

Requests the Secretary-General:

(1) To establish, adopt and publicize mechanisms to maximize the impact of the present resolution and to ensure that it is effectively implemented by all Members, including any resource mobilization activities needed, recognizing the need of some Members for support for their implementation efforts, for example through collaborations with relevant United Nations agencies and other international development partner organizations;

(2) To enact a system to monitor and report on the implementation of the present resolution by Members and to set indicators for the specific and substantive evaluation of its performance;

(3) To strengthen the effective coordination with relevant WMO partners and stakeholders on matters related to data policy and practice and to encourage them to adopt similar policies and practices concerning the free and unrestricted exchange of their relevant data in support of WMO programmes;

(4) To promote further collaboration with numerical weather prediction production centres and other stakeholders to ensure full, free and unrestricted access to Earth system monitoring and prediction data for all Members in order to support them in the provision of their public weather, climate, water and related environmental services;

(5) To develop guidance for Members on the implementation of this policy as concerns the relationship between public sector data providers and private sector users of data, keeping in mind the need to preserve the integrity of the publicly funded international exchange of data as the foundation for all weather, climate, water and related environmental services.

Note: This resolution replaces: Resolution 40 (Cg-XII), Resolution 25 (Cg-XIII), Resolution 60 (Cg-17), and Resolution 56 (Cg-18), which are no longer in force.

Annex 1 to Resolution 1 (Cg-Ext(2021))

Discipline and domain-specific practice for core and recommended data

Purpose

This annex lists the minimum set of **core data** that Members shall exchange on a free and unrestricted basis to underpin the services they provide for the protection of life and property and for the well-being of all nations.

In addition, it identifies certain **recommended** data that should also be exchanged by Members to support Earth system monitoring and prediction efforts.

Evolving data issues: Earth system data is a rapidly expanding and evolving area, in terms of sources, distribution, variables covered and technology. WMO provides relevant and topical guidance in the *Guidelines on Emerging Data Issues* (WMO-No. 1239). These guidelines will be reviewed and updated periodically, and over time the review may lead to additional datatypes being included in this policy as either core or recommended data.

The scope of this annex is data (as defined in Annex 4 to the present resolution) characterizing the past, present and future state of the Earth system, and it encompasses data exchanged in real time or near-real time as well as from historical or archived sources.

The remainder of this annex lists core and recommended data for the following Earth system disciplines/domains:

1. Weather
2. Climate
3. Hydrology
4. Atmospheric Composition
5. Cryosphere
6. Oceans
7. Space Weather

Each discipline/domain has its own categories and set of practices for core data, with subcategories as appropriate, e.g. observations and derived products. These are summarized below and categorized for ease of reference. Importantly, a successful implementation of the Earth system monitoring and prediction approach will depend on all categories as they are intimately linked.

1. Weather-related data

This section lists observational and other data necessary to support weather monitoring and prediction efforts of the WMO Members. Such data are generally exchanged in real or near-real time, depending on the specific application.

1.1 Core observational data:

1.1.1 Surface-based:

Observations provided by the Global Basic Observing Network (GBON) and other observational data, as specified in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

1.1.2 Space-based:

(a) Satellite data required in order to ensure the performance and quality of NWP output, as agreed with Members operating satellites or relevant satellite operators, and listed in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160);

(b) Satellite data required to support nowcasting applications including the generation of warning and advisory products, as agreed with Members operating satellites or relevant satellite operators, and listed in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

1.2 Other core data:

(a) Global analysis and prediction fields provided by global NWP systems of designated producing centres of the Global Data Processing and Forecasting System (GDPFS), as specified in the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485);

(b) Limited area analysis and prediction fields provided by NWP systems of designated producing centres of the GDPFS, as specified in the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485);

(c) All watches, advisories and guidance products for public safety (protection of life and property) issued by WMO mandated centres according to WMO Technical Regulations.

1.3 Recommended data:

(a) All available observations provided by the Regional Basic Observing Network (RBON), which is further specified in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160);

(b) All other watches, advisories, warnings and alerts for public safety (protection of life and property) issued by Members' designated warning and alerting authorities, unless already shared under specific license or terms and conditions.

2. Climate

Note that some core climate data are covered under the weather, cryosphere, hydrology, atmospheric composition and ocean sections. Core data includes current and historic time series data needed to understand climate change, assess the associated impacts and risks for lives, livelihoods, and property and support climate services. Data shall be made available in a timely manner, with a tentative maximum delay of one year.

2.1 Core observational data:

(a) Measurements provided by the GCOS Upper-Air Network (GUAN) and GCOS Surface Network (GSN) stations (see also 1.1.1 (a));

(b) Climate data as defined in the *Manual on High-quality Global Data Management Framework for Climate* (WMO-No. 1238);

(c) Essential Climate Variables (ECVs) as defined by the Global Climate Observing System (GCOS) in *the Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) to the extent that the Member holds the data in a digital archive.

2.2 Other core data:

Climate reanalysis fields provided by GDPFS centres, as listed in the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485).

2.3 Recommended data:

Members should exchange all climate data defined in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) and encourage all data holders to share their climate data.

3. Hydrology

This section lists data, including (near) real time data, historical time series and aggregated data, that are fundamental to global knowledge of the hydrological cycle and essential to the application of such knowledge to support and protect life and health; ensure economic prosperity and well-being; and effectively manage resources through the undertaking of operational hydrology.

3.1 Core observational data:

(a) Observations from reference network stations, to be detailed in the *global hydrological observing network* and subsequently specified and adopted into the WMO *Technical Regulations, Volume III, Hydrology* (WMO-No. 49) and its annexes;

(b) All satellite data needed to ensure the performance and quality of hydrological forecast and outlook, as agreed with Members operating satellites or relevant satellite operators and specified in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

3.2 Other core data:

Data from global and regional (large-basin or economic regions) hydrological models and water-related climate reanalysis fields made accessible to users through GDPFS centres, as specified in the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485).

3.3 Recommended data:

(a) All observations from hydrological observing stations required for users to fulfil the routine functions of National Hydrological Services identified in the WMO *Technical Regulations, Volume III, Hydrology* (WMO-No. 49);

(b) Other data necessary for the understanding of the hydrological cycle and the forecasting of streamflow or future water volumes in catchments at different scales with a focus on the determination of the water balance of catchments, groundwater dynamic, lakes, reservoirs or glaciers;

(c) All advisories and warnings issued according to WMO Technical Regulations.

4. Atmospheric composition

This section refers to the observing component of the Global Atmosphere Watch Programme and other information on the chemical composition and related physical characteristics of the atmosphere that are produced in all parts of the globe. These data support multiple applications and are needed in order to reduce environmental risks to society, meet the requirements of environmental conventions, strengthen capabilities to predict climate, weather and air quality, and contribute to scientific assessments in support of environmental policy. [1]

4.1 Core observational data:

(a) All observational data of atmospheric composition variables as defined in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160), in particular in section 1.2.2. that refers to six focal areas: ozone, greenhouse gases, reactive gases, aerosols, ultraviolet (UV) radiation and total atmospheric deposition;

(b) All watches, warnings, advisories and alerts for public safety (protection of life and property) issued by Members' designated warning and alerting authorities according to WMO Technical Regulations.

4.2 Recommended data:

(a) All data listed under section 4.1 above for which the data originator is bound to policies that require data licences;

(b) Ancillary observational and modelling data of radionuclides and solar radiation as they serve as tracers for atmospheric transport and/or ocean-land-bio atmosphere exchange or influence chemical reactions in the atmosphere.

5. Cryosphere

This section references those cryosphere monitoring data on snow, freshwater and sea ice, glaciers and ice caps, permafrost and seasonally frozen ground, ice sheets, ice shelves and icebergs that are necessary for specified applications.

5.1 Core observational data:

All relevant observations (in situ, and surface, airborne and satellite-based remote sensing) of the cryosphere or processes affecting the cryosphere which are specified in:

(a) The *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160);

(b) The *Manual on Marine Meteorological Services* (WMO-No. 558);

(c) The *Technical Regulations, Volume III, Hydrology* (WMO-No. 49);

(d) The *Manual on the High-quality Global Data Management Framework for Climate* (WMO-No. 1238).

5.2 Other core data:

(a) All relevant cryospheric analysis, prediction, and climate reanalysis fields provided by global NWP systems and other Global or Regional Processing Centres operating

[1] Including obligations specified in the *Paris Agreement to the United Framework Convention on Climate Change* (2015) and *The Vienna Convention for the Protection of the Ozone Layer* (1985).

under the auspices of the GDPFS, as defined in the *Manual on the Global Data-processing and* Forecasting *System* (WMO-No. 485);

(b) All watches, warnings, advisories and alerts for public safety (protection of life and property) issued by Members' designated warning and alerting authorities according to WMO Technical Regulations.

5.3 Recommended data:

Other relevant cryosphere data not listed under 5.1 and 5.2.

6. Ocean

This section lists in situ and remotely sensed observational data both in and above the ocean and at the sea surface, from the open ocean to the coast, along with other data that provide necessary input to ocean monitoring and prediction and for a variety of other Earth system applications.

6.1. Core observational data:

(a) Marine meteorological and oceanographic observations, as defined in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160);

(b) All other physical Global Ocean Observing System (GOOS)[2] Essential Ocean Variables (EOVs) and physical ocean domain GCOS ECVs, some of which are included in section 2, Climate, above made as part of a GOOS observational network, programme or project, consistent with the Intergovernmental Oceanographic Commission (*IOC) Oceanographic Data Exchange Policy* (IOC Resolution XXII-6)

6.2 Other core data:

(a) Ocean analysis and prediction fields provided by global NWP systems operating under the auspices of the GDPFS, as defined in the *Manual on the Global Data-processing and* Forecasting *System* (WMO-No. 485);

(b) All ocean reanalysis fields provided by the Global Processing Centres of the GDPFS;

(c) All watches, warnings, advisories and alerts for public safety (protection of life and property) issued by Members' designated warning and alerting authorities according to WMO Technical Regulations.

6.3 Recommended data:

(a) Physical GCOS ECV and GOOS EOV observations that have been collected outside of designated GOOS activities;

(b) All other observed biogeochemical and biological/ecosystems GCOS ECVs and GOOS EOVs;

(c) Observations of pH, chlorophyll-A, suspended particles and downwelling irradiance which are fundamental to address significant scientific and societal ocean/climate-related issues.

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[2] GOOS is co-sponsored by the Intergovernmental Oceanographic Commission of UNESCO, the World Meteorological Organization, the United Nations Environment Programme and the International Science Council. It is aligned with a Framework for Ocean Observing oriented to an Essential Ocean Variable approach as per *Strengthening and Streamlining GOOS* (IOC Resolution XXVI-8).

7. Space weather

This section references space weather data necessary (core) for provision of the essential operational space weather services. It should be noted that space weather is currently going through the process of being fully integrated into the WMO Integrated Global Observing System (WIGOS) and being specified in the related WMO documents in more detail. Currently global and regional space weather services, requiring near-real time exchange of space weather surface-based and space-based observations, are operated on bilateral and multilateral data exchange agreements between centres. However, as the operational space weather services promptly evolve and are further established, the need for globally coordinated exchange of space weather data will increase significantly in the years to come. Three broad categories of data that need to be considered for such exchange are:

7.1 Surface-based:

All observations required by operational Space Weather Centres providing essential operational services, e.g. International Space Environment Service (ISES) Regional Warning Centres, as detailed in GBON, which will be further specified in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160), as well as data presented in the *WMO Statement of Guidance for Space Weather;*

7.2 Space-based:

All satellite data required for the performance and quality of essential operational space weather services as agreed with Members operating satellites or relevant satellite operators and reflected in the CGMS Baseline, subsequently adopted into the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160), as well as data presented in the *WMO Statement of Guidance for Space Weather*.

7.3 Other data:

(a) Analysis and prediction fields provided by national operational space weather services;

(b) Advisories and warnings for public safety (protection of life and property) provided by national operational space weather services.

Annex 2 to Resolution 1 (Cg-Ext(2021))

Guidelines to Members on the application of the WMO Data Policy

1. Purpose

1.1 The purpose of these guidelines is to help Members, especially through the engagement of their National Meteorological and Hydrological Services (NMHSs) with other national partners, to maximize the benefit obtained by their combined users from the free and unrestricted exchange of Earth system data, as articulated in the WMO Data Policy. While the primary remit of WMO is international collaboration on meteorological and related Earth system data, the national roles of many NMHSs are currently undergoing substantial changes, and many WMO Members have requested guidance on how their NMHSs and national partners

should act with respect to their data within a larger national landscape of Earth system monitoring and prediction.

1.2 This annex draws from the *Guide to the WMO Integrated Global Observing System*, (WMO-No. 1165) Chapter 7, where many aspects of national collaboration on observational data in particular are discussed in more detail. Some of the key points are captured here for ease of reference, and where appropriate expanded to also include other types of Earth system data. (See Annex 4 to the present resolution for the definition of Earth system data.)

2. Current context

2.1 Historically, WMO policy documents and regulatory material have not consistently distinguished between WMO Members, which per the WMO Convention are States and Territories, and their NMHSs. In the early years of WMO's existence, such a distinction would have been unnecessary, since in most countries the NMHS would be not only the sole national provider of both meteorological data and services, but therefore also the primary national user of meteorological data.

2.2 Today, the issue of the national role and responsibilities of the NMHS has become much more complex within many WMO Members. A typical NMHS is now not only responsible for observing and predicting the weather, but also for a growing number of other, closely related services and application areas. At the same time, the NMHS is also often no longer alone within its national territory in undertaking weather observation and prediction activities, and the same may be true for many of its other activity areas.

2.3 It is in the interest of NMHSs to partner with these other operators, which may include different Government agencies operating under various ministries, private companies, non-profit organizations, academia, or even private citizens, in order to be able to base their services on the most comprehensive observational data set possible. This requires technical issues related to data quality, data formats, communication lines and data repositories to be resolved and agreements regarding data policy to be concluded. It is also clearly in the interest of potential collaboration partners to gain free and unrestricted access to Earth system monitoring and prediction data generated by the NMHSs, and in the interest of the Member to minimize duplication and maximize efficiency in the operation of national infrastructure.

2.4 The potential of using national data partnerships as leverage to improve efficiency and effectiveness is well recognized in the context of WIGOS. For example, the *Vision for the WMO Integrated Global Observing System in 2040* (WMO-No. 1243) strongly promotes the integration of Members' observations, whether they come from the NMHS or partner institutions.

3. Guiding principles and recommendations for national collaboration on Earth system data

3.1 The drive for increased national collaboration on Earth system data is similar in nature to the drive for international exchange of data, and it can be articulated simply as follows: *"Data sharing creates mutual benefits for all stakeholders".*

3.2 Over the last two or three decades, Earth system data have become uniformly recognized as potentially being very valuable economically. More recently, various national and international economic analyses have demonstrated that the highest economic impact of Earth system data is obtained with free and unrestricted data policies, with the benefits of sharing all available Earth system data found to far outweigh the costs. These costs are represented by the loss of prospective revenue from selling the data to users willing and able to pay for them.

3.3 The sustainability of the basic infrastructure for data collection, processing and dissemination should be considered the responsibility of the Member as a whole, and not just of its NMHS; and compliance of all national entities with the data policy established via this

resolution should be seen as essential for maximizing the socioeconomic benefits of Earth system data.

3.4 The recommendation to Members is therefore to adopt the following national practice regarding the exchange of Earth system data (see also Annex 3 to the present resolution, regarding Public-Private Sector engagement):

(a) NMHSs should strive to act as integrators for Earth system data at the national level, both by strengthening their own observing systems according to the guidance provided by the WIGOS framework, and by building national partnerships and providing national leaderships based on their experience in the acquisition, processing, and dissemination of observational data for environmental monitoring and prediction purposes;

(b) Data practices should be aligned with the WMO Data Policy to ensure that users from all sectors — public, private and academic — are granted free and unrestricted access, without charge and with no conditions on use, at a minimum to the core data as described in Annex 1 to the present resolution acquired by the NMHS;

(c) The technological solutions for access to the internationally exchanged core data should be fully compliant with the free and unrestricted principle to facilitate access and minimize any charges for the data retrieval and delivery;

(d) The provision of observational data by entities outside the NMHS should be welcomed and facilitated, i.e. by opening access to WMO systems such as the WMO Information System (WIS) and WIGOS and their technical tools as broadly as possible;

(e) Members are encouraged to broaden the provision of their data with a minimum of conditions beyond the minimum set of data listed in Annex 1 to the present resolution.

3.5 In cases where Members choose to apply conditions on the exchange of recommended data, they may wish to consider using forms of license that may be indicated in WMO guidance materials.

4. Guiding principles and recommendations for national collaboration with the research sector

4.1 Research data is collected by universities, research institutes and many others, in some cases over a limited time period. These data cover multiple domains of the Earth system (atmosphere, ocean, cryosphere, hydrology, environmental science, space science, etc.). The diversity of this data reflects the wide range of Earth science disciplines, research interests and research methods.

4.2 Open data policies are well recognized to facilitate science and maximize the value of data, efficiency, and expanded capabilities as well as equity[1]. Most data providers from the research community are of a non-commercial nature, and they generally cannot and will not charge a fee for access to the data. However, they may request attribution of the source of the data, not only when used as a basis for scientific publications, but also if they are integrated into operational products and services.

[1] The FAIR Data Principles (Findable, Accessible, Interoperable, Reusable) FAIR Principles – GO FAIR (go-fair.org) are recognised as a useful framework for sharing research data in a way that will enable maximum use and re-use.

4.3 Given the importance of research as a key enabler of successful weather prediction, and its continued contribution to all WMO application areas, collaboration on data with the research sector is particularly important for WMO, the NMHSs and other related national agencies of the Members of the organization. Regarding the use of Earth system data, there are two main aspects of this collaboration, namely (a) provision of research data for operational use, and (b) access to NMHS-acquired and other Government data for the research sector.

(a) *Provision of research data for operational use.* The WMO community has a long history of using research data as an essential part of the input used to evolve and underpin operational services. For instance, in operational weather prediction, many critical satellite data are provided by research or technology demonstration missions that were not originally designed or deployed for operational purposes. Likewise, within certain domains and for certain application areas, most notably oceanography, cryosphere services and applications related to atmospheric composition, the vast majority of the observational data are provided by research entities;

(b) *Access to NMHS and other Government data for the research sector.* It is necessary to improve data exchange between the operational WMO community and the research community. Research projects are often dependent on external environmental data and services (including weather forecasts), so there is an inherent co-dependency. Harmonizing data formats and data sharing protocols will facilitate much-needed data interoperability, interpretation, and advances in high-quality science. The breadth and scope of the scientific challenge facing the development of an integrated Earth system monitoring and prediction approach is such that even the most well-resourced NMHSs of the most affluent WMO Members cannot take on this effort alone. It is therefore in the interest of all WMO Members to enlist as broadly as possible the scientific community to help in this endeavour. Providing free and unrestricted access wherever possible to all NMHSs' data and, where possible, to the data from national partner organizations dealing with Earth system data should be considered a key incentive for such cooperation.

4.4 This policy therefore calls upon NMHSs and other relevant Government data providers to adopt the following practices in their engagement with the research sector:

(a) Provide free and unrestricted access, without charge and with no conditions on use, to all core observational data (as described in Annex 1 to the present resolution) acquired by or owned by them for all publicly funded research;

(b) Provide access without charge, to all recommended observational data (as described in Annex 1 to the present resolution) acquired by or owned by them for all publicly funded research and education communities for use in their non-commercial activities;

(c) Provide, for all publicly funded research, access without charge to all relevant analysis and prediction data and other products for use in their non-commercial activities;

(d) Honour requests for attribution of data used for operational purposes that are provided by research entities.

Annex 3 to Resolution 1 (Cg-Ext(2021))

Guidelines on the application of the data policy in public-private engagement

1. Purpose

1.1 The purpose of these guidelines is to promote the implementation of the policy of broadening and enhancing the free and unrestricted[1] international exchange of Earth system data through better sharing of data between the public and private sectors. The guidelines are based on the understanding that the application of the free and unrestricted principle depends greatly upon sound, fair, transparent and stable relations between these two sectors.

1.2 Most of the interactions between the public and private sector, including sharing of or access to data and information, happen at the national level. However, private companies operating at an international level interact with the NMHSs and other public entities of different countries. NMHSs and international organizations, such as the European Centre for Medium-Range Weather Forecasts (ECMWF) and EUMETSAT, also act as international data users and providers. Any public-private interaction related to data exchange and sharing must respect *the sovereign right of Members in deciding how weather, climate and water services are organized and provided, specifically the application of national and regional legislation and policies for making data and products available on a free and unrestricted principle, as well as the assignment of key national responsibilities related to public safety (Geneva Declaration-2019 (Resolution 80 (Cg-18)).*

2. General guidelines stemming from the WMO high-level policy on Public-Private Engagement

2.1 *The Geneva Declaration – 2019* (Resolution 80 (Cg-18)*: Building Community for Weather, Climate and Water Actions,* presents the WMO high-level policy on public-private engagement (PPE). It reflects the new paradigm of cooperation and partnership between stakeholders from all sectors of the weather, climate and water enterprise needed for a concerted response to global societal risks related to extreme weather, climate change, water scarcity and other environmental hazards. The Declaration covers inter alia several aspects of the data sharing and exchange between the public and private sectors. The high-level PPE policy supplements the data policy in the current Resolution with the following general guidelines to Members and stakeholders from all sectors:

(a) The expansion and broadening of the free and unrestricted international data sharing should be promoted at all levels with due consideration of national circumstances, and with intellectual property rights duly respected;

(b) All stakeholders should foster and apply fair and transparent data sharing arrangements and adhere to quality and service standards, in order to advance collectively the delivery of the public good;

(c) To establish and maintain a level playing field, all stakeholders should ensure that access to commercial data with use restrictions is treated equally by and between public and private sector entities; [2]

(d) All stakeholders should commit to comply with relevant national and international legislation and policies with respect to both data provision and avoidance of anti-competitive behaviour;

(e) Recognizing their mutual interdependence, all stakeholders should seek opportunities to enhance the sustainability of the global infrastructure through multisector engagements that improve efficiency and better serve society;

[1] The term "free and unrestricted" is defined in Annex 4 to the present resolution.

[2] For more information, see Zillman, John, *Origin, Impact and Aftermath of WMO Resolution 40* (WMO-No. 1244).

(f) Development of innovative data exchange mechanisms and incentives should be encouraged to increase data availability, resolve existing data gaps, promote greater data sharing, and avoid fragmentation.

3. Guiding principles for data exchange between public and private sectors

3.1 Provision and exchange of core data

The draft resolution reinstates the policy of 'free and unrestricted' international exchange of core data (see Annex 1 to the present resolution for the detailed description of core data). Furthermore, the new definition of 'free and unrestricted' makes it clear that these data shall be freely available, with no conditions on use. In applying this policy for the exchange of core data:

(a) Members should ensure that users from all sectors — public, private and academic — are granted free and unrestricted access, without charge and with no conditions on use, to the declared core data;

(b) As articulated in the Geneva Declaration – 2019 (Resolution 80 (Cg-18)), engagement between public and private sectors should be conducted in transparent way and should be aimed at enhancing mutual benefits to both public and private sectors for the benefit of society*;*

(c) Members should ensure that, in case of core data purchased from private sector data providers, such data sets are appropriately licensed for free and unrestricted international exchange;

(d) The technological solutions for access to the internationally exchanged core data should be fully compliant with the 'free and unrestricted' principle[3];

(e) Permanent Representatives of Members, who are responsible for authorizing users of WIS (see the *Manual on the WMO Information System* (WMO-No. 1060)), should authorize access to core data with no obstructions;

(f) Recognizing that the development of Numerical Earth system Weather-to-climate Prediction (NEWP)[4] systems and the improvement of the quality of products and services depends on the availability of more Earth system data; Members are encouraged to broaden the provision of their data under the free and unrestricted principle. Moreover, the unrestricted and free access to all public data adopted by many Members and international organizations, extends significantly the availability of free and unrestricted high-quality data to all other Members.

3.2 Provision and exchange of recommended data

While Members are encouraged to apply the principle of free and unrestricted international exchange to the recommended data they provide, such data sets may have conditions on their use, e.g. for commercial purposes. The originators of such conditions should follow the following general principles:

(a) Fair and transparent setting of the conditions on use;[5]

(b) Level playing field — same rules to apply to public and private entities using the data sets for commercial purposes;[6]

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[3] At the time of adoption of the draft resolution, the main access to core data provided by Members is through the WMO Information System (WIS); other access options may also be available (ftp servers or similar).

[4] 'NEWP' is an extension to the 'NWP' acronym reflecting the new approach to the numerical modelling and prediction, as recommended by the WMO Scientific Advisory Panel.

[5] More detail available in *Guidelines for Public-Private Engagement* (WMO-No. 1258).

[6] More detail available in *Guidelines for Public-Private Engagement* (WMO-No. 1258).

(c) Avoidance of anti-competitive behaviour (e.g. blocking access to public data with a view of creating competitive advantage for the commercial activities of the public sector entities or their spin-offs) should be regarded as a non-compliance with the high-level policy (Geneva Declaration);

(d) Members should make available a catalogue of recommended data to facilitate their use under the established conditions of use. The experience of Economic Interest Grouping of the National Meteorological Services of the European Economic Area (ECOMET) in Europe presents a good practice for such cataloguing as well as for harmonization of the conditions of use imposed by different countries in the same geographic region;

(e) In exchanging data with conditions on use, the conditions which have been posed by the originator of the data should be made known to initial and subsequent recipients.

3.3 Regional (e.g. the European Union) or national open data policies for access to public data requires public agencies, including NMHSs, to provide free and unrestricted access to all their data; in addition, there may be a requirement for facilitation of the free access, with the possibility to recover the marginal costs incurred for the reproduction, provision and dissemination. Such data policy acts in favour of the private sector and stimulates business opportunities. Thus, private sector stakeholders should consider reciprocal approaches to data sharing, where economically justified, in particular for data needed for critical services related to saving lives and the protection of property. This comes with the understanding that all sectors of the enterprise commit to their social responsibility and contribute to delivery of the public good.

4. Access to private sector data

4.1 The rapid growth of the data produced by the private sector has been recognized in many WMO documents (see for example, *Geneva Declaration – 2019* (Resolution 80 (Cg-18)), *Guidance for Public-Private Engagement* (WMO-No. 1258), *WMO Strategic Plan 2020–2023* (WMO-No. 1225), *WMO Guidelines on Emerging Data Issues* (WMO-No. 1239), *Vision for the WMO Integrated Global Observing System in 2040* (WMO-No. 1243)). The main difference of these data from a policy and business model perspective is that they are produced through private investments and thus they have a specific private sector owner. The private sector needs to generate a return on investment; thus the business model is clearly 'for-profit'; nevertheless, the general provisions of the *Geneva Declaration – 2019* (Resolution 80 (Cg-18)), which have been developed in close consultation with the private sector, encourage data sharing with stakeholders from other sectors under mutually beneficial, fair and transparent arrangements.

4.2 The WIS and WIGOS concepts both acknowledge and enable the uptake of private sector data into the WMO systems at national and international levels, and such approach is expected to bring efficiency, innovation and support sustainability. The demand for accurate and reliable user-specific services and for a new generation of weather and climate intelligence products (e.g. for urban areas and megacities) will inevitably require more integration of private sector data into the data assimilation for the high resolution NEWP.

4.3 Members are strongly encouraged to facilitate a dialogue between the public sector and private companies active in the country, and to consider the use of private sector data to fill the gaps and optimize the national integrated observing networks. In doing this, the following considerations are recommended:

(a) Applying a common approach to quality control and maintenance;

(b) Applying the same standard and recommended practices and procedures, e.g. those established by WMO or other relevant organizations, to ensure interoperability;

(c) Building collective capacity and innovation approaches;[7]

(d) Applying adequate regulatory frameworks, including licensing and certification mechanisms, enabling such collaboration with respective independent oversight.

4.4 *Exchange of data purchased by public sector from the private sector*

With the growing activities of the private sector in providing observational data, or in global NWP, in some countries global or regional data sets will be purchased by public sector entities, such as NMHSs, from private companies. The conditions for the redistribution of such data sets to other Members may vary depending on license agreements. Members are encouraged to consult with other Members on the need and added value of the purchased private data sets for their operations, in particular with those Members operating global or regional NWP. Purchasing of commercial data sets with a license for international redistribution (as core or recommended data) and possible adequate cost sharing models with other Members may be considered by Members, based on economic analysis, and bearing in mind the benefits for all parties, as well as the commitment, via the "shall" language in the draft resolution, to exchange all declared core data on a free and unrestricted basis.

5. General guidelines on the use and exchange of non-NMHS data and non-conventional data

5.1 Non-NMHS data include a growing volume of conventional third-party data, new sensor data or non-conventional data from 'Internet of Things' (often produced as by-products of smart systems not intended for meteorological or related purposes). NMHSs are encouraged to study in detail the national data landscape and strive to lead the integration of such data based on the WIGOS principles. Many of the new data come from the private sector and offer opportunities for innovative services. At the same time, NMHSs' main responsibility remains in maintaining the reference data set of proven quality, compliant with the WMO requirements for quality and traceability. In most countries these are the data forming the long-term data series needed for climate change studies and assessments.

5.2 When organizing such data exchange at the national level, the national regulator (if specifically designated, otherwise by default the NMHS) needs to establish procedures for common quality control across the sectors and disciplines, to ensure compliance with international requirements set by WMO and other relevant organizations. In addition, when operationalizing such data in the provision of requisite services (e.g. those for disaster risk reduction), the continuity of data provision must be considered to avoid disruptions.

5.3 The WMO Data Policy does not address specifically the international exchange of non-conventional data. Nevertheless, their importance for the services provided across WMO business areas are recognized to grow in the coming years. Thus, WMO has provided general *WMO Guidelines on Emerging Data Issues* (WMO-No. 1239). As an integral aspect of implementing the draft resolution, the WMO INFCOM will monitor these issues and will consider the need for further guidance or amendments to practice as needed.

Annex 4 to Resolution 1 (Cg-Ext(2021))

Terms and definitions

[7] For more information, see the *WMO Guidelines on Emerging Data Issues* (WMO-No. 1239).

Word or Phrase	Definition
Data	Data refers to Observations, Analyses and Predictions, and Derived Products as defined below. In the context of this resolution, the term 'data' is taken to be inclusive of such terms as data sets, information and products.
Observations	Observations refer to direct or indirect measurements made by any surface-based or space-based instrument of any physical or chemical quantity of the Earth system, as defined below. These may be direct or indirect measurements, and the term may include quantities inferred by a human observer. The term may also be taken to include statistical or derived quantities such as temporal or spatial averages, accumulated values, and temporal maximum or minimum values.
Analyses and Predictions	Analyses and Predictions refer to data sets produced by quantitative algorithms, such as numerical or statistical prediction models, applied to observations, describing the past, present and future states of the Earth system as defined below. Such data sets include, but are not limited to, global and limited area Numerical Weather Prediction and climate reanalysis fields encompassed within the scope of the GDPFS.
Derived Products	Derived Products refer to data generated from one or more of the basic data types listed above (Observations, Analyses and Predictions), typically through application of a quantitative algorithm. In the context of this resolution, the term is understood to include certain watches, warnings, advisories and alerts regarding adverse weather, hydrological or other environmental phenomena exchanged among WMO Members.
Earth system, Earth system data	Earth system refers to the various interacting components, or "spheres", of the overall geosphere and (often also to) the physical, chemical, biological and human-related processes through which these spheres interact. In the context of this resolution, the primary emphasis is on the Earth's land surface, cryosphere, hydrosphere, atmosphere and exosphere and the physical and chemical processes taking place within these spheres and those through which they interact. Earth system data is thus to be understood as data (defined above) describing past, current or future states of the Earth's land surface, cryosphere, hydrosphere, atmosphere and exosphere.
Data exchange	Data exchange means making data accessible and available for national and international users at the required timeliness and via agreed channels or on agreed platforms; this includes ensuring interoperability of the data, e.g. via the use of common agreed formats, provision of necessary decoding software, provision of all necessary metadata, etc. as specified in the relevant parts of the WMO Technical Regulations.
Free and unrestricted	Free and unrestricted means available for use, re-use and sharing without charge and with no conditions on use.

Without charge	Without charge, in the context of this resolution, means at no more than the cost of reproduction and delivery, without charge for the data and products themselves.
Conditions on use	In the context of this resolution, conditions on use may be applied only to recommended data; such conditions may be applied using licenses. Note that attribution is not considered a condition on data use and is strongly encouraged in all cases.

Resolution 2 (Cg-Ext(2021))

Amendments to the Technical Regulations related to the establishment of the Global Basic Observing Network

THE WORLD METEOROLOGICAL CONGRESS,

Recalling

(1) Articles 2 (a), 2 (c) and 8 (d) of the Convention of the World Meteorological Organization,

(2) Resolution 34 (Cg-18) – Global Basic Observing Network,

(3) Resolution 37 (Cg-18) – The WMO Integrated Global Observing System transition to operational status commencing in 2020,

Noting:

(1) Resolution 9 (EC-73) – Plan for the WMO Integrated Global Observing System Initial Operational Phase (2020–2023),

(2) Resolution 1 (Cg-Ext(2021)) – WMO Unified Policy for the International Exchange of Earth System Data,

(3) Resolution 3 (Cg-Ext(2021)) – Systematic Observations Financing Facility: Supporting Members in the Implementation of the Global Basic Observing Network,

Noting further that the draft amendments to the Technical Regulations related to establishment of the Global Basic Observing Network (GBON) were circulated to all Members and that the Members' comments were incorporated in accordance with Recommendation 4 (EC-73) – Update of regulatory material related to the establishment of the Global Basic Observing Network,

Having examined Recommendation 4 (EC-73),

Having considered the draft GBON provisions provided in the annex to the present resolution,

Approves the amendments to the Technical Regulations related to establishment of GBON, as provided in the annex to the present resolution, with the implementation taking effect from 1 January 2023, considering that the GBON implementation plan takes into account the individual capabilities of Members;

Authorizes the Secretary-General to make any subsequent purely editorial amendments to the annex to the present resolution;

Urges Members to immediately commence their implementation of this network, including the necessary preparations for GBON station designation and GBON data exchange, if needed in a phased approach, as allowed by their individual capacities, where applicable, in combination with the support of multilateral and bilateral development partners and financial mechanisms such as the Systematic Observations Financing Facility (SOFF);

Further urges Members to support the implementation of GBON, including by supporting the development and establishment of SOFF, and to consider contributing resources – financial, technical or in-kind – to its development and operation;

Requests the Commission for Observation, Infrastructure and Information Systems (INFCOM):

(1) To develop the technical guidelines, processes and procedures needed to ensure the expedient and efficient implementation of GBON, and to prepare for the effective performance and compliance monitoring of GBON;

(2) To promote the development and adoption of cost-effective and environmentally friendly strategies and technologies to support the implementation and sustainability of GBON, especially in developing countries, particularly for surface-based upper-air observations and automatic weather stations;

(3) In collaboration with the Commission for Weather, Climate, Water and Environmental Services and Applications (SERCOM) and the Research Board, to provide to Members relevant technical and scientific documentation and communication material demonstrating the specific benefits to Members that the different components of GBON are expected to deliver;

(4) To continue exploring potential paths for the future evolution of GBON into broader Earth system domains and disciplines beyond its current scope of support for global NWP and climate analysis;

(5) To explore, in collaboration with the Joint WMO- Intergovernmental Oceanographic Commission (IOC) Collaborative Board, possible initiatives to strengthen the exchange of surface-based Earth system observations over the global ocean, for example via an extension of GBON into this domain*;*

(6) In collaboration with the Research Board, to actively pursue an optimization of the GBON design, considering impact-based metrics, the unique characteristics of individual Members, new scientific advances and new operational technologies, with the aim of presenting proposed amendments to the Technical Regulations to the World Meteorological Congress at its nineteenth session (Cg-19) in 2023*;*

Requests the Secretary-General:

(1) To publish the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160), with the section 3.2.2 Global Basic Observing Network in all WMO official languages;

(2) To ensure the editorial consistency of the relevant documents;

(3) To bring the present resolution to the attention of all concerned;

Further requests the Secretary-General:

(1) In partnership with multilateral and bilateral development partners, to facilitate the resource mobilization Members require for the development and operation of GBON;

(2) In partnership with the members of the Alliance for Hydromet Development and other partners, to consider the possibility of extending the support of SOFF to developing Members not deemed eligible for support in the initial phase in order to ensure the global implementation and sustained operations of GBON;

(3) In partnership with the Intergovernmental Oceanographic Commission (IOC) and the Global Ocean Observing System (GOOS) co-sponsors, to explore the possibility of leveraging international collaboration on marine observations in the implementation and further development of GBON.

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Note: This resolution replaces Resolution 34 (Cg-18), which is no longer in force.

Annex to Resolution 2 (Cg-Ext(2021))

Amendments to the Technical Regulations related to the establishment of the Global Basic Observing Network

3. ATTRIBUTES SPECIFIC TO THE SURFACE-BASED SUBSYSTEM OF WIGOS

3.2.2 Global Basic Observing Network

~~Note: This section will be developed on the basis of Resolution 34 (Cg-18) – Global Basic Observing Network.~~

3.2.2.1 The Global Basic Observing Network (GBON) shall be a subset of the surface-based subsystem of WIGOS, used in combination with the space-based subsystem and other surface-based observing systems of WIGOS, to contribute to meeting the requirements of Global NWP, including reanalysis in support of climate monitoring.

3.2.2.2 Members shall establish and manage the GBON.

Notes:

1. Global NWP provides an essential backbone for all products and services provided by all WMO Members. The geographically relevant component of the GBON provides an essential base component within each Regional Basic Observing Network (see 3.2.3 below).

2. GBON is based on a global design and the implementation is monitored globally.

3. GBON is designed to respond primarily to those Global NWP requirements that are currently not met, or not fully met, by space-based systems.

4. The specification for GBON is laid out in provisions 3.2.2.7 – 3.2.2.20. These are derived from the observational requirements for Global NWP that are recorded in the OSCAR/Requirements database together with an analysis of the operational technologies for collecting such observations and availability of observations from other sources. The technical assessment is conducted for the World Meteorological Congress by the Commission for Observation, Infrastructure and Information Systems (INFCOM).

5. The list of GBON stations/platforms is drawn from the list of all available stations/platforms in WIGOS as registered in OSCAR/Surface by the Members. The identification of the subset to be proposed by Members for

GBON designation is based on the specification of GBON listed below. The list of GBON stations/platforms is elaborated in collaboration between the Members and INFCOM.

3.2.2.3 Members shall maintain the continuous operation of those stations/ platforms that are designated as contributors to GBON.

Note: The designation process is defined in 3.2.2.22–3.2.2.23 below and further detailed in the *Guide to the WMO Integrated Global Observing System* (WMO-No. 1165).

3.2.2.4 Members shall strive to design, install, manage, and operate stations within their networks in an environmentally sustainable fashion.

3.2.2.5 Members shall make available internationally through WIS all GBON observations in real time or near-real time according to the overall WMO data policy.

3.2.2.6 If a Member finds that the horizontal and/or temporal resolution required according to one or more of provisions 3.2.2.7 – 3.2.2.18 is not practically achievable for the observing network within parts of their territory, ~~, e.g. in uninhabited and remote areas,~~ the Member shall inform the Secretary-General of the reasons as per Article 9(b) of the WMO Convention, and paragraph 6 of "GENERAL PROVISIONS".

3.2.2.7 Members shall maintain the continuous operation of a set of surface land observing stations/platforms that observe, at a minimum, atmospheric pressure, air temperature, humidity, horizontal wind, precipitation and snow depth, where applicable, located such that the GBON has a horizontal resolution of 200 kilometres or higher for all of these variables, with an hourly frequency.

Notes:

1. The precipitation observation means an hourly accumulation.

2. The snow depth measurement is reported ~~at a minimum at the main standard times, i.e. 0000, 0600, 1200, 1800 UTC~~in accordance with the provisions 5.1.7 and 5.1.8 of this Manual.

3~~2~~. The *Guide to Instruments and Methods of Observation* (WMO-No. 8), Volume II provides details on measurement of snow.

4~~3~~. A horizontal resolution of 200 km or higher means that stations/platforms~~-~~ are spaced not more than 200 km apart on average.

5~~4~~. Many manual stations/platforms observe less frequently than hourly; these nevertheless provide a valuable contribution to the GBON.

6~~5~~. The provisions do not imply that every station/platform must measure all the variables listed, but that the network as a whole delivers observations at the required horizontal resolution for all the variables.

3.2.2.8 Members should operate surface land observing networks/platforms at horizontal resolutions of 100 km or higher.

3.2.2.9 Where Members operate networks as described in 3.2.2.7 and 3.2.2.8, Members shall make the observations of these networks available internationally according to 3.2.2.5.

3.2.2.10 Where applicable, Members shall maintain the continuous operation of a set of surface marine meteorological observing stations/platforms within their Exclusive Economic Zone~~, where applicable~~ or the corresponding marine areas of their jurisdictions, that observe, at a minimum, atmospheric pressure and sea surface temperature located such that where opportunity exists, GBON has a

horizontal resolution of 500 kilometres or higher, over the marine areas of their jurisdictions, for these variables, with an hourly frequency.

Note: For Small Island Developing States where the surface area of the Exclusive Economic Zone is significantly larger than the land surface area, the provision applies to the entirety of the area of observing responsibility.

3.2.2.11 Where applicable, Members should facilitate other Members ~~to make~~ sharing surface marine meteorological observations within their Exclusive Economic Zone~~, where applicable~~, or the corresponding marine areas of their jurisdictions, subject to the data being ~~shared~~made available internationally according to 3.2.2.5.

3.2.2.12 Members shall~~, as applicable~~ maintain the continuous operation of a set of upper-air stations/platforms over land that observe, at a minimum, temperature, humidity and horizontal wind, with a vertical resolution of 100 m or higher, twice a day or better, up to a level of 30 hPa or higher, located such that GBON has a horizontal resolution of 500 kilometres or higher for these observations.

Notes:

1. Radiosonde systems currently provide the primary means for collecting such observations.

2. A vertical resolution of 100 m or higher means that observations are spaced and reported not more than 100 m apart in the vertical on average.

3. Upper-air observations obtained over remote/isolated islands have a particularly high impact on Global NWP skill, and continued operation of these stations/platforms are of high priority for GBON.

3.2.2.13 Members should operate networks of upper-air stations/platforms providing horizontal resolutions of 200 km or higher.

3.2.2.14 Members should operate a subset of the selected GBON upper-air observing stations/platforms that observe temperature, humidity and horizontal wind up to 10 hPa or higher, at least once per day, located such that, where geographical constraints allow, GBON has a horizontal resolution of 1 000 kilometres or higher, for these observations.

3.2.2.15 Members shall operate~~, as applicable,~~ a set of upper-air stations/platforms that observe temperature, humidity and horizontal wind, with a vertical resolution of 100 m or higher, twice a day or better, up to 30 hPa or higher, located such that, where opportunity exists, GBON has a horizontal resolution of 1 000 kilometres or higher over the marine areas of their jurisdictions, for all these observations.

Note: For Small Island Developing States where the surface area of the Exclusive Economic Zone is significantly larger than the land surface area, this provision applies to the entirety of the area of observing responsibility.

3.2.2.16 Where networks described in 3.2.2.10 and 3.2.2.1~~3~~2 ~~–~~15 are operated, 3.2.2.5 shall apply.

3.2.2. 17 Members should make available aircraft meteorological observations of temperature, humidity (where available) and horizontal wind from aircraft ascents and descents, with 300 m or higher vertical resolution with ~~a temporal frequency of at least hourly~~an hourly frequency or higher.

Note: For aircraft meteorological observations received from any source, conditions on the use, re-use and sharing of such data may be applied by licensing agreements or other appropriate arrangements.

3.2.2.18 Members should make available aircraft meteorological observations of temperature, humidity (where available) and horizontal wind, with a horizontal resolution of 100 kilometres or higher, while at level flight.

Note: ~~For aircraft meteorological observations received from any source, conditions on the use, re-use and sharing of such data may be applied by licensing agreements or other appropriate arrangements.~~Note under 3.2.2.17 applies

3.2.2.19 Members should make available hourly remote sensing profiler observations of temperature (where available), humidity (where available) and horizontal wind with a vertical resolution of 100 m or higher.

3.2.2.20 Members operating observing networks/platforms at higher density than specified above under the provisions 3.2.2.7 – 3.2.2.19 should make available what is observed at least hourly.

Note: 15 kilometres is the current goal of global NWP requirements.

3.2.2.21 Members shall make available the metadata of their GBON observing stations/platforms in accordance with the provisions of section 2.5.

3.2.2.22 Each Member shall designate at a minimum the required number of surface stations and the required number of upper-air stations as per 3.2.2.7–3.2.2.10 and 3.2.2.12–3.2.2.~~16~~15 as their contribution to GBON.

Notes:

1. The INFCOM will undertake an initial GBON implementation analysis that will provide, for each Member, the number of surface stations and the number of upper-air stations that are required for the Member to meet their obligations under 3.2.2.7–3.2.2.10 and 3.2.2.12–3.2.2.~~16~~15.

2. For each Member, the INFCOM will review their designated contribution as per 3.2.2.21 and assess whether it meets the requirements specified in 3.2.2.7–3.2.2.10 and 3.2.2.12–3.2.2.~~16~~15, and will inform the Member in writing of its findings.

3. See Note 3 below 3.2.2.12.

3.2.2.23 Members shall register the stations in OSCAR/Surface and identify that these stations belong to the GBON.

3.2.2.24 Members shall routinely monitor GBON performance across the network to identify non-conformance with the designed performance.

Note: Guidance on data quality monitoring, evaluation and incident management is detailed in the *Guide to the WMO Integrated Global Observing System* (WMO-No. 1165), Chapter 8.

3.2.2.25 Members shall acknowledge, document and rectify any identified non-conformance at one of their stations/platforms within time frames agreed by the WMO Executive Council or the World Meteorological Congress.

Note: Details on relevant time frames and processes are provided in the *Guide to the WMO Integrated Global Observing System* (WMO-No. 1165).

3.2.2.26 Members shall formally notify the Secretary-General, at least three months in advance, of their plan to discontinue the operation of their stations/platforms.

Resolution 3 (Cg-Ext(2021))

Systematic Observations Financing Facility: Supporting Members in the implementation of the Global Basic Observing Network

THE WORLD METEOROLOGICAL CONGRESS,

Recalling

Resolution 34 (Cg-18) – Global Basic Observing Network,

Resolution 74 (Cg-18) – Closing the capacity gap: Scaling up effective partnerships for investments in sustainable and cost-efficient infrastructure and service delivery,

Decision 11 (EC-72) – Scaling up effective partnerships and scope, scale and progress of WMO development projects,

Noting

(1) Resolution 1 (Cg-Ext(2021)) – WMO Unified Policy for the International Exchange of Earth System Data,

(2) Resolution 2 (Cg-Ext(2021)) – Amendments to the Technical Regulations related to the establishment of the Global Basic Observing Network,

Acknowledging the efforts of Members that make valuable contributions in the development and maintenance of existent networks in different regions,

Having been informed of the development of the Systematic Observations Financing Facility (SOFF) (see Cg-Ext(2021) INF. 4.2) as the primary vehicle to provide the necessary financial and technical support for the implementation and sustained operation of the Global Basic Observing Network (GBON) in the least developed countries (LDCs) and small island developing States (SIDS) and of the limited technical advisory support it provides to other developing countries,

Considering the critical importance to all Members of the Earth system model output made freely available by WMO Global Producing Centres and the reciprocal benefit to all Members of improving the availability of global observations in support of those efforts,

Welcomes the commitment of the Alliance for Hydromet Development to seeking innovative ways to finance developing country surface-based observations, aiming at the creation of a SOFF that recognizes the economic value of observations as a global public good.

Takes note of:

(1) The outcomes of the potential funders' forums for the creation of SOFF held in March, June and September 2021;

(2) The statements from the Least Developed Countries Group, the Association of Small Island Developing States and the African Group of Negotiators urging the establishment of SOFF and encouraging bilateral and multilateral partners to contribute to the SOFF United Nations Multi-Donor Trust Fund;

(3) The support expressed by heads of States and heads of international and multilateral organizations for the creation of SOFF;

Welcomes the implementation of the Country Hydromet Diagnostics and notes its role in informing the SOFF readiness phase to provide initial guidance to SOFF implementing entities and other funders' investments across the meteorological value chain to promote links between GBON and last-mile investments;

Decides to endorse the establishment of SOFF, which will provide technical and financial support for the implementation and sustained operation of GBON in LDCs and SIDS and expert readiness technical advisories to other developing countries, including peer to peer support, to assess the national GBON gap and to develop a GBON National Contribution Plan to guide SOFF and other funders' investments, thereby responding to the requirements of GBON;

Requests the Secretary-General, in collaboration with the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP) and the United Nations Multi-Partner Trust Fund Office to pursue the creation of SOFF as a United Nations Multi-Partner Trust Fund as a matter of urgency;

Also requests the Secretary-General, and WMO Members, in collaboration with representatives of other partners, as appropriate, to mobilize the external or extrabudgetary financial resources required to allow SOFF to commence its operations and support to developing Members in 2022;

Further requests the Secretary-General, when SOFF is established, to ensure, through WMO's participation in SOFF as the technical authority, that SOFF contributes to the sound development of GBON, and to regularly report the detailed activities of SOFF, including outcomes and identified challenges to the Executive Council for its overall guidance on GBON implementation;

Urges Members who have the capacity:

(1) To financially contribute to the SOFF United Nations Multi-Partner Trust Fund;

(2) To provide expert readiness technical advisories, including peer to peer, to support the implementation of SOFF; or

(3) To provide any other form of support;

Urges Members who qualify as beneficiaries to take advantage of SOFF to achieve sustained compliance with GBON.

Resolution 4 (Cg-Ext(2021))

WMO Vision and Strategy for Hydrology and its associated Plan of Action

THE WORLD METEOROLOGICAL CONGRESS,

Recalling:

(1) Resolution 24 (Cg-18) – Vision, strategy and organizational arrangements for hydrology and water resources in WMO, which requested the Executive Council to develop, with the support of the Hydrological Coordination Panel (HCP), a Plan of Action for hydrology that will support Member states' efforts to fulfil the eight WMO long-term ambitions, for consideration by the World Meteorological Congress at an extraordinary session in 2021 (Cg-Ext(2021));

(2) Resolution 5 (EC-71) – Hydrological Coordination Panel, the terms of reference of which requested HCP to develop the Vision and Strategy for Hydrology and its associated Plan of Action, to be reviewed by EC-72 in 2020 and to be submitted for consideration to Cg-Ext(2021)

Having examined Recommendation 2 (EC-73) – WMO Vision and Strategy for Hydrology and its associated Plan of Action,

Having further examined the recommendations of the Hydrological Assembly contained in Cg-Ext(2021)/INF. 3.1(2),

Decides to adopt the WMO Vision and Strategy for Hydrology and its associated Plan of Action included in the annex to the present resolution;

Takes note that several elements of the Plan of Action are already in an advanced state of implementation, as detailed in Resolution 5 (Cg-Ext(2021)) – Advanced implementation of elements of the Plan of Action for Hydrology;

Invites Members to become acquainted with the content of the Plan of Action to determine how they can benefit from and contribute to its implementation;

Requests the presidents of the technical commissions and the Chair of the Research Board to review the proposed activities for alignment of the Plan of Action with the workplans of the technical commissions and the Research Board;

Requests the president of the Commission for Observation, Infrastructure and Information Systems (INFCOM) to prepare a concept note in consultation with HCP allowing the incorporation of hydrological and cryosphere data into the Global Basic Observing Network (GBON). This concept note could include considerations around data prioritization and potential funding considerations and should be presented to the Executive Council at its seventy-fifth session (EC-75) in 2022;

Requests the regional associations to promote hydrological activities contributing to the Plan of Action and to develop, with the assistance of HCP, regional action plans for hydrology as part of their regional operating plans to contribute to fulfilling the eight WMO long-term ambitions;

Requests the Secretary-General to widely disseminate the WMO Vision and Strategy for Hydrology and its associated Plan of Action to all Members, international partner organizations, and other relevant public, private and academic sector organizations;

Requests that the president of the Commission for Weather, Climate, Water and Related Environmental Services and Applications (SERCOM), the president of INFCOM, the Chair of the Research Board, the presidents of the regional associations and the Chair of HCP, based on the advice of the Regional Hydrological Advisers and with the support of the Secretariat, ensure that the outputs of the quarterly regional forums of Hydrological Advisers of relevance to their programmes, activities and initiatives are appropriately integrated into the workplans and priorities of the bodies they lead, as well as into the extrabudgetary projects supported by WMO;

Invites the United Nations, United Nations System organizations, other partner international organizations and relevant public, private and academic institutions to consolidate their actions in support of the implementation of the WMO Vision and Strategy for Hydrology and its associated Plan of Action, recognizing it as a fundamental and necessary building block in fulfilling the objectives of the Sustainable Development Agenda.

Annex to Resolution 4 (Cg-Ext(2021))

VISION AND STRATEGY FOR HYDROLOGY AND ASSOCIATED PLAN OF ACTION

About this document

The Eighteenth World Meteorological Congress (Cg-18) approved eight long-term ambitions to address the global water challenge and decided to develop a Vision and Strategy on Hydrology and Associated Plan of Action (Resolution 24 (Cg-18) - Vision, Strategy and Organizational Arrangements for Hydrology and Water Resources in WMO) to fulfil those ambitions. EC-71 requested the Hydrological Coordination Panel (HCP) to develop such a Strategy and Action Plan which Cg-18 called on Cg-Ext(2021) to approve.

HCP-1 prepared a draft Vision and Strategy and an annotated table of contents of the Plan of Action and submitted it for adoption to EC-72 in September 2020.

In September and October 2020, an open online consultation was held to identify Members' needs and gaps as inputs to the identification of activities needed to achieve the eight long-term ambitions for operational hydrology (Resolution 24 Cg-18).

HCP-2, held in November 2020, established drafting groups on identified action areas to propose detailed lists of activities to be included in the Plan of Action. In February 2021, HCP met virtually to review outputs from drafting groups. Based on additional comments from HCP members and invited experts, a first draft for consultations on priorities and risks was compiled.

The second online open consultation was held from 19 April to 31 May 2021 and comments received were incorporated to the text and tables of action.

The resulting final draft document is structured in two major parts, three annexes and an appendix.

Part I includes the definition of Vision and Strategy, which was based on the Preliminary Vision and Strategy for Hydrology developed by the High-level Task Force on Water in February 2019. It had been presented to EC-72 in September 2020. All comments received prior and during EC-72 were considered. Those that proposed changes in the parts already approved in other documents by Cg-18 and CHy-Ext. 2019 were rejected, all others were incorporated to the extent possible to the current version of the document (Part I).

Part II presents the Plan of Action as developed by drafting groups, reviewed by the HCP in February 2021 and including the comments received via the second online open consultation.

Annex I contains the detailed tables of activities contributing to the achievement of each ambition. A logical framework methodology was used to design a holistically consistent structure of goals, outcomes that lead to achievement of these goals, outputs that together will materialize into desirable outcomes, and finally activities through which outputs will be delivered.

Annex II contains a mapping of the Vision and Strategy on to the WMO Strategic Plan and of the Plan of Action on to the WMO Operating Plan.

Annex III includes background material intended to make this a self-contained document.

The appendix contains a list of acronyms used in the document and their meaning.

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PART I: VISION AND STRATEGY

1. VISION STATEMENT

By 2030 a cooperative global community is successfully addressing the growing challenges related to hydrological extremes, water availability and quality, and food security, by advancing operational hydrology through enhanced science, infrastructure, capacity-building and related services, in the context of sustainable development and enhanced resilience.

2. CONTEXT, CHALLENGES AND DRIVERS OF CHANGE (FACTORS)

2.1 Water is essential for life, environmental protection, sustainable development, and international peace and security. Stakeholders, policy and decision-makers at all levels of government and society require enhanced and actionable water information across all space and timescales (transboundary to national to local and minutes to years) to inform efforts to save lives and protect livelihoods, to enhance global economic prosperity and societal well-being. Specific high-level requirements include:

- Policy and decision-making that contribute to the achievement of the Sustainable Development Goals related to water;
- Real time management of flood and drought events and integrated flood and drought management in support to Multi-Hazard Early Warning Systems (MHEWS);
- Integrated water resources management in national and transboundary catchments;
- As regards civil engineering, for design and management of infrastructure;
- As regards agriculture, for decisions on agrotechnical practices, drainage and irrigation schemes and management;
- Ecosystem management;
- Academic support for climate and hydrological regime studies, trend analysis, decision support systems.

2.2 Stakeholders also require an efficient and sustainable coordination of the value chain[1] for the provision of operational hydrology, both across hydrological science, climatology, meteorology and related domains, but also across governments, other United Nations (UN) Organizations and other international bodies, as well as the private sector and the many non-governmental Organizations (NGOs) that work to implement water risk management and to link sustainable development with water management.

2.3 Perception of water-related risks due to their far-reaching impacts have evolved to include political, economic, social demographic, and technological, as well as environmental risks and drivers in their full complexity. Activities of WMO in operational hydrology will be focused on the development of new capabilities to deliver actionable information which informs and mitigates these water-related challenges.

[1] A value chain is a business model that describes the full range of activities needed to create a product or service. For hydrological services, a value chain comprises the steps that involve network design and maintenance, in situ observation of hydrological parameters, data transmission, quality control, sharing and archiving, design, testing and delivery of products and services for the users in the field of water management, disaster risk management, navigation, health, agriculture and others. The purpose of a value-chain analysis and coordination is to increase efficiency so that a hydrological service can deliver maximum value.

Political and Institutional

(a) Considerable fragmentation exists among many water sector players. This is true for institutions concerned with water governance, science, research, as well as operational service provision at the national level. This fragmentation is mirrored in a multifaceted community of regional and international entities including NGOs, research associations/programmes and UN Organizations, where the UN-Water coordination mechanism has been implemented to ensure coordination in response to water-related challenges;

(b) Recent criticism of some aspects of multilateralism show the need for increased alignment and support among Member States, international development banks, donor agencies. New specific initiatives are needed, requiring a clear business case analysis to quantify the value proposition of enhanced hydrologic services worldwide;

(c) A variety of international agendas addressing disaster risk reduction (DRR); development, climate change adaptation and regional cooperation and peace, such as the Sendai Framework for DRR, the Sustainable Development Goals, the United Nations Framework Convention on Climate Change (UNFCCC) process, and others depend, in various aspects, on hydrology, and require adequate support from the operational hydrology community, which needs to be also adequately recognized and supported;

(d) The availability of an increasingly diverse spectrum of 'non-authoritative' sources of information will create competition in the attention of economy for public agency data and has the capacity to undermine public trust and create confusion, preventing appropriate actions;

(e) The WMO reform, while engendering some risks associated with organizational change, affords the opportunity for increased participation and influence of hydrologists within and across the WMO structure, programmes and activities;

(f) Hydrology is transboundary and regional in nature. While NHSs need to build their own competency/capacity in the field of operational hydrology, Members are encouraged to share data and forecast capabilities across jurisdictional boundaries in partnership with River Basin Commissions and other organizations as appropriate.

Economic

(a) There are increasing and competing demands for limited water resources to support a spectrum of industrial, environmental, navigational, recreational, agricultural, and municipal uses. Population growth and economic development, particularly in flood and drought prone regions, are stressing water supplies and increasing vulnerability;

(b) The economic and societal impacts of flood and drought are increasing, as demonstrated by annual upward trends in flood and drought loss data, highlighting the need for increased investment in development and sustainability of early warning systems (including monitoring networks), disaster preparedness and integrated management for extreme water events, as well as other hydrologic services;

(c) Slowing economic growth and limited budgetary resources accentuate the need for innovation and creativity;

(d) A deteriorating global water infrastructure is forcing critical, expensive decisions;

(e) Slow-onset disasters provide a specific set of challenges, creating economic conditions that widen inequality and severely affecting the most vulnerable populations. At the same time, such disasters also create opportunities for early interventions and mitigation before the most serious impacts are realized;

(f) Technological development, globalization, and continuing implementation of an open data policy is opening the hydrometeorological services market to new players, increasing competition and menacing the single voice principle[2] on one hand, but enhancing the potential for public-private partnership on the other;

(g) There is an increased need for the quantification, understanding, and communication of uncertainty and risk on all timescales, to better support investments in community resiliency, mitigation, response and recovery.

Socio-cultural, demographic

(a) The gender imbalance in hydrology must be addressed from the perspectives of equality and poverty alleviation;

(b) An ageing workforce gives rise to the potential loss of experience and expertise, requiring an increased emphasis on engaging, recruiting and developing the next generation of hydrologists. As the new generation enters the discipline, opportunities to exploit new ideas and fresh approaches can be realized, particularly regarding the use of emerging technologies, including citizen science via social or other media;

(c) Demographic development, such as population growth, ageing of population, or urbanization in different parts of the world changes the potential impacts of hydrological hazards through increased exposure and changed vulnerabilities of society;

(d) There are likely to be changes in peoples' perception of information and modes of communication leading to new ways of providing actionable warnings and information to the general public;

(e) Hydrological services are particularly vulnerable to emergency situations affecting society, as the COVID-19 pandemic demonstrated.

Technological

(a) The emerging convergence of disciplines around the Earth system prediction will offer new frameworks and opportunities for the meteorological, hydrological/terrestrial, ocean, and cryospheric communities to strengthen their cooperation to deliver information, products and services responding to the need of a vast array of stakeholders. The development of a seamless Earth system modelling capability should enable a quantum leap forward in operational hydrological prediction;

(b) Satellite and ground-based remote sensing is becoming an operational tool for hydrology and water resources providing a variety of new products with increasing accuracy, resolution and coverage. NHSs will need increased access to and competency in the use of remote sensing as a part of the observation system of the future;

(c) There is a need for increased development and utilization of more physically based modelling approaches to address non-stationarity of the climate system and land-use changes;

[2] It is noted that some private sector involvement may carry risks of multiple voices and messages, some of which may include different motivations. NHSs may need support in formulating policies to deal with such issues.

(d) Enhancements of artificial intelligence might open doors for wider use of machine-learning approaches in modelling and forecasting;

(e) Advances in observations and modelling and the rapid expansion of data and information, also through crowd sourcing and citizen science initiatives, present both opportunities and challenges to leverage new data assimilation techniques, big data analytics, and advanced dissemination and communication capabilities;

(f) The deployment of new technologies creates opportunities for increased knowledge and understanding and the development of authentically new hydrologic services but presents immediate challenges with regard to long-term operation and maintenance.

Environmental

(a) The Intergovernmental Panel on Climate Change (IPCC) in its fifth Assessment Report states that in many regions, changing precipitation or melting snow and ice are altering hydrological systems, affecting water resources in terms of quantity and quality (medium confidence);

(b) While there is low confidence that anthropogenic climate change has affected the frequency and magnitude of fluvial floods and droughts on a global scale, this is due to the current lack of observation and trend analysis possibilities of extreme events (IPCC, AR5);

(c) Changes in precipitation in a warming world will not be uniform. In many mid-latitude and subtropical dry regions, mean precipitation will likely decrease, while in many mid-latitude wet regions, mean precipitation will likely increase under the RCP8.5 scenario. Globally, it is likely that the area encompassed by monsoon systems will increase, monsoon precipitation is likely to intensify and El Niño-Southern Oscillation (ENSO)-related precipitation variability on regional scales will likely intensify (IPCC, AR5);

(d) Sea level rise has resulted in an increase in coastal inundation events, especially exacerbated during high tides, and coastal systems and low-lying areas will increasingly experience submergence, flooding and erosion throughout the twenty-first century and beyond, due to sea level rise (IPCC, AR5). Coastal communities are exposed to multiple climate-related hazards, including tropical cyclones, extreme sea levels and flooding, marine heatwaves, sea ice loss, and permafrost thaw. Extreme sea levels and coastal hazards will be exacerbated by projected increases in tropical cyclone intensity and precipitation (IPCC, SROCC).

2.4 The World Economic Forum has consistently highlighted the high impact and likelihood of weather and water-related events; water is increasingly being identified as one of the highest global risks in terms of impact. Addressing water issues involves consideration of both risks and opportunities: WMO is committed to taking a programmatic approach that will focus on advancing the end-to-end processes for operational hydrology, thus maximizing benefits to Members while minimizing risks.

3. LONG-TERM AMBITIONS

In response to these challenges and drivers of change, the WMO has identified the following eight long-term ambitions designed to yield societal benefits:

- No one is surprised by a flood
- Everyone is prepared for drought
- Hydroclimate and meteorological data support the food security agenda

- High-quality data supports science
- Science provides a sound basis for operational hydrology
- We have a thorough knowledge of the water resources of our world
- Sustainable development is supported by hydrological information
- Water quality is known.

4. GUIDING PRINCIPLES

- Hydrological data and products are a global public good: free and unrestricted access to public and private high-quality hydrological data and products for all.
- Interoperability is key to improved services: related disciplines, data, models, and risk management systems across all scales need to be interoperable and connected wherever it improves our analysis and optimization capabilities.
- Innovation and technology bring opportunities for operational hydrology: established systems which will benefit from new sources of information and new methods of data processing; using the full potential of the digital revolution will improve science and operations in hydrology.
- Hydrological Services provide public benefits: Hydrological Services are recognized as being of high priority and of public interest having clearly defined roles and responsibilities and sustainable financing.
- Partnerships help to enhance delivery: new actors and partners are incorporated along the hydrological value chain from data to product/service.
- All aspects of the water cycle are interconnected: water quality and quantity issues must be addressed in an integrated, holistic way, following the principles of Integrated Water Resources Management (IWRM).
- The weather-water-climate system requires an integrated Earth system approach across multiple temporal and spatial scales: the progress of terrestrial hydrological science and prediction is enhanced significantly through integration with atmosphere, cryosphere, and ocean and coastal processes, recognizing the water cycle itself is the natural connection point for the integration of these basic sciences.

5. CONDITIONS FOR SUCCESS

5.1 The conditions needed for successful achievement of the long-term ambitions include the following:

- The capabilities of national and regional hydrological entities need to be known;
- A comprehensive monitoring of capabilities needs to be agreed and put into routine operation;
- The value chains from hydrological data to products/services must be clear;

- The products and services needed must be defined at local, national and regional level and examples championed by WMO can serve as starting points to design the necessary links in the value chains;

- Capacity issues must be expressed and addressed;

- Capacity gaps with regard to data and products should be analysed and activities linked to developing the necessary value chains harmonized with those linked to capacity-building;

- Cooperation should be wanted and supported;

- Cooperation must be focused and based on a common understanding so that the entire system benefits equally;

- Policies should reflect the fact that economic development is predicated on adequate hydrological infrastructure. The actions of national policymakers should demonstrate that hydrological data and products are essential to economic prosperity and societal well-being.

5.2 Free and unrestricted data policy shall be promoted among Members, including consistent methods for measuring and reporting water use.

PART II: ACTION PLAN

1. PURPOSE

WMO Members/NHMS/UN organizations responsible for other water programmes will collaborate under this Action Plan to implement a strategic suite of enhanced services for operational hydrology to be supported by WMO in the period 2022–2030, to achieve the Long-Term Ambitions (LTA) (see Part I – Section 3), thus significantly improving the capacity of National Hydrologic Services to deliver enhanced products and services based on cutting edge science and technology.

2. OUTPUTS AND ACTIVITIES BY AMBITION

The Eighteenth World Meteorological Congress (Cg-18) in 2019 approved eight LTA that should guide the development of WMO activities relevant to water. Each ambition represents a goal that society aims to achieve in the frameworks of sustainable development and disaster risk management. The following section presents major outcomes necessary to reach each of the ambitions and lists all identified contributing outputs.

2.1 Cross-cutting issues

"Little will be done, if the National Hydrological Service is not fully responding to its goals and objectives due to lack of finance, lack of professional staff, insufficient equipment, and more". Michael Maehaka, consultation on needs and gaps.

2.1.1 Gaps identification and consultations made during the preparation of this Action Plan revealed that some issues are of a clearly cross-cutting nature and are prerequisites to achieve any of the eight long/term ambitions. These issues are related mainly to the functioning of National Hydrological Services, including their visibility, financing, sustainability, governance and management. Unfortunately, in some parts of the world, the responsible agencies struggle to maintain long-term monitoring due to limited financial resources leading to patchy (or no) data. But it is essential to understand the water cycle globally, regionally and locally, which requires permanent operational observations of various hydrological variables within a holistic understanding of the Earth system. The gaps related to targeted research needs to improve operational hydrology are addressed in the Hydrological Research Strategy developed by the Research Board, which underpins this whole Action Plan and will be implemented in conjunction with it.

2.1.2 There is a need to extend the outputs and activities to enhance the visibility of NHSs with their respective governments to ensure recognition and sustainability (adequacy) of budget allocations for hydrological services. At the same time, sustainability of operations (including monitoring networks, capacity-building, personnel stability and training) was identified as a clear prerequisite for any operation and service delivery.

2.1.3 Hand in hand with political recognition comes also the data policy set up. Monitoring, observation and data sharing has been identified as a critical component of National Meteorological and Hydrological Services (NMHSs) operations that needs to be enhanced to deliver the majority of outcomes identified bellow. Downstream and upstream countries in a transboundary basin are in an asymmetric position with respect to data exchange, with downstream countries requiring hydrological data as well as forecasting products from the upstream countries. On top of that, hydrological/water resources data are sometimes considered to be strategic information and possible subject of international disputes over water impacts. In such a case, the decision on data policy is not at the level of Line Agencies such as National Hydrological Service, but at a higher governmental level.

2.1.4 Besides policy issues, technical (easy to use and maintain) capability to effectively exchange data might be a limiting factor in international data sharing (communication links, servers, protocols implemented).

2.1.5 At the same time, involvement of the hydrological community remains limited in particular as regards integrated programmes and activities of WMO like the WMO Information System (WIS)/ the WMO Integrated Global Observing System (WIGOS), Global Data-processing and Forecasting System (GDPFS), Global Climate Observing System (GCOS), etc.

2.1.6 On the other hand, the cooperation of WMO and its programmes with the International Network of Basin Organizations and individual River Basin Organizations remains underexploited.

2.1.7 Therefore, the following outcomes are proposed to support all eight LTA.

Outcomes:

(1) National Hydrological Services operations are sustainable and visible for societies and governments, and the benefits provided are recognized and valued;
(2) The financing schemes of hydrological services are improved to ensure operational sustainability and attractiveness for professional staff;
(3) There is increased sharing of hydrometeorological data for operational hydrology on a free and unrestricted basis across political borders;
(4) There is increased involvement of hydrological communities of Members in the global activities of WMO and greater consequential benefits to national scale services;
(5) There is increased involvement by and cooperation with private sector entities which are responsible for the hydrological operations of their own facilities and do not always share their data (e.g. hydropower).

Metrics: Success in this outcome will be measured by:

(1) Number of Members reporting through the Country Profile Database a sustainable financial (budgeting) situation for their core operations;
(2) Number of stations registered by Members in the reference hydrological network and sharing data;
(3) Number of Members providing operational and historical data and products to the WMO Hydrological Observing System (WHOS) (phase II);
(4) Number of experts registered in the WMO Expert Network with hydrological skills;
(5) Number of experts with hydrology expertise involved in the working structures of technical commissions and regional associations.

Outputs:

A.1 Increased presentation/communication and understanding of value proposition, benefits and risk analysis, and value of hydrological services to foster understanding by ministries and governments

2.1.8 The Hydrological Assembly presents an opportunity for representatives of the hydrological community to participate actively in the strategic work of the organization. NMHSs will be supported to engage with politicians and better describe the value of NMHSs by organizing Regional Associations High-Level Forums, leader’s coalition and by provision of communication materials and toolkits.

A.2 Increased management skills of NHSs managers (including middle and lower management managers) supports the effectiveness and development of NHSs

2.1.9 Capacity-building activities for top and middle management of NMHSs will be prepared including guidelines development, training courses, targeted twinning projects and promotion activities.

A.3 Enhanced regional cooperation, planning and implementation of NMHS-led activities

2.1.10 Regional Associations hydrological activities (e.g. Hydrological Forums) and support to other technical symposia will be organized to coordinate on regional hydrological requirements.

A.4 Enhanced customer orientation and better marketing skills generates better services and products with higher added value

2.1.11 Targeting customer orientation skills of the NMHSs through training materials and case studies will help to establish better services, build tighter connections with and increase satisfaction of users of products and services.

A.5 The end users of hydrological information/data have a clear understanding of what the data means and its relative (un)certainty

2.1.12 Developing of unified communication standards for hydrological information based on definition of guidelines and regulatory material to ensure that communication is based on uptake requirements defined by end users. This will include the communication of uncertainty.

A.6 Institutional development plans and monitoring network development programmes are in place and implemented taking into account the catalogue of products and services

2.1.13 Planning of development and operation will help achieving sustainability of observations and services provided by the NMHSs. Hydrological services providers will have the tools to plan and build hydrological networks that can grow/adapt as needs and resources changes are indicated by targeted research. Guidelines on hydrological monitoring network design, implementation and maintenance will be available.

A.7 Enhanced resource mobilization (increased expertise, financial resources, establishment of partnerships) for capacity-building, technical assistance, training of personnel and sustainability of End-to-End Multi-Hazard Early Warning Systems (E2E MHEWS), flood, drought and water resources management

2.1.14 Project proposals development will be supported by a framework mechanism to sponsor development initiatives through provision of Reimbursable Advisory Services via the WMO/Global Water Partnership (GWP) Associated Programme on Flood Management (APFM) and Integrated Drought Management Programme (IDMP) Helpdesks, Regional offices and in cooperation with other partners.

A.8 Sustainable projects helps build capacities of NHSs

2.1.15 Capacity development projects in monitoring and data assessment will be coordinated across UN bodies and build to support achievement of the eight LTA. Sustainability of projects will be supported by the Systematic Observations Financing Facility (SOFF), use of local resources to maintain equipment, standardization and use of open platforms, and interoperability of equipment.

A.9 Effective and efficient, low-cost methods for hydrological observations are broadly available

2.1.16 Guidance will be developed on how to amplify the information through citizen science, proxy data, and innovation. HydroHub Innovation hub will stimulate development and deployment of low-cost technologies for hydrometric monitoring.

A.10 Increased involvement and enhanced cooperation with the private sector supports Members' flood, drought and water resources management

2.1.17 Examples of success stories will be compiled to demonstrate possibilities and models of mutually beneficial cooperation between public and private partners in the field of hydrological data monitoring and sharing and products and services co-production in support of flood, drought and water resources management.

A.11 Increased availability and national and international exchange and use of hydrometeorological data for operational flood forecasting and early warning purposes and enhanced international cooperation in flood and water resources management, especially for transboundary basins

2.1.18 To support the implementation of the WMO Unified Policy for the International Exchange of Earth System Data, a network of reference observation stations will be established from which Members commit themselves to mandatorily share the data leading to the future inclusion of hydrology and cryosphere data in the Global Basic Observing Network (GBON). WHOS will be further implemented for sharing of operational and historical data among Members including demonstration projects on additional types of data (e.g. forecast products from various producers).

A.12 The operational hydrology community at the national scale knows how to access global and regional products, services and tools and actively participates in the activities of the WMO community.

2.1.19 Overcoming the input obstacles for hydrologists to WMO activities will be done by developing a "Welcome portal" including explanation of the benefits for NHSs to become an active part of the WMO family.

Ongoing activities

2.1.20 Given the cross-cutting nature of the above-listed outputs for enhancement of sustainability of NHSs and increased data sharing, many of the ongoing hydrological activities need to be continued and intensified to achieve the long-term ambitions. **Capacity-building in hydrology and water management** and capacity development through projects supported by **the Associated Programme on Flood Management (APFM)** and **IDMP** programmes will be critical to succeed. Governance of NHSs and their effective operation to deliver high value users-oriented products and services needs to be framed by the principles of the **Quality Management Framework – Hydrology**. At the same time, the development of observation networks and data sharing demands the continuing advancement of **Hydrological data operations and management** through implementation of **WHOS** and intensified use of **The Global Hydrometry Support Facility (HydroHub)** to stimulate development of technology and methods of observation and data processing.

Assumptions and risks

2.1.21 We assume that preventing water and hydrometeorological disasters will continue to be considered both a short-term and a long-term priority for societies, and that emphasis will be put on the management of hydrological services and on providing high-quality data, products and services in the field of operational hydrology.

We further assume that the WMO reform will create a reliable and viable platform for hydrologists to meet and cooperate on operational hydrology issues and affect the strategic and operational activities of the Organization.

Additionally, the activities proposed assume the implementation of the new unified data policy of WMO, including the involvement of private sector.

Possible risks are:

- Change in overall political and societal priorities, e.g. due to the COVID-19 pandemic, decrease the involvement of politicians in the water-related agenda;
- Lack of alignment with other activities in the field of water (e.g. UN-Water, UNESCO-IHP, UNEP, UNECE Water Convention) leads to competition for the attention of governments and hydrological experts;
- Technological innovations might change ways of delivering products and services currently provided by national hydrological services and might change the market in the field of operational hydrology;
- NHSs do not recognize the increase of management skills to be an important factor in the operation and development of services (due to a preference for operational issues only, or internal, cultural conditions and other external conditions);
- Skills drain of NHSs to better (paid and supported) positions in private entities (e.g. water boards, water agencies, hydropower operators);
- Loss of income to NHSs due to open (no-cost) data sharing (seen as a threat to the funding sources of NHSs);
- Replacement of technology of long-term observing stations may cause inhomogeneity in time series;
- Perception of marginalization of hydrological issues in implementing the Earth system approach may arise if hydrological requirements are not considered adequately in the work of various WMO bodies;
- Differing interests of private and public partners causes asymmetry in cooperation.

2.2 Ambition/goal: No one is surprised by a flood

"Lack of trained people and good hydrological monitoring network is the biggest gap in the process of creating flood forecasting and warning service".
Vasko Stojov, consultation on needs and gaps.

2.2.1 Floods represent a major hydrometeorological hazard from the point of view of the number of affected people. While the total economic damage caused by floods has tended to increase, flood early warning systems have proved to be an effective tool to decrease the

numbers of fatalities. Increased understanding of flood hazard and risk and its changes, flood forecasting and warning have enhanced the preparedness and response capacities of nations and communities. The modern concept of early warning system comprises components of risk knowledge, monitoring and warning, dissemination and response capability reaching beyond delivering warning information, to improve its effective use for action.

2.2.2 Further strengthening of Members' early warning systems for floods and their adaptation to climate and societal drivers is necessary to be prepared for future floods and changes in flood hazard and flood risk.

Outcomes:

(a) Impact-based end-to-end Early Warning Systems (EWS) for flood forecasting in the context of a broader integrated flood management strategy implemented by Members;

(b) Public, communities and businesses have enhanced access to and better capacity to react to official national flood forecasts and warnings locally and globally.

Metrics: Success in this outcome will be measured by:

(a) Number of Members having the Multi-hazard Early Warning System set up for floods;

(b) Number of Members providing their flood warnings using the Common Alert Protocol (CAP) to be integrated into the Global Multi-hazard Alert System (GMAS) (at least 50% of Members doing so).

Needs and gaps

2.2.3 Floods are one of the most impactful natural disaster and are a result of a combination of various phenomena and processes. As a consequence, many WMO programmes and activities address different aspects of floods, which constitutes a challenge for effective coordination.

2.2.4 Gaps and needs of national flood forecasting and early warning system are not identified in a consistent and organized way. Additionally, there is a lack of expertise in design and development of a flood forecasting and warning system in some regions and the low standardization of data flows and methods of operation make it difficult to transfer solutions easily, without mentioning the additional challenge of language barriers.

The flood risk assessment process (and related tools) is not available or not fully understood by all Members. Hydrological data might not be sufficient to enable a proper flood regime (flood hazard) assessment, without mentioning the difficulties to estimate future probabilities of flood occurrence under the changing climate and catchment conditions. Estimation of impacts demands close cooperation with other institutions to access (if existing), understand and evaluate data about potential impacts of flood to determine flood risk.

2.2.5 In some countries, collaboration between NHSs, NMSs, and other authorities involved in flood forecasting (national Disaster Risk Reduction (DRR) authorities) towards the creation of Multi-Hazard Early Warning Systems (MHEWS) is not effective enough. Sometimes, processes in flood early warnings are understood as sequential steps where components of MHEWS (risk knowledge; monitoring and forecasting; dissemination; capacity to respond) are dealt as completely separate issues without considering the whole value chain. Such discrimination of actions might lead to ineffectiveness at the interfaces and lack of coordination. Special importance should be given to flash floods that demand for different approaches and tools to be used for efficient early warning. Sustainability of projects at national as well as regional and global level (e.g. Flash Flood Guidance System (FFGS)) must

be ensured to support operation of National Hydrological Services and National Meteorological Services and their joint activities in provision of flash floods warnings.

2.2.6 Financial resources are limited, both at national and international level, to realize all necessary development projects around the world. Additionally, after the investment, lack of resources for operation and maintenance (sustainability) is often a reason for failure, degradation or suboptimal functioning of implemented systems.

2.2.7 Sharing of data in near-real time remains a challenge in some parts of the world. Use of global coverage products (satellite, Numerical Weather Prediction (NWP), hydro models), despite its huge progress over the last few decades, remains limited in operational hydrology (likely due to data policies, IT connections, lack of knowledge of where to search, etc.). When using global products, quantitative interpretation is often needed, but access to basic data (of hydrological meaning) at reasonable scales is rarely available. Experience also shows that a majority of Members have some gaps in conveying forecast and warning information to users, which results in a decrease of effectiveness of forecasts and warnings.

2.2.8 From a wider perspective, flood protection measures sometimes neglect integrated flood risk management principles. Considering development of an end-to-end early warning system without a context of other components of flood protection (land-use planning, reservoir operation, response planning etc.) leads to conflicts and inefficiency where a holistic approach is not applied.

2.2.9 Given the above-mentioned issues, targeted research is essential to improve forecasting methodologies, to better understand the societal response to forecasts, warnings, and flood risk management in a broader sense.

Outputs:

B.1 Enhanced coordination, effectiveness and governance of all WMO activities in supporting Members with respect to Flood Risk Assessment and Flood Forecasting and Warning

2.2.10 The Flood Forecasting Initiative will be reinforced as the coordination mechanisms of activities for flood risk assessment, forecasting and warning across WMO. Effective joint planning and implementation mechanisms must be initiated or strengthened with major partners and activities (e.g. the International Flood Initiative (IFI), the United Nations Office for Disaster Risk Reduction (UNDRR)). Similarly, WMO will develop principles of cooperation with the private sector in this issue.

B.2 A framework is developed for the evaluation of gaps and needs of national flood forecasting and early warning systems

2.2.11 Assessment guidelines will be developed, completed by a community supported web-based tool for self-evaluation.

B.3 Increased exchange of knowledge and technical expertise in flood forecasting among Members

2.2.12 Knowledge transfer will be realized through the community of practice on end-to-end EWS for Flood Forecasting, including guidance on emerging technologies and services for data acquisition and analysis.

B.4 Enhanced collaboration among NHSs, NMSs and other organizations (e.g. DRR authorities) at the national level to develop and operate E2E MHEWS, particularly with respect to floods

2.2.13 Support will be provided for inclusion of different stakeholders' requirements (energy-water-food nexus) by compilation of success stories of collaboration among NMHSs and DRR and other relevant authorities. Promotion of the MHEWS approach (e.g. with the integration of FFGS/the Coastal Inundation Forecasting Initiative (CIFI)/the Severe Weather Forecasting Programme (SWFP)) for integration of hydrology in GMAS (including application of the CAP, humanitarian support and reflecting hydrological hazards in the catalogue of hazardous events) by explaining the concept of EWS and showcasing benefits of co-production of MHEWS services between communities will be pursued.

B.5 Increased availability and international exchange of hydrometeorological data for operational flood forecasting and early warning and enhanced international cooperation in flood management especially for transboundary basins, on a free and unrestricted basis.

2.2.14 See A.10.

B.6 Enhanced resource mobilization (increased expertise, financial resources, establishment of partnerships) for capacity-building, technical assistance, training of personnel and sustainability of E2E MHEWS

2.2.15 See A.7 (Project proposals development will be supported by a framework mechanism to sponsor development initiatives through provision of Reimbursable Advisory Services via the Integrated Flood Management (IFM) and IDMP Helpdesks, Regional offices and in cooperation with other partners).

B.7 Flood related data and products with global and regional coverage are available for use at the national scale by Members

2.2.16 The establishment of hydrological centres with responsibilities in the field of operational flood and flash flood forecasting within the Global Data-processing and Forecasting System (GDPFS) (including integration of ongoing projects like FFGS) to support Members with global and regional product and verification will be pursued. Development of an inventory of worldwide and regional free and public data and products for flood forecasting; and an inventory of international interoperable models and platforms will be finalized.

B.8 Increase in Members' capacities to deliver and communicate information to the public and to raise awareness (to enable action in response to warnings)

2.2.17 A set of guidelines, best practices and training materials will be prepared including flood risk assessment and mapping, Common Alerting Protocol (CAP) application to hydrological hazards, communication of uncertainty, impact-based forecasting, and communication with users on their requirements as well as on interpretation of forecasting results and related risks.

B.9 Increased application of integrated flood risk management principles in flood prevention, preparedness and response by Members and regions (basin authorities).

2.2.18 Continuing APFM activities in capacity-building in integrated flood management will be enhanced and provision of additional guidance material will be pursued.

Ongoing activities

2.2.19 The **WMO Flood Forecasting Initiative** and **APFM** have been the major contributions to flood related disaster risk management activities that need to continue and further develop in order to achieve the long-term ambition 'no one is surprised by a flood'. For example, FFGS regional projects proved to be a viable solution for cooperation of meteorological and hydrological forecasting services (in over 60 countries) on the issue of flash

floods that needs to be included in integrated and sustainable operation in the future[3]. Relevant activities need a continuing support by **Capacity-building in hydrology and water management**, which helped increase capacities of Members in flood risk assessment and flood forecasting and warning in previous years. However, reliable flood forecasting service can be built only if **Hydrological data operations and management** provides sufficient (amount, quality, resolution) data in near-real time and **Quality management framework – Hydrology** properly addresses users' requirements and helps establish and maintain processes to deliver products and services.

Assumptions and risks

2.2.20 We assume that preventing water and hydrometeorological disasters will continue to be considered both short-term and long-term priority issues to be addressed to respond to societal needs.

Possible risks are:

- Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in changes in priorities in the DRR agenda and decreased involvement in the water-related agenda.
- The COVID 19 pandemic is altering WMO modalities of work, with a potential impact on efficiency due to teleworking and the impossibility of face-to-face meetings.
- Lack of alignment with other initiatives (including data and products portals) in the field of water (e.g. UN-Water, UNESCO-IHP, UNEP, EU-Copernicus etc.) leads to competition for attention of governments.
- Technological innovations might change ways of delivering products and services currently provided by National Hydrological Services.
- In the case of the Community of Practice, insufficient contributions from Members and competition from other communities of practices outside WMO for resources (mostly human).
- Lack of candidates to become centres operating under GDPFS rules and development of centres outside the umbrella of GDPFS (including in the private sector), which undermines the idea of GDPFS as well as lack of acceptance of the GDPFS hydrology structure by NHSs.
- Lack of financial resources for the core activities of the Secretariat.

2.3 Ambition/goal: Everyone is prepared for drought

"I believe, we can start somewhere, and we can start simple".
Ram Dhurmea*,* consultation on needs and gaps.

2.3.1 Although drought can cause severe water and food shortages, impact the health of the population (including increased morbidity and death), and have socio–economic and political consequences, many drought-affected countries do not yet have national drought policies or existing policies may need to be updated; countries need further assistance in

[3] The Flash Flood Guidance System Sustainability Strategy should be considered by the EC and Congress in 2021.

enacting policies that incorporate the three pillars of drought management (monitoring and early warning systems, vulnerability and impact assessments, and mitigation, preparedness, and response measures).

2.3.2 Drought is a complex phenomenon connecting meteorological, climatological, hydrological and other communities to support resilience of communities and nations by provision of relevant data and information including on precipitation, low-flows, groundwater, soil moisture, lakes and reservoirs, cryosphere, water withdrawals, etc. WMO activities support Members drought preparedness, using (for instance) current capabilities in seasonal to multi-year climate predictions or in drought risk assessment.

Outcome:

Members reduce adverse impacts of drought at all levels by implementing integrated drought management systems, including drought monitoring, early warnings, vulnerability and impact assessments, and drought mitigation, preparedness and response measures.

Metrics: Success in this outcome will be measured by:

Number of Members providing their drought preparedness, monitoring and assessment products and services that include the water resources (hydrological) component, making them available through the WMO infrastructure (Regional Climate Outlook Forums (RCOFs), GMAS, the Global Hydrological Status and Outlook System (HydroSOS)).

Needs and Gaps

2.3.3 Members sometimes struggle to establish a strategy and process to enhance their drought management systems including drought monitoring and assessment. It is usually expected that the National Hydrological Services (NHS) and National Meteorological Services provide products for drought-related decisions on a seasonal scale. But, capacities to run seasonal drought-related forecasts at Members' level are often not available. one of the causes is the difficulty to reach users to understand their needs and requirements. Successful drought risk assessment needs close cooperation between the hazard community (met-hydro) and the impact community (agronomy, DRR, etc.), which often lacks functional platforms at national scale.

2.3.4 Furthermore, insufficient amount and quality of data to perform drought hazard, vulnerability and risk assessment, is an obstacle for developing drought policies and establishing drought management systems. Despite substantial progress in remote sensing methods and Earth system modelling, drought-related data/estimates from satellites are not well verified on the ground; access to global (satellite and other) products is limited – due to data policies, limited broadband, or lack of know-how. In addition, graphical products are not enough – some consequent quantitative interpretation is often needed, but access to basic data (of hydrological meaning) at reasonable scale is often not available. Similarly, climate (seasonal) forecasts are not always detailed enough (e.g. global products are not easily accessible in quantitative form at useful scales) to be of use for sound hydrological interpretation at national or subnational level. There's also a challenge in building thrust in seasonal products through demonstration of their benefits for water management.

2.3.5 Groundwater remains often under-represented in drought management activities (monitoring and assessment) although unsustainable ground water withdrawal and recharge proved to be a critical issue in various areas with intensive agriculture production based on groundwater resources. Better understanding of the interaction between surface and groundwater is needed to fully understand the phenomenon of hydrological drought.

2.3.6 When designing and implementing capacity development projects, coordination remains suboptimal in some activities at all levels – national, regional as well as global (e.g. among the Food and Agriculture Organization (FAO), WMO, United Nations Convention to Combat Desertification (UNCCD), UNESCO) leading to duplication or implementation of

different tools and systems in one country resulting in obstacles for an effective operation and maintenance. A critical issue is often the sustainability of projects after the first few years (investment costs of projects are secured, but financing of maintenance and operation often fails).

2.3.7 Training of experts in various aspects of drought managements and their support through community of practice and provision of tools and methods remains a challenge for future years.

2.3.8 Finally, applied research should provide tools and methods to enhance capabilities to manage water resources under drought conditions and to adapt to changing climate, as well as societal changes and dynamics affecting water demand and use.

Outputs:

C.1 Enhanced coordination, effectiveness and governance of all WMO activities to support Members with respect to integrated drought management

2.3.9 Streamlining of ongoing activities on droughts across the WMO constituent and subsidiary bodies will ensure coherence, consistency, and efficient use of resources, building on the IDMP continuing community of practice and Helpdesk. Building of partnerships for effective joint planning and implementation mechanisms with major partners and initiatives (the International Drought Initiative (IDI), UNDRR, FAO, UNCCD, the International Fund for Agricultural Development (IFAD), etc.) as well as with the private sector to support drought risk management is needed. Organization of the High-Level Meeting of National Drought Policies – 10 years later (HMNDP+10) with partners should be explored.

C.2 Drought-related data and products with global and regional coverage are available for use at the national scale by Members

2.3.10 Drought-related GDPFS centres should support NMHSs to process and apply the information to the local context. Initiating from an identification of requirements from NHSs on globally/regionally produced information for their use in drought assessment, modelling and prediction at national scale, an interface, guidelines, and training materials for NHSs will be developed to search, use, interpret and verify products.

C.3 Gaps in Members capabilities with respect to drought assessment, monitoring, modelling and prediction are known

2.3.11 A checklist to enable reviewing current capacities of Member will be developed within the framework for evaluation of gaps and needs of national drought forecasting and early warning systems. Review of available and reliable methodologies to be used for specialized applications of seasonal forecasts will be done as an initial step to decide on further actions in supporting sectors such as agriculture, inland navigation, energy, or health by specialized outlook products.

C.4 The need for an effective national drought policy is understood by Members

2.3.12 Support to Members will be provided in developing proactive drought impact mitigation, preventive and planning measures (within the frame of local/national development policies), drought risk management, to improve the public awareness of drought risk and its preparedness for drought.

C.5 Training to increase the capacities of Members in drought management (drought monitoring, modelling and early warnings, drought vulnerability and impact assessments, and drought adaptation, mitigation, preparedness and response measures)

2.3.13 Capacity-building activities related to drought management will be organized through the IDMP and regional cooperation, including development of curricula and training material based on Members' needs identification; and support to twinning projects in user-driven drought-related products development.

C.6 Increased capacities of Members through development projects in the areas of drought monitoring, early warnings, vulnerability and impact assessments, adaptation and mitigation, preparedness and response measures

2.3.14 See A.6

C.7 Increased cooperation (and co-production of services) among the hydrological, meteorological and climatological communities and international exchange of experiences (e.g. increased involvement of hydrologists in climate outlook forums, increased involvement of meteorologists and climatologists in river basin commissions)

2.3.15 Increased co-production of services at regional level through implementation of water segments within RCOFs to provide complete outlooks on climate and water availability to users. Regional Associations will be assisted in producing regular (annual/seasonal/monthly) statements on status and outlook of water resources.

C.8 Increased Members capabilities in drought vulnerability of, and impact assessment on, different sectors by meaningful drought indicators and indices used at all relevant scales.

2.3.16 Development of a Global Drought Classification System and guidance on drought indicators, including a water scarcity and other hydrological indicators, will be supported by development of guidelines on harmonizing drought early warning and risk information for end user communication, with special attention to transboundary basins and aquifers.

Ongoing activities

2.3.17 **The IDMP** has been developed to support activities in drought-related disaster risk management across domains. Recently, the hydrological community has started developing a major contribution to drought management by designing and promoting the **HydroSOS**. As for other ambitions, **Capacity-building in hydrology and water management** and **Quality management framework – Hydrology** traditionally helped in establishing services at Members' and basin's levels supporting drought management activities.

Assumptions and risks

2.3.18 We assume that integrated drought management is a priority at national level for Members.

Possible risks are:

- Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda.
- The COVID 19 pandemic is altering WMO modalities of work, with a potential impact on efficiency due to teleworking and the impossibility of face-to-face meetings.
- Lack of alignment with other activities in the field of water (e.g. UNESCO-IHP, FAO) leads to competition and duplication of work and funding.
- Lack of candidates to become centres operating under GDPFS rules and development of centres outside the umbrella of GDPFS (including in the private

sector), which undermines the idea of GDPFS as well as lack of acceptance of the GDPFS hydrology structure by NHSs.

- Lack of financial resources for the core activities of the Secretariat.

2.4 Ambition/goal: Hydroclimate and meteorological data support the food security agenda

2.4.1 Resolving the equation of satisfying water demand for environment and ecosystems, human consumption, irrigation requirements, water availability and potential water storage, needs support and advice to optimize rain-fed and irrigated agriculture. A multidisciplinary approach, by integrating the agrometeorological, climatological and hydrological expertise with socioeconomic and geophysical data and water resources management practice, should be developed.

Outcomes:

(a) Food security is enhanced by informed end users' decisions at all levels from regional to local;

(b) The concept of Integrated Water Resources Management (IWRM) including water use and allocations for supporting food production is widely accepted and followed.

Metrics: Success in this outcome will be measured by:

(a) Decreased number and magnitude[4] of famine/hunger emergencies due to drought and water scarcity (in 2021–2030 relative to 2001–2020);

(b) Number of Members monitoring and accounting for water consumption in their water budgets at the basin scale.

Needs and Gaps

2.4.2 Drought and floods were historically, together with violent conflicts, the most common causes of food insecurity. While droughts remain at the centre of focus when speaking about food security, a wider understanding of processes and feedbacks within the water-food-energy nexus is needed to enable water management to support food production in general. Water is understood to be a strategic commodity by some countries and mostly for this reason water and hydrological data remains unshared.

2.4.3 Successful agrometeorological and climatological products and services were developed in the past decades to support rain-fed agriculture, like those developed by RCOFs. Hydrological data, products and services need to complement these, in particular in regions where production depends on irrigation and water allocation schemes depend on water availability and its prediction, concerning both surface and groundwater.

2.4.4 Users’ needs and requirements are a critical factor in developing and delivering products and services. In this aspect, there is no universal solution, as priorities and preferences of society are different in different parts of the world. On the other hand, benefits of hydrometeorological services for food production can be easily demonstrated and assessed on the basis of yields.

[4] Number of affected people, duration of the emergency

2.4.5 At global level, coordination of development projects and cooperation in operational activities needs to be ensured with relevant partners, in particular FAO and the World Food Programme (WFP).

2.4.6 Finally, applied research should provide tools and methods to enhance capabilities to maintain and expand agricultural productivity under a changing climate, understanding the water-food-energy nexus and its consequences.

Outputs:

D.1 Increased production and availability of agrometeorological and hydrological forecasts from sub-seasonal to seasonal

2.4.7 Methodology and tools will be developed to interpret HydroSOS data and information (including snow, ice, soil moisture, groundwater, irrigation, water storage) for agricultural applications.

D.2 Effective dialogue between users and providers established

2.4.8 Guidelines based on good practices on dialogues with users will assist Members to establish consultation platforms and communication with users, including research on user requirements and expectations, case studies of product and service development, marketing strategies, and processes to support strategic service planning of NMHSs (including e.g. catalogue of products and services).

D.3 Strengthened capacity of NMHSs personnel in user-driven product and service design and delivery (to support food production and security)

2.4.9 See C.5.

D.4 Water-food-energy nexus and ecosystem services are better understood and inform water resources management

2.4.10 Activities will facilitate discussion on the role of hydrology in providing the required data for optimizing the management of water resources to accommodate the three sectors' needs; through symposia, open panels, TED talks, or case studies (e.g. building on UNECE Water convention work) on the water-food-energy nexus.

Ongoing activities

2.4.11 Food security is closely connected to water resources availability and droughts, therefore the **IDMP** might again be seen as a major contributing activity in this regard, together with the continued implementation of the **HydroSOS** and relevant activities in the frame of **capacity-building in hydrology and water management,** targeting development and delivery of food production relevant services at Members' level.

Assumptions and risks

2.4.12 We assume that food security remains a priority at the national level for Members.

Possible risks are:

- Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda.

- The COVID-19 pandemic is altering WMO modalities of work, with a potential impact on efficiency due to teleworking and the impossibility of face-to-face meetings.

- Lack of alignment with other activities in the field of supporting food production (e.g. FAO) leads to competition for attention of governments and confusing of users.

- In case of RCOFs, lack of coordination and linkages to stimulate necessary involvement of hydrological services to the established format of cooperation and lack of acceptance of the RCOF hydrology activities by NHSs.

- Lack of financial resources for the core activities of the Secretariat.

2.5 Ambition/goal: High-quality data supports science

"Globally accepted and free accessible data infrastructure is lacking – monitoring data from NHSs and research is not brought together".
Harald Köthe and Stephan Dietrich, consultation on needs and gaps

2.5.1 The interoperability between science and data generates knowledge and progress. The value of data accessibility, usability and reliability has been proved to be a strong driver for science development.

2.5.2 Core data availability policy has been established and enforced in some sectors, but increased efforts are still needed to establish common standards and policies for data management and sharing, to support generation of high-quality hydrometeorological data as well as corresponding information products and services development for the benefit of Members.

Outcome:

Increased discoverability, availability, and use of high-quality hydrological and hydrometeorological data for scientific analysis.

Metrics: Success in this outcome will be measured by:

- Number of river discharge/groundwater/lakes and reservoirs/cryosphere time series with data available for the 2021–2030 period that are accessible via the WMO infrastructure and programmes (such as WIS, WMO Hydrological Observation System (WHOS), the Global Cryosphere Watch (GCW), the Global Runoff Data Centre (GRDC), the International Groundwater Resources Assessment Centre (IGRAC), HYDROLARE, the Global Terrestrial Network – Hydrology (GTN-H)) for scientific purposes on a free and unrestricted basis;

- Number of Members performing routine hydrological data quality assessments in line with Quality Management Framework – Hydrology (QMF-H) recommendations.

Needs and gaps

2.5.3 To ensure production of quality data, the concept of QMF-H was developed and promoted by WMO, however it is likely still not well understood or not considered to be a priority by all Members. Guidance material is not easily implementable (among other reasons due to the language barrier) or the implementation cost is too high.

2.5.4 At the same time, the variety of hydrological conditions and regimes is extreme, finding one fit-for-all solution for hydrological observation standardization and quality control procedure is a challenge. While developed countries concentrate often on the accuracy of measuring devices, a need for development of low-cost measuring instruments is often

expressed from developing countries. In addition, differences in development and capacities among Members are great – application of methods from developed countries might be too demanding for some developing Members, while on the other hand, low-cost but imprecise methods might not suite countries with developed monitoring programmes. Naturally, the ultimate goal is for all countries to be capable of producing quality data.

2.5.5 Exchange of data for the scientific community remains limited at global level, due to restricting data policies of some Members, but also due to lack of flexible, easy to use technical platforms. In addition, the research community requirements on data (and its characteristics) is not always well defined and may differ from day-to-day operational needs.

2.5.6 Research institutes and operational agencies under certain conditions compete for resources – both financial (funding) and human. It is usual that NHSs perform some research activities, as work at the NHSs might be feared to degrade to routine operation only, which would cause decreased motivation for staff and decreased prestige for the institution. This competition might be overcome by balanced partnership and mutual cooperation on applied research. Similarly, combination of data from long-term in situ observing networks with short research observations, experimental data, and other sources of information (e.g. satellite) to a 'common stock' is an opportunity for better cooperation towards shared goals.

Outputs:

E.1 Methods for standard assessment of data quality developed

2.5.7 Guidelines on assessment and flagging of hydrological data reflecting its quality will be developed, including practical methods for such assessment. Continuous process of revision and updating of *Basic Documents No. 2, Technical Regulations Volume III: Hydrology* (WMO-No. 49) will be initiated, targeting in particular the annex on Hydrometry. Other hydrology related materials/documents will be revised for QMF-H compliance.

E.2 Quality assured hydrometeorological data by NHSs are generated through increased compliance with the culture of Quality Management Framework – hydrology (QMF-H)[5]

2.5.8 Activities will support Members to achieve QMF compliance by development of generic data production processes (schemes), metrics and internal guidelines for easy customization for NMHSs. Training materials and e-learning on QMF will be produced, including basic field safety manual/training course. Members will be encouraged to implement QMF through the dissemination of information highlighting the benefits of QMF.

E.3 Improved development and maintenance of technical platforms to support data discovery and accessibility for exchange for research and science

2.5.9 Integration of hydrological networks to relevant WMO platforms through implementation of WHOS. Role of existing global data centres will be redefined to better support needs of Members in data sharing and joining WIS/WIGOS, including sharing of data from research basins and projects by academia and targeted monitoring projects.

E.4 Improved coordination on observing networks to fit research purposes

[5] The goal of Quality Management Framework – Hydrology (QMF-H) is to provide strategy, advice, guidance and tools for the National Hydrological Services to attain quality, efficiency and effectiveness in their functioning. As such it provides documentation on approaches to a Quality Management System (QMS) and guidance on its adoption and implementation by NHSs; documentation and guidance on management of NHSs; documentation on technical approaches for the provision of hydrological data, products and services; and development of training modules and materials.

2.5.10 Based on a colloquium/conference on data for scientific purposes that would identify what and how to measure to enhance the scientific progress of hydrology, a concept paper on a joint distributed hydrological laboratory will be developed for further consideration.

E.5 Enhanced culture of research & development projects co-design and joint management (operational hydrology and academia)

2.5.11 See F.1.

Ongoing activities

2.5.12 **Quality management framework – Hydrology** has been promoted as a key principle to ensure production of high-quality and quality-controlled data for various purposes, including research. As measurement technology developed, **Assessment of the performance of flow measurements** has become a major initiative to support NHSs in the correct and effective use of new equipment in everyday operation. It needs to continue supporting hydrologists by providing guidance on methods of hydrometric measurements and their quality and uncertainty assessment. At the same time a need for new possibilities of measuring data, where conventional methods are not available or too expensive, was recognized. **The Global Hydrometry Support Facility (HydroHub)** has been initiated in response helping developing Members to increase the number and reliability of observations. The **WMO Hydrological Observation System (WHOS)** ensures hydrological data operations and management in the frame of WIS/WIGOS with foreseen continuation of its implementation (phase II).

Assumptions and risks

2.5.13 We assume that Members will continue to be motivated to adequately support research and monitoring in order to better understand the behaviour and changes of the water cycle as a prerequisite for making informed decisions on water management and adaptation to climate change.

Possible risks are:

- Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda and thus in the sustainability of monitoring networks (especially at long-term-observing sites) and in projects in the field of hydrology and water management.
- The increase in automated data availability and alternative sources of data is not accompanied by an equivalent increase in competence and capacity to manage data quality control and QMF-H compliance.
- Satellite data will replace in situ observations without sufficient verification, and continuity of the long-term observation series is not maintained.
- Technological solutions of monitoring (e.g. satellites), data transfer (internet, cell phone networks) and data storage (cloud solutions) will become more vulnerable to cyber-security incidents (hacking attacks, single point of failure).
- Lack of alignment with other activities in the field of water (e.g. UNESCO-IHP) leads to competition for attention of governments.
- Lack of financial resources for core activities of the Secretariat.

2.6 Ambition/goal: Science provides a sound basis for operational hydrology

2.6.1 The development of operational services needs to be based on the state of knowledge of the water resources and the current and foreseeable pressures on them. Fundamental research, on the other hand, needs to be tailored to user needs, in an applied research approach. Earth system science in an integrated perspective broadens the hydrological perspective and the advancement of hydrological science.

Outcomes:

- Reduced gap between research and operational hydrology applications; operational hydrology uses improved understanding of Earth system science
- There is a greater understanding of how the hydrological system responds to extreme conditions.

Metrics: Success in this outcome will be measured by:

- Number of WMO (co-)sponsored research programmes/projects that include implementation of operational hydrological applications at Members' level during 2021–2030
- Number of cooperation agreements between NHSs and research institutions at the national, regional and global levels; exchange of scientific personnel, increase of staff with a science-based education and training at MSc and higher levels.

Needs and gaps

2.6.2 The gap between research and practice paradoxically increases. One of the reasons is that NHSs are not always recognized as beneficiaries (clients) and users of research results. It points to possible weak customer orientation of some research teams towards operational services, and to limited understanding of the production/value chain from meteorology/climatology to hydrology/water management in case of research topics stretching over scientific domains. Obviously, a separation of scientific and operational communities is recognized as a problem that needs to be overcome by closer cooperation and twinning. It is agreed that enhancement of operational hydrology calls for an interdisciplinary approach not limiting the scope to hydrological sciences.

2.6.3 Among identified research needs for operational purposes, there is an urgent need for inexpensive sensors and telemetry, cloud-based platforms and free satellite data reception. Satellite observation and other emerging types of data are a promising source of information but demand appropriate calibration and ,merging with in situ observations. It is also recognized that Earth system science has developed significantly over last decades, yet the transfer to practice lacks behind in many parts of the world. Due to the extreme dynamism of research, it has become impossible for practitioners from NHSs to observe, follow, test and use all relevant products and outputs. In addition to those products operationally available, few other fit operational hydrological needs as regards resolution (basin scale), sets of parameters, frequency of data, formats, etc. A big challenge for use of meteorological and climate data for hydrological applications remains the fact that, without bias correction, the water balance might be disturbed, but bias corrected data do not always keep a physical sense.

Outputs:

F.1 Enhanced culture of research and development-to-operation projects to be co-designed by the operational hydrology and academia sectors) – (demonstration) projects are developed, with beneficiaries being National Meteorological and Hydrological Services

2.6.4 Implementation of the research strategy for hydrology being developed by the Research Board in the frame of the overall WMO research programme, will help closing research to operation gap (including close cooperation with UNESCO-IHP, UNEP, FAO, the International Association of Hydrological Sciences (IAHS) and International Association for Hydro-Environment Engineering and Research (IAHR)). It will be supported by developing a catalogue of case studies/best practices of cooperation for direct enhancements of NHSs operations by targeted/customized research and continuous updating of a database of research needs from NHSs as a repository of project topics for scientists.

F.2 Enhanced collaboration between hydrology and meteorology communities of practice, including academia

2.6.5 See B1.4 and B2.7.

F.3 Inventory of the compiled data and products from Earth systems science projects for hydrological applications

2.6.6 See B0.11, B1.7 and B2.2.

F.4 Improved Earth system models at high resolution for local and regional applications

2.6.7 NHSs should have the tools to assess and predict the current and future state of the water resources. Information should be available to fully integrate surface and groundwater resources to improve Earth system modelling and forecasting, in particular Quantitative Precipitation Estimation (QPE) and Quantitative Precipitation Forecast (QPF).

F.5 There is a greater understanding of how the hydrological system responds to extreme conditions

2.6.8 Tools and modules to assess and analyse uncertainty of extreme conditions should be available. The research community will be encouraged to further develop uncertainty and scenario analysis that can be directly used to design/manage infrastructure and water systems.

Ongoing activities

2.6.9 **Assessment of the performance of flow measurements** represents an example of applied research transformation for the benefits of operational hydrology by evaluation of performance and uncertainties associated with new technologies for flow measurement. With a broader scope, **the Global Hydrometry Support Facility (HydroHub)** is intended to stimulate applied science for operational hydrology through development of new methods, instruments, and tools for practice. In the field of floods, several research demonstration projects were developed within the frame of the **WMO Flood Forecasting Initiative (FFI)**. However, in the field of hydrology, to the main responsibility for research falls with UNESCO-IHP at the UN level. Therefore, cooperation and coordination of research activities will be necessary with external partners including UNESCO-IHP and IAHS through the Hydrological Coordination Panel and the Research Board.

Assumptions and risks

2.6.10 We assume that Members will continue to be motivated to adequately support research and development in order to better understand the behaviour and changes of the water cycle as a prerequisite for making informed decisions on water management and adaptation to climate change.

Possible risks are:

- Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased resources for scientific projects and research;
- Increased competition between the science and operational sectors for funding and staff as a result of limited resources;
- Asymmetry in benefits from cooperation between operation (providing data free of charge) and science (e.g. paywall publications) decrease the willingness to work together;
- Unhealthy competition with UNESCO-IHP in the field of hydrological research competence;
- Globalization of research leads to "non-recognition" of NHSs as users of research outputs.

2.7 Ambition/goal: We have a thorough knowledge of the water resources of our world

2.7.1 Collecting, managing and sharing data on water resources and uses, (all the key variables associated with operational hydrology) are fundamental for a better understanding of these resources and for developing appropriate water management solutions, informing the decision-making process from local to global scale.

2.7.2 Despite the advances in technology and policy, we are far from having comprehensive information on the state of water management across the world, or regarding major characteristics, trends, constraints and prospective changes.

2.7.3 Regional analyses need to be supported by systematic, up to date and reliable information on water and serve as a reference for large-scale planning and predictive studies.

Outcome:

Members implement reliable water resource assessment systems and use these to complete and share information on the availability of water resources.

Metrics: Success in this outcome will be measured by:

- Number of Members completing and sharing water resource assessments, including via HydroSOS or WMO regional systems;
- Annual reports on the status of global water resources published from 2025 onwards.

Needs and gaps

2.7.4 Many Members, especially in developing countries, require investments and support to build the skills, tools and infrastructure (hydrological and meteorological monitoring networks; framework and IT infrastructure for data curation, archival and retrieval systems and quality assurance) needed to enhance their NMHS's capacity to transform hydrological and meteorological observations into actionable water resources information. This includes investments in the reporting framework (including use of common standards) for hydrological status and outlooks information and human capacities to develop and operate it.

2.7.5 As a result of the above-mentioned issues, access to water resources assessment (WRA) information for the general public and for advanced users with proper contextualization

is missing. To develop it, integration and coordination between climate and hydrology communities of practice would be necessary. Improved water, food, energy security and public safety requires due consideration of the river basin scale, but at the moment, there is a lack of methods for blending high resolution datasets of streamflow, gauged rainfall, lake levels, soil moisture and evaporative demand at hydrologic relevant scales.

2.7.6 What is currently missing seems to be a 'catalogue' of hydrological tools describing capabilities and credible information on the fit-for-purpose nature of the tools and investments available to Member's NHSs for their adoption and use. There is also a need for capacity-building in hydrological modelling technologies and prediction systems that focus on resolving the weather and climate to hydrology problem for empowering Member states to develop decision support systems to manage water supply and demand pressures.

2.7.7 In some cases, NMHSs struggle to understand stakeholders' and users' needs due to limited communication and cooperation (connection to) these communities. Water resources management needs to be framed in well-developed planning processes at various levels and be well linked to assessment of its impacts and benefits.

Outputs:

G.1 Current and future status/assessments of water resources are available at different spatial and temporal scales and cover a large range of products, including snow, groundwater, lakes, and reservoirs

2.7.8 Increased and enhanced WRA activities performed at national scale will provide inputs to the HydroSOS at global scale. HydroSOS will be implemented in line with its implementation plan. Future water availability will be assessed on country and river basin scale to support infrastructure and development planning.

G.2 The WMO community informs high-level policy discussions at the global scale

2.7.9 Based on a concept note, format and specification of general hydrology advisory will be developed and later implemented (including building support network/structure for regular production).

G.3 Data, products and model results, at adequate spatial and temporal resolutions, are available for actionable planning and operations at the local scale

2.7.10 WMO will develop a system of GDPFS centres that produce data and information specialized to support WRA of Members, based on their requirements. Members will be provided with training materials and tools, if needed, to interpret GDPFS products for national and local applications for water resources management.

G.4 Increased national capacities to collect water-related data and transform them to useful/relevant products through capacity-building (The staff members of NMHSs understand the societal impacts of water and water resources management plans and decisions and the importance of WRAs for various stakeholders, and are well informed on the technologies available for them to best carry out their tasks and experts in those that best suit their key applications)

2.7.11 A compendium of societal, economic and ecologic relations/dependency on water/hydrological cycle will be developed based on a review of existing studies, synergizing and collating information. The community of practice for water resources assessment will support NMHSs, including support to apply available tools and products, help in selection of proper methodologies and tools for WRA by Members (including support to twinning projects between Members targeting water resources assessment and water resources management).

Training curriculum for WRA will be developed as part of the capacity development strategy of WMO. Based on curricula, courses and training materials will be developed. WRA 'manual' will be kept updated online.

Ongoing activities

2.7.12 Historically water resources have been considered at national or basin level mostly. **HydroSOS** is implemented as a critical activity in the field of assessment of water resources at global and regional levels. Its implementation will be enabled by the enhancement and implementation of **WHOS** and will be supported by continued **capacity-building in hydrology and water management**.

Assumptions and risks

2.7.13 We assume that Members will keep recognizing water management to be a critical service for nations and at the transboundary level.

Possible risks are:

- Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda.
- The post-COVID situation will change Members' priorities and limit resources for the wider implementation of HydroSOS.
- The COVID 19 pandemic is altering WMO modalities of work, with a potential impact on the efficiency of implementation of new activities due to teleworking and the impossibility of face-to-face meetings.
- Lack of alignment with other activities in the field of water (e.g. UNESCO-IHP, UNEP) leads to competition and duplication of work and funding.
- Loss of support from Members in key activities such as providing resources, data and information for shared systems.
- Lack of financial resources for the core and extrabudgetary activities of the Secretariat.

2.8 Ambition/goal: Sustainable development is supported by hydrological information

2.8.1 The availability of hydrological information does support all water–dependent sectors for optimal water resources management as well as for planning and adapting to transient environmental conditions. The majority of goals of the UN Sustainable Development Agenda have connections to water, therefore hydrological information is important for the achievement of Sustainable Development Goals (SDGs), and the monitoring and assessment of their progress.

Outcome:

Hydrological information of adequate resolution, quality and timeliness is available and is used to make informed decisions on sustainable development at all scales.

Metrics: Success in this outcome will be measured by:

- Number of Members including hydrological aspects and water budget information in their development plans at the national level;

- Number of Members reporting on SDG using reliable hydrological data and indicators.

Needs and gaps

2.8.2 When speaking about the Sustainable Development Agenda, it seems that a lack of awareness of the central role of water in the achievement of the SDGs and of the need for integrated actions prevails in the community of operational hydrologists. So far, there was no need for the creation of indicators that are monitored by hydrological services for the purpose of international SDG monitoring. In some countries, understandably, priorities are in delivering flood and drought warnings and developing capacities in these fields, while the creation of information and products to support SDG monitoring is second order priority at the moment. If such products are developed, we may face hesitation to send data to be stored somewhere else for global purposes and back-up.

Outputs:

H.1 Improved data policies and financing schemes and enhanced political arrangements to collect hydrologic data and derived products

2.8.3 Implementation of the Resolution on the WMO unified data policy will be supported by development of the reference network for hydrology and a recognition mechanism of long-term observing stations in hydrology to highlight the importance of their sustainable contribution.

H.2 Intensified national, basin, transboundary and international cooperation and activities to meet the SDGs

2.8.4 This output will be delivered by supporting the building of national, basin and transboundary partnerships for water-related SDGs through a compilation of success stories. At global level, a partnership with UN-Water, FAO and UNESCO will be established in the framework of the Water and Climate Coalition, WMO's contribution to the United Nations' SDG 6 Global Acceleration Framework, to develop a plan for hydrological data/information/products collection for support of the SDGs. For this purpose, definition of a set of parameters to monitor and support sustainable development on a long-term scale is foreseen.

H.3 Basic tools to assist Members are created, including an archive of relevant information, tools for transforming data to information, and maintenance of essential "treasury/heritage" variables to support sustainable development

2.8.5 A concept note/feasibility study will be developed to assess the possibility to develop a WMO hydrology cloud for storage of essential data of Members, for consideration of Congress and potential implementation. Sharing of data from recognized long-term observing/reference network will be supported leading to implementation of Global Basic Observing Network (GBON) and the Systematic Observations Financing Facility (SOFF) for the hydrological domain. Software tools (or cloud solutions) for computation of parameters for support of SDG, including its web presentation, will be implemented

Ongoing activities

2.8.6 **UN-Water** aims to coordinate efforts related to water agendas across UN agencies with responsibilities connected to water. **The World Water Data Initiative** of WMO aims to reply to needs of sustainable development and policy implementation in the field of water/hydrology information. While concrete tools and activities targeting sustainable development have not been fully developed yet by the WMO community, obviously the **WMO Global Hydrological Status and Outlook System (HydroSOS)** will be the central activity in this regard supported by **Hydrological data operations and management** infrastructure. There is also the necessity to improve liaison with other related UN and non-UN activities and programs (e.g. Group on Earth Observations (GEO)).

Assumptions and risks

2.8.7 We assume that the Sustainable Development Agenda will remain a key priority of the United Nations and will receive adequate support from Member states throughout its implementation. The new Unified Data policy is adopted by the Cg in 2021.

Possible risks are:

- Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda in support of SDGs;
- The COVID 19 pandemic is altering WMO modalities of work, with a potential impact on the efficiency of implementation of new activities due to teleworking and the impossibility of face-to-face meetings, delaying development of new activities;
- Lack of alignment with other activities on SDG implementation related to water (UN-Water, UNESCO-IHP, etc.) leads to competition and duplication of work and funding;
- Loss of support from Members for developing new activities (including HydroSOS, GBON, SOFF etc.) by providing resources, data and information for shared systems;
- Lack of expertise mobilized by Members for the WMO Expert Network to deliver on planned activities given the fact that SDG support is not a common responsibility of NHSs;
- Lack of financial resources for the core and extrabudgetary activities of the Secretariat.

2.9 Ambition/goal: Water quality is known

"Without water quality information, the decisions made on the use of the water resource will be partial and biased".
José Alberto Zúñiga, consultation on needs and gaps.

2.9.1 Water quality is an integral part of the water cycle. The monitoring of surface and groundwater quality is a necessary condition for the basic requirements of society and ecosystems, and the possibility to adopt timely corrective solution whenever needed.

Outcome:

Increased cooperation at the national, regional and global level on water quality monitoring and water quality data exchange.

Metrics: Success in this outcome will be measured by:

- Number of Members running water quality monitoring programmes, performing water quality assessments and sharing their data.

Needs and gaps:

2.9.2 The main gap in this area is the limited awareness of society and politicians of the need for water quality assessments resulting in limited financial resources for this field and the lack of a coordinated and integrated monitoring programme in water quality in some Member Countries. Water quality monitoring is technically and financially demanding and in many parts of the World it has not become a priority due to limited resources. This might be connected to a missing or limited understanding of the principles of IWRM and of the interconnection of all water-related processes at decision-making level as well at the level of relevant institutions.

2.9.3 It is often a different authority, other than the Hydrological Service, that bears responsibility for water quality (and related health issues). In some cases, functional partnerships of responsible organizations at national/regional level have not been established yet. In the past, there has been a lack of impetus of the majority of hydrological services to start their involvement in water quality monitoring, resulting in limited coordination between quantity and quality monitoring networks and separate assessments of quality and quantity aspects of water.

2.9.4 At WMO, water quality has not been given the priority it deserves so far, mostly due to a lack of demand from Members' NHS. While basic cooperation with UNEP, UNESCO-IHP, UNECE and World Health Organization (WHO) exists, NHSs have limited knowledge of programmes and activities from outside of WMO (such as the Global Environmental Monitoring System (GEMS)). In addition, development projects are usually not designed to address the solution of joint quantity-quality complex issues. A need to cooperate with existing water quality activities at global level, in particular with UNEP GEMS, is well recognized. At the same time, there are no internationally agreed standards for exchanging water quality sampling data and sharing of water quality data is limited – likely also due to the variety of responsibilities distributions at national scale in the field of water quality.

2.9.5 As a consequence, it seems that the scarcity of water quality data, even in major water bodies (surface and underground), does not allow to perform the environmental baseline studies required for Environmental Impact Assessment and Environmental Management Programmes of engineering projects etc. And finally, unavailability of water quality data limits the applicability and enforcement of relevant environmental policies and regulations of industrial/domestic effluents.

2.9.6 In addition, the lack of water quality standards (limits) for environmental water quality is limiting the effort of many Members to improve in this area. Similarly, more guidelines are demanded to help develop water quality monitoring programmes at national level differentiating between surveillance monitoring (for regulatory or enforcement purposes) and systematic monitoring of water quality (for detection of long-term changes) and to establish alarm systems for pollution accidents. All of these are important but serve different purposes and involve different stakeholders. The role of NHSs and WMO seems to be most prominent in systematic monitoring of specific parameters.

2.9.7 On the positive side, methods of space-based observations of selected water quality parameters have developed in recent years and seem to be promising to support especially developing countries in their water quality assessment efforts. Methods for continuous monitoring of water quality parameters must be one of the main focuses for research and development in the coming years. Finally, it is recognized that sediment load demands specific attention, in particular with respect to reservoirs.

Outputs:

I.1 Partnership at the United Nations level exists and promotes the provision of water quality data from NHSs to existing information systems (such as WHOS, UNEP GEMS/Water, the UNESCO-IHP International Initiative on Water Quality (IIWQ) and the International Sediment Initiative (ISI))

2.9.8 Responsibility on Water Quality at UN level is shared between WMO, UNESCO, WHO and UNEP. Establishing a WMO-UNEP-WHO-UNESCO partnership or coordination mechanism on water quality building on the World Water Quality Alliance is a key to enhance availability of water quality information at global level and increase the effectivity of development activities through a joint work plan. Existing systems (WHOS, GEMS, IIWQ) need to be interconnected to share and exchange data in standardized formats and procedures.

I.2 Increased NHS involvement in the co-production of water quality related data and products thanks to promotion of IWRM principles

2.9.9 Not all NHSs hold responsibilities in the field of water quality currently, but water quality aspects are becoming more important in the frame of national policies and the SDGs and thus monitoring, and assessment systems are being developed by Members. Activities aim to support the building of partnerships for water quality at national and international basin scale, to support formulation of the National Water Quality Management Strategy, Action Plans and Monitoring Programs including data policies. Based on identified needs water quality training materials will be developed.

I.3 Increased joint water quantity and water quality assessment (monitoring and modelling) for operational management and for planning

2.9.10 A review of the state of operational monitoring, modelling and assessment of water quality at Members and basin level and its systematic update will inform other activities on needs and gaps at Members level and will help to develop joint WMO-UNEP-WHO-UNESCO strategy to increase availability of water quality assessments from Members and on international basins. A concept paper for inclusion of water quality in HydroSOS will be developed for further consideration of the WMO water community.

I.4 Water quality aspects are included in country support activities/projects in the spirit of IWRM and in cooperation with other organizations

2.9.11 Water quality determines availability of water resources just as water quantity. Both needs to be considered adequately in development projects to ensure successful enhancement of Members' abilities to manage water resources and achieve SDGs. Through the partnership with UNEP, UNESCO, WHO, and in cooperation with the United Nations Development Programme (UNDP) and the World Bank (WB) a definition of minimum requirements/checklist for water quality aspects to be included in country support activities will be developed and applied.

I.5 Partnership at the United Nations level delivers co-produced guidelines related to water quality

2.9.12 WMO-UNEP partnership will gather an expertise to develop consistent guidelines for water quality monitoring and assessment for the use of responsible authorities at the national level. Most prominently to develop and update the *Basic Documents No. 2, Technical Regulations Volume III: Hydrology* (WMO-No. 49), Annex on water quality.

Ongoing activities

2.9.13 Water quality has been an underdeveloped domain among WMO operational hydrology activities so far. While it has been partly considered within **quality management**

framework – hydrology documentation, it is obvious that much has to be done in **capacity-building in hydrology and water management**, and **hydrological data operations and management** needs to be accommodated to include water quality information processing. There's a great potential to benefit from **the Global Hydrometry Support Facility (HydroHub)** infrastructure and mechanisms to help develop non-expensive water quality monitoring programmes of Members where these are not in place yet.

Assumptions and risks

2.9.14 The proposed activities and outputs are based on the basic assumption that relevant partners (UNEP, UNESCO, WHO, UNDP, WB) will join WMO in these activities, aiming for the same goals and providing the necessary resources. Additionally, there is the assumption that there will be an increased demand from Members for water quality related actions from WMO. In particular, Members with no systematic programmes for water quality monitoring and assessment will aim to develop and maintain these programmes as a priority and will contribute to the achievement of SDGs.

Possible risks are:

- The global COVID-19 pandemic represents an imminent risk of failing to achieve all outputs. The post-pandemic economic situation might further limit the development of relatively expensive measures in water quality due to a decrease with respect to the resources available and a potential shift in priorities at the national and global level to recovery from the pandemic.

- Limited resources might limit both the demand from Members, as well as the capacity of the United Nations system to react.

- An additional risk would be the failure of Members to mobilize the expertise required for the WMO Expert Network to deliver on planned activities. Given the fact that water quality is not always the responsibility of NHSs, experts are often located outside of NMHSs, and it might be difficult to approach them and to encourage them to contribute.

3. PARTNERSHIPS

Successful achievement of the Long-Term Ambitions and implementation of enhanced services will require partnerships to:

(a) Foster collaboration for sustainable, improved, tailored and affordable hydrological services;

(b) Strengthen the capacities of National Hydrological and Hydrometeorological Services;

(c) Support regional and transboundary initiatives and approaches that optimize basin-wide water management, including hydrological data exchange;

(d) Improve the general understanding of the societal benefits of hydrological services;

(e) Assist in responding to the requirements of international processes;

(f) Stimulate the establishment of partnerships at global, regional, national, and local level including partners from academia, public, and private sectors to enhance monitoring and use of data and products.

4. WAY FORWARD

Monitoring and assessment of the Action Plan implementation

4.1 The monitoring and assessment of the Action Plan implementation will be done by the Hydrological Coordination Panel based on inputs and monitoring of progress of work plan of Technical Commissions, Research Board, Regional Associations and other implementing bodies and by assessment of defined milestones and success criteria for all activities, outputs and outcomes. Report on progress will be produced biannually for consideration of EC and Congress (CG)/Hydrological Assembly.

Review of the Action Plan

4.2 Based on the monitoring and assessment, the Hydrological Coordination Panel will develop in coordination with the Commission for Weather, Climate, Water and Related Environmental Services and Applications (SERCOM), the Commission for Observation, Infrastructures and Information Systems (INFCOM), Research Board and Regional Associations a periodic update of the Action Plan and submit it to the Hydrological Assembly for endorsement and to Cg-19 (2023) and Cg-20 (2027) for adoption.

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Annexes: 3

ANNEX I – ACTIVITY TABLES

Cross-cutting issues

Outcome	(a)	National Hydrological Services operations are sustainable and visible for societies and governments, and the benefits provided are recognized and valued;
	(b)	The financing schemes of hydrological services are improved to ensure operational sustainability and attractiveness for professional staff;
	(c)	There is increased sharing of hydrometeorological data for operational hydrology on a free and unrestricted basis across political borders;
	(d)	There is increased involvement of hydrological communities of Members in the global activities of WMO and greater consequential benefits to national scale services;
	(e)	There is increased involvement by and cooperation with private sector entities which are responsible for the hydrological operations of their own facilities and do not always share their data (e.g. hydropower).
Measure of success	(a)	Number of Members reporting through the Country Profile Database a sustainable financial (budgeting) situation for their core operations;
	(b)	Number of stations registered by Members in the reference hydrological network and sharing data;
	(c)	Number of Members providing operational and historical data and products to the WMO Hydrological Observing System (WHOS) (phase II);
	(d)	Number of experts registered in the WMO Expert Network with hydrological skills;
	(e)	Number of experts with hydrology expertise involved in the working structures of technical commissions and regional associations.

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
A.1 Increased presentation/communication and understanding of value proposition, benefits and risk analysis, and value of hydrological services to foster understanding by ministries and governments	High-level regional association forums	A.1.1	Organization of high-level forums at each regional association session to involve politicians and better describe the value and benefits provided by the NMHSs to decrease the risk of hydrometeorological disasters	1,2,3,4,5,6,7,8	1.3, 4.1, 4.2, 5.1	Number of governments represented at high-level forums (20 % of countries participated)	Regularly starting from 2021	Regional associations		Member, WB, UNDP	Regional programme, regional offices		
	Hydrological Assembly	A.1.2	Water and Climate Coalition: Presentation of the Water and Climate Leaders group in Cg-Ext.			Number of relevant high-level participants	Next Congress (Cg-19)						

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
			Present Declaration and to broaden hydrological community to participate in WMO work at Cg-Ext.										
	Creation of communication materials for NHSs to use with their governments	A.1.3	Development of easy-to-digest presentations of benchmarking and success stories demonstrating benefits of NMHSs and their services	1,2,3,4,5,6,7,8	1.3, 4.1, 4.2, 5.1	NHSs use materials for national argumentation	2023, with updates every two years	Secretariat		WB			
	Emphasize the convenience of linking flood and drought management plans to local/national development policies	A.1.4	Organization of regional seminars and other educational and practice-oriented actions	1, 2, 3,				HCP		NHSs			
	Creation of a toolkit to evaluate service quality and inclusion of self-guided benchmarking in the WMO Country Profile Database	A.1.5		1,2,3,4,5,6,7,8	1.3, 4.1, 4.2, 5.1	Analysis available in country profile database, continuously in support of strategic planning of NHSs	2023	HCP, Secretariat		NHSs		QMF-H	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	Using the Water and Climate Leaders group and the coalition to communicate effective WMO messaging to governments and ministries.	A.1.6	Proper communication materials that can be used by the coalition and at the national level	1,2,3,4,5,6,7,8	1.3, 4.1, 4.2, 5.1			Secretariat		Members governments, UN			Water and Climate coalition
Assumptions	Preventing water and hydrometeorological disasters will continue to be considered both a short-term and a long-term priority for societies.												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, decrease the involvement of politicians in the water-related agenda. • Lack of alignment with other activities in the field of water (e.g. UN-Water, UNESCO-IHP, UNEP, UNECE Water Convention) leads to competition for attention of governments and hydrological experts. • Technological innovations might change ways of delivering products and services currently provided by national hydrological services and might change the market in the field of operational hydrology												
A.2 Increased management skills of NHS managers (including middle and lower management managers) supports the effectiveness and development of NHSs	Development of a curriculum for top and middle management training	A.2.1	A basic instruction package (similar to the basic instruction package for meteorology and hydrology) should be developed regarding NHS management. This package should include a description of the skills needed in the areas of HR, operations, project management, strategy, finance, and	Cross-cutting	1.3, 4.1, 4.2,	Curriculum approved by Hydrological Assembly in 2023	2023	CDP, in cooperation with HCP		UN System Staff College, UNOG	Capacity development programme	CB, QMF-H	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
			information marketing and should be tailored to the conditions of NHSs.										
	Development of e-learning training courses for the management of NHSs	A.2.2	Development of e-learning courses to enhance the management skills of NHS staff (including in the areas of HR, operations, project management, strategy, finance, and information marketing and should be tailored to the conditions of the NHSs.	Cross-cutting	1.3, 4.1, 4.2,	Participation or at least 50 NHS representatives in the e-learning courses in 2025	2025	CDP, in cooperation with HCP		UN System Staff College, UNOG	Capacity development programme	CB, QMF-H	
	Guidance on managing NHSs	A.2.3	Basic guidance on needed management skills for NHS staff (including in the areas of HR, operations, project management, strategy, finance, information marketing and	Cross-cutting	1.3, 4.1, 4.2,	Guidance published	2025	CDP, in cooperation with HCP		UN System Staff College, UNOG	Capacity development programme	CB, QMF-H	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
			should be tailored to the conditions of the NHSs										
	Twinning projects targeted at management skills	A.2.4	Twinning projects used for knowledge transfer among Members, including management skills of the NHS staff.	Cross-cutting	1.3, 4.1, 4.2,	Number of twinning projects that include management skills training	2027	CDP, in cooperation with HCP		Members NHSs	Capacity development programme	CB, QMF-H	
	Management programme TED Talks	A.2.5	Sharing experience through videos in the TED Talks format videos explaining basic management issues of NHSs and methods to cope with them, etc.	Cross-cutting	1.3, 4.1, 4.2,	25 videos	2025	HCP		UN System Staff College, UNOG, Members NHSs		CB	
Assumptions	QMF-H remains a top priority activity supporting hydrology in WMO, and Members recognize the importance of management and governance at the institutional level.												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, decrease the involvement of politicians in the water-related agenda. NHSs do not recognize the increase of management skills to be an important factor in the operation and development of services (due to a preference for operational issues only or internal, cultural conditions and other external conditions)												

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
A.3 Enhanced regional cooperation, planning and implementation of NMHS-led activities	Hydrological activities of regional associations (e.g. Hydro Conference in RAVI) and provision of support by regional associations to other technical symposia organized at the regional level	A.3.1	Conference to promote knowledge sharing					RAs, HCP		NHSs			
Assumptions	Reform of the working structure of regional associations creates a reliable and viable platform for hydrologists to meet and cooperate on operational hydrology issues.												
Risks	• Lack of alignment with other activities in the field of water (e.g. UN-Water, UNESCO-IHP, UNEP, UNECE Water Convention) leads to competition for attention of governments and hydrological experts; • Perception of marginalization of hydrological issues in implementing the Earth system approach may arise if hydrological requirements are not considered adequately in the work of various WMO bodies.												
A.4 Enhanced customer orientation and better marketing skills generate better services and products with higher added value.	E-learning training course(s) on marketing	A.4.1	E-learning courses are developed to enhance management skills of NHS staff in marketing tailored to the conditions of NHSs	Cross-cutting	1.3, 4.1, 4.2,	Participation of at least 30 representatives of NHSs in the e-learning courses in 2025	2025	CDP, in cooperation with HCP		UN System Staff College, UNOG	Capacity development programme	CB, QMF-H	Part of the curriculum for top and middle management training

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	TED Talk format management programme on marketing and customer orientation	A.4.2	Sharing experience through TED Talk format videos targeting explaining basic marketing principles and methods to cope with them, etc.	Cross-cutting	1.3, 4.1, 4.2,	7 videos available	2025	HCP		UN System Staff College, UNOG, Members' NHSs			Part of the TED Talk format management programme
	Catalogue of case studies of product and service development as well as marketing strategies for customers and development of process/checklist, methodology to support strategic service planning of NMHSs, including catalogues of products and services in response to customer requirements	A.4.3	Demonstration of good practice in the development of customer/user-oriented products and services	Cross-cutting	1.3, 4.1, 4.2,	Catalogue made available	2025	HCP		UN System Staff College, UNOG		CB, QMF-H	
Assumptions	QMF-H remains a top priority activity supporting hydrology in WMO, and Members recognize the importance of management and governance at the institutional level.												

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, decrease the involvement of politicians in the water-related agenda. • Technological innovations might change ways of delivering products and services currently provided by national hydrological services and might change the market in the field of operational hydrology. • NHSs do not recognize the increase of management skills to be an important factor in the operation and development of services (due to a preference for operational issues only or internal, cultural conditions and other external conditions). Skills drain of NHSs to better (paid and supported) positions in private entities (e.g. water boards, water agencies, hydropower operators).												
A.5 The end users of hydrological information/data have a clear understanding of what the data means and its relative (un)certainty	Development of unified communication standards for hydrological information	A.5.1	Development of unified communication standards for hydrological information based on the definition of guidelines and regulatory material to ensure that communication is based on uptake requirements defined by end users	Cross-cutting		Guidelines available	2025	RB, SERCOM			HCP, CDP		From research strategy
Assumptions	QMF-H remains a top priority activity supporting hydrology in WMO, and Members recognize the importance of management and governance at the institutional level.												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, decrease the involvement of politicians in the water-related agenda. • Technological innovations might change ways of delivering products and services currently provided by national hydrological services and might change the market in the field of operational hydrology.												
A.6 Institution development plans and monitoring network development programmes are in place and implemented, taking into account the catalogue of	Guidance on how to write development plans for various aspects of NHS operation	A.6.1	Guidance should support enhancement of managerial capabilities within NHSs and provide general advice on strategy development	Cross-cutting	1.3, 4.1, 4.2,	Guidance published	2025	HCP		UN System Staff College, UNOG	Capacity development programme	CB, QMF-H	Part of the curriculum for top and middle management training

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
products and services			and planning tailored to the conditions of NHSs										
	E-learning training course(s) for management of NHSs	A.6.2	E-learning courses are developed to enhance the management skills of NHS staff in strategic and operational planning, project development and management.	Cross-cutting	1.3, 4.1, 4.2,	Participation of at least 30 NHS representatives in the e-learning course in 2025	2025	CDP, in cooperation with HCP		UN System Staff College, UNOG	Capacity development programme	CB, QMF-H	Part of the curriculum for top and middle management training
	NHS providers have the tools to plan and construct hydrological networks that can grow/adapt as needs and resources change	A.6.3	Delivered by targeted research, guidelines on hydrological monitoring network design, implementation and maintenance are available.	Cross-cutting		Guidelines published	2024	RB, INFCOM		UNESCO-IHP, IAHS, IAHR	HCP, HydroHub	CB, QMF-H	From research strategy
Assumptions	QMF-H remains a top priority activity supporting hydrology in WMO, and Members recognize the importance of management and governance at the institutional level.												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, decrease the involvement of politicians in the water-related agenda. Technological innovations might change ways of delivering products and services currently provided by national hydrological services and change the market in the field of operational hydrology.												

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
A.7 Enhanced resource mobilization (increased expertise, financial resources, establishment of partnerships) for capacity-building, technical assistance, training of personnel and sustainability of E2E MHEWS, flood, drought and water resources management	Project proposals development support	A.7.1	Put in place a framework mechanism to sponsor development initiatives through Project Proposal development and provision of Reimbursable Advisory Services through e.g. the IFM Helpdesk			Number of projects developed	Review of progress by 2025	Secretariat, HCP		WB, UNDP, UNECE, EU, USAid, GWP	APFM		
Assumptions	Preventing water and hydrometeorological disasters will continue to be considered both a short-term and a long-term priority for societies.												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, decrease the involvement of politicians in the water-related agenda.												
A.8 Sustainable projects helps build capacities of NHSs	Capacity development project are coordinated to support achievement of long-term ambitions and sustainability	A.8.1	SOFF supports hydrological development projects	cross-cutting	1.3, 4.1, 4.2,	Number of projects financed through SOFF that target floods, drought and water resources management	Review at 2025	SOFF	SOFF	NHSs		HDOM	
	Support of local production of monitoring equipment to enhance maintenance	A.8.2	HydroHUB supports development of locally producible low-cost instruments	cross-cutting	1.3, 4.1, 4.2,	Number of projects finalized in frame of the HydroHub	Review at 2025	INFCOM (HydroHub)		Private companies, HRC	HCP	HDOM	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	availability and reduce cost.												
	Support to twining projects between national hydrological services	A.8.3		Cross-cutting		Number of twinning projects reported from Members	Review at 2025	RAs, HCP		NHSs			
Assumptions	Preventing water and hydrometeorological disasters will continue to be considered both a short-term and a long-term priority for societies.												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, decrease the involvement of politicians in the water-related agenda.												
A.9 Effective and efficient, low-cost methods for hydrological observations are broadly available	Guidance on how to amplify the information through citizen science, proxy data, and innovation.	A.9.1		Cross-cutting		Guidance published	2025	RB, INFCOM		UNESCO-IHP, IAHS, IAHR	RAs, HCP, HydroHub	GHSF	
	HydroHub Innovation hub will stimulate the development and deployment of low-cost technologies for hydrometric monitoring.	A.9.2	HydroHub Innovation Platform	cross-cutting		Number of HudroHub innovation calls that are successfully implemented at the site	Regular review at each Cg/HA	INFCOM, RB		IAHS, IAHR	RAs, HCP, HydroHub	GHSF	Explore potential for 3D printing of equipment, etc.
Assumptions	Preventing water and hydrometeorological disasters will continue to be considered both a short-term and long-term priority for societies.												
Risks	• Replacement of technology of long-term observing stations may cause inhomogeneity in time series.												

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
A.10 Increased involvement and enhanced cooperation with the private sector supports Members' flood, drought and water resources management	Compilation of success stories on mutually beneficial cooperation in the field of hydrology	A.10.1	Examples to describe functional data sharing models and co-production of services with socioeconomic assessments of generated benefits	Cross-cutting		Compilation presented on the web page of the WMO and used in training materials	2024	HCP		NHSs, RAs	PWS	QMF-H	
	Invitation of private sector partners to meetings and sessions such as RA Hydrological Forum, RA session, etc. to share knowledge	A.10.2		Cross-cutting		Number of private partners participating in RAs activities	2025	RAs		Private sector	HCP	QMF-H	
Assumptions	Private companies will further cooperate with WMO Members in the spirit of the WMO new unified data policy.												
Risks	• Differing interests of private and public partners causes asymmetry in cooperation												
A.11 Increased availability and national and international exchange and use of hydrometeorological data for operational flood forecasting and early warning purposes and enhanced international cooperation in flood	Basic observation network – hydrology and cryosphere established	A.11.1	In the spirit of (and to support) Resolution 42 and its implementation, a network of reference observations is established from which Members commit	1,2,3		At least 50 members with their stations registered with the network by 2024	Concept note: 2022, implementation plan: 2023, update of Tech Regs vol III: 2023	INFCOM		UNESCO, EU (Copernicus UNEP)	GBON, GRDC, IGRAC, HYDRO-LARE, GEMS, WWDI	HDOM	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
and water resources management, especially for transboundary basins			themselves to mandatory sharing of data – GBON hydrology and cryosphere data (snowmelt floods, ice related flood risks)										
	WHOS – operational data exchange	A.11.2	Development of WHOS as the common platform for international sharing of operational data among Members.	1,2,3		At least 50 Members providing operational data through WHOS by 2025	2025 for review	INFCOM				HDOM	
	Increased additional voluntary data sharing, including forecast products and satellite data/products; availability for flood forecasting	A.11.3	"Resolution 42" promotion in hydrology for forecast products. Further development of transboundary policy issues (Legal Paper on IFM, transboundary flood risk management). Demonstration project in selected basins built using WHOS.	1		Number of Members sharing additional data		INFCOM, SERCOM, RAs		UNECE Water Convention	HCP	HDOM	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	Statement on network design with respect to flood forecasting and management	A.11.4	Easy to understand advice on how to best design a network for flood forecasting and warning purposes (location of gauges, reporting frequency, etc.)			Statement presented	2023	INFCOM, SERCOM			HCP	QMF-H, HDOM	
Assumptions	Resolution 42 on data policy will be adopted by Cg-2021. Members support the development, maintenance and sustainability of hydrological networks, including near-real time data transmission.												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, decrease the involvement of politicians in the water-related agenda. • Differing interests of private and public partners cause asymmetry in cooperation.												
A.12 The operational hydrology community at the national scale knows how to access global and regional products, services and tools and actively participates in the activities of	Entry point up to date; catalogue/directory available	A.12.1	Catalogue provides information and describes where to find relevant information and products generated by WMO and its community for use by NHSs	Cross-cutting		Catalogue available and up to date by 2023		INFCOM, SERCOM, HCP, RAs				HDOM	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
the WMO community.	Motivation, benefits clearly described and understood	A.12.2		Cross-cutting		More representatives of NHSs participate in WMO intergovernmental sessions		INFCOM, SERCOM, HCP, RAs					
Assumptions	Preventing water and hydrometeorological disasters will continue to be considered both a short-term and a long-term priority for societies.												
Risks	Lack of alignment with other activities in the field of water (e.g. UN-Water, United Nations Educational, Scientific and Cultural Organization -Intergovernmental Hydrological Programme (UNESCO-IHP), the United Nations Environment Programme (UNEP), the United Nations Economic Commission for Europe (UNECE) Water Convention) leads to competition for the attention of governments.												

Ambition/goal: No one is surprised by a flood

Outcome	(a)	Impact-based end-to-end Early Warning Systems (EWS) for flood forecasting in the context of a broader integrated flood management strategy implemented by Members;
	(b)	Public, communities and businesses have enhanced access to and better capacity to react to official national flood forecasts and warnings locally and globally.
Measure of success	(a)	Number of Members having the Multi-hazard Early Warning System set up for floods;
	(b)	Number of Members providing their flood warnings using the Common Alert Protocol (CAP) to be integrated into the Global Multi-hazard Alert System (GMAS) (at least 50% of Members doing so).

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	linkages	MOA	Comments
B.1 Enhanced coordination, effective-ness and governance of all WMO activities in supporting Members in with respect to Flood Risk Assessment and Flood Forecasting and Warning	FFI-AG reinforced coordination mechanisms of activities for Flood Risk Assessment, Forecasting and Warning across WMO, as well as in collaboration with international actors	B.1.1	To streamline ongoing hydrological programmes and initiatives, ensuring coherence and consistency, alignment to the plan, effectiveness and efficient use of resources, and support for the international agenda for DRR, establishing new coordination mechanisms	1	1.1, 1.3, 3.1, 3.2, 4.3, 5.1,5.2	Report presented regularly to EC FFI workplan fulfilled.	2023	SERCOM	Budget needed for at least one face-to-face meeting per intersessional period	See Annex to Res. 3 (EC-72), IFI, UNDRR, UNEP, UNECE, UNESCO, regional organizations	SC-HYD. SC-DRR. RHAs RB	FFI	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	linkages	MOA	Comments
	Establish effective joint planning and implementation mechanisms with major partners and activities (IFI, UNDRR, UNEP….)	B.1.2	Better coordination of UN flood related activities brings more effective delivery on flood risk assessment and forecasting around the globe.	1	1.1, 1.3, 3.1, 3.2, 4.3, 5.1,5.2			SERCOM via FFI		IFI, UNDRR, UNEP, UNECE, UNESCO, regional organizations, UN-WATER	RAs, RB	FFI	
	Establish guiding principles and agreements with the private sector to support flood related early warnings and risk management	B.1.3	The private sector could offer technologies such as AI or cell phone applications, social network analysis, to enhance services in flood forecasting. Searching for opportunities for cooperation via agreements and pilot projects.	1				SERCOM		Private sector, NMHSs		FFI	
Assumptions	Preventing water and hydrometeorological disasters will continue to be considered both a short-term and a long-term priority for societies.												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in changes in priorities in the DRR agenda and decreased involvement in the water-related agenda. • Lack of alignment with other initiatives (including data and products portals) in the field of water (e.g. UN-Water, UNESCO-IHP, UNEP, EU-Copernicus etc.) leads to competition for the attention of governments. Technological innovations might change ways of delivering products and services currently provided by national hydrological services.												
B.2 A framework is developed for the evaluation of gaps and needs of national flood forecasting and	Assessment Guidelines web-based tool and community	B.2.1	Further development and implementation of the assessment guidelines as a tool for self-	1	1.3	Web tool available on the WMO website; assessment teams available	2023	SC-HYD (to finalize the Assessment Guidelines), Secretariat (to manage requests and	Resources to respond to the Members' requests will have to be mobilized/allocated on a case-by-case	Experts of TCs, Support Base Partners	Checklist for MHEWS	FFI	Members' gaps and needs will also be identified through the Hydro Assembly and the RA

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	linkages	MOA	Comments
early warning systems			assessment (or assessment by expert teams through WMO) to identify capabilities and needs regarding national capabilities to deliver flood forecasting services and warnings; implementation of a web-based tool based on simplified assessment guidelines to identify national capabilities and needs			for deployment once request received through the Helpdesk; repository of assessed NMHSs.		coordinate the requested expertise)	basis. Possibility to provide RAS (reimbursable advisory services) for the implementation of assessments				Hydrological Forums
Assumptions	Preventing water and hydrometeorological disasters will continue to be considered both a short-term and a long-term priority for societies.												
Risks	None												
B.3 Increased exchange of knowledge and technical expertise in flood forecasting among Members	Community of Practice on End-to-End Early Warning Systems for Flood Forecasting, including guidance on emerging technologies and services for data acquisition and analysis	B.3.1	Developing mechanisms on implementing recommended practices via a team of experts to support knowledge exchange. This will be complemented by a repository of capacity-building materials	1				SERCOM	Technical platform for the Community of Practice (webpage, discussion forums, wiki, social network), training materials and targeted workshops	UCAR		FFI	Guidance on, e.g. selection of hydrological/hydraulic models, developing holistic flood intelligence systems, selection and appropriate use of different weather products, ensemble flood prediction

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	linkages	MOA	Comments
			(guidance, e-learning), including those relating to the role of the new technologies intended to address geographical constraints or insufficient local resources.										methods and verification, network design with respect to flood forecasting and management; development of global hydrological characteristics usable to derive parameters of hydrological models.
Assumptions	Preventing water and hydrometeorological disasters will continue to be considered both a short-term and a long-term priority for societies.												
Risks	In the case of the Community of Practice, insufficient contributions from Members and competition from other communities of practices outside WMO for resources (mostly human).												
B.4 Enhanced collaboration among NHSs, NMSs and other organizations (e.g. DRR authorities) at the national level to develop and operate E2E MHEWS, particularly with respect to floods	Inclusion of the needs and requirements of different stakeholders (energy, water, food), moving towards an MHEWS approach (e.g. with the integration of FFGS/CIFI/SWFP) for the possible future integration of hydrology in GMAS (including the application of CAP (see B.8) and reflecting hydrological hazards in the catalogue of hazardous events)	B.4.1	Compilation of success stories for collaboration among NMHSs and DRR authorities Creation of incentives to work together and share data/information and services	1		Compilation of success stories available	2025	SERCOM		Members	Links to FFI in terms of improved cooperation among NHSs and NMSs	FFI	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	linkages	MOA	Comments
	Support to humanitarian organizations for real time risk assessments	B.4.2	Contribution to GMAS related to flood hazards relevant for humanitarian activities around the world			Number of flood events interpreted for humanitarian activities through GMAS	2025	SERCOM		UNHCR	GMAS	FFI	
Assumptions	Preventing water and hydrometeorological disasters will continue to be considered both a short-term and a long-term priority for societies.												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in changes in priorities in the DRR agenda and a decreased consideration of water-related disasters in the DRR agenda. • Lack of alignment with other initiatives (including data and products portals) in the field of water (e.g. UN-Water, UNESCO-IHP, UNEP, EU-Copernicus etc.) leads to competition for the attention of governments. • Technological innovations might change ways of delivering products and services currently provided by national hydrological services.												
B.5 Increased availability and international exchange of hydrometeorological data for operational flood forecasting and early warning purposes and enhanced international cooperation in flood management, especially for transboundary basins on a free and unrestricted basis.	See cross-cutting issues	B.5	See cross-cutting issues, points A.10.1, A.10.2, A.10.3, A.10.4										Will be considered in the context of the Earth system approach

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	linkages	MOA	Comments
B.6 Enhanced resource mobilization (increased expertise, financial resources, establishment of partnerships) for capacity-building, technical assistance, training of personnel and sustainability of E2E MHEWS	Development support of project proposals	B.6.1.	See A.7.1			Number of projects developed with the support of WMO	Review in 2023 and 2027	Secretariat	Secretariat staff	UNDP, WB, UNECE, FAO	HCP, APFM, IDMP	FFI	
B.7 Flood related data and products with global and regional coverage are available for use at the national scale by Members	GDPFS – development of hydrological centres, including regional forecasting centres/systems	B.7.1	Establishment of RSMC centres which include, among their functionalities, the issuing of operational flood forecasting to support Members with global and regional products and verification.	1		At least 2 specialized centres operational by 2024	2024	SERCOM, INFCOM		Members, RSMC	GDPFS, HydroSOS, RCOFS, FFGS	HDOM	
	Creation of an inventory of worldwide and regional free and public data and products for flood forecasting and an inventory of international interoperable models and platforms	B.7.2	Development of an update the inventory of state of the art tools that are freely available for use in flood forecasting or products that might be used at the national and local scale to support flood forecasting activities (such	1		Inventory accessible for NHSs	2025	SERCOM		Members, academia	GDPFS, RCOFS, NMHSs	HDMO	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	linkages	MOA	Comments
			as DEWETRA, Glofas, efas, DHI-UNEP, Sustainable FFGS) as an entry reference page										
Assumptions	Preventing water and hydrometeorological disasters will continue to be considered both a short-term and a long-term priority for societies.												
Risks	• Lack of candidates to become centres operating under GDPFS rules and development of centres outside the umbrella of GDPFS (including in the private sector), which undermines the idea of GDPFS, as well as a lack of acceptance of the GDPFS hydrology structure by NHSs.												
B.8 Increase in Members' capacities to deliver and communicate information to the public and to raise awareness (to enable action in response to warnings)	Collection of success stories, challenges and needs	B.8.1	Inclusion of case studies on CAP application to hydrological hazards, showcasing good ways to communicate uncertainties to authorities and the public	1		Document published	2025	SERCO, INFCOM		UNDRR, Meteo-ALARM (EUMETNET), NMHSs	Public weather services programme, GMAS	FFI	
	Guidelines on flood risk assessment/mapping and "Impact-Based Forecasting"	B.8.2	Better understanding of flood hazards and flood risks and their changes within the year, season, day, as well as long-term trends based on concepts used, e.g. EU Floods Directive, etc.	1		Document published	2025	SERCOM		UNDRR, EU	PWS	FFI	

	Enhanced national consultations/communication between forecasters and users	B.8.3	(i) Guidelines based on good practices developed and implemented (ii) Compilation of a list of requirements from users and their decisions/expectations and how to research on these (guide) (iii) Catalogue of case studies of products and service development as well as marketing strategies for customers and development of processes/check lists, methodology to support strategic service planning of NMHSs, including a catalogue of products and services in response to customer requirements, including: raising awareness regarding flood risk management (follow up from previous APFM activities, such as Capacity-Building in Flood Management)	1		Documents published	2025	SERCOM				FFI	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	linkages	MOA	Comments
	Guidelines for harmonizing information and products that are used to communicate forecasting results and related risks	B.8.4		1		Guidelines published	2025	SERCOMINFCOM	RB, RAs	UNDRR, OGC, academia	APFM, FFI	FFI	
Assumptions	Preventing water and hydrometeorological disasters will continue to be considered both a short-term and a long-term priority for societies.												
Risks	None												
B.9 Increased application of integrated flood risk management principles in flood prevention, preparedness and response by Members and regions (basin authorities).	APFM capacity-building	B.9.1	Capacity-building activities in flood forecasting and integrated flood management	1		Indication by Members of their satisfaction; number of helpdesks satisfied		APFM	Support to APFM technical unit	GWP	APFM	FFI	
Assumptions	Preventing water and hydrometeorological disasters will continue to be considered both a short-term and a long-term priority for societies.												
Risks	Lack of financial resources for core activities of the Secretariat.												

Ambition/goal: Everyone is prepared for drought

Outcome	(a)	Members reduce adverse impacts of drought at all levels by implementing integrated drought management systems, including drought monitoring**, early warnings, vulnerability and impact assessments, and drought mitigation, preparedness and response measures.**
Measure of success	(a)	Number of Members providing their drought preparedness, monitoring and assessment products and services that include the water resources (hydrological) component, making them available through the WMO infrastructure (Regional Climate Outlook Forums (RCOFs), GMAS, the Global Hydrological Status and Outlook System (HydroSOS)).

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
C.1 Enhanced coordination, effectiveness and governance of all WMO activities to support Members with respect to integrated drought management	Streamline ongoing activities on droughts across WMO constituent and subsidiary bodies, ensuring coherence, consistency, and efficient use of resources.	C.1.1		2, 3	5.1	Map of activities with potential overlaps identified	2022	SERCOM, INFCOM		GWP, FAO, UNESCO	IDMP,	FFI-DRR	
	Ensure that IDMP continues providing a technical resource for drought management through a Community of Practice and a helpdesk providing: (i) expert advice and exchange of experiences (Joint Technical Support Unit of GWP and WMO), (ii) guidelines and tools, (iii) project preparation support, (iv) capacity development	C.1.2		2, 3	5.1	Indication by Members of their satisfaction; number of helpdesks satisfied	Continuous, review on biannual basis	SERCOM (SC-HYD, SC-AGR, etc.)		GWP		FFI-DRR	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	Establish effective joint planning and implementation mechanisms with major partners and activities (IDI, UNDRR, FAO, UNCCD, IFAD, European Commission, etc.)	C.1.3	Better coordination of UN drought-related activities brings more effective delivery on drought monitoring and EWS and forecasting around the globe.	2,3	5.1	Joint plans available for drought actions		SERCOM		IDI, UNDRR, UNCCD, FAO, IFAD, European Commission	RAs	FFI-DRR	
	Establish guiding principles and agreements with the private sector to support drought-related early warning and risk management measures	C.1.4	The private sector could offer technologies such as AI or cell phone applications to enhance services in flood forecasting. Searching for opportunities for cooperation via agreements and pilot projects.	2,3	5.1	Number of joint collaboration projects/activities		SERCOM		I Private sector, NMHSs	RAs	FFI-DRR	
Assumptions	Integrated drought management is a priority at the national level for Members												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda. • The COVID 19 pandemic is altering WMO modalities of work, with a potential impact on efficiency due to teleworking and the impossibility of face-to-face meetings. • Lack of alignment with other activities in the field of water (e.g. UNESCO-IHP, FAO) leads to competition and duplication of work and funding. Lack of financial resources for the core activities of the Secretariat.												
C.2 Drought-related data and products with global and regional coverage are available for use at the national scale by Members	(i) Identification of requirements on globally/regionally produced information for use in drought assessment, modelling and prediction at the national scale by NHSs, and	C.2.1	The identification of requirements includes, at a minimum, an indication of the data required, their temporal and spatial resolution, latency, formats, and	2, 3	2.1, 1.1., 1.2, 4.1	Requirements known and reflected to GDPFS manual	2023	INFCOM				IDMP	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	(ii) Development of an interface for NHSs to search, use and interpret the products.		transfer/access mechanisms.										
	Establishment of global centres on drought within GDPFS and training of NMHSs to process and apply the information to the local context	C.2.2	Global centres must have the capacity to regularly produce/make available the required data and products. NMHSs need the capability and tools/methodology to apply global/regional info effectively	2, 3	2.3, 1.1, 1.3	Number of drought centres in GDPFS supporting Members with hydrologically relevant products	2025	INFCOM, SERCOM			Activity 1 (outcome 7 on GDPFS)	IDMP	
	Operational guidance and tools for verification of available products	C.2.3	Guidelines / training materials / tools for interpretation for using products of GDPFS drought centres are available together with a tool and guidance how to verify derived products at National/local scale.	2	2.3, 1.1., 1.3, 3.2	Guidelines published	2025	INFCOM, SERCOM				IDMP	
Assumptions	Integrated drought management is a priority at the national level for Members.												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda. • The COVID 19 pandemic is altering WMO modalities of work, with a potential impact on efficiency due to teleworking and the impossibility of face-to-face meetings. • Lack of candidates to become centres operating under GDPFS rules and development of centres outside the umbrella of GDPFS (including in private sector), which undermines the idea of GDPFS as well as a lack of acceptance of the GDPFS hydrology structure by NHSs.												
C.3 Gaps in Members' capabilities with respect to drought assessment,	Development of a checklist to enable current capacities to be reviewed by experts	C.3.1	Inspired by MHEWS checklist and Sendai monitoring evaluation of Global Target G	2	4.1	Checklist online	2024	SERCOM		GWP, FAO, UNDRR, UNESCO-IHP		FFI-DRR	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
monitoring, modelling and prediction are known													
	Development of a framework for the evaluation of gaps and needs with respect to national drought forecasting and early warning systems	C.3.2	Provision of guidance on how to make use of the framework in order to perform the evaluation. Establishment of a repository of assessed NMHSs.	2	4.1	Framework approved at SERCOM	2024	SERCOM		GWP, FAO	Country profile database	FFI-DRR	
	Incorporate specialized forecasting abilities for relevant sectors such as agriculture, inland navigation (forecast of the depth of water in navigable rivers), energy, health, etc.	C.3.3	Review of available and reliable methodologies to be used for specialized applications of seasonal forecasts as an initial step before deciding on further actions.	2, 3, 6	1.3, 1.2	Number of applications for sectors	2027	SERCOM		Stakeholders, Members	SG-ENE, SG-HEA, SC-AGR,, SG-CRYO	Hydro SOS	
Assumptions	Integrated drought management is a priority at the national level for Members												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda. • The COVID 19 pandemic is altering WMO modalities of work, with a potential impact on efficiency due to teleworking and the impossibility of face-to-face meetings.												
C.4 The need for an effective national drought policy is understood by Members	Support Members in the development of proactive drought impact mitigation, preventive and planning measures and risk management measures including possible organization of HMNDP+10	C.4.1	Good examples of national drought policies and plans are compiled in cooperation with partners (FAO, UNESCO, UNCCD, UNDRR) and communicated to policy makers – e.g. via side meetings on droughts at high-level meetings, such as COP or the Global Platform for DRR	2	4.1, 4.2, 1.2, 1.3	SERCOM, Secretariat	2025	SERCOM		GWP, FAO, UNCCD, UNDRR, UNESCO-IHP		FFI-DRR	
	Help increase public awareness of drought	C.4.2	Making available examples/templates of	2	1.3, 1.2,	Toolkit available	2025	SERCOM		GWP, FAO,		FFI-DRR	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	risk and preparedness issues		communication materials (toolkit)		1.4	in English				UNDRR, UNESCO-IHP			
	Demonstrate the convenience of linking drought management plans to local/national development policies	C.4.3	Compilation of success stories	2	1.2	Compilation published	2025	SERCOM		GWP, FAO, UNDRR, UNESCO-IHP		FFI-DRR	
Assumptions	Integrated drought management is a priority at the national level for Members												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda.												
C.5 Training to increase the capacities of Members in drought management (drought monitoring, modelling and early warnings, drought vulnerability and impact assessments, and drought adaptation, mitigation, preparedness and response measures)	Capacity-building activities organized through IDMP, including curricula and training material based on needs identification, developed to enhance Members' drought management capacities and capabilities	C.5.1	Training materials are to be included for: (i) drought monitoring, modelling and early warnings, (ii) drought vulnerability and impact assessments, and (iii) drought adaptation, mitigation, preparedness and response measures	2,3	4.1, 4.2	Curricula developed	2023	CDP, SERCOM		GWP, UNESCO-IHP, FAO	IDMP	Capacity Development	
	Training materials based on curricula developed to support Members	C.5.2	Training materials (e-learning) are to be included for: (i) drought monitoring, modelling and early warnings, (ii) drought vulnerability and impact assessments, and (iii) drought adaptation, mitigation, preparedness and response measures (iv) food production industry support	2,3	4.2, 4.1	Number of e-learning courses, Number of participants	2025, 2027	CDP, SERCOM		GWP, UNESCO-IHP, FAO	IDMP	Capacity Development	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	Twinning projects in user-driven product development	C.5.3		2,3	4.2, 4.1	Number of twinning projects reported	2027	RAs		Members			
C.6 Increased capacities of Members through development projects in the areas of drought monitoring, early warnings, vulnerability and impact assessments, adaptation and mitigation, and preparedness and response measures	See A.6	C.6											
Assumptions	Integrated drought management is a priority at the national level for Members												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda. • The COVID 19 pandemic is altering WMO modalities of work, with a potential impact on efficiency due to teleworking and the impossibility of face-to-face meetings.												
C.7 Increased cooperation (and co-production of services) among the hydrological, meteorological and climatological communities and international exchange of experiences (e.g. increased involvement of hydrologists in climate outlook forums,	Widen the implementation of a water segment in the creation of Regional Outlook Forums (ROFs) based on the successful experience of RCOFs with the water segment in Central America	C.7.1		2, 3	1.3, 1.2	Number of ROFs with hydrology	2025	RAs, SERCOM		GWP, FAO, Members	RAs, SERCOM	Hydro SOS, HDOM	
	Regular (annual/seasonal/monthly) RA statements on water resources	C.7.2		2, 3	1.3, 1.2	Number of RAs producing statements	2025	RAs		Members, FAO, GWP	RCOFs, RCCs,	Hydro SOS, HDOM	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
increased involvement of meteorologists and climatologists in river basin commissions)													
Assumptions	Integrated drought management is a priority at the national level for Members												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda. • The COVID 19 pandemic is altering WMO modalities of work, with a potential impact on efficiency due to teleworking and the impossibility of face-to-face meetings.												
C.8 Increased Members capabilities in drought vulnerability of, and impact assessment on, different sectors by meaningful drought indicators and indices used at all relevant scales.	Development of Global Drought Classification System and guidance on drought indicators, including water scarcity and other hydrological indicators – regional/national/basin indicators to be developed	C.8.1		2, 3, 6	1.3, 1.2	Drought indicators for hydrological drought approved by SERCOM	2025	SERCOM		GWP, FAO	RCOFs, RCCs	FFI-DRR, SC-AGR, IDMP	
	Development of guidelines on harmonizing drought early warning and risk information for end user communication including decision-making support to the relevant authorities	C.8.2	How to best communicate drought information in a form to enable informed decision-making, including advice to authorities on setting decision criteria and systems (including the use of other types of data and information on water demand and impacts from the local level)	2, 3	1.1, 1.2, 1.3	Guidelines published	2025	SERCOM		GWP, UNDRR, FAO	RCOFs, RCCs	FFI-DRR SC-AGR. IDMP	
Assumptions	Integrated drought management is a priority at the national level for Members												
Risks	The COVID 19 pandemic is altering WMO modalities of work, with a potential impact on efficiency due to teleworking and the impossibility of face-to-face meetings.												

Ambition/goal: Hydroclimate and meteorological data support the food security agenda

Outcomes	(a)	Food security is enhanced by informed end users' decisions at all levels from regional to local;
	(b)	The concept of integrated water resources management, including water use and allocations supporting food production, is widely accepted and followed.
Measure of Success	(a)	Decreased number and magnitude of famine/hunger emergencies due to drought and water scarcity (in 2021–2030 relative to 2001–2020);
	(b)	Number of members monitoring and accounting for water consumption in their water budgets at the basin scale.

Output	**Activity**	**ID**	**Description**	**LTA**	**SOP**	**Success criteria**	**Time frame**	**Responsibility**	**Resources**	**Partners**	**linkages**	**MOA**	**Comments**
D.1 Increased production and/or availability of agrometeorological and hydrological forecasts from sub-seasonal to seasonal	Provide methodology and tools to interpret HydroSOS data and information for agricultural applications (snow, ice soil moisture, groundwater, irrigation, water storage, etc.)	D.1.1		2, 3, 6	1.3, 1.2	Guidelines /advice on interpreting hydrological data and outlooks for agriculture	2024	SERCOM, INFCOM			Link to output 5 above	Hydro SOS SC-AGR	
Assumptions	Food security remains a priority at the national level for Members.												
Risks	• The COVID-19 pandemic is altering WMO modalities of work, with a potential impact on efficiency due to teleworking and the impossibility of face-to-face meetings.												
D.2 Effective dialogue between users and providers established	National consultations between forecasters and users in the agricultural sector:	D.2.1		2, 3, 6	1.3, 1.2	Guidelines published	2025	SERCOM		FAO	IDMP	FFI-DRR, Hydro SOS,	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	linkages	MOA	Comments
	(i) guidelines based on good practices developed and implemented (ii) compilation of list of requirements from users and their decisions/expectations and how to research these (guide) (iii) catalogue of case studies of product and service development as well as marketing strategies for customers and development of processes/checklists, methodology to support strategic service planning of NMHSs, including catalogue of products and services in response to customer requirements											SC-AGR	
Assumptions	Food security remains a priority at the national level for Members.												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda. • The COVID-19 pandemic is altering WMO modalities of work, with a potential impact on efficiency due to teleworking and the impossibility of face-to-face meetings.												
D.3 Strengthened capacity of NMHS personnel in user-driven product and service design and delivery (to support food production and security)	See C.5 "Training to increase the capacities of Members in drought management…"	D.3											
Assumptions	Food security remains a priority at the national level for Members.												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda. • The COVID-19 pandemic is altering WMO modalities of work, with a potential impact on efficiency due to teleworking and the impossibility of face-to-face meetings.												

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	linkages	MOA	Comments
D.4 Water-food-energy nexus and ecosystem services are better understood and inform water resources management	Facilitate discussion on the role of hydrology in providing the required data for optimizing the management of water resources to accommodate the three sectors' needs (through symposia, open panels, TED talks, etc. on the water-food-energy nexus)	D.4.1		3	1.3	TECO or side event on the topic at SERCOM-2	2023	SERCOM (Sc-HYD, SC-AGR, SG-ENE, etc.)		---	CEPAL, FAO, SG-ENE, SC-AGR	FFI-DRR, Hydro SOS	
	Showcase case studies on the water-food-energy nexus (CEPAL, ENANDES, other)	D.4.2		3	1.3	Studies promoted via community of practice by 2023	2023	SERCOM (Sc-HYD, SC-AGR, SG-ENE, etc.)		---	CEPAL, FAO, SC-AGR, SG-ENE	FFI-DRR, Hydro SOS	
Assumptions	Food security remains a priority at the national level for Members.												
Risks	• The COVID-19 pandemic is altering WMO modalities of work, with a potential impact on efficiency due to teleworking and the impossibility of face-to-face meetings.												

Ambition/goal: High-quality data supports science

Outcome	(a) Increased discoverability, availability, and use of high-quality hydrological and hydrometeorological data for scientific analysis.
Measure of success	(a) Number of river discharge/groundwater/lakes and reservoirs/cryosphere time series with data available for the 2021–2030 period that are accessible via the WMO infrastructure and programmes (such as WIS, WHOS, the Global Cryosphere Watch (GCW), the Global Runoff Data Centre (GRDC), the International Groundwater Resources Assessment Centre (IGRAC), HYDROLARE, the Global Terrestrial Network – Hydrology (GTN-H)) for scientific purposes on a free and unrestricted basis; (b) Number of Members performing routine hydrological data quality assessments in line with Quality Management Framework – Hydrology (QMF-H) recommendations

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
E.1 Methods for standard assessment of data quality developed	1.1 Guidelines on/development of practical methods for assessment (flagging) of hydrological data	E.1.1	While metadata provide some information on data quality and reliability for particular uses, additional assessments/classification of data uncertainty or reliability (e.g. by flagging) might help the research community in data processing. Providing guidelines and assessing the potential benefits of harmonized data assessments/classification systems/tools	5	2.1, 2.2	Guidelines published Assessment of benefits provided for further decision on the issue	2025	INFCOM		RB, RAs, SERCOM	OSCAR, WIS, WHOS, Capacity development programme	HDOM, QMF-H	Development of automated processes for data QC, with AI/big data and training for members in how to use them should be considered by the research community

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	1.2 Continuous development and update of Technical Regulation Vol. III and its annex on hydrometry and other materials (including QMF-H compliance)	E.1.2		1, 2, 3, 4, 5, 6, 7, 8	2.1, 2.2	TechReg updated each CG	2023, 2027	INFCOM, SERCOM, HCP		ISO, UNEP	RAs	QMF-H	
Assumptions	Members will continue to be motivated to adequately support research and monitoring in order to better understand the behaviour and changes of the water cycle												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda and thus in the sustainability of monitoring networks (especially at long-term-observing sites) and in projects in the field of hydrology and water management. • The increase in automated data availability and alternative sources of data is not accompanied by an equivalent increase in competence and capacity to manage data quality control and QMF-H compliance.												
E.2 Quality assured hydrometeorological data by NHSs are generated through increased compliance with the culture of Quality Management Framework – hydrology (QMF-H)	Development of generic data production processes (schemes), metrics and internal guidelines (such as ISO 9001)	E.2.1	Internal system of QMF comprising manuals, guidelines, defined processes and metrics is necessary for each enterprise, providing products and services	1, 2, 3, 4, 5, 6, 7, 8	2.1, 2.2	Generic QMS schemes and guides develop-ped, number of Members that implemented QMS based on those (CPDB)	2025	HCP, INFCOM, SERCOM		ISO, Members	RAs	QMF-H	
	Training materials and e-learning on QMF	E.2.2	Review of requirements of Members on training in the field of QMF/QMS should lead to the	1, 2, 3, 4, 5, 6, 7, 8	2.1, 2.2	Review of requirements ready by 2023,	2023 review of progress	CDP			INFCOM, SERCOM, HCP	QMF-H, CB	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
			development of a training plan for NHSs and its implementation based on identified priorities			training plan (curriculum) by 2024, first training course launched in 2025							
	Information/promotion campaign – TED talks, What a difference quality makes	E.2.3	What benefit investment in QMS brings, why it is key to deliver quality services, sharing of good and bad experiences with community members	1, 2, 3, 4, 5, 6, 7, 8	2.1, 2.2	10 TED talks available, number of views	2025	HCP	Technical support for recording and publishing	Members, Secretariat	Capacity development programme,		
	Field safety manual/training course)	E.2.4	Generic annotated structure of field safety manual will help Members to develop their fit-for-purpose guidelines. Interactive courses, describing problems, sharing bad and good examples (such as problems with cyber security) is developed for practitioners in the field	1, 2, 5	2.1	Manual published, interactive course available with at least 50 participants by 2025	2025	INFCOM	Technical support	Members, RAs	Capacity development programme, HCP	QMF-H	Potential to involve external partners e.g. through hackathons
Assumptions	Members will continue to be motivated to adequately support research and monitoring in order to better understand the behaviour and changes of the water cycle												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda and thus in the sustainability of monitoring networks (especially at long-term-observing sites) and in projects in the field of hydrology and water management. • The increase in automated data availability and alternative sources of data is not accompanied by an equivalent increase in competence and capacity to manage data quality control and QMF-H compliance. • Lack of alignment with other activities in the field of water (e.g. UNESCO-IHP) leads to competition for attention of governments.												

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
E.3 Improved development and maintenance of technical platforms to support data discovery and accessibility for exchange for research and science	WHOS/WIS/WIGOS as a tool for data provision	E.3.1	Including improving WIGOS OSCAR platform to suit hydrological purposes	1, 2, 3, 4, 5, 6, 7, 8,	2.1, 2.2	Number of countries implementing WHOS phase II	2025	INFCOM		WHOS		HDOM	
	Evolving role of data centres helps Members to share and rescue their data	E.3.2	Updated definition of roles of GTN-H centres to better support WHOS	4	2.2	New role definition adopted by CG	2023	INFCOM		GTN-H		HDOM	
Assumptions	Members will continue to be motivated to adequately support research and monitoring in order to better understand the behaviour and changes of the water cycle												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda and thus in the sustainability of monitoring networks (especially at long-term-observing sites) and in projects in the field of hydrology and water management. • The increase in automated data availability and alternative sources of data is not accompanied by an equivalent increase in competence and capacity to manage data quality control and QMF-H compliance. • Satellite data will replace in situ observations without sufficient verification, and continuity of the long-term observation series is not maintained. • Technological solutions of monitoring (e.g. satellites), data transfer (internet, cell phone networks) and data storage (cloud solutions) will become more vulnerable to cyber-security incidents (hacking attacks, single point of failure). • Lack of financial resources for core activities of the Secretariat.												
E.4 Improved coordination on observing networks to fit research purposes	WMO, UNESCO-IHP, IAHS, ERB, FRIEND, colloquium on data for scientific purposes – what and how to measure to enhance scientific progress	E.4.1	Building a mutual understanding and stimulating efforts to compile the largest sets of data possible for scientific assessment and research of the hydrological cycle and its changes	4	2.2, 2.1	Conclusions of colloquium leads to concept note on coordination of networks	2024	INFCOM		UNESCO-IHP	HCP, RB,	HDOM	
	same as E.3.1	E.3.1											
	same as E.3.2	E.3.2											

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Respon sibility	Resources	Partners	Linkages	MOA	Comments
Assumptions	Members will continue to be motivated to adequately support research and monitoring in order to better understand the behaviour and changes of the water cycle												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda and thus in the sustainability of monitoring networks (especially at long-term-observing sites) and in projects in the field of hydrology and water management. • The increase in automated data availability and alternative sources of data is not accompanied by an equivalent increase in competence and capacity to manage data quality control and QMF-H compliance. • Satellite data will replace in situ observations without sufficient verification, and continuity of the long-term observation series is not maintained. • Lack of alignment with other activities in the field of water (e.g. UNESCO-IHP) leads to competition for attention of governments.												

Ambition/goal: Science provides a sound basis for operational hydrology

Outcomes	(a) Reduced gap between research and operational hydrology applications; operational hydrology uses improved understanding of Earth system science; (b) There is a greater understanding of how the hydrological system responds to extreme conditions.
Measure of success	(a) Number of WMO (co-)sponsored research programmes/projects that includes implementation of operational hydrological applications at Members' level during 2021–2030; (b) Number of cooperation agreements between NHSs and research institutions at national, regional and global levels; exchange of scientific personnel, increase of staff with a science-based education and training at MSc and higher levels.

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
F.1 Enhanced culture of research and development to operation projects to be co-designed by the operational hydrology and academia sectors – (demonstration) projects are developed, with the beneficiaries being National Meteorological and Hydrological Services	Catalogue of case studies/best practices (or may be bad practices as well)	F.1.1	Where cooperation between scientific and operational entities led to a speeding up of practice through implementation of research (on-demand) outputs, where lack of coordination led to wasted resources and competition	5	3.2, 4.1	Catalogue published	2024	RB		UNESCO-IHP	HCP, SERCOM, INFCOM		
	Database of research needs from NHSs as a project topics repository for scientists	F.1.2		5	3.2, 4.1	Database available	2023	RB		UNESCO-IHP, IAHS	HCP, SERCOM, INFCOM		
	Implementation of research strategy for hydrology and its update based	F.1.3	In cooperation with UNESCO and IAHS	5	3.1, 3.2, 3.3, 4.1	As defined in the research strategy	Review on a biannual basis	RB		UNESCO-IHP, IAHS	HCP, SERCOM, INFCOM		

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	on changing requirements												
Assumptions	Members continue to be motivated to adequately support research and development to better understand the behaviour and changes of the water cycle as a prerequisite for making informed decisions on water management and adaptation to climate change.												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased resources for scientific projects and research • Increased competition between the science and operational sectors for funding and staff as a result of limited resources • Asymmetry in benefits from cooperation between operations (providing data free of charge) and science (e.g. paywall publications) decreases the willingness to work together • Unhealthy competition with UNESCO-IHP in the field of hydrological research competence • Globalization of research leads to "non-recognition" of NHSs as users of research outputs												
F.2 Enhanced collaboration between hydrology and meteorology communities of practice, including academia	Similar to activities relating to the inventory of operational products, research outputs are compiled to be accessible for operational hydrology applications where relevant	F.2.1	See A.11, B.7 and C.2: Various research activities produce data and products that are valuable as potential inputs for hydrological analysis on regime change and design and which can be used in the area of water management; making these data and products easily accessible will allow NHSs to perform their duties more effectively.	5	3.4, 4.1	Inventory is accessible	2024	RB		UNESCO-IHP, IAHS	INFCOM, SERCOM		
Assumptions	Members continue to be motivated to adequately support research and development to better understand the behaviour and changes of the water cycle as a prerequisite for making informed decisions on water management and adaptation to climate change.												
Risks	None												

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
F.3 Inventory of the compiled data and products from Earth system science projects for hydrological applications	Improving QPE and QPF by research focus	F.3.1	Global community of NWP and downscaling works together on providing QPE and QPF at relevant scales (< 1 square km)	5, 1, 2	3.1, 3.2	Increased performance of QPE and QPF at 1 km resolution from the perspective of hydrological applications	2027	RB		Academia, Members, NWP consortia	INFCOM, SERCOM, WWRP, WCRP		
	Guidance on coupled model systems, interfaces	F.3.2	Provision of case studies, compendium of relevant methodologies	5, 1, 2	3.1, 3.2	Applications	2027	RB			INFCOM, SERCOM, WWRP, WCRP		
Assumptions	Members continue to be motivated to adequately support research and development to better understand the behaviour and changes of the water cycle as a prerequisite for making informed decisions on water management and adaptation to climate change.												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased resources for scientific projects and research • Globalization of research leads to "non-recognition" of NHSs as users of research outputs												

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
F.4 Improved Earth system models at high resolution for local and regional applications	Development of tools and modules to assess and analyse the uncertainty of extreme conditions are available.	F.4.1	Research community further develops uncertainty and scenario analysis that can be directly used to design/manage infrastructure and water systems.	5, 1, 2	1.3, 3.2			RB		UNESCO, academia	SERCOM		
Assumptions	Members continue to be motivated to adequately support research and development to better understand the behaviour and changes of the water cycle as a prerequisite for making informed decisions on water management and adaptation to climate change.												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased resources for scientific projects and research • Globalization of research leads to "non-recognition" of NHSs as users of research outputs												
F.5 There is a greater understanding of how the hydrological system responds to extreme conditions	Inclusion of the needs and requirements of different stakeholders (energy-water-food), moving towards an MHEWS approach (e.g. with the integration of FFGS/CIFI/SWFP) for the possible future integration of hydrology in GMAS (including reflecting hydrological hazards in the catalogue of hazardous events)	F.5.1	Same as B.4.1	5, 3	5.2, 3.2			SERCOM		UNESCO	RB	FFI-DRR	
	Widen the implementation of a water segment towards the creation of Regional Outlook	F.5.2	Same as C.7.1										

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	Forums (ROFs), based on the successful experience of RCOFs with the water segment in Central America												
Assumptions	Members continue to be motivated to adequately support research and development to better understand the behaviour and changes of the water cycle as a prerequisite for making informed decisions on water management and adaptation to climate change.												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased resources for scientific projects and research. • Unhealthy competition with UNESCO-IHP in the field of hydrological research competence. • Globalization of research leads to "non-recognition" of NHSs as users of research outputs.												

Ambition/goal: We have a thorough knowledge of the water resources of our world

Outcome	(a) Members implement reliable water resource assessment systems and use these to complete and share information on the availability of water resources.
Measure of success	(a) Number of Members completing and sharing water resource assessments, including via HydroSOS or WMO regional systems; (b) Annual reports on the status of global water resources published from 2025 onwards

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
G.1 Current and future status/assessments of water resources are available at different spatial and temporal scales and cover a large range of products, including snow, groundwater, lakes, and reservoirs	Implementation of HydroSOS at the global scale,	G.1.1	HydroSOS is implemented according to its implementation plan – water resource assessment activities at the national scale provide inputs to the HydroSOS.	6	1.3, 1.2	Number of Members contributing to HydroSOS	2021 – 2030	HCP			INFCOM, SERCOM	Hydro SOS	
Assumptions	Members will keep recognizing water management to be a critical service for nations and at the transboundary level.												
Risks	The post-COVID situation will change Members' priorities and limit resources for the wider implementation of HydroSOS.												
G.2 The WMO community informs high-level policy discussions at the global scale	Developing the format and specifications for a general advisory (specification of the aim, users, content, template, frequency of production, responsibilities)	G.2.1	Concept note on the general advisory will be developed as an initial step for operation	6	1.3, 1.2	Concept note presented to EC in 2022	2022	HCP, SERCOM			RAs	Hydro SOS	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	Support network/structure for production of the advisory is established (preferably building on regional and global centres of GDPFS) based on G.2.1	G.2.2	Based on a concept note, a framework and process for production of the advisory	6	1.3, 1.2	Framework established by 2023	2023	SERCOM, HCP			RAs	Hydro SOS, HDOM	
	Launch of the product and support of its use and sharing	G.2.3		6	1.3, 1.2	First report launched for 2023	2024	SERCOM, HCP, Secretariat			RAs	Hydro SOS, HDOM	
Assumptions	Members will keep recognizing water management to be a critical service for nations and at the transboundary level.												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda. • Lack of alignment with other activities in the field of water (e.g. UNESCO-IHP, UNEP) leads to competition and duplication of work and funding.												
G.3 Data, products and model results, at adequate spatial and temporal resolutions, are available for actionable planning and operations at the local scale.	Global products for local use – Regional Specialized Hydrological Centre (RSHC) of GDPFS provide to Members WRA products, including training products and tools for interpretation.	G.3.1	Develop a system of GDPFS centres that produce data and information that are specialized to support Members' water resources assessments based on their requirements. Members are provided with training materials and tools if needed to interpret GDPFS	6, 2, 3	2.3, 1.2, 1.3	At least one GDPFS centre provides WRM supporting products at global scale.	2025	SERCOM, INFCOM			HCP	HDOM	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
			products for national and local applications for WRM.										
Assumptions	Members will keep recognizing water management to be a critical service for nations and at the transboundary level.												
Risks	• The post-COVID situation might change the availability of resources for establishing new or widening the scope of current GDPFS centres to deliver desired products. • Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda. • Lack of alignment with other activities in the field of water (e.g. UNESCO-IHP, UNEP) leads to competition and duplication of work and funding.												
G.4 Increased national capacities to collect water-related data and transform them to useful/relevant products through capacity-building. (The staff members of NMHSs understand the societal impacts of water and water resources management plans and decisions and the importance of WRAs for various stakeholders, and are well informed on the technologies available for them to best carry out their tasks and experts in those that best suit their key applications.)	Development and implementation of WRA community of practice (which provides up to date information and enables knowledge transfer in the field of water resources assessment)	G.4.1	Community of practice for water resources assessment supports NMHSs, including support to apply available tools and products (such as DWAT); community of practice is vital for sharing of knowledge and tools among Members.	6	4.2, 4.1, 1.3	Number of Members participating to activities of the community	2023	SERCOM			HCP	Hydro SOS	
	Within the framework of G.4.1, a decision tree/checklist (comparison engine) is developed to enable the selection of proper methodologies and tools for WRA by Members	G.4.2		6	4.2, 4.1, 1.3	Checklist available through the community by 2024	2024	SERCOM				Hydro SOS	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	Training curriculum for WRA developed as a part of the capacity development strategy of the WMO	G.4.3	Needs (topical, and on form) of Members are properly identified to propose curricula of courses and training materials in support of capacity-building in the domain of WRA	6, 2, 3	4.2, 4.1, 1.3	Capacity development strategy updated in 2023	2023	CDP		Members, Ras.	HCP, SERCOM	Capacity Development, Hydro SOS	
	E-learning training course(s) for water resources assessment	G.4.4	Based on curricula, courses and training materials are developed	6, 2, 3	4.2, 4.1, 1.3	Review of progress presented to Hydrological Assembly/Cg	2025	CDP			SERCOM	Capacity Development, Hydro SOS	
	Twinning projects targeted at WRA skills	G.4.5	Twinning projects between Members target WRA and WRM	6	4.2, 4.1, 1.3	Review of progress presented to Hydrological Assembly/Cg	2025	SERCOM		Members, RAs.	HCP		Linked to output 9, activity area 2
	Compendium of societal, economic and ecological relations/dependency on water/hydrological cycle	G.4.6	Compendium will be based on based on review of existing studies, synergizing and collating information	6	4.2, 4.1, 1.3	Compendium presented	2005	RB, SERCOM		Members, RAs.	HCP	Hydro SOS, Capacity Development	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	WRA 'manual' published	G.4.7	Finalization of WRA manual and its publication	6	4.2, 4.1, 1.3	WRA manual published	2023	SERCOM			HCP	Hydro SOS	
Assumptions	Members will keep recognizing water management to be a critical service for nations and at the transboundary level.												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, results in decreased involvement in the water-related agenda. • Lack of alignment with other activities in the field of water (e.g. UNESCO-IHP, UNEP) leads to competition and duplication of work and funding. • Loss of support from Members in key activities, such as providing resources, data and information for shared systems. • Lack of financial resources for core and extrabudgetary activities of the Secretariat.												

Ambition/goal: Sustainable development is supported by hydrological information

Outcome	(a) Hydrological information of adequate resolution, quality and timeliness is available and is used to make informed decisions on sustainable development at all scales.
Measure of success	(a) Number of Members including hydrological aspects and water budget information in their development plans at the national level; (b) Number of Members reporting on SDGs using reliable hydrological data and indicators.

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
H.1 Improved data policies and financing schemes and enhanced political arrangements to collect hydrologic data and derived products	Implementation of WMO unified data policy at Members' level (assessment of compliance with respect to the provision of essential and desirable data) to enhance the quality of local/national/regional/global observation networks and delivery systems	H.1.1	See cross-cutting activities	6,7	2.1, 2.2	Update of TechReg with mechanism for core data by 2023, number of Members providing core data by 2027	2023, 2027	INFCOM			HCP, Members RAs	HDOM	Activity needs to reflect ongoing work on data policy by SG-DIP
	Recognition mechanism of long-term observing station in hydrology	H.1.2		6,7	2.1, 2.2	First hydrological stations are recognized by Cg	2023	INFCOM			HCP	HDOM	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	For additional see action area on NHSs for cross-cutting data activities												
Assumptions	The Sustainable Development Agenda will remain a key priority of the United Nations and will receive adequate support from Member States throughout its implementation. The new WMO unified data policy is adopted by the Cg-Ext. 2021												
Risks	• Changes in overall political and societal priorities, e.g. due to the COVID-19 pandemic, result in decreased involvement in the water-related agenda in support of SDGs. • Lack of expertise mobilized by Members for the WMO Expert Network to deliver on planned activities given the fact that SDG support is not a common responsibility of NHSs.												
H.2 Intensified national, basin, transboundary and international cooperation and activities to meet the SDGs	Support building of national, basin and transboundary partnerships for water SDGs	H.2.1	Compilation of success stories and good examples (EU, basin organizations, etc.), basic advice on modes of operation for partnerships of various organizations	7	1.3	Document ready by 2025	2025	HCP		INBO		WWDI, HDOM	Output on meeting SDGs
	Partnership with FAO (AquaStat) and UNESCO established to develop a plan to define which data/information/ products produced by Members should be collected in global databases supporting the SDGs	H.2.2		7	1.3	Joint plan developed	2024	Secretariat, HCP		FAO, UNESCO WHO, UN-WATER		WWDI, HDOM	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	Define set of parameters to monitor and support sustainable development on a long-term scale in cooperation with relevant organizations	H.2.3		7	1.3	Set of parameters agreed by WMO, UNESCO and FAO	2024	Secretariat, HCP, INFCOM		FAO, UNESCO UN-WATER	INFCOM	WWDI, HDOM	
Assumptions	The Sustainable Development Agenda will remain a key priority of the United Nations and will receive adequate support from Member States throughout its implementation.												
Risks	• Lack of alignment with other activities on SDG implementation related to water (UN-Water, UNESCO-IHP, etc.) leads to competition and duplication of work and funding												
H.3 Basic tools to assist Members are created, including an archive of relevant information, tools for transforming data to information, and maintenance of essential "treasury/heritage" variables to support sustainable development	Concept note for WMO hydrology cloud developed (for storage of essential data of Members (based on a review of the role of data centres role))	H.3.1	Feasibility study of hydrology cloud to support SDGs and Members, will need requirements from Members, viable technical and organizational solutions to be described	6,7	2.2, 4.1	Feasibility study submitted to EC for decision	2024	INFCOM			WHOS, HCP	HDOM	
	Eventual implementation if agreed by Cg	H.3.2			2.2, 4.1							HDOM	
	Sharing of data from recognized centennial/reference (GBON hydrology and Data centres) stations in hydrology	H.3.3	Need to be updated based on concept of data resolution implementation for hydrology – see also cross-cutting activities	6,7	2.2, 4.1, 2.1	GBON hydrology established	2025	INFCOM			WHOS, HCP	HDOM	Need to reflect results of review of the role of data centres

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	Software (possibly a cloud solution) for computation of parameter defined under H.2.3	H.3.4	Supporting Members with automatic computation of selected parameters based on data they measured	6,7	4.1, 2.2,	Feasibility study presented to EC, possibly jointly with 8.1	2024	INFCOM			WHOS, HCP	HDOM	
	Presentation of data sets for evaluation - web presentation of data sets for SDGs	H.3.5		6,7	1.3	Web page launched	2027	INFCOM			WHOS, HCP		
Assumptions	The Sustainable Development Agenda will remain a key priority of the United Nations and will receive adequate support from Member States throughout its implementation. The new Unified Data policy is adopted by the Cg in 2021.												
Risks	• Loss of support from Members for developing new activities (including HydroSOS, GBON, SOFF etc.) by providing resources, data and information for shared systems. • Lack of expertise mobilized by Members for the WMO Expert Network to deliver on planned activities given the fact that SDG support is not a common responsibility of NHSs.												

Ambition/goal: Water quality is known

Outcome	(a)	Increased cooperation at the national, regional and global level on water quality monitoring and water quality data exchange.
Measure of success	(a)	Number of Members running water quality monitoring programmes, performing water quality assessments and sharing their data.

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
I.1 Partnership at the United Nations level exists and promotes the provision of water quality data from NHSs to existing information systems (such as WHOS, UNEP, GEMS/Water, UNESCO-IHP, IIWQ and ISI).	WMO participates in and contributes to the World Water Quality Alliance convened by UNEP	I.1.1	Develop a work plan to reinforce collaboration with UNEP and UNESCO and to provide expertise to WWQA on standardization methods and information systems.	8	1.3, 4.3	Working procedure and work plan presented to Cg	2023	HCP, Secretariat		UNEP and WWQA partners, UNECE Water Convention	INFCOM, SERCOM		
	WHOS interconnection to GEMS/IIWQ	I.1.2	Water quality data are registered and shared via WHOS, interconnecting national and global data portals.	8	1.3, 2.1, 2.2, 4.1, 4.2, 4.3	Number of Members providing water quality data through WHOS	2027	INFCOM		UNEP, UNESCO	INFCOM, WHOS	HDOM	
	Supporting WaterML-WQ development	I.1.3	WaterML-WQ format is further developed and adopted as standard for WQ data transfer and sharing	8	1.3, 2.1, 2.2	Standard adopted by Cg	2027	INFCOM		OGC, UNEP, UNESCO	INFCOM, WHOS	HDOM	
Assumptions	Relevant partners (UNEP, UNESCO, WHO, UNDP, WB) will join WMO in these activities, aiming for the same goals and providing the necessary resources. Additionally, there is the assumption that there will be an increased demand from Members for water quality related actions from WMO. In particular, Members with no systematic programmes for water quality monitoring and assessment will aim to develop and maintain these programmes as a priority and will contribute to the achievement of SDGs.												

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
Risks	• The global COVID-19 pandemic represents an imminent risk of failing to achieve all outputs. The post-pandemic economic situation might further limit the development of relatively expensive measures in water quality due to a decrease with respect to the resources available and a potential shift in priorities at the national and global level to recovery from the pandemic. • Limited resources might limit both the demand from Members, as well as the capacity of the United Nations system to react. • An additional risk would be the failure of Members to mobilize the expertise required for the WMO Expert Network to deliver on planned activities. Given the fact that water quality is not always the responsibility of NHSs, experts are often located outside of NMHSs, and it might be difficult to approach them and to encourage them to contribute.												
I.2 Increased NHS involvement in the co-production of water quality related data and products thanks to promotion of IWRM principles.	Water quality training materials development	I.2.1	After identification of the priority needs for training from Members' NHSs, needs training materials and activities are developed building on WWQA Capacity Development Consortium (CDCm).	8	1.3	Basic training curricula for water quality available for Members by the end of 2025, at least 25 participants finalized (e-course).	Identification of priorities - 2023, priority training materials ready by 2025	CDP		UNEP	INFCOM, SERCOM	CB	
	Supporting building of national partnerships for water quality	I.2.2	Compilation of success stories and good examples (EU, basin organizations, etc.), basic advice on modes of operation for partnerships of various organizations, compilation of WWQA partners best practices including Africa Use Cases and other examples of partnership building across workstreams	8	1.3	Compilation available to Members	2023	HCP		UNEP	INFCOM, SERCOM	CB	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	Support of development of data policies that support water quality monitoring and assessment	I.2.3	Review of the definition of essential data in view of water quality assessment needs	8	1.3	Hydrological data requirements for water quality monitoring programmes and essential water quality data identified and adopted in Annex to Res. 42	2023	INFCOM		UNEP (GEMS)	HCP, SERCOM	HDOM	GEMS/ Water and GEMStat need to be considered together with a United Nations Environment Data Strategy /Policy to make sure data can be used across the board and in various contexts and easily feed into GEMStat while considering interoperability
	Supporting basin organization in the water quality agenda	I.2.4	Compilation of success stories and good examples (EU, basin organizations, Africa etc.), basic advice on water quality monitoring and assessment programmes and action plans	8	1.3	How to handbook available to Members	2025	HCP		UNEP	SERCOM, INFCOM	HDOM	
	Supporting formulation of the National Water Quality Management Strategy, Action	I.2.5	Guidelines supporting Members NHSs in developing complete frameworks for	8		Guidelines published	2027	INFCOM, HCP		UNEP		HDOM	Synergies with GEMS/ guidelines on water quality monitoring

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	Plan and monitoring programs (Task #1)		water quality monitoring from definition of strategy, through development of National Water Quality Management Plan/Framework and screening of relevant issues (pollutants, processes etc.), to design and systematic realization of monitoring programmes										must be assured
Assumptions	Relevant partners (UNEP, UNESCO, WHO, UNDP, WB) will join WMO in these activities aiming for the same goals and providing the necessary adequate resources. Additionally, there is the assumption that there will be an increased demand from Members for water quality related actions from WMO. In particular, Members with no systematic programmes for water quality monitoring and assessment will aim to develop and maintain these programmes as a priority and will contribute to the achievement of SDGs.												
Risks	• The global COVID-19 pandemic represents an imminent risk of failing to achieve all outputs. The post-pandemic economic situation might further limit development of relatively expensive measures in water quality due to a decrease with respect to the resources available and a potential shift in priorities at the national and global level to recovery from the pandemic. • Limited resources might limit both the demand from Members, as well as the capacity of the United Nations system to react. • An additional risk would be the failure of Members to mobilize the expertise required for the WMO Expert Network to deliver on planned activities. Given the fact that water quality is not always the responsibility of NHSs, experts are often located outside of NMHSs and it might be difficult to approach them and to encourage them to contribute.												
I.3 Increased joint water quantity and water quality assessment (monitoring and modelling) for operational management and for planning	Review of the state of operational monitoring, modelling and assessment of water quality at the Member and basin level building on the World Water Quality Assessment	I.3.1	Based on I.2.5, a review of the state of operational monitoring, modelling and assessment of water quality will be done to inform other activities	6, 7, 8	1.3, 4.1	Review presented to Cg	2023	HCP, Secretariat		UNEP, UNESCO	INFCOM, SERCOM	HDOM, Hydro SOS	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	undertaken by the WWQA												
	Development of joint WMO-UNEP-UNESCO strategy to increase water quality assessment availability from Members and basins	I.3.2	SDGs 3.9, 11.6, 12.4, 14.1, 14.2, 6.3, 6.5 are closely related to water quality. Their achievement requires a coordinated effort from all United Nations agencies involved to develop projects to establish sustainable system of monitoring and assessment of water quality in countries where such a system does not exist. Based on the World Water Quality Assessment and the work plan developed under 3.1, the inclusion of WQ aspects in development projects will be supported.	6, 7, 8	1.3, 4.1	Strategy adopted by Cg/EC	2024	HCP, Secretariat		UNEP, UNESCO	INFCOM, SERCOM	Hydro SOS	
	Development of concept paper for inclusion of WQ for HydroSOS	I.3.3	Based on I.3.2, a concept paper on how to enlarge the scope of HydroSOS by adding water quality information provided by Members will be developed	6, 7, 8	1.3, 4.1	Concept paper presented to Cg/EC	2025	SERCOM		UNEP, UNESCO	INFCOM, HCP	Hydro SOS	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
	Country profile database collects basic information on water quality monitoring programmes	I.3.4	Optimized structure of information on water quality monitoring and assessment is used for evaluation of performance and needs for development and to support activities of WMO/UNEP/UNESCO partnership on water quality. Implementing basic supporting information to CPDB in coordination with GEMS/Water Capacity Development Centre.	8	1.3, 2.1, 4.1, 4.3	Water quality monitoring network and assessment report	2023	HCP, Secretariat		Member states	Community of practice, INFCOM, SERCOM		
Assumptions	Relevant partners (UNEP, UNESCO, WHO, UNDP, WB) will join WMO in these activities, aiming for the same goals and providing the necessary resources. Additionally, there is the assumption that there will be an increased demand from Members for water quality related actions from WMO. In particular, Members with no systematic programmes for water quality monitoring and assessment will aim to develop and maintain these programmes as a priority and will contribute to the achievement of SDGs.												
Risks	• The global COVID-19 pandemic represents an imminent risk of failing to achieve all outputs. The post-pandemic economic situation might further limit the development of relatively expensive measures in water quality due to a decrease with respect to the resources available and a potential shift in priorities at the national and global level to recovery from the pandemic. • Limited resources might limit both the demand from Members, as well as the capacity of the United Nations system to react. • An additional risk would be the failure of Members to mobilize the expertise required for the WMO Expert Network to deliver on planned activities. Given the fact that water quality is not always the responsibility of NHSs, experts are often located outside of NMHSs and it might be difficult to approach them and to encourage them to contribute.												
I.4 Water quality aspects are included in country support activities/projects in the spirit of IWRM and in cooperation with other organizations	Partnership with UNEP, UNESCO, UNDP and WB on how to implement water quality aspects to develop projects	I.4.1	SDGs 3.9, 11.6, 12.4, 14.1, 14.2, 6.3, 6.5 are closely related to water quality. Their achievement demands on coordinating the efforts of all involved United Nations agencies to develop projects to	8	1.3, 4.1, 4.2, 4.3	50% of country support projects in hydrology include the water quality aspect	2023	Secretariat, HCP		UNEP, UNESCO, WB, UNDP		HDOM	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
			establish a sustainable water quality monitoring and assessment system in countries where such a system does not exist. Defining how to best coordinate efforts with respect to this issue needs to be the first step.										
	Definition of minimum requirements/checklist for water quality aspects to be included in country support activities based on I.4.1	I.4.2		8	1.3, 4.1, 4.2, 4.3	50% of country support projects in hydrology include the water quality aspect	2023	Secretariat, HCP		UNEP, UNESCO, WB, UNDP		HDOM	
Assumptions	Relevant partners (UNEP, UNESCO, WHO, UNDP, WB) will join WMO in these activities, aiming for the same goals and providing the necessary resources. Additionally, there is the assumption that there will be an increased demand from Members for water quality related actions from WMO. In particular, Members with no systematic programmes for water quality monitoring and assessment will aim to develop and maintain these programmes as a priority and will contribute to the achievement of SDGs.												
Risks	• The global COVID-19 pandemic represents an imminent risk of failing to achieve all outputs. The post-pandemic economic situation might further limit the development of relatively expensive measures in water quality due to a decrease with respect to the resources available and a potential shift in priorities at the national and global level to recovery from the pandemic. • Limited resources might limit both the demand from Members, as well as the capacity of the United Nations system to react. • An additional risk would be the failure of Members to mobilize the expertise required for the WMO Expert Network to deliver on planned activities. Given the fact that water quality is not always the responsibility of NHSs, experts are often located outside of NMHSs and it might be difficult to approach them and to encourage them to contribute.												

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
I.5 Partnership at the United Nations level delivers co-produced guidelines related to water quality	Establishing WMO-UNEP partnership/ mechanism on guidelines delivery and updating	I.5. 1	Responsibility for water quality at the United Nations level is shared between WMO and UNEP. Building on existing UNEP work (guidelines), a jointly coordinated effort needs to be established to compile guidelines and for operational hydrological services. The joint group should establish working procedures and develop a work plan.	8	1.3, 4.1, 4.2, 4.3	Joint group established and plan created for work to be done and deliverables (guidelines, etc.)	2023	INFCOM (JET/HYDMON)		UNEP, (UNESCO-IHP for sediment transport)	SERCOM (SC-HYD) if water quality assessment issues are considered	CB, QMF-H	Likely to be part of activity 3.1 and connected to 2.5
	Development of technical regulation annex on water quality	I.5. 2	New structure of Technical Regulation Vol. III foreseen to develop annex on water quality. It shall be developed via mechanism of cooperation between WMO and UNEP and other partners as appropriate	8	1.3, 4.1, 4.2	Annex adopted by Cg	Based on 4.1	INFCOM (JET/HYDMON)		UNEP, UNESCO-IHP	SERCOM (SC-HYD) if water quality assessment. Issues are considered	QMF-H	
	Development of guidelines according to 4.1.	I.5. 3	Based on identification of joint work group, necessary guidelines supporting NHSs involvement in water quality monitoring and assessment will be developed.	8	1.3, 4.1, 4.2,	Guidelines published	Based on 4.1	INFCOM (JET/HYDMON)		UNEP, UNESCO-IHP	SERCOM (SC-HYD) if water quality assessment issues are considered	QMF-H	

Output	Activity	ID	Description	LTA	SOP	Success criteria	Time frame	Responsibility	Resources	Partners	Linkages	MOA	Comments
Assumptions	The proposed activities and outputs are based on the basic assumption that relevant partners (UNEP, UNESCO, WHO, UNDP, WB) will join WMO in these activities, aiming for the same goals and providing the necessary resources. Additionally, there is the assumption that there will be an increased demand from Members for water quality related actions from WMO. In particular, Members with no systematic programmes for water quality monitoring and assessment will aim to develop and maintain these programmes as a priority and will contribute to the achievement of SDGs.												
Risks	• The global COVID-19 pandemic represents an imminent risk of failing to achieve all outputs. The post-pandemic economic situation might further limit the development of relatively expensive measures in water quality due to a decrease with respect to the resources available and a potential shift in priorities at the national and global level to recovery from the pandemic. • Limited resources might limit both the demand from Members, as well as the capacity of the United Nations system to react. • An additional risk would be the failure of Members to mobilize the expertise required for the WMO Expert Network to deliver on planned activities. Given the fact that water quality is not always the responsibility of NHSs, experts are often located outside of NMHSs and it might be difficult to approach them and to encourage them to contribute												

ANNEX II

MAPPING OF THE VISION AND STRATEGY FOR HYDROLOGY
ON TO THE WMO STRATEGIC PLAN

WMO Strategic Plan	Vision and Strategy for Hydrology
Vision	
By 2030, we see 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; and underpin their sustainable development through the best possible services, whether over land, at sea or in the air	By 2030, a cooperative global community is successfully addressing the growing challenges related to hydrological extremes, water availability and quality, and food security, by advancing operational hydrology, through enhanced science, infrastructure, capacity-building and related services, in the context of sustainable development and enhanced resilience
Mission	
To facilitate worldwide cooperation on monitoring and predicting changes in weather, climate, water and other environmental conditions through the exchange of data, information and services, standardization, application, research and training	
Key Drivers/ High-level requirements	
Global agenda creating unprecedented demand for actionable, accessible and authoritative science-based information Increasing threats of extreme weather and climate urge action for resilience, mitigation and adaptation Growing capacity gap threatens global infrastructure and services Rapid advancements in science and technology and changing landscape of data and service delivery urge for innovative partnerships	Policy and decision-making that contribute to the achievement of Sustainable Development Goals related to water Real time management of flood and drought events and integrated flood management and planning, including inundation mapping in support to MHEWS Integrated water resources management in national and transboundary catchments, including information on water quality, sediments and other elements Civil engineering for design and management of infrastructure (including dams and fluvial transport) Agriculture for decisions on agrotechnical practices, drainage and irrigation schemes and management Ecosystem management including wetlands

WMO Strategic Plan	Vision and Strategy for Hydrology
	Academic support for climate and hydrological regime studies, trend analysis, decision support systems
Overarching Priorities/Guiding principles	
Enhancing preparedness and reducing loss of life, critical infrastructure and livelihood from hydrometeorological extremes Supporting climate-smart decision-making to build or enhance adaptive capacity or resilience to climate risk Enhancing socioeconomic value of weather, climate, hydrological and related environmental services	Hydrological data and products are a global public good: Free and unrestricted access to public and private high-quality hydrological data and products for all Interoperability is key to improved services: Related disciplines, data, models, and risk management systems across all scales need to be interoperable and connected wherever it improves our analysis and optimization capabilities Capabilities are catalysed through digital revolution: Using the full potential of the digital revolution to improve science and operations Innovation and technology will improve established systems which will benefit from new sources of information Hydrological services are sustainable: Hydrological services are recognized as being of high priority and of public interest having clearly defined roles and responsibilities and sustainable financing. New actors are incorporated along the hydrological value chain from data to product/service Water quality and quantity issues must be addressed in an integrated, holistic way, following the principles of integrated water resources management (IWRM)
Long-term Goals/ Ambitions	
Goal 1: Better serve societal needs: delivering, authoritative, accessible, user-oriented and fit-for-purpose information and services	• No one is surprised by a flood • Everyone is prepared for drought • Hydroclimate and meteorological data support the food security agenda • Science provides a sound basis for operational hydrology • We have a thorough knowledge of the water resources of our world • Sustainable development is supported by hydrological information • Water quality is known

WMO Strategic Plan	Vision and Strategy for Hydrology
Goal 2: Enhance Earth system observations and predictions: Strengthening the technical foundation for the future	• No one is surprised by a flood • Everyone is prepared for drought • High-quality data supports science • We have a thorough knowledge of the water resources of our world • Sustainable development is supported by hydrological information • Water quality is known
Goal 3: Advance targeted research: Leveraging leadership in science to improve understanding of the Earth system for enhanced services	• Science provides a sound basis for operational hydrology
Goal 4: Close the capacity gap on weather, climate, hydrological and related environmental services: Enhancing service delivery capacity of developing countries to ensure availability of essential information and services needed by governments, economic sectors and citizens	• No one is surprised by a flood • Everyone is prepared for drought • Hydroclimate and meteorological data support the food security agenda • High-quality data supports science • Science provides a sound basis for operational hydrology • We have a thorough knowledge of the water resources of our world • Sustainable development is supported by hydrological information • Water quality is known
Goal 5: Strategic realignment of WMO structure and programmes for effective policy- and decision-making and implementation	• No one is surprised by a flood • Everyone is prepared for drought • Science provides a sound basis for operational hydrology
Objectives/outputs	
Goal 1: Better serve societal needs: delivering, authoritative, accessible, user-oriented and fit-for-purpose information and services	
Objective 1.1 Strengthen national multi-hazard early warning/alert systems and extend reach to better enable effective response to the associated risks	Enhanced coordination, effectiveness and governance of all WMO activities in supporting Members in Flood Risk Assessment and Flood Forecasting and Warning Enhanced collaboration among NHSs, NMSs and other organizations (e.g. DRR authorities) at national level in developing and operating E2E MHEWS particularly including floods Increased Members' capacities to deliver and communicate to the public and to raise the awareness

WMO Strategic Plan	Vision and Strategy for Hydrology
	Increased capacities of Members through development projects in the area of drought monitoring, early warning, vulnerability and impact assessment, adaptation and mitigation, preparedness and response
Objective 1.2 Broaden the provision of policy- and decision-supporting climate information and services	The need of an effective national drought policy is understood by Members *Increased Members capabilities in drought vulnerability of and impact assessment on different sectors by meaningful drought indicators and indices used at all relevant scales*
Objective 1.3 Further develop services in support of sustainable water management	Increased Members' capacities to deliver and communicate to the public and to raise the awareness Increased Members' and regions' (basin authorities) application of Integrated flood risk management principles in flood prevention, preparedness and response The need of an effective national drought policy is understood by Members Increased Members capabilities in drought vulnerability of and impact assessment on different sectors by meaningful drought indicators and indices used at all relevant scales Increased cooperation (and co-production of services) among the hydrological, meteorological and climatological communities and international exchange of experiences (e.g. higher involvement of hydrologists in climate outlook forums, of meteorologists and climatologists in river basin commissions) Increased capacities of Members through development projects in the area of drought monitoring, early warning, vulnerability and impact assessment, adaptation and mitigation, preparedness and response Increased production and/or availability of agrometeorological and hydrological forecast from sub-seasonal to seasonal Effective dialogue between users and providers established

WMO Strategic Plan	Vision and Strategy for Hydrology
	Water-food-energy nexus and ecosystem services are better understood and inform water resources management There is a greater understanding of how the hydrological system responds to extreme conditions Current status/assessment of water resources is available at different spatial and temporal scales and covers a large range of products including e.g. snow, groundwater, lakes, and reservoirs The WMO community informs high-level policy discussions at global scale with (e.g. a global assessment or hot spot report) Increased NHSs involvement in co-production of water quality related data and products thanks to promotion of IWRM principles Partnership at UN level exists and promotes provision of water quality data from NHSs to existing information systems (such as WHOS, UNEP GEMS/water and UNESCO-IHP IIWQ and ISI) Increased presentation/communication and understanding of value proposition, benefits and risk analysis, and value of hydrological services to foster understanding by ministries and governments
Objective 1.4 Enhance the value and innovate the provision of decision-supporting weather information and services	Flood related data and products with global and regional coverage are available for use at national scale by Members Increased Members' capacities to deliver and communicate to the public and to raise the awareness

WMO Strategic Plan	Vision and Strategy for Hydrology
Goal 2: Enhance Earth system observations and predictions: Strengthening the technical foundation for the future	
Objective 2.1 Optimize the acquisition of Earth system observation data through the WMO Integrated Global Observing System (WIGOS)	Drought-related data and products with global and regional coverage are available for use at national scale by Members Methods for standard assessment of data quality developed Quality assured hydrometeorological data by NHSs are generated through increased compliance to the culture of Quality Management Framework – hydrology (QMF-H) Improved guidance for development and maintenance of technical platforms to support data exchange for research and science Improved data policies, financing schemes, and enhanced political arrangements to collect hydrologic data and derived products Increased joint water quantity and water quality assessment (monitoring and modelling) for operational management and for planning Sustainable projects help build capacities of NHSs Effective and efficient, low-cost methods for hydrological observations are broadly available *Increased availability and international exchange of hydrometeorological data for operational flood forecasting and early warning and enhanced international cooperation in flood management especially for transboundary basins on a free and unrestricted basis.*
Objective 2.2 Improve and increase access to, exchange and management of current and past Earth system observation data and derived products through the WMO Information System	Improved guidance for development and maintenance of technical platforms to support data exchange for research and science Improved coordination on observing networks to fit research purposes Basic tools to assist members are created, including an archive of relevant information, tools for transforming data to information, and maintenance of essential

WMO Strategic Plan	Vision and Strategy for Hydrology
	"treasury/heritage" variable to support sustainable development Increased NHSs involvement in co-production of water quality related data and products thanks to promotion of IWRM principles *Increased availability and international exchange of hydrometeorological data for operational flood forecasting and early warning and enhanced international cooperation in flood management especially for transboundary basins on a free and unrestricted basis*
Objective 2.3 Enable access and use of numerical analysis and Earth system prediction products at all temporal and spatial scales from the WMO seamless Global Data Processing and Forecasting System	Flood related data and products with global and regional coverage are available for use at national scale by Members Drought-related data and products with global and regional coverage are available for use at national scale by Members Data, products and model results, at adequate spatial and temporal resolutions, are available for actionable planning and operations at the local scale (High resolution data and modelled information are available for actionable planning and operations at the local scale)
Goal 3: Advance targeted research: Leveraging leadership in science to improve understanding of the Earth system for enhanced services	
Objective 3.1 Advance scientific knowledge of the Earth system	Enhanced culture of research and development to operation projects co-design (by operational hydrology and academia) – (Demonstration) projects are developed with beneficiaries being National Meteorological and Hydrological Services Improved Earth system models outputs and its availability at high resolution for local and regional applications
Objective 3.2 Enhance the science-for service value chain ensuring scientific and technological advances improve predictive capabilities	Enhanced culture of research and development to operation projects co-design (by operational hydrology and academia) – (Demonstration) projects are developed with beneficiaries being National Meteorological and Hydrological Services Inventory of the compiled data and products from Earth systems science projects for hydrological applications

WMO Strategic Plan	Vision and Strategy for Hydrology
	Effective and efficient, low-cost methods for hydrological observations are broadly available Enhanced collaboration between hydrology and meteorology communities of practice, including academia
Objective 3.3 Advance policy-relevant science	Intensified national, basin, transboundary and international cooperation and activities to meet the SDGs The end users of hydrological information/data have a clear understanding of what the data means and its relative (un)certainty
Goal 4: Close the capacity gap on weather, climate, hydrological and related environmental services: Enhancing service delivery capacity of developing countries to ensure availability of essential information and services needed by governments, economic sectors and citizens	
Objective 4.1 Address the needs of developing countries to enable them to provide and utilize essential weather, climate, hydrological and related environmental services	A framework is developed for the evaluation of gaps and needs of national flood forecasting and early warning systems Increased exchange of knowledge and technical expertise in flood forecasting among Members Enhanced coordination, effectiveness and governance of all WMO activities in supporting Members in Integrated Drought Management Gaps in Members' capabilities in drought assessment, monitoring, modelling and prediction are known The need of an effective national drought policy is understood by Members Training to increase capacities of Members in drought management (monitoring, modelling, early warning & drought vulnerability and impact assessment & drought adaptation and mitigation, preparedness and response) Basic tools to assist members are created, including an archive of relevant information, tools for transforming data to information, and maintenance of essential "treasury/heritage" variable to support sustainable development

WMO Strategic Plan	Vision and Strategy for Hydrology
	Water quality aspects are included in country support activities/ projects in the spirit of IWRM and in cooperation with other organizations Partnership at UN level exists and promotes provision of water quality data from NHSs to existing information systems (such as WHOS, UNEP GEMS/water and UNESCO-IHP IIWQ and ISI) Increased presentation/communication and understanding of value proposition, benefits and risk analysis, and value of hydrological services to foster understanding by ministries and governments Increased management skills of NHSs management (including middle and lower management) supports effectiveness and development of NHSs Enhanced customer orientation and better marketing skills generates better services and products with higher added value Institutional development plans and monitoring network development programmes are in place and implemented taking into account the catalogue of products and services
Objective 4.2 Develop and sustain core competencies and expertise	Increased Members' and regions' (basin authorities) application of Integrated flood risk management principles in flood prevention, preparedness and response Training to increase capacities of Members in drought management (monitoring, modelling, early warning & drought vulnerability and impact assessment & drought adaptation and mitigation, preparedness and response) Strengthened capacity of NMHSs personnel in user-driven products and services design and delivery (in the field of support of food production and security) Increased national capacities to collect water-related data and transform them to useful/relevant products through capacity-building (The staff of NMHSs understands the societal impacts of water and water resources management plans and decisions, the importance of water resources assessments for various

WMO Strategic Plan	Vision and Strategy for Hydrology
	stakeholders, and is well informed on the technologies available for them to best carry out their tasks and are expert in those that best suit their key applications) Water quality aspects are included in country support activities/ projects in the spirit of IWRM and in cooperation with other organizations Increased management skills of NHSs management (including middle and lower management) supports effectiveness and development of NHSs Enhanced customer orientation and better marketing skills generates better services and products with higher added value. Institutional development plans and monitoring network development programmes are in place and implemented taking into account the catalogue of products and services
Objective 4.3 Scale up effective partnerships for investment in sustainable and cost-efficient infrastructure and service delivery	Partnership at UN level delivers co-produced guidelines related to water quality Enhanced resource mobilization (expertise, financial, partnership) for capacity-building, technical assistance, training of personnel and sustainability of E2E MHEWS, and flood, drought and water resources management Increased involvement and enhanced cooperation with private sector support Members' flood, drought and water resources management Sustainable projects help build capacities of NHSs

WMO Strategic Plan	Vision and Strategy for Hydrology
Goal 5: Strategic realignment of WMO structure and programmes for effective policy- and decision-making and implementation	
Objective 5.1 Optimize WMO constituent body structure for more effective decision-making	Increased presentation/ communication and understanding of value proposition, benefits and risk analysis, and value of hydrological services to foster understanding by ministries and governments Enhanced regional cooperation, planning and implementation of NMHSs led activities The operational hydrology community at national scale knows how to access the global and regional products, services, tools, and actively participates in the activities and community of WMO
Objective 5.2 Streamline WMO programmes	Enhanced coordination, effectiveness and governance of all WMO activities in supporting Members in Integrated Drought Management The operational hydrology community at national scale knows how to access the global and regional products, services, tools, and actively participates in the activities and community of WMO Enhanced collaboration between hydrology and meteorology communities of practice, including academia
Objective 5.3 Advance equal, effective and inclusive participation in governance, scientific cooperation and decision-making	The operational hydrology community at national scale knows how to access the global and regional products, services, tools, and actively participates in the activities and community of WMO

Note: the detailed mapping of activities vs the WMO Strategic and Operating plan is available here

ANNEX III

BACKGROUND INFORMATION

Formation of the WMO Hydrological Assembly (from Resolution 24 Cg-18, Annex 2 – Terms of Reference of the Open Committee of Congress Entitled the WMO Hydrological Assembly)

1. Building on the long history and work of the WMO Commission for Hydrology, the Eighteenth World Meteorological Congress (Cg-18) convened an open committee to create a new WMO Hydrological Assembly, as part of the larger reform of WMO constituent bodies.

Among its findings, the Assembly found that WMO should take a more proactive coordination and leadership role in global water issues, focusing on its mandate in Operational Hydrology.

2. The Assembly is structured as an open Committee of Congress to make recommendations to Congress and relevant constituent bodies on matters related to hydrology including but not limited to Article 2(e) of the WMO Convention, namely, to promote activities in operational hydrology and to further close cooperation between Meteorological and Hydrological Services. The activities of the Hydrological Assembly are guided by the WMO Strategic Plan and the agenda of Congress and focus on: (a) Contributing to the integration of hydrology in working programmes of WMO; (b) Mobilizing the operational hydrological community to participate in WMO governing bodies at all levels; (c) Advising the heads of Congress delegations on emerging hydrological issues as well as on their consideration within the governing structures of WMO; (d) Motivating Governments to improve the integration of weather, water and climate topics on national and regional levels.

WMO Hydrological Coordination Panel (from Resolution 5 (EC-71) – Hydrological Coordination Panel)

3. Following Cg-18, the seventy-first session of the Executive Council (EC-71) established the WMO Hydrological Coordination Panel (HCP) as "the WMO think tank on hydrology". The HCP supports and advises on an integrated delivery of WMO water-related activities and undertakes preparatory work for the Hydrological Assembly, in relation to current and emerging scientific and technical water-related global challenges. The Panel integrates the hydrological work of WMO into the wider global water agenda and supports and advises the WMO Executive Council's Technical Coordination Committee (EC/TCC). The Panel works in accordance with the purposes of the Organization related to hydrology including but not limited to Article 2(e) of the Convention: To promote activities in operational hydrology and to further close cooperation between Meteorological and Hydrological Services.

4. HCP supports the efforts of EC and TCC to identify service and related science and technology gaps associated with each element of the seamless end-to-end operational prediction process whose elements include data, data services, modelling, forecasting, warnings, dissemination, decision support, training and outreach. Once identified and prioritized, information regarding these gaps can be used to inform investment decisions made by Members to build operational capacity.

Mandate for the Vision and Strategy for Hydrology and associated Plan of Action (from Resolution 24 (Cg-18) – Vision, Strategy and Organizational Arrangements for Hydrology and Water Resources in WMO and Resolution 25 (Cg-18) - Major Hydrological Initiatives, Resolution 5 (EC-71) Annex 1 - Terms of Reference of the Hydrological Coordination Panel)

5. Cg-18 requested the Executive Council to develop, with the support of HCP, a Plan of Action for consideration of an extraordinary session of Congress in 2021 taking into consideration, the reinforcement of the importance of operational hydrology in addressing global water challenges, opportunities in the future in the broader WMO Earth system approach and interdisciplinary context and the recommendation of the Hydrological Assembly, and to explore mechanisms that improve effective engagement and enable a stronger presence of the hydrological community in WMO activities.

6. Cg-18 also determined that eight ongoing hydrological activities and systems are fundamental pillars that support the WMO Strategic Plan and its further development. The eight initiatives include:

Quality Management Framework – Hydrology and its further implementation:

7. With the aim of promoting a stronger culture of compliance and quality assurance, the Commission for Hydrology (CHy) decided to engage in an in-depth review, to be completed by 2021, of its technical and regulatory material, ensuring alignment with other WMO regulatory material and its consistency with other sources of standardization such as ISO. This work started from the *Basic Documents No. 2, Technical Regulations Volume III: Hydrology* (WMO-No. 49) and will also include the review of existing material and guidance and the development of new material, responding to Members' requirements including innovative technologies and citizen science.

Assessment of the performance of flow measurement instruments and techniques:

8. The development of software to assist NHSs in the assessment of the uncertainty of river discharge measurements is nearing completion and will be widely distributed to WMO Members under the coordination of the Management Committee of Project X; the project will continue to provide support and advice to members on flow measurement techniques, including innovative approaches.

The Global Hydrometry Support Facility (HydroHub)

9. The implementation of Hydrological Cycle Observing System (HYCOS) components according to Members' priorities, under the new World Hydrological Cycle Observing System (WHYCOS) framework and integrating innovative monitoring approaches, is being revamped. Innovation in hydrometry is being harmonized into the hydromet development activities that are financed by the international donor community. A community of practice is being built to support hydrometric requirements of NHSs and an information system developed for stakeholders. The Meteorological, Climatological and Hydrological (MCH) Database Management System will, in coordination with climate data management systems continue to be developed and implemented according to hydrological and climatological needs and the existing MCH community of practice will be extended to other languages in addition to English.

Hydrological data operations and management

10 The implementation of the WHOS Phase II, in accordance with its Implementation Plan endorsed by EC-71, with its governance and architecture compliant with WIGOS, WIS and the Global Data-processing and Forecasting System (GDPFS), will be extended to other regions, on the basis of the successful experiences in the Plata and Sava river basins, as well as in the Arctic; the contributions of global data centres (GRDC, GPCC, IGRAC, HYDROLARE, federated under GTN-H) are relevant for the Global Climate Observing System (GCOS) Implementation Plan and their role, especially in the implementation of WHOS, will be reviewed in order to enhance it.

The WMO Flood Forecasting Initiative and hydrological contributions to disaster risk management, including flood (APFM) and drought (IDMP) management:

11. Assessment guidelines for end-to-end Early Warning Systems for flood forecasting and to assist Members in the assessment of their flood forecasting capabilities are being finalized and are being implemented through extrabudgetary resources in Burkina Faso and Dominican Republic, with additional donor interest being expressed for their implementation in Ecuador and other RA III/IV countries. Phase III of the project for the advancement and sustainability of a flash flood guidance system with global coverage project started in March 2019. It will allow additional benefits to be accrued to Members including further development and implementation of the Flash Flood Guidance System (FFGS), with advanced features such as landslide susceptibility, urban flash flood forecasting, riverine flood forecasting, and seasonal prediction. Cooperation with the Global Water Partnership (GWP) in the implementation of APFM and IDMP continues and is being reaffirmed through an MoU.

WMO Global Hydrological Status and Outlook System (HydroSOS)

12. HydroSOS, launched in 2018, will continue to be implemented building on the existing efforts from a number of Members to produce regular analyses of the current national hydrological condition complemented by forward looking assessments of how the water situation may change over sub-seasonal to seasonal timescales, and taking into consideration the need to link this initiative closely with other related WMO activities such as WIGOS (in particular by making use of the opportunities provided by WHOS) and the GDPFS. Pilot projects have been initiated in the Lake Victoria and Ganges-Brahmaputra basins to test the concept, with the ultimate objective of reaching global coverage; this activity can be supported by the Dynamic Water Resources Assessment Tool (DWAT) which allows the assessment of the impacts of land-use changes within the basin over time on water availability. DWAT can be used to assess a wide variety of scenarios as well as the interactions between climate, water and landscape on the availability of water resources.

Capacity-building in hydrology and water resources management

13. The WMO strategy for capacity-building in hydrology and water resources management agreed by CHy and endorsed by EC, will continue guiding the activities. Current developments consist of the distance learning course on hydrometry for field hydrologists, developed for the Pacific small islands and later adapted for African countries, being further adapted for other regions. A distance learning course on hydrological data sharing using the WHOS Phase II approach will be developed and the first edition delivered in early 2022.

***The World Water Data Initiative (WWDI*)**

14. Together with the World Bank and the Australian Government among other key partners, will promote modern national strategies, including an open data policy, to improve water information and contribute to reinforce the capabilities of countries and other data providers in building and operating hydrometeorological monitoring networks as well as successful water data management. Together with the HydroHub, identify barriers to effective monitoring and propose approaches for overcoming them, including innovative solutions and modernization of standardization processes.

15. Following Cg-18, EC-71 concluded the terms of reference for the HCP, which include direction to the HCP to "develop the Vision and Strategy for Hydrology and its associated Plan of Action, which support the achievement of water-related WMO Strategic Plan goals to be reviewed by EC-72 in 2020 and submitted for consideration of the extraordinary session of Congress in 2021". The WMO Vision and Strategy will be continuously updated for regular sessions of the Hydrologic Assembly.

Definition of Operational Hydrology (from Cg-18, Resolution 24, Annex 1)

16. Operational Hydrology is the real time and regular measurement, collection, processing, archiving and distribution of hydrological, hydrometeorological and cryospheric data, and the generation of analyses, models, forecasts and warnings which inform water resources management and support water-related decisions, across a spectrum of temporal and spatial scales. Operational hydrology requires capacity-building and scientific and technical advancement and innovation in the areas of observation, data standards and services, modelling, prediction, hydro-informatics and decision support, communications, training, and outreach.

Annotation

17. These data include, but are not limited to, precipitation; air temperature and humidity; water level of streams, lakes, deltas and estuaries; streamflow; snow and ice cover, depth and water equivalent; river and lake ice; glacier mass balance; reservoir storage; soil moisture; groundwater and ground frost; evaporation and evapotranspiration; water temperature; sediment dynamics; water and sediment quality and other related variables, including within the context of global change. Global change is expressed through different aspects, such as land-use changes, socioeconomic dynamics, climate variability and climate change.

Relationship to the WMO Strategic Plan

18. The Strategic Plan adopted by the Eighteenth World Meteorological Congress, in June 2019, sets the directions and priorities to guide the activities of the WMO during 2020–2023 and up to 2030 to enable all Members to improve their information, products and services.

19. It also sets three overarching priorities: (i) enhancing preparedness for hydrometeorological extremes, (ii) supporting climate-smart decisions, and (iii) enhancing socioeconomic benefits of related services – with a view to contributing to the societal needs reflected in the global agenda to realize sustainable development.

20. The Plan recognizes the demand for actionable, accessible and authoritative science-based information to address the increasing threats of extreme weather and the urgency of climate action for resilience, mitigation and adaptation, as well as the need to reduce the growing capacity gap in infrastructure and services by making use of rapid advancements in science and technology and innovative partnerships.

21. To address these ambitious aspirations, the Strategic Plan pursues five long-term goals and associated objectives:

1. Better serve societal needs: Delivering, authoritative, accessible, user-oriented and fit-for-purpose information and services;

2. Enhance Earth system observations and predictions: Strengthening the technical foundation for the future;

3. Advance targeted research: Leveraging leadership in science to improve understanding of the Earth system for enhanced services;

4. Close the capacity gap on weather, climate, hydrological and related environmental services: Enhancing service delivery capacity of developing countries to ensure availability of essential information and services needed by governments, economic sectors and citizens;

5. Strategic realignment of WMO structure and programmes for effective policy- and decision-making and implementation.

22. The WMO Strategic Plan provides a reference framework for the HCP plan of action and forms the basis to set the priorities for its implementation, establishing also the clear contribution of WMO Members to major international agreements.

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APPENDIX

LIST OF ACRONYMS

APFM: Associated Programme on Flood Management

AMCOW: African Ministers' Council on Water

CAP: Common Alerting Protocol

CB: Capacity-building

CHy: Commission for Hydrology

Cg: Congress

CIFI: Coastal Inundation Forecasting Initiative

DRR: Disaster Risk Reduction

DWAT: Dynamic Water Resources Assessment Tool

EC: Executive Council

E2E MHEWS: End-to-End Multi-Hazard Early Warning Systems

ENSO: El Niño-Southern Oscillation

EWS: Early Warning System

FAO: Food and Agriculture Organization

FFI: Flood Forecasting Initiative

FFGS: Flash Flood Guidance System

GBON: Global Basic Observing Network

GCOS: Global Climate Observing System

GCW: Global Cryosphere Watch

GDPFS: Global Data-processing and Forecasting System

GEMS: Global Environmental Monitoring System

GEO: Group on Earth Observations

GHSF: Global Hydrometry Support Facility (HydroHub)

GMAS: Global Multi-hazard Alert System

GRDC: Global Runoff Data Centre

GTN-H: Global Terrestrial Network – Hydrology

GWP: Global Water Partnership

HCP: Hydrological Coordination Panel

HDOM: Hydrological Data Operations and Management

HydroSOS: Global Hydrological Status and Outlook System

IAHR: International Association for Hydro-Environment Engineering and Research

IAHS: International Association of Hydrological Sciences

IDI: International Drought Initiative

IDMP: Integrated Drought Management Programme

IFAD: International Fund for Agricultural Development

IFI: International Flood Initiative

IFM: Integrated Flood Management

IGRAC: International Groundwater Resources Assessment Centre

IIWQ: International Initiative on Water Quality

INFCOM: Commission for Observation, Infrastructures and Information Systems

IPCC: Intergovernmental Panel on Climate Change

ISI: International Sediment Initiative

IWRM: Integrated Water Resources Management

LTA: Long-term ambition

MCH: Meteorological, Climatological and Hydrological

MHEWS: Multi-Hazard Early Warning Systems

NGO: Non-governmental Organization

NHSs: National Hydrological Services

NMHSs: National Meteorological and Hydrological Services

NMS(s) – National Meteorological or Hydrometeorological Service(s)

NWP: Numerical Weather Prediction

QMF-H: Quality Management Framework – Hydrology

QPE: Quantitative Precipitation Estimation

QPF: Quantitative Precipitation Forecast

RCOFs: Regional Climate Outlook Forums

SERCOM: Commission for Weather, Climate, Water and Related Environmental Services and Applications

SOFF: Systematic Observations Financing Facility

SDG: Sustainable Development Goal

SOP: Strategic and operation plan

SWFP: Severe Weather Forecasting Programme

UNDP: United Nations Development Programme

UNDRR: United Nations Office for Disaster Risk Reduction

UNECE: United Nations Economic Commission for Europe

UNESCO-IHP: United Nations Educational, Scientific and Cultural Organization – Intergovernmental Hydrological Programme

UNEP: United Nations Environment Programme

UNFCCC: United Nations Framework Convention on Climate Change

WB: World Bank

WFP: World Food Programme

WHOS: WMO Hydrological Observing System

WIGOS: WMO Integrated Global Observing System

WIS: WMO Information System

WMO: World Meteorological Organization

WWDI: World Water Data Initiative

WWQA: World Water Quality Alliance

Resolution 5 (Cg-Ext(2021))

Advanced implementation of elements of the Plan of Action for Hydrology

THE WORLD METEOROLOGICAL CONGRESS,

Recalling:

(1) Annex 2 to Resolution 24 (Cg-18) – Terms of reference of the open committee of Congress entitled the WMO Hydrological Assembly,

(2) Resolution 25 (Cg-18) – Major hydrological initiatives,

(3) Resolution 6 (EC-73) – Concept note on the sustainability strategy for the Flash Flood Guidance System with Global Coverage,

(4) Decision 2 (EC-73) – Consideration of the reports, in particular EC-73/INF. 2.4(2) – Report by the Chair of the Research Board,

(5) Resolution 5 (INFCOM-1) – Implementation of hydrological activities under the new WMO structure,

Noting Resolution 4 (Cg-Ext(2021)) – WMO Vision and Strategy for Hydrology and its associated Plan of Action,

Noting also the successful completion of the pilot phase of the WMO Hydrological Status and Outlook System (HydroSOS) and the recently initiated development of HydroSOS regional implementation plans in all WMO regional associations,

Noting further the Hydrological Coordination Panel's efforts so far to familiarize the Permanent Representatives and Hydrological Advisers with HydroSOS and the Flash Flood Guidance System with Global Coverage (FFGS/WGC) Sustainability Strategy in information sessions and during the Hydrological Assembly, as well as the numerous interactions of the Research Board with the research community to finalize the Hydrological Research Strategy,

Having examined the recommendations of the Hydrological Assembly contained in Cg-Ext(2021)/INF. 3.1(2),

Decides:

(1) To endorse the WMO Hydrological Research Strategy 2022–2030: "Operational Hydrology Research Priorities", included in Annex 1 to the present resolution, which was prepared by the Research Board as a fundamental element that underpins the whole Plan of Action for Hydrology and lays out concrete steps for the way forward to achieve the long-term ambition "*Science provides a sound basis for operational hydrology"*;

(2) To approve the Sustainability Strategy for FFGS/WGC, the Executive Summary of which is included in Annex 2 to the present resolution;

(3) To approve the End of Pilot Phase Report of HydroSOS;

(4) To close the HydroSOS pilot phase and to start operationalizing the global HydroSOS through regional implementation plans led by the regional associations based on the recommendations on the way forward included in Annex 3 to the present resolution;

(5) To approve the new terms of reference of the Global Hydrometry Support Facility (GHSF) governing bodies, included in Annex 4 to the present resolution;

(6) To note the recommendations made by the Hydrological Assembly to other constituent bodies pursuant to its terms of reference;

Requests the Chair of the Research Board and the Chair of the Hydrological Coordination Panel to take the appropriate actions, including the establishment of adequate mechanisms, to catalyse and guide the implementation of the WMO Hydrological Research Strategy;

Requests the presidents of the technical commissions to consider, at their earliest convenience, the recommendations of the Hydrological Assembly addressed to the commissions in order to ensure the continuity of the relevant activities;

Requests the president of the Services Commission to explore ways of ensuring operational support to FFGS and other flash flood and flood forecasting systems as part of the Flood Forecasting Initiative (FFI), one of the major hydrological initiatives identified by Resolution 25 (Cg-18);

Requests the Hydrological Coordination Panel to establish the "Coordination and Support", "Implementation" and "Technical Development" Teams by 31 December 2021 and to support and advise on the integrated delivery of HydroSOS, ensuring the coordination of the technical commissions, the Research Board and the regional associations;

Requests the presidents of the regional associations and the Chair of the Hydrological Coordination Panel to jointly report on the progress of regional HydroSOS implementation to the World Meteorological Congress at its nineteenth session (Cg-19);

Requests the Secretary-General to send a communication to the National Science Foundations or equivalent bodies of Members, annexing the Hydrological Research Strategy, describing it as the consensus of the international scientific community on the research needed to enhance operational hydrology in support of Sustainable Development Goal 6 and requesting their support for its implementation;

Further requests the Secretary-General to continue his valuable efforts in mobilizing extrabudgetary resources to support the implementation of the aforementioned initiatives;

Invites Members to familiarize themselves with the initiatives outlined above, to organize national workshops with relevant stakeholders to jointly identify national benefits with respect to these initiatives, and to ensure the participation of relevant experts in their implementation;

Further invites Members to prioritize activities to achieve the identified benefits and actively support the implementation of the aforementioned initiatives at the national, regional and global levels.

Annex 1 to Resolution 5 (Cg-Ext(2021))

WMO Hydrological Research Strategy 2022-2030: "Operational Hydrology Research Priorities"

The purpose of this document is to provide input to the global research community on the areas of priority research needed to support the provision of improved hydrological services. Its focus is on research that has a direct application to improving operational hydrology and the operations of National Hydrological and Meteorological Services in support of the eight ambitions described in the World Meteorological Organization's (WMO) Action Plan on Hydrology. Ideally, this document provides a framework for research to support National Meteorological Services (NMSs) and National Hydrological Services (NHSs), a tool for building new research partnerships and collaborations, and a means of effectively communicating the needs and benefits of hydrological research in support of operational hydrology. These priorities will help guide the actions by the WMO's Research Board and other relevant bodies and partnerships, in support of the WMO's Action Plan on Hydrology in coordination with other partner organizations outside the WMO.

The Challenge

Water is essential to human health, economic development, and peace and security. Yet within the next 10 years, more than half of the world's population will be living under water stressed conditions and more than a billion people will face absolute water scarcity and lack the water to meet human, economic, and environmental needs.[1] Future land-use and climate changes will exacerbate these conditions – affecting the timing, distribution, and intensity of rainfall events; decreasing available water storage; and contributing to floods, droughts, and other water-related disasters.[2] Together, these changes will increasingly drive energy and food insecurity, ecosystem degradation, state fragility and failure, mass migration and humanitarian disasters, and insecurity at the regional, national, basin, and individual levels.

Water security is human security. Being water secure, means that people have access to sustainable supplies of water of the right quality and quantity to meet their domestic, social, economic, and environmental needs while preventing and mitigating the impacts of floods and droughts. Achieving water security and the water-dependent/water-related Sustainable Development Goals requires the sound management of water resources across both space and time at all scales. This cannot be done without providing all stakeholders, including the public, with sound knowledge of the hydrological and associated processes within the Earth System; an understanding of the interconnections between water, land, and air; and access to trusted

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[1] UN World Water Development Report 4. Volume 1: Managing Water under Uncertainty and Risk, http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/WWDR4%20Volume%201-Managing%20Water%20under%20Uncertainty%20and%20Risk.pdf

[2] Climate Change and Water: IPCC Technical Paper VI, https://www.ipcc.ch/site/assets/uploads/2018/03/climate-change-water-en.pdf

and reliable data – across space, time and frequency – that can be used to support decision-making.[3]

To solve these challenges, we must understand the complex processes and systems that occur at the narrow interface between the atmosphere, geosphere, biosphere and human geography – what is often called the "critical zone". Within this zone, human, hydrological, meteorological, and climate forces drive extreme spatial and temporal heterogeneity and push us towards compartmentalized approaches. Interactions with the land surface, critical ecosystems, and anthropogenic activities add to this complexity. While we are making progress at a small scale, hydrological sciences at the catchment level remain observational and highly data dependent. Our development of Earth systems modelling approaches for hydrological purposes are diverse and fragmented. Setting a thoughtful research agenda can help integrate these diverse efforts and focus much needed attention on key gaps in knowledge, methods, tools and services. That is our goal – to catalyse self-organization within the hydrological scientific community around the key challenges to rapidly advance our understanding of the Earth System and our ability to provide hydrologic knowledge and information for service providers.

That said, it is important to note that the development of research priorities must be informed by the work of the NHSs and NMSs themselves. By making data, models, and the evaluation metrics for forecasting systems available, NHSs and NMSs can help the research community better understand current gaps and practical constraints of operational hydrology and facilitate the research-to-operations enterprise.

The Vision and Goal of the WMO's Research Strategy on Hydrology

The mission of the World Meteorological Organization (WMO) is to "protect the safety and welfare of humanity by improving and increasing access to meteorological and hydrological information and services".[4] Simply put, the WMO's vision is to improve meteorological and hydrological observation, modelling, and forecasting to better serve societal needs.[5]
With regards to water, these needs have been articulated in the WMO's Action Plan on Hydrology as eight hydrological ambitions.[6] These are:

a) No one is surprised by a flood;

b) Everyone is prepared for drought;

c) Hydroclimate and meteorological data support the food security agenda;

d) High-quality data supports science;

e) Science provides a sound basis for operational hydrology;

f) We have a thorough knowledge of the water resources of our world;

g) Sustainable development is supported by information covering the full hydrological cycle; and

h) Water quality is known.

[3] Blöschl, G., et al. 2019: Twenty-three unsolved problems in hydrology (UPH) – a community perspective, Hydrological Sciences Journal, 64:10, 1141-1158, DOI: 10.1080/02626667.2019.1620507

[4] Convention of the World Meteorological Organization

[5] WMO Strategic Plan 2020-2023

[6] Decides (1) of Resolution 24 (Cg-18)

Each of these ambitions represents an area of broad societal and economic benefit and serves as the long-term vision and aspirational goals of the WMO's work on hydrology and strengthens the Earth System Approach.

The practice of providing hydrological information and services in support of these ambitions is known as *operational hydrology*.

The primary goal of the WMO's Research Strategy on Hydrology is to address the scientific and knowledge gaps necessary to improve the delivery and the use of hydrologic data, information, and services (i.e., operational hydrology) within the context of the WMO's broader mission on water, weather, and climate.

The Approach – Implementing the WMO's Research Strategy on Hydrology

The role of the WMO is to enable the conduct of science that advances implementation of this research agenda. This includes clearly articulating a coordinated, transparent, and user-driven set of research objectives and activities; the building of broad-based support for this research agenda among national, regional, and global leaders; establishing unique partnerships among the scientific and user communities (including civil society) to advance implementation of the strategy; and supporting the identification and solicitation of funds to carry out research activities.

Advancement of the priorities identified in this Strategy will be led by the Research Board taking into account the recommendations of the Hydrological Coordination Panel (HCP) and in close coordination with the Infrastructure and Services Commissions and other partners/organizations, in particular the Intergovernmental Hydrology Program (IHP) of UNESCO and IAHS.

Implementation of this strategy will be guided by the following principles:

- Delivering research outcomes that meet user-defined needs and expand the capacity and capabilities of National Hydrological and Meteorological Services providers (NHSs and NMSs) and close the loop between researchers, developers, service providers, and other stakeholders.
- Conducting research that leverages the unique strengths and capacities of the WMO including the ability to develop global/regional partnerships, facilitate access to NHSs and NMSs, and to make use of WMO Projects and Programs.
- Progressively improving service delivery – i.e., "leap-frogging" is not always possible, particularly in low-resource settings. The goal is to progressively improve levels of service and not let perfection be the enemy of the good or better.
- Maximizing complementarity with the broader research community on hydrology and, in particular, with relevant WMO programs and initiatives (e.g. WCRP, WWRP, GAW, GEWEX, ESMO, WGNE, GCOS, GTOS, GOOS), and partner organizations and their relevant initiatives such as IAHS Unsolved Problems in Hydrology, IAHR and UNESCO's IHP Strategic Plan of the IX Phase of IHP (IHP-IX, 2022-2029).
- Prioritizing gender equity and the creation of research and educational opportunities for practitioners and scientists from under-represented groups and in small island developing states (SIDSs) and low- and middle-income countries (LMICs).
- Strengthening the dialogue between stakeholders, end-users, the research community, and service providers to ensure that research is user-driven and meets stakeholder needs.

Research Objectives

The goal of this strategy is to improve the delivery of hydrological services and ensure access to hydrological data and information necessary for sound water resources management, sustainable economic growth and development, and disaster risk reduction. The focus is on building the tools and capabilities of the NHSs and NMSs, particularly in SIDSs and LMICs. The specific objectives and outcomes of the research strategy are described below and based on the roles and operational needs of NHSs and NMSs[7]: (Note: Some overlaps exist, and activities identified in one area often support multiple research objectives.)

1. Improve Hydrological Monitoring to generate hydrologic and cryospheric information that enhances our understanding and assessment of the quantity and quality of water resources, including both surface and groundwater

You cannot manage what you cannot measure. The collection and generation of hydrological data and information is fundamental to operational hydrology and is essential to the protection and management of water resources. Knowing the current state and trends of a country's water resources (surface, ground, snow, and ice), across both space and time, is critical to ensuring that supplies can meet current and future demands; to allocating water among competing uses; to the planning, design and operation of water projects; to assessing the environmental, economic and social impacts of existing and proposed water projects and strategies; and to providing security for people and property against water-related hazards, particularly floods and droughts. The need is for data that allows the determination of hydrological statistics, including extremes, important to future planning and design including the mean annual, monthly, or seasonal values; maxima, minima and selected percentiles for durations ranging from instantaneous to 30 days; and measures of variability (e.g., variance). Together, these data define the hydrological system to be managed and provide important inputs into weather and climate models. To achieve this objective, the following are specific priority areas of research for the WMO:

1.1. Hydrologic data collection

This includes the collection, processing and curating of both in-situ and remote sensing data related to: a) the measurement of precipitation (rain and snowfall, fog drip); snow cover extent and water equivalent of snow cover; evaporation; river levels and flows; lake and reservoir levels; groundwater levels and flows; sediment concentrations and flows in rivers; bacteriological, chemical, and physical quality of surface water and groundwater; water use; and surface and subsurface properties, states, and fluxes at a range of spatial and temporal scales; and b) the collection of geophysical data and information necessary to improve hydrological systems modelling, such as cross section topographic and bathymetric profiles, basin topography, catchment and sub catchment delineation, land cover, and soil types.

Some hydrological properties remain difficult to observe or are costly to measure at the scale or resolution needed. Research should include the development of tools and techniques to make measurements more cost-effective and complement, where appropriate, a few accurate data by many less accurate data (e.g. machine learning) that expands or improves our observational data at minimal cost. Attention should be paid to understanding the relative value of traditional hydrological observations versus soft data (qualitative observations from lay persons and citizen scientists, data mining, etc.), and

[7] Guidelines on the Role, Operation and Management of National Meteorological and Hydrological Services, WMO-No. 1195, 2017; Guidelines on the role, operation and management of National Hydrological Services, WMO No. 1003, 2006.

under what conditions we can infer the future behaviour of hydrological systems from contemporary spatial data.

Outcome: *Effective, efficient, context-appropriate low-cost methods for hydrological observations are broadly available and easy to use.*

1.2. Design and evaluation of hydrological monitoring networks

The development of hydrological data collection systems (at all scales) must be done thoughtfully to be effective, sustainable, and address the current and future needs of all users while minimizing costs and maximizing coverage. These systems will need to adapt and grow as needs, capabilities, and resources change. Critical questions include but are not limited to: What data is needed for which purpose across all users and stakeholders? Where? How often or at what temporal resolution? What functional standards are required for hydrological monitoring networks? How do we optimize data collection (e.g., by combining multiple data sources of different quality and integration of remote sensing data, citizen observations, internet of things, and low-cost technologies)? What data combination methods do we use? How do we make better use of in-situ and remote sensing data, and decrease uncertainty? Can we reduce uncertainty by, for example, using Bayesian statistics to assess model performance against observations over a selected control period?

What is the proper sequencing of investments necessary to meet the system requirements while progressively improving data quality, resolution, and delivery?

Outcome: *NHSs and/or NMSs have the tools to plan and construct hydrological monitoring networks that can grow/adapt as needs and resources change.*

2. Improve hydrological forecasting

A key function of NHSs and NMSs is to provide knowledge and information on how the hydrometeorological system behaves or reacts and to predict, based on measured or simulated inputs (objective 1), the future state of water resources across multiple timescales – very short term (flash floods), short- and mid-term (riverine floods), long-term (sub-seasonal and seasonal forecasts and outlooks), and very long-term (climate projections). This knowledge and information is absolutely essential to the daily management of water resources, the planning and design of infrastructure and human settlements, and the protection of lives and property from extreme hydrological events. It should be based on the clearly identified needs of the end-users and the hydrological and meteorological communities consistent with the objectives of NHSs and NMSs. Adoption of an end-to-end hydrological forecasting value chain approach will support the integration of different aspects of hydrology (from observation, data management, through modelling and dissemination of early warnings) and other disciplines, including the social sciences, to ensure the effectiveness of interventions that enhance disaster preparedness and response. To achieve this objective, the following are specific priority areas of research for the WMO:

2.1. Hydrological and Cryospheric Modelling and Forecasting

This includes the improvement of near-real time data assimilation and forecasting procedures and modelling techniques (physically-based models, data-driven models or hybrid models) to assess the current and future state of water resources – both quantity and quality across all forms – and their impact on weather and climate systems over space and time. Understanding and proper attribution of uncertainty throughout these processes is critical to support robust decision-making. There is also a need to improve methods for model state updating and modelling and forecasting of water quality, including through the development of innovative monitoring methods such as surrogate measurements or remote sensing techniques. Perhaps most important, these tools must be accessible to the NHSs and NMHs and made user ready.

Outcome: *Improved modelling and forecasting of hydrological systems across both space and time.*

2.2. Precipitation Estimation and Forecasting

Timely and spatially appropriate quantitative precipitation estimates and forecasts (QPE and QPF) are the most critically needed inputs into hydrological models. In many ways, much of what underpins QPE and QPF estimation is still not well understood. To provide these products, a number of different methods are used to estimate precipitation amounts from data collected by station observation, radar, satellites, or other remote sensing platforms but a number of critical gaps remain, including: achieving the spatial and temporal resolution necessary for the hydrological models; reducing/estimating the uncertainty of the quantity, location, and time of QPE/QPF products and the impacts of climate change; aligning QPE/QPF products with hydrological requirements; reducing the propagation of uncertainty from QPF through downstream models; and, in conjunction with other priority research areas, improving coupled hydrometeorological modelling including understanding of how surface fluxes of water impact weather and climate systems as part of an "Earth systems" modelling approach. Earth systems integrated thinking, or a seamless approach, will require strong collaboration across and combining different scientific disciplines from exact and social sciences, in particular meteorology, climatology and hydrology.

Outcome: *QPE and QPF outputs are improved across space, time, and accuracy and are better matched to the required inputs for hydrological models.*

2.3. Understanding and Predicting Hydrological extremes

Extreme hydrological events – such as droughts, flood, heavy precipitation, etc. – have received greater attention in recent decades due to their widespread impacts on society and ecosystems and their connections to climate change. Under extreme conditions, the hydrological system responds differently, and focusing on a single hydroclimatic variable or extreme is not sufficient to comprehensively characterize the hydrological systems behaviour or the socio-economic impacts of these extreme events. This is often further complicated by compound events in which a combination of multiple drivers and/or hazards, or sequential occurrence of multiple extremes at single or multiple locations, have a multiplicative effect and are often responsible for many of the most severe weather- related and climate- related impacts. Understanding and modelling these complex and extreme events to improve very short and long-term forecasting – including empirical approaches, multivariate stochastic analysis, predictive uncertainty estimation, the indicator approach, quantile regression, artificial intelligence, etc. – will be critical to predicting and managing the impacts of climate change and reducing the risks from hydrological/weather disasters. In addition, data series extension methods (using paleodata, proxydata, regionalization, etc.) should become widely operationally used. Re-analysis data should become instrumental to understanding past weather extremes and related hydrological responses. Artificial intelligence and machine learning should be explored to improve modelling including in river basins with limited observational data based on well-modelled basins.

Outcome: *There is a greater ability to model how the hydrological system responds to extreme and compound conditions.*

2.4. Assessing/modelling human-water-ecosystem interactions

The goal of operational hydrology is to contribute to the sustainable management of water to serve societal needs. It is therefore critical to understand the relationships between water and societal needs and to assess the impacts that changing hydrologic

and climatic conditions and the management of water resources will have on people and the environment. This includes the impacts on human health and the social/cultural, economic, environmental, and security dimensions of water that people value. It requires full characterization of the hydrological system (i.e., quality, quantity, location, timing, uses, etc.) in terms that can be easily integrated into environmental, ecological, and other environmental health models in response to user/stakeholder needs and taking into consideration various interactions, e.g., in coastal and estuaries regions or in High Mountain areas. It also requires quantifying human impacts and water management decisions on the water cycle (e.g., irrigation, development in flood plains and shifting inundation areas, reservoirs operation, population growth, urbanization of landscapes, and land-use competition). This will require mixed methods analysis that combines quantitative and qualitative data to better understand the value of water across all dimensions and all stakeholders.

Outcome: *There is improved modelling of the interactions between human, water, and environmental systems.*

3. Develop and improve relevant methods, procedures, and techniques for the collection, analysis, and transmission/communication of hydrological data for the user community

Perhaps the most important function of NHSs is to provide users with trusted hydrological data to inform decision-making. This means providing timely and accurate data and information about past, present, and future conditions in a manner that is readily accessible and usable to all stakeholders. With terabytes of hydrologic information being produced every second, the challenges of data collection, validation, curation, and dissemination can be overwhelming, particularly in SIDSs and LDCs. Many tools and platforms currently exist to facilitate access to hydrological data and information (e.g., WIGOS, WHOS, OSCAR, WIS, HydroSOS and WDQMS). These need to be improved and new tools and methods need to be developed to ensure that people have access to the data they need, when they need them, in the form they need it, in an equitable manner, without creating an unsustainable burden on NHSs.

All of this must be based on a sound understanding of if and/or how different users use the information in their decision-making, the best means for quantifying and conveying uncertainty, the challenge of providing real-time hydrological information to NHSs and NMSs, and completing the supply chain from data to information to knowledge to action.

3.1. Data Processing and Quality Control

Once collected, what are the tools and methods for cleaning and validating data, particularly in SIDSs, LDCs and LMICs. How can this be done at scale, at low-cost, and sustainably?

Outcome: *That data collected is trusted.*

3.2. Data Storage, Access and Dissemination

What are the tools and methods for archiving and storing data, to facilitating access to data in an equitable and sustainable manner, and to ensuring that users have access to the data they need, when they need it? An open data policy is needed to maximize the value of data, improve efficiencies, and expand research and learning equitably. The hydrological community should further promote and adhere to the FAIR Principles (Findable, Accessible, Interoperable, Reusable) and/or open access approaches (already adopted by several communities across the different domains of the Earth System – e.g., atmosphere, atmospheric composition, ocean, climate, cryosphere communities). Hydrological data access needs to be both technically open (i.e., available in a machine-readable standard format to be processed by a computer application including open and freely available processing software) and legally open (i.e., explicitly licensed that allows

commercial and non-commercial use and re-use without restrictions). The interoperability between data providers and users also needs to include the interoperability of tools with the aim of a comprehensive advanced approach to remove the digital divide in hydrology.

Outcome: *That the data is made accessible to all users, in the form they need it, when they need it.*

3.3. Communications

Fundamental to this strategy, and central to the mission of WMO, is the use of science, data, and information to inform the management of water resources. A key measure of this Strategy's success is whether end-users – of all types in all places – have access to, and understanding of, the hydrological information they need to make better decisions. Confidence in scientific information, data, and tools must not be taken for granted but carefully built and curated by making the science accessible and being fully transparent about what is known, unknown, or maybe known. The impacts of these uncertainties – where they matter and where they don't - need to be fully explained in terms that are understandable and meaningful to end-users and stakeholders. This must be a fully integrated component into the design of all research activities throughout this Strategy. Communications processes and products should be considered up-front in the project design process, support NMSs and NHSs, and include end-users and stakeholders in the design.

Outcome: *End-users of hydrological information/data have a clear understanding of the meaning of data and other hydrological science products and the interpretation of their uncertainty.*

Advancing Actions

The following steps will be taken by the WMO and its partners to catalyse actions that address these priority research areas:

I. **Solicit Research Proposals** (January of even years starting in 2022): Conduct outreach through WMO and partners' expert networks to solicit proposals that address the priority research areas using the template below.

II. **Develop and Draft Proposals** (February) (1-1.5 pages each; 3-4 total). Each will include the following elements:

- Identification of a specific area of work / question to be answered / product to be developed
- Description of how this activity will advance the NMHS mission in operational hydrology and support other WMO central/regional programs/initiatives
- Specific steps/research activities through 2032 to be undertaken with key indicators
- Identification of relevant programs/partnerships – both inside and outside of the WMO - that could support, compliment, or inform implementation of this research agenda
- Relevant Figures, Tables to synthesize and visualize ideas, visions, etc.

III. **Review Proposals:** Establish a review panel of 4-5 experts that will review proposals for purpose, clarity, and ability to implement. The panel will include one representative

from the HCP, the RB, UNESCO, and IAHS, and include both operational and research expertise.

IV. **Review and Consolidate Proposals (March/April):** The Review Panel will work with authors to strengthen/clarify and consolidate where appropriate.

V. **Virtual Workshop to Review and Rank Order Proposals (April):** Proposed research activities will be presented, discussed, and ranked. A final selection of 3-5 proposals will be made. In addition to the Expert Review Panel, the workshop will include the chair and vice chair of the Hydrological assembly, officers (presidents and vice-presidents) of Technical Commissions (TCs) with a background in hydrology, the chair of the hydrology-related standing committees and study groups of TCs, the regional hydrological advisors.

Research Proposal Template
(1-3 pages)

Background (1-2 paras): Describe the problem you are trying to solve, why it matters, and how it relates to the WMO's mission on operational hydrology.

Goal (one sentence): A clear statement of the research area, the question you want answered, or the methodology/tool you'd like developed

Impact (1 para): What achieving this goal would change/enable. What WMO policy or programmatic goals this would support.

Research Activities: An itemized list of specific activities that would be undertaken to achieve the goal.

Outputs and Indicators: A concise set of specific outputs (the direct product of the research activity) and indicators that can be used to measure success.

Estimated cost (in USD):

Potential Partners: Both within and outside the WMO.

Annex 2 to Resolution 5 (Cg-Ext(2021))

Executive Summary of the Sustainability Strategy for the Flash Flood Guidance System with Global Coverage

Executive Summary

A. Background

Recognizing the disastrous impact on lives and properties of affected populations by flash floods, the World Meteorological Organization (WMO), in collaboration with the Hydrologic Research Center (HRC), U.S. Agency for International Development/Bureau for Humanitarian Assistance (USAID/BHA)[1] and U.S National Oceanic and Atmospheric Administration/National Weather Service (NOAA/NWS) have created the Flash Flood Guidance System (FFGS) with Global Coverage (hereafter, the FFGS/WGC) to assist forecasters by providing the guidance needed to formulate and issue timely and accurate flash flood warnings for small basins. The FFGS/WGC is implemented for individual countries and for regions comprising several countries with the Flash Flood Guidance System being used operationally by National Meteorological and Hydrological Services (NMHSs) to develop flash flood warnings. The FFGS/WGC is also training forecasters on the effective use of the System. It is estimated that over 3,000 individuals have been trained in various aspects of the FFGS operations and maintenance by HRC and WMO since the beginning of the collaborative effort. The main objective of the FFGS/WGC is to advance the capacity of NMHSs to forecast the potential occurrence of hydrometeorological hazards, namely flash flooding, and related secondary hazards, such as rainfall induced landslides, to save lives, alleviate human suffering and reduce social and economic impacts of these hazards. Currently, the FFGS/WGC serves approximately 40% of the world's population covering almost 3 billion people in over 60 countries[2]. Its governance is documented in a

[1] Formerly USAID/Office of U.S. Foreign Disaster Assistance, USAID/OFDA.

[2] Visit the website https://public.wmo.int/en/projects/ffgs to view the list of countries participating in the FFGS/WGC.

Memorandum of Understanding (MoU) among WMO, HRC, USAID/BHA and NOAA/NWS, hereafter the *FFGS MoU Partners*. The WMO Flood Forecasting Initiative (FFI), established by Resolution 21 (CG-XV), supports and overviews the WMO flood forecasting programmes and projects, including FFGS and its associated activities.
The FFGS/WGC has a long, successful history. The concept makes use of a regional approach to support NMHSs for the detection, forecasting, and warning of flash floods and was first applied in the implementation of the Central America Flash Flood Guidance System (CAFFGS) in 2004. The CAFFGS was designed and built by HRC. It provided products to all seven countries in Central America with Regional Centre functions being undertaken by Costa Rica.

Based on the successful operations of the CAFFGS, HRC, USAID/BHA and NOAA/NWS met with WMO to initiate discussions on globally expanding the application of the FFGS. Following the meeting, the concept for the FFGS/WGC was documented in a prospectus in 2007 authored by HRC, WMO, USAID/BHA, and NOAA/NWS. Later that same year, the Fifteenth World Meteorological Congress (CG-XV) met and approved the implementation of the FFGS/WGC, which was promoted by the WMO Commission for Hydrology (CHy) jointly with the WMO Commission for Basic Systems (CBS) and in collaboration with NOAA/NWS, HRC and USAID/BHA. Subsequently, the partnership was formalized through the previously mentioned MoU.

B. Sustainability Goal

As illustrated in many countries, the FFGS is critical in saving lives by enabling government agencies to issue warnings of flash flood events. Since over 60 NMHSs rely on FFGS operations to develop these warnings for their countries, it has become increasingly evident that there is an urgent need for efforts to be now undertaken to ensure the sustainability of the System's operations. Accordingly, this *Sustainability Strategy for the Global Flash Flood Guidance System* has been developed with the goal of providing the vision and approaches to be taken to help attain the sustainability of the FFGS/WGC, operations of the FFGS itself, and its implementations. The Strategy to achieve long-term sustainability is through undertaking various transitional measures.

This Strategy was founded on the findings of an external Review of the FFGS/WGC that was completed in 2018, the outcomes of the FFGS/WGC Workshop held in 2019, experience gained in forecasting and provision of warnings of flash floods, the insights of the FFGS MoU Partners and the authors of the initial draft, and the suggestions of the report's many reviewers. The draft sustainability strategy and its four critical factors were used to help focus discussions of the sustainability sessions held during the FFGS/WGC Workshop. These critical factors are described in the Proceedings of the Global Flash Flood Guidance System Workshop as being the draft sustainability strategy.

These critical factors, which were identified and discussed during the Workshop, are the focus of this Sustainability Strategy and help to organize both thoughts and activities to help attain the much-desired sustainability. These factors are: 1) Developing an inclusive and broadened governance model; 2) Increasing and strengthening the training effort; 3) Increasing visibility of the FFGS; and 4) Developing additional financial and human resource support. The global Workshop was important in setting the vision and activities needed to help attain sustainability, and it resulted in the Antalya Statement on the Future of the Flash Flood Guidance System (Annex 1) and material on each of these critical factors (Annex 2).

In developing the Strategy, it was recognized that the FFGS is used within a national End-to-End Early Warning System for flash floods. Within the broader System, the FFGS ingests data and products, models on-going and future conditions and produces diagnostic and prognostic products. It also allows experts to view and adjust forecasts based on last minute data and expert knowledge. The FFGS is more than a hydrological model but rather is designed to help national forecasters prepare and communicate warnings. In effect, the FFGS contributes significantly to making the best information available to enable effective response to allow reduction of losses.

One of the FFGS MoU Partners, namely the World Meteorological Organization, is in the process of reforming itself to streamline the work of the organisation and its decision making. The sustainability strategy as outlined herein attempts to reflect the positive impacts of this reorganisation and take advantage of these for the future sustainability of the FFGS/WGC.

An initial draft of the Strategy was prepared in July of 2020 and was subsequently circulated to all FFGS Regional and National Centres as well as the FFGS MoU Partners, resulting with approximately 28 reviews being received. This resulted in a revised draft Version 1.1 being prepared dated 1 April 2021 that was further circulated with additional 12 additional reviews being received[3]. Many of the comments received indicated broad support for the Strategy and highlighted a variety of concerns, at times confirming points raised, and at other times raising additional points for consideration. Examples of the comments received are provided in Chapter III, Section D, of this report. All review comments were considered in the preparation of this Version 1.3 of the Sustainability Strategy.

C. Critical Outcomes

The four critical factors noted above were evaluated, deriving in the identification of the most important elements to be considered for each when addressing the sustainability issues for the FFGS/WGC. Overviews of these elements are as follows:

Critical Factor 1 – Developing an inclusive and broadened governance model

- **New Management Structure** – Within this first critical factor, there is the need to identify and promulgate strong and inclusive governance through a modified FFGS Programme Management Committee that would have a newly crafted Terms of Reference, Membership and oversight responsibilities, including monitoring and evaluation of the entire end-to-end early warning system and its component parts and regional FFGS implementations. The FFGS Programme Management Committee should be comprised of members who are proactive and have experience in maintaining, sustaining, and improving the FFGS and the FFGS/WGC. This reformulated FFGS Programme Management Committee (PMC) would be responsible for instigating the new Flash Flood Research to Operations (R2O) Process and developing a Concept Note on how it would function. It is important to ensure that the PMC in its Terms of Reference is designed such that operational decisions can be made in a timely manner.

  The PMC would also develop and approve the Terms of Reference for the new founded FFGS Technical Support Group that would report to it. This new Technical Support Group (TSG) would have the responsibility of overseeing the R2O Process and in ensuring version control of the System to be broadly implemented. This Committee would also be given the responsibility of recommending to the PMC any changes to the delivery structure of the FFGS including the need for new centres, as well as any modifications to the roles and responsibilities of all pieces of the overall System (Global Centres (GCs), Regional Centres (RCs), and National Centres (NCs)).

  The FFGS PMC should, in principle, follow recommendations of the Flood Forecasting Initiative Advisory Group (FFI-AG), established by Resolution 15 (CG-XVI) as the advisory body of the WMO Flood Forecasting Initiative.

[3] Visit the WMO website to view a compilation of all reviews received.

The new formulation of the PMC is broad and is intended to allow representation of those organisations that are contributing to the continued success and sustainability of the FFGS/WGC. The makeup and governance of the new PMC will be determined by the FFGS MOU Partners, likely considering several options. The PMC members would potentially include representatives of the USAID/BHA, the WMO Technical Commission(s), the WMO Hydrological Coordination Panel (HCP), the WMO FFI-AG, the WMO Secretariat, and other relevant WMO bodies as appropriate, the System Developer (HRC), NOAA/NWS as a major contributor, and invited experts. Importantly, this new management structure would also include representation of the FFGS Global Centres, FFGS Regional Steering Committees (RSCs) as well as representation from the NCs of stand-alone FFGS applications. Major donors supporting the development and implementation of Early Warning Systems using, in part, the FFGS could also be extended an invitation to participate in the governance of the overall FFGS/WGC.

This broadened management forum allows for improved leadership, coordination of efforts, and feedback on the implementation and sustainability of the FFGS/WGC, its regional and national implementations, and the FFGS.

- **New Global, Regional and National Centres Approach** – There is a need to develop a modified or new approach to the design and operations of Global Centre(s) and its (their) interactions with Regional Centres that would sustain existing and allow growth of future implemented Systems. Currently, various global centre roles or functions are being undertaken by a few institutions of one or more national governments and the HRC that are fundamentally important for the provision of early warnings of flash floods through the regionally deployed Systems. These global centre functions provide critically important data and products. This new approach should consider the following:

    - There is a need to articulate the requirements of the FFGS/WGC and its regional FFGS applications for consideration in the future design of the WMO Information System (WIS) and to develop a modified seamless Global Data-Processing and Forecasting (GDPFS) functional model reflecting the needs of the FFGS/WGC. It is important that any proposed changes to the System or to its data and product flow be proven to be reliable and that they meet its operational requirements, so that the goal of the FFGS is not jeopardized.

    - There is the need to identify the functions that are currently being provided by organisations that are not currently recognized within the GDPFS. There is the need to *formally* define and implement a GDPFS-type structure for the FFGS/WGC, possibly within the broader context of hydrological modelling and early warning in general. These GDPFS oriented activities would best be undertaken by WMO through efforts of its Technical Commission(s) and its Hydrological Coordination Panel.

    - It is recognized that WIS is under development, and WMO will need to assess whether its data management and communications system will be able to meet the FFGS/WGC' requirements. Until then, proven solutions such as FTP approaches will continue to be implemented and supported. For long-term sustainability, it is hoped that the infrastructure resources of WMO will be of utility for the FFGS/WGC and more generally for hydrological forecasting. Eventually and only if it is proven to reliably meet the FFGS/WGC' requirements, a WIS oriented structure may be fashioned based on the FFGS/WGC' requirements that support the global flow of data and products for use at the FFGS RC and NC levels.

- There is a need to investigate the viability of designating under the new seamless GDPFS:
  - A Global Centre for FFGS Satellite Data and Products to access products (e.g., the Global HydroEstimator (GHE)) and produce products (e.g., Microwave-adjusted GHE (MWGHE)) that would be for global distribution to its appropriate FFGS RCs and stand-alone NCs. Should WIS eventually be proven to reliably meet the requirements of the FFGS/WGC, it might prove beneficial to investigate the viability of designating the Global Centre for FFGS Satellite Data and Products as a WIS Global Information System Centre (GISC).
  - Regional and National Centres for FFGS, where National Centres may be either or both National Meteorological Centres and National Hydrological Centres. The Regional Centres for the FFGS would also likely be candidates for designation as WIS Data Collection or Production Centres (DCPCs).
  - A Global Centre for FFGS Operational Support that would likely be assisted by a specialized Community of Practice.

- Activities are needed to clearly identify the strengths, weaknesses and explicit roles and responsibilities within any new formalized GC, RC, and NC framework for the FFGS/WGC and to identify and take steps to remedy the existing weaknesses. The critical operational functions of the FFGS/WGC are being provided by organisations that are not yet part of the GDPFS, nor are they likely providing products through the WIS lens. It is also recognized that some existing mandated Regional Centre and National Centre responsibilities are not always being adequately fulfilled. The Terms of Reference of GCs, RCs, and NCs as well as the Regional Steering Committees (RSCs) will need to be written and efforts will be made to ensure that there is no unintentional duplication and that all roles and responsibilities assigned are clear and functionally align to allow for sustainable operations of the FFGS/WGC within the new seamless GDPFS.

- **Increased FFGS Monitoring and Evaluation** – As part of the strengthening of governance, additional effort is needed on formalizing the FFGS Monitoring and Evaluation process. This will allow improved understanding of where help to developing countries is most needed and to ensure that proper development, implementation, and use of the System are occurring. It provides the basic information necessary to allow corrective actions to be considered and acted upon. Sustainability strongly depends on sound monitoring and evaluation to track what is working or not and allow corrections to take place. It will help monitor if roles and responsibilities are effectively being met, track overall performance, and assess and obtain feedback on the FFGS/WGC' implementations. Monitoring and Evaluation should be led by WMO under the auspices of the PMC. The WMO Technical Commission(s), Regional Steering Committees, the Regional Centres, and participating NMHSs will be playing important roles in this process. It is also important that those providing input to the Monitoring and Evaluation process (e.g., RCs, NCs, RSCs) receive feedback as to what actions are or are not being taken to address concerns.

- **New Flash Flood Research to Operations Process** – To allow broader community involvement and participation throughout the FFGS development cycle, a revised, more inclusive governance approach needs to include a more broad-based, structured, and well-defined Flash Flood Research to Operations (R2O) Process.

- The proposed R2O Process will allow increased flexibilities so that capable NMHSs can: adjust parameters to see how System performance changes such as revised land use and soil data; calibrate models and redefine basin boundaries themselves; add GIS layers to the MapServer Interface; use Quantitative Precipitation Forecasts (QPFs) from nowcasting or Numerical Weather Prediction (NWP) models as input that is different than that used in the operational System; explore the application of new functionalities (e.g., riverine forecasting, urban flash flood forecasting) over their domain; and generally explore improvements to their specific applications. As part of this increased flexibility, a regimented change management process, developed and overseen by the FFGS Technical Support Group, will be applied to ensure the merit of the change, version control and stability of improvements before operationally implementing them broadly. Given that many lives depend on the warnings developed with assistance of the System, it is imperative that version control and System stability be maintained and that protocols are in place and followed to "control" changes to the primary System that is operationally implemented.

  Note that this process of "control" does not apply to all possible changes to implemented Systems, as it is envisaged that certain prescribed changes may be undertaken by the Regional Centre, having been trained to do so, and in communication and in conjunction with its participating countries' NCs. Examples of the latter would include inclusion of new precipitation gauge stations and new NWP model outputs when they become available, removal of discontinued gauge stations, and reparameterizations of hydrological models within the System. As part of the implementation process, a refined and relatively complete list and description should be developed outlining what changes require scrutiny of the FFGS Technical Support Group and which ones can be undertaken directly by the RC, possibly in conjunction with one or more of its participating countries.

- In order to facilitate this R2O Process, an "Analysis" version of the FFGS should be developed. This Analysis version should be a stand-alone System, run in parallel with the operationally implemented production System. It should be designed to allow the broader community flexibility in exploring improvements and enhancements to the operational version. This newly proposed System is given the acronym Analysis FFGS or simply "AFFGS". It is preferred that the development of the design specifications of the AFFGS be undertaken by a small group of experts under the purview of the FFGS Technical Support Group. In so doing, this small team would consider the AFFGS design document already prepared by the HRC developed under its own Technology Transfer Program, and it may consider employing a phased approach to align with available or potential budgets. Ideally, development work on the AFFGS should not proceed prior to approval of the PMC on recommendation of its Technical Support Group. AFFGS documentation should be prepared to provide guidance, almost in the form of a template, on how it could be employed by national experts.

- **WMO FFGS/WGC Administration and Management** – an important consideration of overall governance for the sustainability of the FFGS/WGC is its administration and management within the WMO Secretariat. The FFGS/WGC has been successfully administered by the WMO Secretariat since its inception in 2009, and it is imperative that WMO not only maintain but enhance this strong management support and its technical leadership. Given the importance of the FFGS/WGC to over 60 WMO Members in advancing abilities to issue warnings of flash floods and in saving lives, it should be recognized as an important and fundamental activity of WMO. WMO needs to increase its support to the FFGS/WGC and to enhance sustainability efforts.

The WMO Secretariat should also provide secretariat support to the FFGS Programme Management Committee and its Technical Support Group. This Strategy fully supports WMO's efforts to develop an MHEWS environment that integrates the FFGS products with other, similar products made available through other currently administered and managed initiatives by WMO, namely the Coastal Inundation Forecast Initiative (CIFI) and the Severe Weather Forecast programme (SWFP), where such endeavours are needed or are being implemented to assist its Members.[4] Efforts are needed to ensure geophysical processes that are contributing to flooding are adequately reflected in the MHEWS environment (e.g., hydraulic/hydrodynamic modelling of rapidly varying unsteady open channel flow influenced by ocean surge). In this regard, the broad external review noted the importance of aligning the development of the Multi-Hazard Early Warning System (MHEWS) environment and its complementary forecaster tools such as the FFGS, with the FFGS being a conduit to flash flood, riverine flood and landslide potential.

- **Strong Commitments from Participating Countries** – Countries, in general, must commit to fulfilling their responsibilities as doing so ensures attaining the benefits of the FFGS implementation for national interests, such as decreasing loss-of-life and property damage resulting from flash floods, and achieving sustainability of the System itself. This commitment not only is important for all aspects of the critical factor on broadening Governance to attain sustainability but also for the Training, Visibility, and Resourcing factors. Implementation of a regional FFGS application should not proceed until countries are formally committed to it. To this end, WMO must continue to urge strong commitments from participating countries to be as fully engaged in the FFGS/WGC to the extent possible and should monitor their involvement as part of its Monitoring and Evaluation role, recognizing the enormity of the challenges of capacity development and financial resource priorities.

Critical Factor 2 – Increasing and strengthening the training effort

The second critical factor is on increasing and strengthening the training effort that speaks to maintaining, improving, and expanding the scope of the current ongoing training activities associated with the FFGS/WGC. A Training Plan needs to be developed to include: the redesign and revitalization of the existing FFGS Hydrometeorologist Training Programme; National Disaster Management Agencies (NDMAs) and other users; and Regional Centre experts including IT and System Administration staff. It was also recognized that such a Training Plan should also include training and guidance material to increase the abilities of RCs and NMHSs to implement new functionalities of the FFGS, as well as making best use of the new R2O Process and the AFFGS. The Training Plan also needs to consider adjustments to the traditional training approaches, its delivery mechanisms, enhancing existing training material, and in making all training material such as a "self-learning" training guide readily available and accessible. The Training Plan needs to be developed that specifies how training will be expanded, how it should be redesigned to reduce costs with an emphasis on asynchronous distance learning, how it will be more hands-on, how it will take advantage of a Communities of Practice to share training material and experiences and a "training-of-trainers" approach, and how this will lead to more involvement of national experts in delivering the training. Many of these efforts are currently underway, and it is important that they continue and are given emphasis for ensuring sustainability.

[4] The authors of the initial report kindly expressed their willingness to provide their assistance in efforts to develop and implement an MHEWS given its fundamental importance in providing enhanced early warnings by Members of WMO.

Critical Factor 3 – Increasing visibility of the FFGS

It is recognized that major international players in hydrometeorology were generally not aware of the FFGS and its global implementation. This underscored the importance of the FFGS/WGC and the System itself to gain visibility with the broader international hydrometeorological community, which may attract additional financial and human resources support. It was felt that gaining increased visibility may lead to more widespread implementation of the System, resulting in increased benefit to participating countries and their citizens.

Marketing the FFGS was viewed as being of importance to increasing its visibility and subsequently on building the financial support. On this point, there is a need to show how products can be used, and that they are effective, by drawing upon examples. In doing so, an important and critical linkage is with the disaster reduction policy community. It was also felt that such efforts can be complemented through activities such as enhanced web sites, papers in technical journals, articles, videos, and use of appropriate social media platforms. A Marketing Plan and associated marketing material on how the FFGS products (and other NMHSs' services) should be developed. Key elements of the Plan include:

- Developing incentives (e.g., international and national recognition) to encourage the active participation by Global and Regional Centres, NMHSs and NDMAs in activities that contribute to the sustainability of the FFGS/WGC and further advances the timely and accurate early warnings of flash floods;
- Being involved in national and international projects to advance early warnings of hydrometeorological hazards as well as international research efforts (e.g., Hydrological Ensemble Prediction Experiment) would help raise visibility, potentially help forge new partnerships, and create new opportunities;
- Undertaking public awareness campaigns, possibly through the NMHSs' communications department, to increase knowledge of the FFGS and NMHSs capabilities and actions necessary to decrease loss-of-life and property damages from flash floods through, for example, issuance of warnings and preparedness messages outlining actions to be taken;
- Developing "Virtual Simulation Videos" to help show the benefits of using the FFGS versus not using it (or another system);
- Improving cooperation and interaction in general with NDMAs on a regular basis, allowing for the building of trust and respect through synergetic working relationships;
- Engaging with those setting policies on disaster risk reduction at the national level to have floods and in particular flash floods recognized as a national priority;
- Including NDMAs from the beginning of any FFGS project;
- Improving collaboration with agencies that may benefit from use of quality-controlled FFGS products tailored for their operations (e.g., high resolution quality-controlled precipitation estimates and forecasts, soil water fraction indices) such as NHSs, agriculture, hydroelectric power generation, and water resources management;
- Developing partnerships with media to illustrate the value of the early warnings of flash floods, such as providing training to journalists on understanding and communicating products and services involving flash flood warnings in partnership with NDMAs;
- Working with local governments on dissemination of information and being involved in coordination activities to inform decision making processes;
- Conducting case studies demonstrating the effectiveness and success of the System's operations or illustrating where strengthening them would be appropriate; and
- Organizing annual or more frequent meetings with stakeholders to receive feedback.

The organisations represented on the PMC, including the Regional Steering Committees (RSCs) and the participating countries, must work together to increase the visibility of the FFGS/WGC and forecasting and provision of warnings of flash floods as a national priority.

Critical Factor 4 – Developing additional financial and human resource support

The fourth critical factor focuses on increasing available resources from a diverse group of donors, funding institutions and national sources. Visibility and proven utility of the FFGS/WGC and the FFGS were viewed to be important ingredients in maintaining and attracting additional financial and human resources. The FFGS Programme Management Committee, their respective organisations, the Regional Steering Committees and their NMHSs should be responsible for maintaining and obtaining resources and should actively develop and implement strategies for so doing. These efforts include:

- Determining the necessary budgetary resources and on-going costs of specific sustainability items and based on available financial and human resources, prioritize activities;
- Developing a Marketing Plan as discussed in Critical Factor 3 to assist on acquiring additional resources while improving visibility, noting that the Plan should also consider reflecting strategies of this factor;
- Identifying active partners that may be willing to provide human and/or financial support for products that have lifesaving and economic value and sharing/presenting the Marketing Plan along with success stories and endorsements;
- Soliciting new and maintaining existing strategic partnerships;
- Making concentrated efforts to learn about and be involved in donor funded projects, such as those focusing on disaster risk reduction activities, hydrometeorological modernization efforts, and agricultural related endeavours, that would benefit from existing FFGS products (e.g., Mean Areal Precipitation Estimates, Forecast Mean Areal Precipitation, soil water saturation fraction estimates, Forecast Flash Flood Threat) or from products resulting from the implementation of new FFGS functionalities (e.g., riverine forecasting, urban flash flood forecasting, landslide susceptibility);
- Developing case studies and making use of "Virtual Simulation Videos" to help show the benefits of using the FFGS versus not using it (or another system);
- Making efforts to ensure that the FFGS and associated early warning activities are well placed within the national plans, including the National strategic plan (for example on Disaster Risk Reduction), National/institutional investment plans (for example on Multi-Hazard Early Warning Systems or strengthening of hydrometeorological service provision), and mid-term development and/or financial plans; and
- Engaging with those formulating and implementing policy on disaster risk reduction at the national level (this is an important national FFGS leadership role as policy-level support can be essential to establishing a national mindset that the forecasting and provision of warnings of flash floods is a critical funding priority).

D. The Way Forward

In the final Chapter of this Strategy, a way forward has been proposed by prioritizing efforts needed to ensure sustainability. They have provided a summary of the major activities in tabular form to be addressed in making the FFGS sustainable, identified leads for these, assigned a priority and associated timeline for achieving the item. Suggestions have also been provided on immediate next steps. Implementation of the activities outlined in that Chapter, especially in the development of the various plans, must follow and incorporate the priority areas identified in this Strategy. The next step is the development of a subsequent Plan that outlines the implementation of these priorities that will provide details on what needs to be done, by whom, in what time frames and with an estimated cost.

The top priorities noted in the Chapter include:

- Putting the proposed governance structure in place as the overall top-most priority to addressing sustainability concerns as it will oversee and manage all activities that make it successful, vibrant and sustainable. Putting the proposed governance structure in place is a prerequisite to addressing long-term sustainability concerns. The reformulated FFGS Programme Management Committee (PMC) and its FFGS Technical Support Group (TSG) would oversee the revamping of the FFGS/WGC so that it can attain sustainability. Subsequently there are four important areas identified associated with governance, namely: 1) designing the GC-RC-NC framework that meets the needs of the FFGS/WGC (e.g., developing GCs, policies and assessment material similar to that of the GDPFS for its centres); 2) developing (and implementing) the Flash Flood Research to Operations (R2O) Process; 3) establishing the functionalities of the Analysis FFGS and undertaking its development and implementation, as a key element of the R2O Process; and 4) assisting the development of an MHEWS environment and in the integration of the FFGS within it.

- The way forward involves transitioning the FFGS/WGC from how it has been accomplishing its "global flow of data and products" to one that takes better advantage of the seamless GDPFS approach and potentially over time WIS, should these prove to be viable options. Designing the GC-RC-NC framework and developing its associated policies and approaches (e.g., how to undertake assessing whether Centres are adequately fulfilling their roles) that meet the needs of the FFGS/WGC is viewed as important to attaining sustainability. Concerted effort will be needed to ensure that solutions are pragmatic, workable and take advantage of and contribute to the development of the seamless GDPFS and potentially WIS. It is understood that this will not necessarily be easy with respect to WIS, nor will it be able to operationally meet requirements of the FFGS for some time, as WIS is under development and needs to reflect on how its design can meet the needs of the broader WMO community. (There is also the possibility that it might not be able to meet all requirements, which means other solutions will be required.) As this will be a process that will take considerable time, pragmatic stop-gap solutions will need to be taken, such as continuing the use of FTP for data sharing, until the approaches used by WIS are being used by NMHSs, have been shown to work, and have been proven to be reliable. Along this path, efforts are needed to ensure the operational data communication approaches continue to work. This overall effort needs to ensure the continuous and smooth flow of FFGS Data and Products are maintained, as the seamless GDPFS is developed and WIS transforms itself over time.

- The GC-RC-NC framework also requires: the creation of FFGS Global Centre(s); developing mandatory functions of GC(s) and RCs; developing approaches for evaluating GC and RC candidates; and developing the approach and material for assessing and strengthening of FFGS Regional Centres. Part of the solution lies in strengthening Centres so they can better fulfil their responsibilities. This involves ensuring each Centre fully understands and commits to its responsibilities, assessing the adequacy of the resources available to the Centre to fulfil these, and assessing whether the Centre's staff have enough training to properly operate and maintain the implemented System. In essence, periodical monitoring of GCs and RCs' operations is required, with efforts needed to address weaknesses when and should they arise.

- The FFGS should very much be an integral and important part of the relatively new initiative on developing an MHEWS environment. In doing so, the reformulated FFGS Programme Management Committee (PMC) and its FFGS Technical Support Group (TSG), with support of the WMO Secretariat, should contribute to the development of this new MHEWS environment. As part of this effort, it is important to ensure the associated forecaster tools reflect the geophysical processes and resulting hazards at play. The Coastal Inundation Forecast Initiative (CIFI), the Severe Weather Forecast programme (SWFP), and the FFGS/WGC constitute parts of an "end-to-end" system, with the FFGS

and CIFI being, in part, dependent on meteorological forcing, while the SWFP could benefit from using the quality-controlled precipitation fields provided by the FFGS for performing validations. All three are significant components of an MHEWS focusing on hydrometeorological hazards, with additional efforts needed to address areas requiring hydraulic/hydrodynamic modelling of riverine conditions. Integrating the capabilities of the FFGS with the Severe Weather Forecast programme and the Coastal Inundation Forecast Initiative through a Multi-Hazard Early Warning System, or possibly System-of-Systems, environment is an important consideration for maintaining and increasing national capacities for providing early warnings of hydrometeorological hazards.

- The item of highest priority related to training is to develop an overall Training Plan that addresses all training activities and areas, termed the FFGS Training Programme. This includes: revitalizing the existing Hydrometeorologist Training Programme; training of NDMAs and other users, RC IT and System Administration staff; and training on how to implement new FFGS functionalities (e.g., riverine forecasting, urban flash flood forecasting), and on how to take advantage of the R2O Process including the AFFGS. It should clearly describe the training approaches including steps, modules (material), knowledge transference process, and modalities of training. This would likely include the development of at least one Community of Practice to help make existing, enhanced, and new training material easily available for use by all trainers. The design would make best efforts to address perceived weaknesses as documented in the external Review process and the FFGS/WGC Workshop, as well as those identified through discussions with experts. The development of the Plan on Revitalizing the FFGS Training Programme might well prove to be a template for how training should be approached generally within the FFGS Training Plan, and as such its development is given a high priority. The Training Plan will need to adjust training approaches based on the Coronavirus (COVID-19) disease that is affecting countries and the type of training activities that are permissible. The development of the FFGS Training Plan including the Hydrometeorologist Training Programme and its delivery approaches would be led by the WMO Secretariat with involvement of HRC. These activities would be undertaken with oversight of the PMC.

- The third critical factor in addressing sustainability is on visibility, while the fourth is on increasing available resources from a diverse group of donors, funding institutions and national sources for the FFGS/WGC and its regional implementations. These two critical focus areas are interlinked. The Strategy lists a number of activities that are intended to help make the FFGS/WGC more visible and increase its ability to attract funding. These activities include development of a Marketing Plan to clearly show what steps or actions will be taken to achieve the goals of increasing visibility and available human and financial resources. Efforts are needed to raise general awareness and to effect inclusion of flash flood (and flood) forecasting into national policies and strategic plans, thereby providing the foundation for allocating additional human and financial resources to develop the necessary capacities to address flash flood (and flood) forecasting using an end-to-end concept.

E. Next Steps

This Strategy provides the vision of how the FFGS/WGC should be adjusted to attain operational sustainability into the future. A Transition Plan is needed that outlines very briefly the necessary steps to move from the current management paradigm to the new Programme Management Committee. An Implementation Plan is also needed to provide more detail on what needs to be done, by whom, in what time frames, and with an estimated cost. The immediate next step in this process would be the broad review, revision, and adoption of the Sustainability Strategy by the current PMC, with efforts then proceeding without delay in

putting in place the new governance structure as elaborated in the Strategy. It is then recommended that efforts proceed on preparation of the Implementation Plan based on the guidance provided in this Sustainability Strategy. In so doing, various pieces of the potential Implementation Plan could be initiated in parallel with its preparation, thereby better informing its further development.

While the modified governance structure is being established, additional "planning" efforts should proceed without delay, as these would better inform the crafting of the Implementation Plan on addressing sustainability issues. These planning efforts include preparing: a) a Concept Note on the Flash Flood Research to Operations Process; b) a document on the functionalities and priorities for the development of the Analysis FFGS (AFFGS), which would consider attributes of the design already documented by HRC; c) a plan for revitalizing the FFGS Training Programme; and d) a Marketing Plan.

As well, following the adoption of the new governance paradigm, efforts could proceed on developing the design of the GC-RC-NC framework for the FFGS/WGC including the roles and responsibilities of all proposed Global Centres. This may lead to refinements or more substantial changes to the proposals made within the Sustainability Strategy on the GC-RC-NC framework as part of the Implementation Plan process.

F. Other Considerations

It is expected that the impacts from the COVID-19 pandemic on the quantity and quality of weather observations and forecasts and atmospheric and climate monitoring will be felt for the next few years at a minimum. A recent survey conducted by the WMO Secretariat did however indicate that the FFGS applications continued to perform during the pandemic and supported the issuance of forecasts and warnings of flash floods. As well, major travel restrictions put in place to help curb transmission of the disease has seen an impact on the maintenance of some stations and the growth of electronically supported meetings and training events through video conferencing services. This has led to considerations that some training approaches could be modified to reflect lessons learned during the pandemic, resulting in an increased demand for more distance learning. There remains a grave concern that degradation of human, financial and infrastructure resources may be exacerbated by the pandemic resulting in many countries having a decreased national ability to: provide the full range of accurate and timely hydrometeorological warnings; work with vulnerable communities; facilitate the communication of warnings and their impacts to society; and follow-up closely with disaster response efforts.

More so now than ever, the concept of the FFGS operating in a global, regional and national hydrometeorological environment has the ability to help maintain and build capabilities to provide early warnings and mitigate the impacts of pending high impact hydrometeorological events. To do so, sustainability challenges must be dealt with thereby allowing critical and essential end-to-end early warning systems to be sustained, which are needed by all countries.

Annex 3 to Resolution 5 (Cg-Ext(2021))

Recommendations on the way forward for the operational phase of HydroSOS, extract from the End of Pilot Phase Report of the WMO Hydrological Status and Outlook System (HydroSOS)

3 Way forward

The following section is divided into recommendations for the next phase of HydroSOS, followed by the expanded concept for HydroSOS and the proposed structure for the functioning

of the initiative going forward. This section also contains basic guidance for regional implementation as well as the partnerships and resources needed to fund different spatial scales of implementation.

3.1 Recommendations based on experiences in pilot phase

General recommendation:

1. WMO Members should start operationalising the global HydroSOS through regional implementation plans led by the Regional Associations. The pilot phase showed that the system yields great potential for improving:

- Technical capacity for monitoring, analysis and understanding of hydrological variability at local level;
- Benefits of integrating national level hydrological monitoring capacity/data/products into river basin scale cooperative information to improve water resources management;
- National and river basin level sub-seasonal to seasonal outlooks for design and implementation of robust water management solutions for all water-dependant sectors;
- Regional and global monitoring systems that can help to evaluate the impact of climate change on the hydrological cycle, support attribution science and underpin the assessment of future water availability;
- The links between top down global methods and bottom up local approaches in order to strengthen mandates of local, national and regional decision makers through information systems.

Specific recommendations:

Key recommendations

1. Make a set of standard products available, targeted at specific sectors: hydropower, agriculture, and water resources management, to help NMHS showcase the value of hydrological products to their different stakeholders.
2. Organise an open network of NHMSs across the world who act as global/regional/sub-regional processing and analysis centres for the initiative, in line with the Global Data-processing and Forecasting System (GDPFS). This means developing hydrological centres (at global and regional scale) to perform specific tasks for HydroSOS, which can support NMHSs to produce outlooks. Examples of such specific tasks are: downscaling, running regional hydrological models, performing regional forecast verifications, establishing and maintaining information exchange systems for monitoring and forecasting.

Technical short-term recommendations

3. Perform evaluations of the additional benefits that global and regional products can bring to basin scale hydrological products, including evaluations of local hydrological forecasts against global ones for each basin of implementation
4. Develop local capabilities related to the WMO Hydrological Observations System (WHOS) for countries that want to share data and products at regional/transboundary scales.
5. Explore the replicability and adaptation of the Integrated Riverine Flood Forecasting (IRFF) project in Dominican Republic in order to upscale solutions to other river basins. This includes building a HydroSOS platform based on Tethys for custom applications. Data and information shared through this platform can be made accessible with WHOS.

(An example of use of the platform can be seen in Central America and the Dominican Republic, developed by the Brigham Young University (BYU))

6. Create and share a repository of technical applications amongst the meteorological and hydrological services to create a collaborative community resource, strengthening the cooperation between meteorological and hydrological services.
7. Define, together with the climate community, how climate and weather regional products can serve as a basis for basin-scale hydrological products.
8. Look into best practices from WMO (ie. Meteorology, Climatology and Hydrology Database Management System (MCH), Flash Flood Guidance System (FFGS), WHOS, IRFF, etc.) for providing training and capacity building opportunities within the context of HydroSOS (i.e. through a Moodle platform or similar).

WMO-linkages recommendations

9. Support WMO's Climate Branch project "Operationalization of Objective Seasonal Forecasts and Tailored Products on Sub-Regional Scales", especially its component 6 (Tailored Seasonal Forecast Products) for Regional Climate Outlook Forums (RCOFs), where the hydrological community should elaborate, together with the climate community, tailored seasonal prediction products as inputs for hydrological models.
10. Work closely with the Global Cryosphere Watch (GCW) to link cryosphere products to the HydroSOS portal and to better represent key cold-region processes (e.g. snowpack, glacier, and active layer depth dynamics, suppressed evapotranspiration from cold, open water, ice jams, snow dams, etc.) in hydrological models used for hydrologicals status and outlook products.
11. Where available, synergize with WMO initiatives such as the WMO Severe Weather Forecasting Programme (SWFP), Coastal Inundation Forecasting Initiative (CIFI), and the Flash Flood Guidance System (FFGS) to share and use meteorological products as inputs for hydrological models.
12. Collaborate with projects that aim at building the capacity of Members to enhance/develop their seasonal hydrological prediction capabilities and make synergies with projects that use similar inputs as for Early Warning Systems (for example the Climate Risk and Early Warning System initiative (CREWS)) .
13. Ask the Technical Commissions to develop specific regulations, manuals and guidelines for the different components of HydroSOS.
14. Encourage the Regional Associations to prioritise and support the development and implementation of regional HydroSOS components.

3.2 Brief overview of HydroSOS Concept

Based on the findings of the HydroSOS pilot phase, an initial concept that describes possible steps for implementing and operationalising HydroSOS was developed. It builds upon on the vision for the initiative and its relationship with other hydrological activities.

It is envisioned that HydroSOS will have three streams:

- Stream 1: operationalize current status assessment and outlook systems at the sub-seasonal to seasonal timeframe for basic water cycle indicators
- Stream 2: provide interoperability with observed data and short to medium and long-term products (i.e. satellite data products, flash floods, riverine floods, droughts, impacts of climate variability and change) and build up a repository of hydrological information
- Stream 3: strengthen the system with coupling additional components of the water cycle, as well as with products related to, for example, the environment, socioeconomy, and health.

These streams will ensure that HydroSOS develops with necessary flexibility to address the different needs and requirements of NMHS and their end-users. HydroSOS will not replicate

efforts for short-term forecasting, instead, it provides the possibility to seamlessly integrate them into the array of products available within a basin or region.

HydroSOS is providing an interface for complementary tools as required, developed mainly by other international and UN agencies but also by national agencies, transboundary basin authorities and private companies, and will provide suitable information in an interoperable way to feed into national and regional decision support systems that have been or will be implemented in several regions and basins over the world.

3.3 New HydroSOS Structure

The HydroSOS Team has proposed a potential structure and distribution of tasks and activities that will ensure a successful HydroSOS implementation.

Three specific work components have been identified (see Figure 1). These components are inter-dependent. Therefore, good project governance is a key in regional to global HydroSOS implementation.

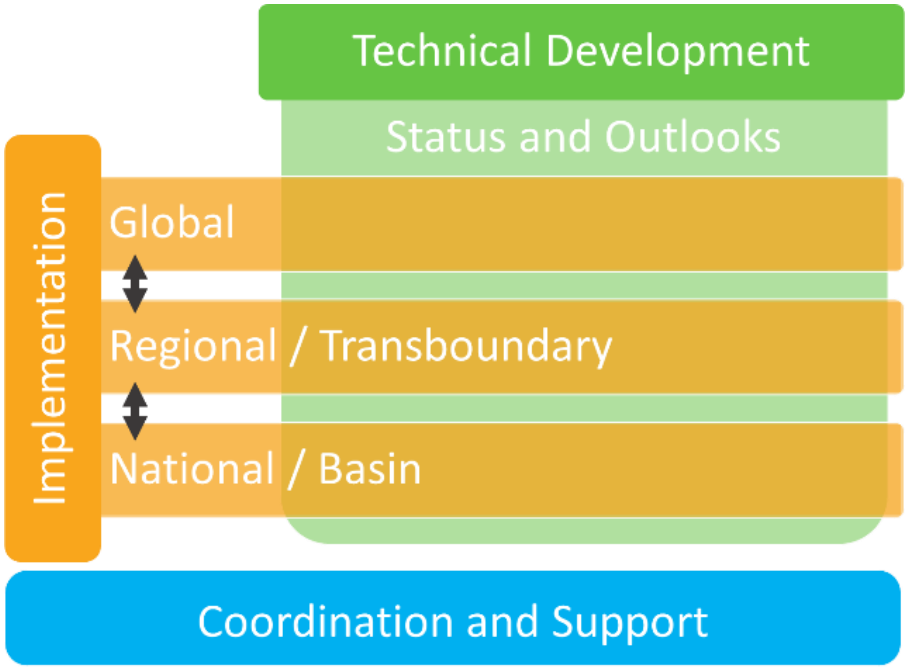

Figure 1. Proposed new HydroSOS structure

a) Technical Development Component

This component will continuously work on the technical aspects of HydroSOS, including research and innovation, and will be responsible for:

- Developing technical protocols for HydroSOS IT infrastructure and information transfer
- Analysing and developing methods, models and tools to help Members implement HydroSOS
- Producing product standards and guidance on dissemination.

The Technical Development Component will also need to undertake quality assurance, standardization and produce guidelines for users.

b) Implementation Component

This component will work with and across the Global, Regional/Transboundary and National/Basin implementation partners, including regional agencies and NMHS, their users and stakeholders. This will include:

- Conducting capacity and institutional assessments
- Ensuring stakeholders and users are engaged and their needs assessed
- Developing and implementing projects to build and operate HydroSOS based on guidance from the Technical Component
- Engaging in capacity building efforts – by identifying local needs, organising regional or national workshops and training

The implementation component will ensure widespread collaboration amongst NHMSs from across all WMO Regions and the development of multiple projects which provide hydrological status and outlook assessments.

c) Coordination and Support Component

This component is responsible for the overall programme management of HydroSOS, monitoring risks of the programme, ensuring and producing policies and procedures, risk and quality management, finances, budgeting and cost control. Daily operational tasks of resource and organisational management, business development, strategy and planning and reporting will also be undertaken in this element.

The Coordination component will also be responsible for the long-term sustainability and viability of the operation through developing relationships with funders and partnerships in the regions and guiding the process of establishing a community of practice for hydrological status and outlooks.

3.3.1 Governance of HydroSOS

The Hydrological Coordination Panel (HCP) of WMO will coordinate and guide the initiative due to its cross-cutting nature which spans RAs, Technical Commissions, the Research Board and hydrological stakeholders outside WMO. Oversight by the Hydrological Assembly will ensure appropriate engagement with WMO's Members and their National Hydrological Services. Advisory for individual HydroSOS projects will be provided by specific Steering Committees established for each transboundary and basin implementation.

HydroSOS components are coordinated with relevant WMO bodies (see Figure 2). For example, the Infrastructure and Services Commissions (INFCOM and SERCOM respectively) as well as the Research Board will provide inputs to the Technical Development Component and the Regional Associations will provide inputs and steer efforts of the implementation component.

- Infrastructure Commission: development of hydrological monitoring and data infrastructure aspects of HydroSOS as well as linkages with meteorological modelling and forecast systems through GDPFS.
- Services Commission: development of end user specific hydrological status and outlook products in relation to water resources management and other applications as well as linkages with hydrological modelling and forecast systems through GDPFS.
- Research Board: support for research-to-operations interactions, guidance on new developments from both the climate and hydrological sides. This will be the key link to the research community and to sources of innovation to continue offering up-to-date solutions to operational agencies.
- Regional Associations: Through their Regional Hydrological Adviser and their respective groups/panels in hydrology and water resources, Regional Associations will be the main owner of the development of implementation plans and their execution. They will ensure cohesion with their hydrology operational plans.

Additionally, regional partnership building and tailoring of activities will be done through their Hydrological Advisers Forums.

The figure also includes the different partners that will be considered under the technical and implementation components. It is important to reiterate that NMHS remain the most important partner for HydroSOS.

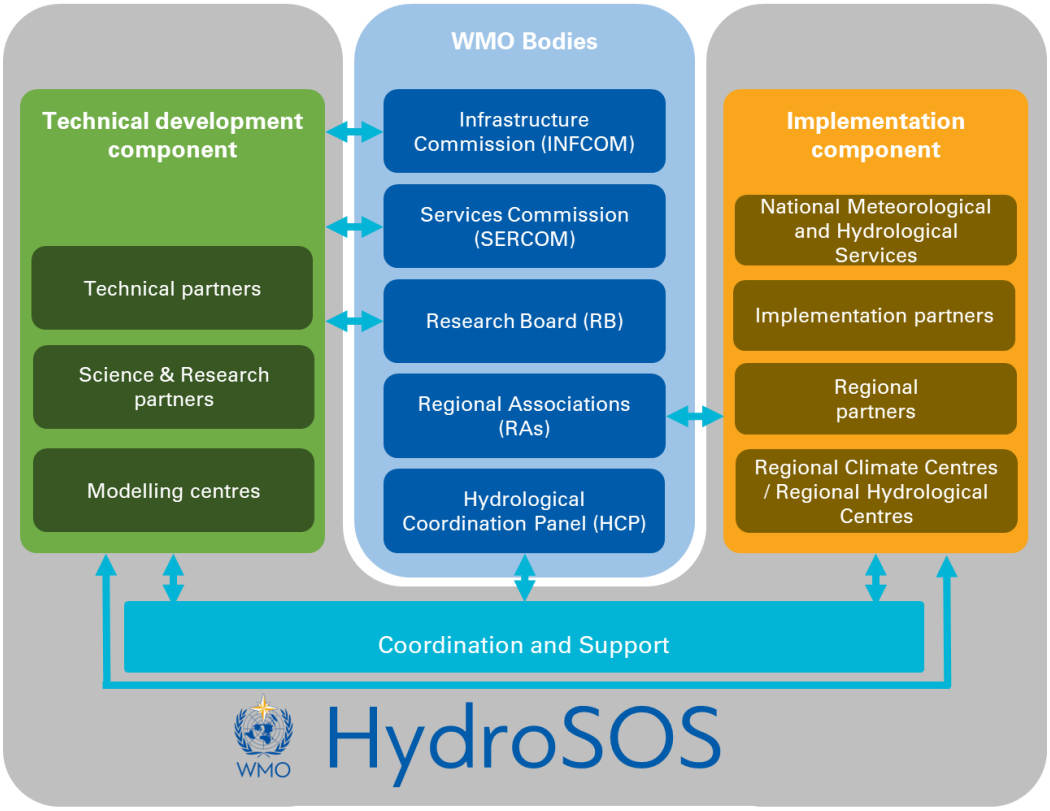

Figure 2. HydroSOS, partners and WMO Bodies within the proposed structure

3.4 Regional implementation plans

HydroSOS implementation has been requested through three different Regional Association (RA) Sessions and identified as a priority activity within their work plans. A brief summary of relevant recent RA decisions is provided below.

RA I - 18th Session:

- Decision 9 (RA I-18) – WMO Strategic and Operating Plan: Regional Priorities-RA Implementation Plan, item (9): "Meteorological and hydrological communities are invited to working closer together in developing major hydrological initiatives such as […] the WMO Global Hydrological Status and Outlook System (HydroSOS)".
- Resolution 9 (RA I-18) – Regional progress on Hydrological and Water Resources Services components: "Requests the RA I Hydrological and Water Coordination Panel to develop a regional implementation plan for HydroSOS and to present this plan to Cg-Ext. (2021), conditioned to the availability of the documents on results of the pilot phase of HydroSOS three months in advance of Cg-Ext.(2021)" and "Requests the Secretary-General to […] support regional and subregional hydrological outlook forums".

RA II - 17th Session:

- Resolution 6 (RA II-17) – Regional progress on Hydrological and Water Resources components: "Requests the RA II CP Hydrology to develop a regional implementation plan for HydroSOS and to present this plan to Cg-Ext.(2021), conditioned to the availability of the documents on results of the pilot phase of HydroSOS" and "Requests the Secretary-General to […] support regional and subregional hydrological outlook forums".

RA III - 18th Session:

- Resolution 1 (RA III-18) – Regional hydrological priorities: "requests the Working Group on Hydrology and Water Resources to develop a regional implementation plan for HydroSOS and to present this plan to Cg-Ext. (2021)".
- Annex to Decision 5 (RA III-18) – Establishment of regional priorities identifies as a priority to "(7) Reduce the capacity gap among NMHS in the Region, enhancing their respective capacities, sharing good practices, and promoting collaborative work and adoption of gender policies within the NMHS and at the regional level";
- Resolution 4 (RA III-18) – RA III Working group on Hydrology and Water Resources decides to establish a Working Group on Hydrology and Water Resources that, among other things, will "promote regional projects that follow global guidelines or contribute to WMO initiatives and report on their progress to the RA III Management Group", identifying HydroSOS as one of such WMO initiatives.

RA IV - 18th Session:

- Resolution 3 (RA IV-18) – Hydrology and water resources: "requests the RA IV Hydrological and Water Coordination Panel to develop a regional implementation plan for HydroSOS and to present this plan to Cg-Ext. (2021)".
- Annex to Decision 12 (RA IV-18) – Proposed regional priorities for 2024–2027 identifies the following HydroSOS-related activities as priority for the region: Status and Outlook Systems for the Regional Climate/Hydrology Outlook Forum; downscaling of global models in the basins of the Region; include delivering products for Hydrological seasonal predictions (e.g. quantitative precipitation predictions).
- Resolution 5 (RA IV-18) – Regional Association IV Hydrological and Water Coordination Panel decides to establish a RA IV Hydrological and Water Coordination Panel that, among other things, will "promote regional projects that follow global guidelines or contribute to WMO initiatives and report on their progress to the RA III Management Group", identifying HydroSOS as one of such WMO initiatives.

RA V - 18th Session:

- Resolution 4 (RA V-18) – Regional progress on Hydrological and Water Resources components: "Requests the RA V subsidiary body in charge of hydrology to develop a regional implementation plan for HydroSOS and to present this plan to Cg-Ext(2021), conditioned to the availability of the documents on results of the pilot phase of HydroSOS".
- Annex to Decision 3 (RA V-18) – Regional Association V Priorities for 2021–2023: "Improve hydrological services, forecasts and warnings for water resources, drought and flood risk management and planning […]".

RA VI - 18th Session:

- Resolution 1 (RA VI-18) – Regional Association VI Working Group for Observation, Infrastructure and Information Systems (1)(h) decides to "support the technical aspects of the Hydrological Status and Outlook System and the State of the Water report".

First steps for regional implementation plans

As mentioned earlier, the implementation of the System must be done by WMO Members. As such, it is recommended that they develop implementation priorities and plans for each of the Regional Associations based on the initial proposals listed below. These should be written by Members of the relevant regions and supported through their WMO Regional Hydrological body (such as Working group in Hydrology, Regional Hydrological Panel, Regional Hydrological Assembly, etc.) and the global HydroSOS Coordination Team. The goals of each regional implementation are likely to include:

- Development of national and regional "Status of Hydrology" products and reports;
- Production of national and regional Hydrological Outlooks produced and linked to RCOFs and National Climate Outlook Forums (NCOFs);
- Identification of further regional hydrological status and outlook products to meet specific stakeholder needs.

Members, through their Regional Associations, will draft their own plans according to their needs, capacities and requirements, with the support of the HydroSOS Coordination Team. A list of general activities is suggested for the consolidation of the plans:

- Assign HydroSOS as one of the main tasks for the WMO Regional Hydrological body[1]
- Define sub-group (ie HydroSOS regional implementation team) to work for HydroSOS and a focal point within the Panel (the sub-group can rely on experts outside the panel – NMHS, Universities, etc.)
- Define activities for the HydroSOS regional implementation team based on:
  - Identification of priority countries/basins/stations where development of enhanced hydrological status and outlook information would have the highest impact for NMHS stakeholders;
  - Consideration of any short-term opportunities: integration of hydrological status and/or outlook information already available as published products (including those shared within the HydroSOS Demonstration Portal);
  - Conducting regional and national assessments of hydrometeorological capacities and needs related to the development of hydrological status and outlook products;
  - Development of stakeholder engagement mechanisms (i.e. workshops) to understand the needs of current and possible future end-users of HydroSOS products;
  - Organise how NMHS will be engaged in HydroSOS and their respective roles and responsibilities.
- Establish plans for implementing HydroSOS within the region in order to address identified needs, including:
  - Setting up project proposal writing team(s) for basin/national/regional implementation which include NMHS and other relevant stakeholders;
  - Identifying potential resources to support HydroSOS and developing project proposal(s) with the help of WMO and identified partners;

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[1] RA I: Hydrological and Water Coordination Panel
RA II: Coordination Panel on Hydrology and Water Resources (CP Hydrology)
RA III: Working group in hydrology and water resources
RA IV: Regional Hydrological and Water Resources Panel
RA V: Coordination Panel on Hydrology and Water Resources
RA VI: Regional Hydrological Assembly

- Conducting initial training to develop capacity around initially identified gaps with the support of the HydroSOS Coordination Team (depending on funding)

Additional sample steps

Some of the additional activities that can be performed within the first years of implementation in the regions are the following:

- If a project is formulated, then project endorsement and funding is sought
- Capacities are assessed thoroughly
  - NMHS operational and technical capacities are assessed
  - Available methods/tools are identified
  - Current data availability and needs are identified
  - Weakest/critical areas are defined
- Stakeholder engagement is conducted continuously
- Methods/tools for status and outlook are selected
- Use of global datasets is evaluated using regional and local hydrological models
- Evaluation of performance of global forecasts vs national forecasts is performed
- Integration of systems is performed where required
- Information sharing mechanisms are suggested – ie. WHOS.
- Secure all required inputs for a "Status of Hydrology Report"
- Ensure climate outlooks provide information as required by the hydrological community
- Link together RCOFs with hydrological outlook forums / Participate in the user forums from RCOFs
- Develop capacity building strategy
- Securing national and regional (financial) agreements for ensuring sustainability

As additional reference on activities, a diagram on the flow of activities required for setting up a Hydrological Prediction System for HydroSOS is provided in **Error! Reference source not found.**.

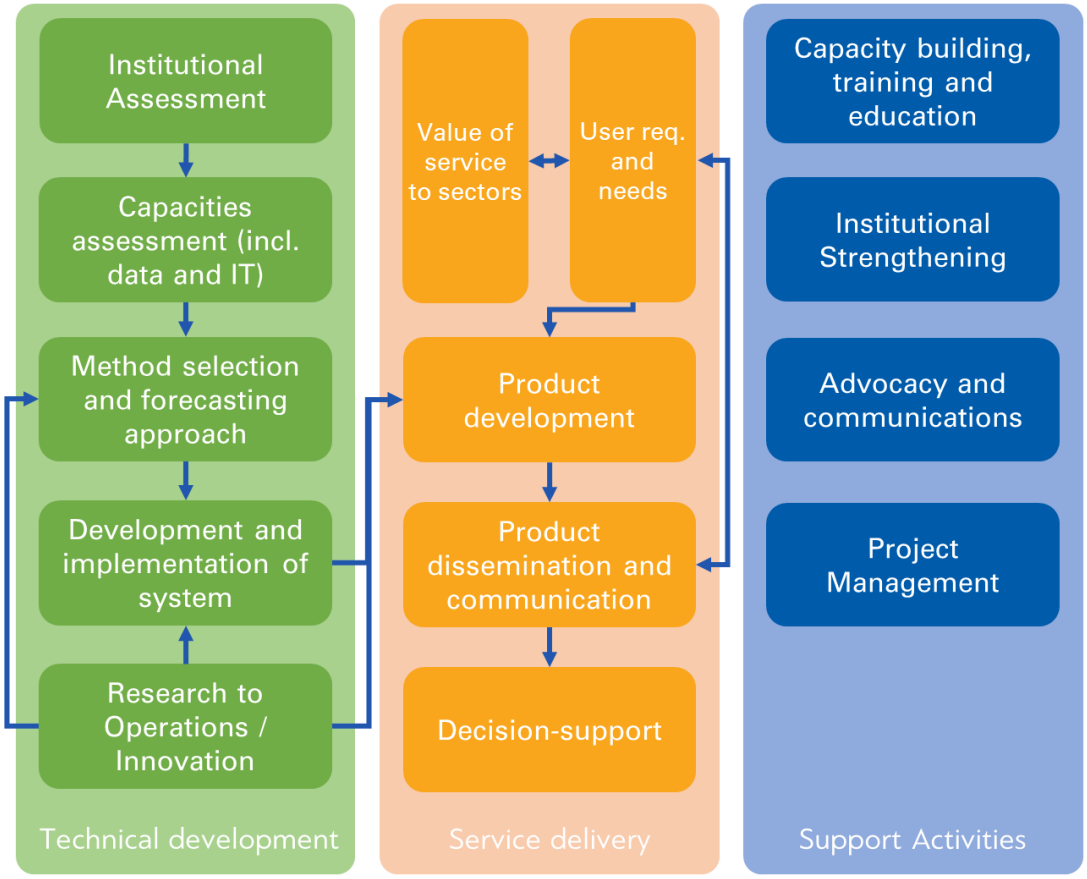

Figure 3. Activities for setting up a Hydrological Prediction System

3.4.1 Possible membership for regional groups working in HydroSOS

Membership is decided by each region and could include the following experts:

- Regional Hydrological Adviser to oversee implementation
- Experts from the respective WMO Regional Hydrological body[1]
- Experts from infrastructure and from services sides
- Experts from climate community
- Experts from research community
- Experts from regional water and hydromet institutions (they could be from NMHS, Water Authorities, Universities, etc)

3.4.2 Role of NMHS (during project implementations)

During the implementation of the project, the NMHS will be expected to work closely with WMO and project partners (including relevant regional institutions) to channel and receive support, funded through the project. NMHS will work alongside WMO and partners in the implementation of all national and regional activities. Specifically, playing a key role in developing partnerships and taking the lead on national consultations.

For example, any capacity development activities which require relevant training, support and infrastructure that NMHS requires will be financed by the project. Dedicated staff will need to be appointed to perform the different tasks required for the HydroSOS products to be operational (i.e. data management, analysis and modelling, product development, web-portal developer, etc.)

Example of responsibilities while implementing:

- NMHS will be the focal point for the collection of the required available spatial and historic hydrometeorological data needed for system development.
- NMHS will be assist by the HydroSOS technical team in coordinating delivery of products and data sets used during system development.
- NMHS will disseminate HydroSOS products nationally (as applicable per protocols) in a HydroSOS-consistent format, as well as incorporating other information and tools available.
- NMHSs will support routine training/workshops to their HydroSOS-related staff (ie on system operations, product interpretation and development, product verification, etc).
- NMHS coordinate with the HydroSOS technical developers for conveying information regarding potential improvements that will affect the national products.
- NMHSs will provide necessary input data/boundary conditions to run the hydrological models.

Moreover, a NMHS or regional institution will need to be selected to perform the role of regional HydroSOS Centre to collect and produce the necessary inputs and products basin-wide, including ensuring flow of information among NMHS.

3.5 Brief overview of required resources and partnerships

3.5.1 Resources

Given that conditions and levels of technical development are different in many river basins, HydroSOS will not be applied as a one size fits all solution. This also means that the required funding will not come from one single source for all possible HydroSOS developments.

In terms of activities to be funded, the following are identified:

- HydroSOS core activities [activities under the Coordination and Support Component]
- Ad-hoc support activities [to be determined]
- Advisory services [dependent on the services to be provided]
- Project formulation [up to ~100,000 USD]
- Sub-basin and basin scale implementation projects [up to ~2 million USD]
- National implementation projects [up to ~5 million USD]
- Transboundary basin projects [between ~5 and 10 million USD]
- Regional implementation projects [more than 10 million USD]
- HydroSOS components as part of a larger project [dependent on the scope of activities]

<u>Potential financial partners</u>

Given the limitations of funding from WMO regular budget, HydroSOS will require partnerships with Members, funding institutions, and Global Funds to ensure the activities can be carried out. In this sense, opportunities for funding will be sought from:

- NMHSs and other national institutions [for meeting their country-specific needs, dependent on their available funds]
- Regional organizations and Basin authorities [for meeting their regional-specific needs, dependent on their available funds]
- Bilateral funding (i.e. from country development agencies) [for target amounts between ~1 and ~5 million USD]
- Multilateral funding (i.e. from Multilateral Development Banks) [for target amounts between ~5 and ~10 million USD]
- Grants from global funds (i.e. Adaptation Fund, Green Climate Fund) [for target amounts of more than ~10 million USD]
- UN Agencies (i.e. UNEP, UNDP, FAO, etc.) [for supporting specific aspects of cooperation, dependent on scope of activities]

3.5.2 Partnerships

Linkages with other global initiatives

Linkages with other global initiatives can be classified in technical cooperation, user community and strategic perspective.

From the technical point of view, global initiatives are already contributing to, and benefiting from, the global demonstrator of HydroSOS, including GloFAS (ECMWF), HYPE (SMHI), GEOGloWS (GEO), and Today's Earth (University of Tokyo). HydroSOS is willing to extend such collaboration and reinforce existing conversations with, e.g., the satellite community (SWOT program, CNES-LEGOS /IRD HydroWeb, H-SAF, CEOS, among others), and with other research programs such as GEWEX.

From a user perspective, closer connections could be established with especially UNEP which is leading the World Water Quality Alliance (HydroSOS and related tools can contribute to the global and regional knowledge of water quality, with a possible common pilot for Lake Victoria). UNEP could benefit as well from HydroSOS for GRID Environment and for its World Environment Situation Room. Closer collaboration will be sought as well with FAO and its water information system AQUASTAT. The Pacific Institute, the World Resources institute and the Mountain Research Institute, and IUCN for ecosystems and nature-based solutions might also be interested in benefiting from HydroSOS.

From a strategical perspective, HydroSOS will seek closer ties to research, education and policy developments such as UNESCO IHP, IHE Delft, Future Earth, Third Pole Environment, the Arctic Monitoring and Assessment Programme (AMAP) and the International Arctic Science Committee (IASC), to name a few. In terms of general cooperation and infrastructure support, as well as general enhancement of hydromet services, more formal relations should be established with the World Bank and with Regional Development Banks active in HydroMet projects.

Linkages with WMO initiatives

HydroSOS is a critical component of the WMO operational hydrology value chain, developing a new paradigm aiming at improving water information systems in a sustainable and efficient way. Three main hydrological initiatives are developed hand in hand with HydroSOS, ranging for data collection (HydroHub/WHYCOS), to data sharing (WHOS) and data policy (WWDI):

1. The WMO Global Hydrometry Support Facility (WMO HydroHub) aims at increasing national and regional capacity in data collection, management and sharing, by providing innovative operational solutions to National Meteorological and Hydrological Services and their partners. The core of WMO HydroHub is the World Hydrological Cycle Observing System (WHYCOS) program.
2. As the hydrological component of the WMO Information System (WIS) 2.0, WHOS allows hydrological data discovery and sharing thanks to interoperable, modular IT solutions and unified data formats. Together with MCH, WHOS is foreseen as one of the major data management components for HydroSOS.
3. The World Water Data Initiative (WWDI), providing policy and institutional support to national hydrological services and other relevant players with a view to improve water observing and data sharing. Current focus of WWDI is on user requirement process and on contribution to the unified data policy of WMO, both being critical for HydroSOS.

These three activities are closely interconnected with HydroSOS: WWDI provides a structured approach to supporting evidence-based decision making for sustainable water resources management and supports HydroHub with policy and outreach to decision makers; HydroHub supports implementation of the HydroSOS thanks authoritative data and information platform;

WHOS is the main data platform for HydroSOS, which showcases the necessity of data as a support to WWDI policy, and express monitoring requirements to HydroHub.

The GCW, as the cryosphere component of WIGOS, is expected to be instrumental for all aspects related to snow and ice as part of the hydrological cycle.

HydroSOS is further connected to other activities such as the Flood Forecast Initiative, the Associate Programme on Flood Management (APFM) and the Integrated Drought Management Programme (IDMP). HydroSOS will provide initial and boundary conditions to activities such as FFGS and the Dynamic Water Assessment Tool (DWAT), increasing thus their accuracy and timeliness.

In addition, well established WMO systems such as the already mentioned GDPFS and WIS will provide a solid background for data management and modelling mechanisms, and WIGOS, especially with tools such as the Observing Systems Capability Analysis and Review Tool (OSCAR) (metadata management) and the WIGOS Data Quality Monitoring System (WDQMS) will be beneficial to HydroSOS. Furthermore, connections with the Global Basic Observing Network (GBON) and related Systematic Observations Financing Facility (SOFF) and the HydroMet Alliance will be beneficial to HydroSOS.

One of the important outcomes of HydroSOS is the transformation of climate information into actionable hydrological services by having Hydrological Outlook Forums closely related to the climate ones (regional and national climate outlook forums - RCOFs and NCOFs). Such mechanism, which already exists in Central America for example, would also set requirements for RCOFs. In return, HydroSOS can provide useful outputs for validation of climate models and increase the consistency between climate and hydrological outlooks.

Linkages with WMO projects

HydroSOS is supporting the project Enhancing Adaptive Capacity of Andean Communities through Climate Services (ENANDES) to develop hydrological services for hydropower management and flood information in Andean basins. Moreover, the System is considered as a module of the approved Adaptation Fund pre-concept note "Integrated water resources management and early warning system for climate change resilience in the Lake Chad Basin", and it is a central piece of a water information system for the Niger basin, expected to be funded by the Dutch government. HydroSOS will be connected to every water information system WMO is participating to, with the example of HYCOS projects that are currently being drafted for the Southern Africa region and the Pacific Islands, among others.

Linkages with stakeholders

HydroSOS is committed to developing value added services for sectors dependant on water information, beyond the basic outputs of the initiative. Through the provision of hydrological status and outlooks, NMHSs will be able to provide services which will support different sectors such as:

- Agriculture - benefits from hydrological status and outlook products as it will assist with assessments of water prospects for irrigation, planting, harvesting and grazing for both rain-fed and irrigated agriculture.
- Disaster Risk Reduction – will be able to view national, regional and global scale water resources to identify areas at risk of extreme hydrological conditions, enabling informed preparation, risk reduction, and timely deployment of aid.
- Energy – benefits from hydrological status and outlook data for decision support in operations related to water use matching generation, storage, environmental flows and other considerations for power demand.
- Industry – benefits from hydrological status and outlook products in a variety of ways, including understanding of potential restrictions on water abstractions for manufacturing, and modulating effluent releases

- Environment - will be able to review hydrological status and outlook information to determine environmental risk associated with prolonged and extreme deviations from normal. Both high and low flow conditions pose challenges for pollution, streamflow connectivity and more.

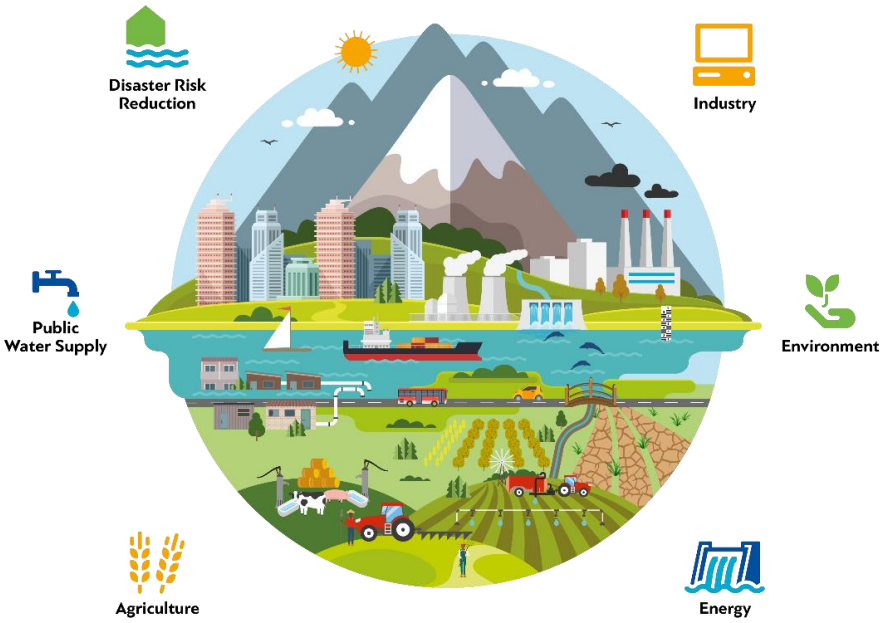

Figure 4. Different sectors to which HydroSOS will be beneficial

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Annex 4 to Resolution 5 (Cg-Ext(2021))

Terms of reference of the Global Hydrometry Support Facility (GHSF) governing bodies

ADVISORY COUNCIL OF THE GLOBAL HYDROMETRY SUPPORT FACILITY (AC)

1. Terms of reference

(a) Provide strategic oversight of the GHSF, considering and advising the GHSF Office on the concept, objectives, expected benefits/costs, operational issues, and future development of the GHSF and its components;

(b) Review and approve the annual GHSF workplan, considering status of each GHSF component, and the progress toward fulfilling their respective objectives against available budget, and propose strategies for necessary remedial action;

(c) Review the relationship of the GHSF with other relevant international programmes, particularly from the point of view of coordination, collaborative opportunities and avoidance of overlap/ duplication and recommend corrective actions;

(d) Appoint the members of and oversee the activities of the GHSF Think Tank, including tasking it with activities and periodically reviewing its composition;

(e) Approve the GHSF Strategic Plan and associated documents, including the GHSF Innovation Plan and GHSF Capacity Development Plan;
(f) Periodically review and advise on its terms of reference and composition;
(g) Periodically reports on progress to the WMO Hydrological Assembly.

2. Membership

(a) A Chair appointed by the WMO Hydrological Assembly;
(b) A Vice-Chair – with relevant expertise – appointed by the WMO Hydrological Assembly;
(c) Representatives from organizations providing financial support to the GHSF's activities;
(d) One representative of National Meteorological and Hydrological Services (NMHSs) or other organizations involved in capacity development projects related to operational hydrometry;
(e) One representative of a research or private sector organization with past or current experience with innovation in hydrometry;
(f) One representative of the Association of the Hydro-Meteorological Equipment Industry (HMEI);
(g) One representative from UN-system organizations with an interest in hydrometry.

At each meeting of the Advisory Council, one or more member(s) of the Think Tank will be invited to attend to provide technical advice in relation to key agenda items. Efforts will be made to ensure rotation amongst the Think Tank Members invited to attend in order to promote new ideas and a diversity of expertise within the GHSF's decision making.
Observers such as financial partners and WMO regional hydrological advisors may be invited on an as-needed basis.
A senior management-level member of the WMO Secretariat having administrative oversight for the GHSF activities shall serve as focal point to the Advisory Council.

The term of membership coincides with the intersessional period of the Hydrological Assembly. The same representative may be re-appointed by his/her parental organization for a maximum of two terms.

3. Other provisions

If it is considered necessary for the implementation of the project, the Chair of the Hydrological Coordination Panel, after consultation with the other organizations involved, may revise these terms of reference and the composition of the membership.

The GHSF Advisory Council shall meet preferably two times a year, mainly by videoconferences, and with at least one face-to-face meeting during the intersessional period. Between meetings of the Advisory Council the Chair of the Council and Chair of the Think Tank will provide strategic oversight of progress with GHSF activities, escalating issues which require input from the whole Council to it by correspondence as required.
The Secretary will produce minutes and action points.

THINK TANK OF THE GLOBAL HYDROMETRY SUPPORT FACILITY (TT)

1. Terms of Reference

Under the general guidance of the GHSF Advisory Council, the GHSF Think Tank will:

I. Promote and support innovation within all GHSF activities and enhance their effectiveness and efficiency by:

(a) Providing guidance to the Advisory Council and Secretariat on advances in innovative hydrometric monitoring and data technologies and the individuals/organizations doing so;
(b) Reviewing, endorsing and periodically updating the GHSF Innovation Road Map including the tools/mechanisms by which the GHSF supports innovation and the selection criteria for Innovation Activities, such as impact and benefit on the goals of the GHSF, multiplication potential and probability to succeed, etc.;
(c) Assessing, approving or rejecting proposals of Innovation Activities, including endorsing allocation of resources related to personnel and financial support of Innovation Activities within the budget approved by the Advisory Council;
(d) Guiding and assisting in the implementation of Innovation Activities, including helping to organize and run innovation events and calls;
(e) Identifying opportunities to publicize, roll-out and/or scale-up innovations.

II. Promote and support the sustainable development of hydrometric monitoring capacity through GHSF activities by:

(a) Providing guidance to the Advisory Council and Secretariat on the capacity development needs and opportunities related to operational hydrometry;
(b) Reviewing, endorsing and periodically updating the GHSF Capacity Development Road Map, including the tool/mechanisms by which the GHSF supports hydrometry capacity development projects and the selection criteria for projects to be supported by the GHSF;
(c) Guiding and assisting in the implementation of GHSF capacity development activities, including helping to organize and run mentoring activities.

III. Support the GHSF activities that develop and foster engagement with and amongst hydrometric communities around the world.
IV. Engage partners in relevant GHSF activities.

2. Membership

(a) The Chair and Vice-Chair of the Advisory Council (one of whom will serve as Chair of the Think Tank);
(b) Two Industry Experts (including one nominated by HMEI);
(c) Two representatives from NMHSs or other organizations undertaking operational hydrometry (preferable those with current or previous involvement in GHSF activities);
(d) Two representatives nominated to provide links to the scientific and educational expertise within the International Association of Hydrological Sciences (IAHS), UNESCO Intergovernmental Hydrological Programme or from the International Association for Hydro-Environment Engineering and Research (IAHR); and
(e) Up to 8 external members with expertise in operational hydrometry, innovation and/or capacity development recruited on a staggered timetable via open calls to the global community.

Explicit attention will be paid to promoting gender, regional and age diversity within the Think Tank Membership.

The GHSF Project Coordinator shall serve as Secretary to the Think Tank.

The Think Tank may invite guests to attend the meeting, such as financial partners, other WMO Hydrological Coordination Panel Members or WMO regional hydrological advisors.

The term of membership will be decided by the GHSF Advisory Council. The same representative may be re-appointed by his/her parental organization for an indefinite number of terms, but rotation will be sought amongst the Members appointed from the Open Call.

3. Other provisions

The WMO Director for Water and Cryosphere will ensure the WMO Secretariat internal coordination and collaboration, may invite WMO representatives to attend Think Tank meetings as guests.

The Think Tank shall meet preferably three times a year, mainly by videoconferences but at least one face-to-face meeting during the intersessional period. Steps will be taken to promote continuous interaction between Members of the Think Tank using online communication tools, to encourage a dynamic, free-flowing ideas culture within the group. The Secretary will facilitate this and produce minutes and action points from meetings.

Resolution 6 (Cg-Ext(2021))

WMO Water Declaration and Water and Climate Coalition

THE WORLD METEOROLOGICAL CONGRESS,

Recalling:

(1) Resolution 24 (Cg-18) – Vision, strategy and organizational arrangements for hydrology and water resources in WMO, which requested the Executive Council (EC) to develop, with the support of the Hydrological Coordination Panel (HCP), a draft Declaration for consideration by the World Meteorological Congress at its extraordinary session in 2021 (Cg-Ext(2021)) taking into consideration the reinforced importance of operational hydrology in addressing global water challenges, future opportunities in the broader WMO interdisciplinary context and the recommendation of the Hydrological Assembly,

(2) Resolution 1 (EC-73) – Draft WMO Water Declaration including the Water and Climate Coalition, which noted the opportunity for WMO to contribute to the Water and Climate Coalition (WCC) and endorsed the draft Water Declaration,

Acknowledging the integral role of water and hydrology in the five long-term goals of the WMO Strategic Plan (2020–2023) and in the mandate of the two technical commissions – the Commission for Weather, Climate, Water and Environmental Services and Applications (SERCOM) and the Commission for Observation, Infrastructure and Information Systems (INFCOM),

Recognizing the role of HCP in coordinating WCC with Regional Hydrological Advisers, National Hydrological Advisers, and the hydrological expert community in WMO,

Having examined the report of the Hydrological Assembly endorsing the WMO Water Declaration contained in Cg-Ext(2021)/INF. 3.1 and the information on the status of WCC, as well as the possible benefits to be obtained by National Meteorological and Hydrological Services (NMHSs), contained in Cg-Ext(2021)/INF. 3.2,

Considering that in 2023, the United Nations will convene its second water conference in New York (the first was held in 1977 in Mar del Plata, Argentina) and that a WMO Declaration on water will help to define the key role and requirements of WMO and its Members' NMHSs with respect to providing essential decision support services,

Taking note of the activities that have been undertaken to familiarize the Permanent Representatives, the presidents of the regional associations and technical commissions, the Chair of the Research Board and National Hydrological Advisers with the Water Declaration and WCC,

Having further examined the WMO Water Declaration contained in the annex to the present resolution, which reflects the input received during the extensive consultation process carried out by HCP,

Adopts the WMO Water Declaration;

Welcomes the Secretary-General's initiative to contribute to the implementation of the WMO Vision and Strategy for Hydrology and its associated Plan of Action through WCC, a key initiative which will highlight synergies between policies for Sustainable Development Goals 6 and 13 and those of the Paris Agreement and which will create partnerships to support Members in the implementation of integrated weather, water and climate activities;

Requests the Secretary-General to ensure a transparent screening of and reporting on membership of WCC to Members as appropriate;

Requests the Executive Council, based on the advice of HCP, to review the guidance put forward by WCC and to develop recommendations to be taken up by the technical commissions, the Research Board and the regional associations, as appropriate;

Requests the president of SERCOM, the president INFCOM, the Chair of the Research Board and the presidents of the regional associations, in coordination with the Chair of HCP, to incorporate the WCC-related recommendations of the Executive Council in developing their workplans and activities;

Further requests the Secretary-General:

(1) To disseminate and promote the WMO Water Declaration among Members, United Nations and other international partner organizations, particularly at United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP) meetings, and among relevant public, private and academic sector organizations, emphasizing the vital importance of the mission of NMHSs in monitoring, understanding and predicting weather, climate and water conditions and in providing related information, warnings and services that meet river basin, regional, national, and global needs, especially in the context of climate change;

(2) To provide the Executive Council with an accounting of planned budgetary and extra budgetary resources for WMO activities in WCC;

(3) To facilitate the alignment and integration of WMO activities in WCC with the decisions of the World Meteorological Congress, the Hydrological Assembly and the WMO technical commissions;

Calls on Members to distribute the WMO Water Declaration widely and to motivate national stakeholders to join WCC.

Annex to Resolution 6 (Cg-Ext(2021))

WMO Water Declaration

We, the delegates of 116 Member States and Territories of the World Meteorological Organization (WMO), meeting from 11 to 22 October 2021 at the Extraordinary Session of the World Meteorological Congress,

Considering:

(1) That, by 2030, more than half of the world's population is projected to be living under water stressed conditions and that expected climate change will further exacerbate these conditions and increase our vulnerability to water-related disasters,

(2) The central role of the water cycle in the water-climate-weather continuum,

(3) That WMO Members' National Meteorological and Hydrological Services play a key role in providing essential services, information, and scientific knowledge for sustainable development, climate change mitigation, as well as resilience and adaptation to key societal needs-sectors,

(4) That essential information includes the hydrosphere and cryosphere as key components of the Earth system,

(5) That mountains are a global asset as water towers that store and transport water via glaciers, snowpacks, lakes and streams, thereby supplying invaluable resources to roughly a quarter of the world's population for drinking, irrigation and power generation; are a life-saving buffer during droughts; and that climate change already alters the sustainability of these freshwater resources;

We applaud:

(1) The hydrological community's effort to lay out a decadal Vision and Strategy for Hydrology as an integral part of the WMO Strategic Plan for an Earth system approach to weather, water and climate science and services;

(2) The development of an Action Plan with eight long-term ambitions to address national, regional and local water challenges[1];

Declare:

(1) That by 2030 early warnings for early action related to floods and droughts will be available for people everywhere on the planet to access;

(2) That policies for water and climate action developed within the sustainable development agenda be integrated to yield maximum benefit for our people;

(3) That we will pursue these goals through capacity development, knowledge exchange and information sharing, and by establishing policies, institutional and legal/regulatory

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[1] Eight long-term ambitions to address the water challenge (https://public.wmo.int/en/our-mandate/water)

frameworks at all levels that enable enhanced partnerships among all stakeholders from all sectors of society;

We agree:

(1) That the integration of hydrological, cryosphere, meteorological, ocean, climate and environmental information is a prerequisite to providing solutions that increase resilience and more effectively enable adaptation to climate change;

(2) That the unrestricted sharing of Earth system data and information[2] at the regional, national, and local scales, taking an integrated river basin approach, is vital to create benefits that will allow us to optimize water resources management, national adaptation planning, including planning of quality infrastructure, as well as effective disaster risk reduction, including early warning systems;

(3) That we will work through WMO programmes and initiatives, such as the Water and Climate Coalition (WCC), to promote the sharing and access to integrated hydrological, cryosphere, meteorological and climate information to plan and operate resilient and sustainable water resources systems at local, national, regional and river basin scales;

(4) That we will develop international, mountain-specific monitoring and services to safeguard the amount of water stored in the mountain water towers.

We note:

(1) The central role of water, in achieving the United Nations Sustainable Development Goals (SDGs), and of the WCC, as a mechanism for integrating water and climate agendas, as well as the fundamental importance of strengthening operational and scientific-technological capacities at national, regional and global level to address water-related sustainable development and climate change adaptation challenges;

(2) The importance of the Sendai Framework for Disaster Risk Reduction 2015–2030 and its guiding principles for disaster risk reduction;

(3) The Paris Agreement and the importance of strengthening the global response to the threat of climate change through implementing efficient mitigation measures as well as effective adaptation measures that lead to more resilient societies and sustainable environmental conditions;

(4) The coordinating role of UN-Water to align its members' and partners' initiatives, fostering synergies towards the accomplishment of SDG 6 "Ensure availability and sustainable management of water and sanitation for all", and the directing role of the UN's custodian agencies over their corresponding SDG indicators.

We recognize:

(1) The need to integrate and strengthen the entire Earth system services value chain — from acquisition and exchange of observations, information and scientific knowledge, through data processing and forecasting, to service delivery — to meet growing societal needs;

[2] As outlined in the WMO Unified Policy for the International Exchange of Earth System Data

(2) The pressure on public funding which inhibits the ability of some National Meteorological and Hydrological Services (NMHSs) to sustain and improve the required hydrometeorological infrastructure and services;

(3) That despite the availability of low-cost technologies and solutions, currently deteriorating local monitoring networks and the lack of capacity of some NMHSs continue to undermine efforts to provide reliable hydrological services;

(4) The need to have access to integrated Earth system information and services for designing appropriate solutions, with an ever-increasing scientific base, that will support a growing demand for water in a sustainable way;

(5) The need for more effective incentives, guidelines, standards and decision support systems to ensure that relevant data and information is easily accessible, interpreted and effectively used in planning and management processes;

(6) The need to promote the emergence of a regional hydrometeorological awareness, especially on the scale of shared basins;

We reaffirm:

(1) The mission of WMO outlined under Article 2 of the WMO Convention to facilitate worldwide cooperation on monitoring and predicting changes in weather, climate and water through the exchange of information and services, standardization, application, research and training and to explicitly promote activities in operational hydrology and further enable close cooperation between Meteorological and Hydrological Services;

(2) The WMO strategic objective to develop services in support of sustainable water resources management and to reduce related risks and subsequent losses through improved access to reliable global, regional, and river basin information on the current status and future conditions of water resources;

(3) The vital importance of the mission of the NMHSs in monitoring, understanding and predicting weather, climate and water behaviour, and in providing related information, warnings and services that meet river basin, regional, national, and global needs;

(4) The responsibility of Members' governments to maintain, sustain, and where possible, expand requisite hydrometeorological infrastructure and the operation of systems and facilities for observations, data exchange and information supply;

(5) The importance of NMHSs' cooperation to promote the development of international agencies or commissions for the management of water resources in shared basins;

(6) The importance of promoting the creation of additional monitoring and research centres for high mountains and centres for drought monitoring and research to operate in different regions;

We welcome:

(1) The contributions of Members, partner organizations and the WCC members to sustaining and developing the global hydrological information and data infrastructure coordinated by WMO through its programmes;

(2) The opportunities that globalization, digitalization and scientific-technological development bring about for a wider engagement of end users, stakeholders, partners from the private sector, civil society and scientific organizations in setting requirements for and supporting decision processes;

We urge Governments:

(1) To facilitate and support enhanced cooperation and partnerships at all relevant levels involving National Meteorological, Hydrometeorological and Hydrological Services, and other relevant partners for delivering integrated early warnings and services to society relevant for the water-food-energy nexus, future water availability, clean water and sanitation, and disaster risk reduction;

(2) To scale up human and financial investments to ensure the sustainable production, provision and maintenance of hydrological services;

(3) To ensure real time information is available to the extent necessary to save lives and property at all relevant scales, taking an integrated river basin approach;

(4) To establish partnerships between National Meteorological Services, National Hydrological Services and other relevant stakeholders, including community organizations, using an integrated water resources management approach, taking advantage of existing collaborations to actively pursue, plan and document integration of their capacities and structures that are needed to deliver services for the benefit of society;

We invite Governments and International Partners to come together in the WCC to define principles for integrating water and climate policy developments and to agree on incentives and guidelines that will help to ensure the financial and institutional sustainability and increased coverage of hydrological observation networks, and that their data is actionable.

Resolution 7 (Cg-Ext(2021))

WMO constituent body reform: Status, advancement, impacts of the COVID-19 pandemic and further directions

THE WORLD METEOROLOGICAL CONGRESS,

Recalling:

(1) Resolution 5 (Cg-18) – WMO Executive Council, Resolution 6 (Cg-18) – WMO regional associations, Resolution 7 (Cg-18) – Establishment of WMO technical commissions for the eighteenth financial period, Resolution 8 (Cg-18) – Research Board, Resolution 9 (Cg-18) – Joint World Meteorological Organization-Intergovernmental Oceanographic Commission Collaborative Board, Resolution 10 (Cg-18) – Scientific Advisory Panel, and Resolution 11 (Cg-18) – WMO reform – next phase, concerning the constituent body reform and the related Transition Plan,

(2) Resolution 89 (Cg-18) – Extraordinary session of Congress in 2021, and subsequent decisions approved by the Executive Council at its seventy-second session (Decision 3 (EC-72) – Extraordinary session of Congress in 2021) and at its seventy-third session (Decision 3 (EC-73) – Extraordinary session of the World Meteorological Congress in 2021),

(3) Decision 4 (EC-72) – Follow up to the Constituent Bodies Reform Task Force,

(4) Decision 4 (EC-73) – Evaluation of the constituent body reform, and Decision 5 (EC-73) – Impacts of COVID-19 and response of WMO,

(5) Resolution 75 (Cg-18) – Amendments to the General Regulations of the World Meteorological Organization,

Expresses appreciation to the presidents of the Infrastructure Commission and the Services Commission, the Chairs of the Research Board, the Scientific Advisory Panel, the Joint WMO-Intergovernmental Oceanographic Commission (IOC) Collaborative Board and the committees and panels of the Executive Council, the presidents of the regional associations, WMO Members and experts and the Secretariat for their efforts and close collaboration to fulfil the decisions on the constituent body reform adopted by the World Meteorological Congress at its eighteenth session (Cg-18) and to continue advancing the mission of the Organization under the challenging conditions imposed by the COVID-19 pandemic,

Notes:

(1) That despite the limitations brought about by COVID-19, the Transition Plan for the constituent body reform has been fully implemented according to the schedule, and in this regard:

(a) The technical commissions have conducted their first sessions, established and populated working structures, adopted workplans for the intersessional period fully aligned with the WMO Operating Plan, organized many important virtual technical conferences/workshops (for example, the WMO Data Conference, and so forth), ensured close cooperation with each other and other bodies and submitted recommendations to both the Executive Council and World Meteorological Congress at its extraordinary session,

(b) The Research Board and the Scientific Advisory Panel have conducted sessions, organized important online international events (for example, the International Symposium: Climatological, Meteorological and Environmental Factors in the COVID-19 pandemic, and so forth) and initiated and pursued their activities, and the Scientific Advisory Panel has begun preparing visionary papers on the future of observing systems, Earth System services, science and related IT infrastructures,

(c) The Joint WMO-IOC Collaborative Board has established and populated its working structure, conducted several virtual sessions, and developed a WMO-IOC Collaborative Strategy fully aligned with the WMO Operating Plan, which was adopted in 2021 by the Executive Council and the IOC Assembly,

(d) The regional associations have conducted sessions, established working structures aligned with the technical commissions and adopted operating plans guided by the WMO Operating Plan,

(e) The Executive Council decision-making process has improved considerably thanks to the preparatory work of the Technical Coordination Committee (TCC) and the Policy Advisory Committee (PAC). The number of documents has also been reduced, and their content has improved, and the new concept has led to more efficient meetings, although COVID-19 has somewhat complicated the decision-making of the Executive Council,

(f) Every session of the WMO bodies was conducted through virtual means, for which methods of work have been developed and interpretation services provided as required, thus enabling a much wider attendance of delegates and experts of Members,

(g) Rules of procedure for all bodies have been developed and adopted by the Executive Council,

(h) The WMO Experts Database is functioning as an interactive self-service system that allows Members to nominate, review and update information about their experts who are contributing to the work of the Organization,

(i) The departmental structures of the Secretariat have been reorganized in line with the bodies established by the constituent body reform, and the modernization of working practices is demonstrating innovation and cross-cutting cooperation, as well as generating efficiencies and synergies,

(j) The reallocation of the resources of the Secretariat, as requested by Cg-18, has been carried out, and the recruitment of professional staff in order to strengthen regional, infrastructure, services and scientific duties has mostly been completed and will allow considerably better services for Members,

(k) The reformed constituent bodies and the Secretariat have enabled the preparation of the revised WMO Data Policy, the concept of the Global Basic Observation Network and the concept of the Systematic Observation Financing Facility, have brought about progress in the integration of previously separate weather, climate, water, ocean and environment infrastructures, services and science, have brought about the better engagement of the private and academic sectors and have enabled WMO to have a stronger role in the United Nations family as a key climate, disaster and water organization,

(2) That efforts need to be continued to achieve a wider membership in the technical commissions, with currently slightly over half of the WMO Members having participated in one or both of the technical commissions, to ensure a more balanced geographical, country and gender representation in their subsidiary bodies, especially with respect to experts from the southern hemisphere, and to pursue a combination of physical, hybrid and virtual meetings to maximize the participation of delegates and experts,

(3) That the comprehensive review of the WMO regional concept and approaches is addressed through Resolution 8 (Cg-Ext(2021)) – Comprehensive review of the WMO regional concept and approaches and Resolution 9 (Cg-Ext(2021)) – Terms of reference of regional associations and their presidents and vice-presidents;

Reaffirms that it is important that the bodies established through the reform:

(1) Be aligned with and collectively ensure the implementation of the WMO Strategic Plan;

(2) Better support Members' efforts to unify operational prediction systems, observations and services through the Earth system approach; and

(3) Facilitate the uptake of research and scientific and technological advances into operational systems;

Recognizes that the expected outcomes of the constituent body reform will become fully evident in the longer term and **appreciates** the actions taken by the Executive Council to assess the effectiveness and efficiency of the constituent body constructs, structures and processes established by the reform based on the results of an independent and external evaluation overseen by PAC;

Requests the Executive Council to continue to monitor and guide the independent and external evaluation of the reform and to report on the results of the reform to the World Meteorological Congress at its nineteenth session (Cg-19);

Encourages Members to realize the full benefits of the constituent body reform, including by establishing their membership in the technical commissions and by nominating experts as candidates to serve in the subsidiary bodies of the regional associations, the technical commissions and the Research Board.

Resolution 8 (Cg-Ext(2021))

Comprehensive review of the WMO regional concept and approaches

THE WORLD METEOROLOGICAL CONGRESS,

Recalling:

(1) Resolution 6 (Cg-18) – WMO regional associations,

(2) Resolution 11 (Cg-18) – WMO reform – next phase,

(3) Resolution 1 (EC-72) – Effective coordination between regional associations, technical commissions and the Research Board,

(4) Resolution 2 (EC-72) – Activities and working mechanisms of the regional associations,

Having considered the overall rationale and the key current challenges and opportunities as articulated in Annex 1 to the present resolution and **having agreed on** Recommendation 1 (EC-73) – Comprehensive review of the WMO regional concept and approaches,

Decides to adopt the following decisions on the Comprehensive review of the WMO regional concept and approaches:

(1) To uphold and focus on the core basic functions of the regional associations as outlined in Article 18 of the WMO Convention and General Regulation 130 (Annex II of the General Regulations), which remain highly relevant;

(2) To pursue enhanced working modalities for the organization of the regional associations' business with a view to enhancing efficiency and effectiveness by:

   (a) Including a standing agenda item on "Implementation of Congress and Executive Council decisions and resolutions" in each session of the regional associations to review and assess the degree of implementation of decisions and resolutions relevant to the regions;

   (b) Adopting a phased approach for the organization of regional association sessions, as appropriate and as allowed by resources, and by having more regionally focused agendas;

   (c) Addressing critical issues of interest to the regions that will promote initiatives and activities of interest to the Members in support of and in alignment with the WMO Strategic and Operating Plan, increasing the implementation of the decisions and resolutions of the World Meteorological Congress and the Executive Council;

   (d) Sequencing the strategic and operational planning of WMO to start with the identification of the key capacity gaps and priorities of the regional associations, which should be communicated to the Executive Council and the World Meteorological Congress to form the basis of and start of the process for the development of the WMO Strategic and Operating Plan in support of concrete actions related to regional priorities;

(e) Leveraging and/or formalizing relations with groupings based on language/geographical/economic/political commonalities, such as those listed in Annex 2 to the present resolution, as platforms for addressing groups/region-specific issues and promoting cooperation through specific activities for WMO Members in those constituencies;

(f) Promoting more technical and thematic meetings of regional associations and discussions in the intersessional period, availing of online meeting facilities, to address specific priorities for regions as well as to regularly monitor and evaluate the progress of the implementation of their workplans;

(g) Strengthening the interaction of the regional associations, technical commissions, and Research Board through improved working arrangements and communication, including consultations and sharing of their workplans, participation of the presidents and chair of each body in the sessions of other bodies, and participation of experts serving under the substructure of the regional associations in the work of the technical commissions and the Research Board;

(h) Facilitating the development of subregional, regional and interregional communities of practice on issues of major interest to the regional associations, such as observation networks, service provision, research priorities, and multi-hazard early warning systems implementation and operations;

(i) Developing strategies to determine the impact and risks associated with the proposed decisions and resolutions relevant to the region;

(j) Strengthening the function of the available WMO Centres in the region and using them in implementing regional priority activities in the region;

(3) To enhance the engagement with the United Nations system, regional economic communities, regional organizations, and other international partners by:

(a) Formalizing and effectively monitoring memoranda of understanding for the implementation of joint initiatives and/or activities with United Nations Economic Commissions in all regions, regional organizations such as regional economic communities, regional intergovernmental organizations, development partners, regional development financial institutions, and so forth;

(b) Participating actively, with the support of the regional offices, in relevant issue-based coalitions of United Nations Economic Commissions and high-level events organized by regional partners;

(c) Promoting the induction of resident coordinators and key officials of partner organizations to increase their awareness of the role of WMO and the role and contribution of National Meteorological and Hydrological Services (NMHSs) and to promote closer cooperation with NMHSs;

(d) Organizing ministerial and/or high-level events associated with the sessions of the regional associations and other WMO bodies at the appropriate time according to the expected results, focusing on hydrometeorological hazards and impacts, multi-hazard early warning systems, socioeconomic benefit studies to promote the role of NMHSs and the value of weather, water and climate services, and other strategic and important emerging issues, as appropriate and relevant to the region;

(e) Fully utilizing WMO senior Secretariat officials in advocacy and diplomatic engagement with United Nations entities and regional economic commissions and in regional ministerial meetings and so forth, as appropriate;

(f) Launching, through high-level events co-organized with key United Nations and regional partners, annual reports on the state of regional climates, documenting critical regional weather/climate extremes and their socioeconomic impacts, and identifying critical gaps in Member capacities, as appropriate;

(g) Exploring and proposing region-specific ways for enhancing the visibility and authoritative voice of NMHSs in the regions with the support of the regional offices;

(4) To adopt measures to enhance the role of the presidents and vice-presidents of the regional associations and the effectiveness of their work in accordance with and consistent with the terms of reference of the regional associations and their presidents and vice-presidents by:

(a) Distributing leading roles and tasks among Management Group members of regional associations, EC members, and a set of Permanent Representatives to lead specific/thematic tasks, with support from the leads of the regional associations' subsidiary bodies, as appropriate, to enable enhanced engagement and implementation of regional priorities in alignment with World Meteorological Congress and the Executive Council decisions and resolutions;

(b) Using numerical indicators (key performance indicators (KPIs)) to track the progress of the implementation of World Meteorological Congress and Executive Council decisions and resolutions relevant to the regions, regional associations' decisions and plans, as well as status changes in Members' capabilities, with the support of the regional offices. The regional associations shall review and assess the degree of implementation of decisions and plans using the KPIs, which shall be reported by the presidents of the regional associations, together with the regional associations' experiences and best practices with respect to addressing critical capacity gaps, to the World Meteorological Congress and the Executive Council at their sessions;

(c) Strengthening the staffing, technical and coordination capacities of the regional offices to provide support to the presidents of the regional associations (PRAs) in fulfilling their duties, as appropriate;

(5) To strengthen and enhance educational and training capacities in the regions, especially Regional Training Centres (RTCs) in the respective regions, and to promote the participation of early career and female experts in WMO work;

(6) To strengthen the engagement of the private sector and academia by allowing the participation, as associate members and/or observers, of regional industry bodies representing WMO stakeholders' interests, for example, regional farmers associations, association of air transporters and so forth;

(7) To promote the use of the new WMO Community Platform and the regular updating of information as an essential tool for the regional associations to identify the capacity development needs of Members, to track the progress of the implementation of World Meteorological Congress and Executive Council decisions and resolutions, and to facilitate the planning or formulating of regional priorities as well as the targeting of investments by WMO and partner organizations;

Requests the presidents of the regional associations:

(1) To submit to the Secretary-General, within six months after each session of the World Meteorological Congress, the decisions of the regional associations with regard to its regional implementation plan based on regional priorities and focusing on key decisions and resolutions of relevance to the regions;

(2) To apply measurable KPIs and milestones to the regional implementation plan, with the support of the regional offices, to enable the effective review of the progress of the implementation of World Meteorological Congress and Executive Council decisions and resolutions relevant to the regions. These KPIs should be based upon the coordinated working plans of the regional associations, the technical commissions, the Research Board and the relevant departments of the Secretariat;

(3) To update the regional implementation plan within three months after each Executive Council session taking into consideration new decisions and resolutions relevant to the regional associations;

(4) To coordinate the organization of regional meetings, as appropriate, using videoconferencing to address specific issues of interest to the regions and Members with the support of the regional offices and to ensure that the progress and decisions taken are adequately documented and communicated to the regional associations, other WMO bodies and partners, as appropriate;

(5) To facilitate, to the extent possible, the link between the regional associations, the technical commissions, the Research Board and other bodies and partners of the Organization by promoting the participation of experts, especially early career and female experts, involved in the work of the WMO bodies in the activities of the regional associations;

(6) To encourage enhanced cooperation between the National Meteorological Services (NMSs) and National Hydrological Services (NHSs) for an improved delivery of integrated products and services for the benefit of impacted sectors such as disaster risk reduction, energy and so forth;

(7) To consult and engage the Management Group of each region in the distribution of leading roles and tasks among Management Group members, Executive Council members and Permanent Representatives from the region in question to lead specific/thematic tasks, with support from the leads of the regional associations' subsidiary bodies, as appropriate, in order to enable enhanced engagement and implementation of regional priorities in alignment with World Meteorological Congress and Executive Council decisions and resolutions;

(8) To coordinate and convene regular, structured engagement sessions with Management Group members, Executive Council members, and Permanent Representatives from each region in an effort to promote collective ownership on agreed decisions and resolutions of the World Meteorological Congress, the Executive Council and the regional associations;

(9) To facilitate more subregional, regional and interregional cooperation through collaboration among regional centres and lead centres to enhance capacity development within and across the regions;

(10) To develop regional priorities as the start to the strategic and operational planning process and to form the basis for the WMO Strategic and Operating Plan and to communicate these to the Secretary-General;

(11) To encourage the engagement of NMHSs in public and private engagements (PPEs) in order to support their capacity development activities and supplement their limited budgets by using such mechanisms as the Open Consultative Platform (OCP) on business models and partnerships between the public and the private sector;

Requests the Secretary-General:

(1) To engage an independent review of the effectiveness of WMO regional and subregional offices with a view to improving support to Members and the coordination of regional activities, identifying requirements for WMO, maximizing WMO's participation in partner activities and enhancing the effectiveness, visibility and/or impact of these offices. This should take into consideration, inter alia, their strategic location vis-à-vis United Nations regional hubs and/or regional political/economic agencies' locations, opportunities offered by online meetings, and existing resources;

(2) To develop measurable KPIs and milestones for regional implementation plans, under the guidance of the presidents of the regional associations, in order to enable an effective review of the progress of the implementation of World Meteorological Congress and Executive Council decisions and resolutions. These KPIs should be based upon coordinated working plans of the regional associations, the technical commissions, the Research Board and the relevant departments of the Secretariat;

(3) To assess, in consultation with the presidents of the regional associations, staff requirements for the regional and representative offices, based on the characteristics and requirements of each region, in order to enable more effective support for the work of the presidents of the regional associations, enhanced engagement with United Nations and regional partner organizations, and enhanced support for Members in implementing World Meteorological Congress and Executive Council decisions and resolutions and WMO initiatives;

(4) To strengthen the activities of the regional offices and regional associations, as appropriate, through the allocation of region-specific technical expertise, including human resources, as appropriate, and other means for their more effective functioning, including more systematic support for their work and support to the presidents and vice-presidents of regional associations for the fulfilment of their duties;

(5) When aligned with regional priorities and needs, to ensure a further strengthening of the WMO Secretariat's engagement in advocacy and diplomatic/policy-related meetings with United Nations entities, regional economic commissions and relevant regional ministerial meetings;

(6) To develop guidelines to enable the use of measurable KPIs and milestones for the pragmatic development of regional implementation plans by the regional associations taking into account their needs, requirements and available resources and to facilitate the provision of training in the use of these guidelines, as appropriate;

(7) To facilitate the induction of incoming Permanent Representatives, Hydrological Advisers and senior NMHS staff on WMO matters, including the development of an online self-induction module for use by Members and updating and disseminating the *Reference Guide for Permanent Representatives of Members with the World Meteorological Organization on Relevant Procedures and Practices of the Organization* (WMO-No. 939) and the *Guidelines on the Role, Operation and Management of National Meteorological and Hydrological Services* (WMO-No. 1195) in the context of the WMO reform;

(8) To facilitate the support of the regional offices to the regional associations in the identification of key capacity gaps and priorities in order to inform the development of WMO strategic and operational planning and the formulation of measurable KPIs and milestones to enable the monitoring of progress and to facilitate the liaison of the

regional associations with the Secretariat for more effective support in addressing the needs of the regional associations;

(9) To facilitate enhanced communication from the Secretariat, from the presidents and Hydrological Advisers of the regional associations, and from other WMO bodies to Members, as well as to experts, on matters of interest to the regions, including the strengthening of the use of tools and platforms for communication and including repositories for information, as appropriate;

(10) To support the regional associations in developing priorities which form the basis for the WMO Strategic and Operating Plan and in communicating regional associations' priorities to other constituent bodies and WMO programmes and to prepare a WMO Strategic and Operating Plan based on the regional associations' priorities as the start to the Strategic and Operational Planning process;

(11) To further support the continued work of the Executive Council Task Force on the Comprehensive Review of the WMO Regional Concept and Approaches in accordance with the Task Force's approved terms of reference and with respect to its submission of recommendations to the World Meteorological Congress at its nineteenth session in 2023;

(12) To develop guidelines to facilitate the engagement of NMHSs in PPEs to support their capacity development activities and to supplement their limited budgets;

(13) To develop and maintain, in consultation with the regional associations, a list of important regional meetings (see the living document presented in Annex 2 to the present resolution) and to seek opportunities to establish linkages with these meetings in order to encourage regional cooperation and activities;

(14) To assist with resource mobilization efforts to enable designated regional institutions/centres, such as RTCs, Regional Telecommunication Hubs (RTHs) and Regional Specialized Meteorological Centres (RSMCs) to effectively deliver on their mandates and to position them in line with WMO reform packages;

Further requests the Secretary-General to provide the needed support and resources for the effective implementation of the above-mentioned decisions;

Requests the regional associations, the technical commissions, the Research Board, and the other bodies of the Organization to actively support the implementation of the above-mentioned decisions.

Annex 1 to Resolution 8 (Cg-Ext(2021))

The overall rationale and the key current challenges and opportunities for the comprehensive review of the WMO regional concept and approaches

Overall Rationale:

Following Cg-18 and EC-72 decisions, the overall rationale for undertaking a comprehensive review of the WMO regional concept and approaches can be viewed as a 'back to basics' approach to ensuring the continued delivery and implementation of the priorities of WMO Members. The role and function of the regional associations are outlined in the WMO

Convention. The Convention states that the regional associations should: *1. Promote the execution of the resolutions of Congress and the Executive Council in their respective Regions; 2. Consider matters brought to their attention by the Executive Council; 3. Discuss matters of general interest and coordinate meteorological related activities in the Regions; 4. Make recommendations to Congress and the Executive Council on matters within the purpose of the Organization.*

WMO General Regulation 130 and Annex II — Regional Associations General Terms of Reference, articulate important fundamental features and core values which ***remain highly relevant*** and can be summarized as follows:

- Coordinating Members' activities in the planning, implementation, monitoring and evaluation of agreed programmes, strategies and activities at regional and subregional level.

- Ensuring visibility of WMO and engaging key stakeholders in regional initiatives and projects related to the strategic priorities of the Organization for capacity development and sustainability of long-term modern services and addressing critical deficiencies.

- Identifying requirements and any impediments of the timely implementation of planned programmes and activities to the technical commissions; collaborating with Members, technical commissions and other bodies to support, monitor and review all the regional centres established by WMO bodies.

- Ensuring the identification of common expertise and gaps with technical commissions and sharing regional priorities.

- Engaging Members in achieving the expected results in the strategic plan.

- Building and promoting partnerships with Regional Economic Commissions, United Nations bodies, etc.

- Advocating to regional political and economic entities and supporting PRs in financial and political support to Members' vital capabilities in information and services.

There is a critical need to ensure that regional associations are refocused on their basic mandate envisaged in the Convention and General Regulations. It is important to clearly outline how these basic roles and functions will be achieved by the President and the association members and be fully supported by the WMO Secretariat. The underlying core values remain highly relevant, however the modalities on how they are achieved should be clearly enhanced.

This comprehensive review plus the Survey of Members identifies the current challenges and opportunities. Proposed practical enhancements and recommendations are made to ensure that WMO initiatives in support of enhancing Members' capabilities are at the heart of the business of regional associations. Enhanced advocacy with regional economic and political bodies will also ensure the necessary investments in priority areas.

Key Current Challenges:

There are a number of important challenges and current weaknesses in the way that regional associations function, which could be identified as gaps in substantive support, engagement and connection with the strategic initiatives identified as important by Congress and the Executive Council.

These challenges can be summarized as follows:

- The implementation of Congress resolutions and Executive Council decisions is limited.

- There are important gaps in observations or Multi-Hazard Early Warning Systems and services.

- The heterogeneous nature of some regions and differences/diversity of processes both politically and economically is not sufficiently recognized and adjusted.

Key Current Opportunities:

There are several important benefits and opportunities for making changes to the way the regional associations function and how the WMO Secretariat's expertise, convening power and advocacy can be fully utilized in support of Members in addressing existing gaps through identified priorities. In particular:

- The regional associations will have a higher impact by focusing on the implementation of selected strategic priorities.

- There should be a more systematic use of numerical indicators tracking the changes of the capabilities in observations and early warning systems and services.

- We should ensure opportunities for connections to important regional meetings such as CIMHET, League of Arab States, SIDS Pacific, EUMETNET, among others, to promote cooperation and regional activities.

- The benefits of a more extensive use of videoconferencing technology thereby encouraging a wider participation in meetings, could be further explored.

- The need for a greater utilization of senior Secretariat officials such as the Secretary-General and WMO Executive Management for engagement in United Nations and political processes to advocate for regionally focused attention and investments could be pursued.

- Enhancing partnership and cooperation with the United Nations development system, regional coordinators and the private sector and academic institutions, could be strengthened.

- Regional and interregional cooperation through the use of regional specialized centres such as regional training centres and regional climate centres in support of capacity development of Members in the Regions could be enhanced.

Annex 2 to Resolution 8 (Cg-Ext(2021))

Important meetings WMO could leverage to encourage and promote regional cooperation

- The Ibero-American NMHS Directors Conference (CIMHET)
- The Arab League
- The Pacific Small Island Developing States (PSIDS)
- The European Meteorological Services Network (EUMETNET)
- The ASEAN Sub-Committee on Meteorology and Geophysics (SCMG)
- Informal conferences of National Meteorological and Hydrological Services Directors
- Informal Conference of South-East European Directors of NMHSs (ICSEED)
- Informal Conference of Central European Directors of NMHSs (ICCED)
- Informal Conference of Western European Directors of NMHSs (ICWED)
- Commonwealth of Independent States/Interstate Council on Hydrometeorology (CIS/ICH)
- Caribbean Meteorological Organization (CMO)
- Archipelagic and Island States (AIS) Forum
- Pacific Meteorological Council (PMC)
- Intergovernmental Oceanographic Commission (IOC-UNESCO)
- Meteorological Association of Southern Africa
- African Ministerial Conference on Meteorology (AMCOMET)

Resolution 9 (Cg-Ext(2021))

Terms of reference of regional associations and their presidents and vice-presidents

THE WORLD METEOROLOGICAL CONGRESS,

Recalling:

(1) The general terms of reference for regional associations, contained in Annex II to the General Regulations (*Basic Documents No. 1* (WMO-No. 15)),

(2) Resolution 6 (Cg-18) – WMO regional associations,

(3) Resolution 11 (Cg-18) – WMO reform – next phase,

(4) Recommendation 1 (EC-73) – Comprehensive review of the WMO regional concept and approaches,

(5) Resolution 8 (Cg-Ext(2021)) – Comprehensive review of the WMO regional concept and approaches,

Reaffirming the need and the importance of continuing with the WMO reform efforts in the eighteenth financial period with a focus on regional associations,

Emphasizing that the WMO Convention and the General Regulations of the Organization, which provide the rationale for the existence of the regional associations, including their terms of reference, remain highly relevant,

Recognizing the need to improve the working mechanisms of the regional associations to enhance their effectiveness and to enhance the utilization of the expertise available in the regions and the contributions of the regional associations to the WMO strategic planning and achievement of its objectives,

Recognizing further the differences between regions and among Members within the same regional association that result in varying interests, priorities and requirements for interregional and intraregional collaboration and coordination,

Taking into account the decisions made on the comprehensive review of the WMO regional concept and approaches as part of Resolution 8 (Cg-Ext(2021)),

Having examined further recommendations of the Executive Council (Recommendation 1 (EC-73)) and its Policy Advisory Committee regarding the terms of reference of regional associations and their presidents and vice-presidents,

Decides to adopt the following decisions on the terms of reference of regional associations, their presidents and vice-presidents:

(1) To amend Annex II to the General Regulations (*Basic Documents No. 1* (WMO-No. 15)) as follows:

3. Identify requirements and priorities among Members and regional bodies with the support of Regional Offices and communicate them, together with any impediments to the timely implementation of planned programmes, strategies and activities, to the Executive Council, technical commissions and other bodies, as appropriate, as the starting point of the WMO Strategic and Operational Planning Process; collaborate with Members, technical commissions and other bodies, as necessary, to support, monitor and regularly review all the regional centres established by WMO bodies, ensuring excellent performance, sustainable operations and effective services to regional Members; consult with technical commissions, Research Board, and other bodies, as appropriate, on the identification of common experts to assist with the sharing of regional priorities and requirements and the implementation of technical priorities and associated capacity-building activities; identify technical gaps and promote training to develop future experts;

5. Contribute to the WMO Strategic Plan, Operating Plan and other implementation plans, as necessary, to reflect agreed strategic priorities from a regional perspective and ensure the engagement of Members in focused activities aimed at achieving the expected results of the WMO Strategic Plan;

(2) To amend General Regulation 136 as follows:

Sessions of an association shall normally be held at a place within its Region or through virtual means, and/or hybrid format, as appropriate,

(3) To amend General Regulation 134 as follows:

The duties of the president of an association shall be:

1. To preside over the sessions of the association;

2. To guide and coordinate the activities of the association and its subsidiary bodies between sessions of the association with the support from Regional Offices and technical departments and in coordination with the technical commissions, the Research Board and other relevant bodies;

3. To carry out such specific duties as are prescribed by decisions of Congress and the Executive Council and by the Regulations of the Organization;

4. To ensure that the activities, recommendations and resolutions of the association are in accordance with the provisions of the Convention, decisions of Congress and the Executive Council and the Regulations of the Organization;

5. To present the views of the association to Congress and to the Executive Council;

6. To facilitate intra and interregional collaboration and cooperation taking advantage of available forums, groupings and meetings. To arrange for appropriate representation of the association in sessions of other associations, technical commissions and other relevant WMO bodies and engage in high-level political advocacy, visibility and partner engagement, where ~~if~~ necessary ~~and needed~~;

7. To conduct, either directly or through the Secretary-General on behalf of the association, correspondence on matters relating to the activities of the association~~;~~.

~~8. To maintain files of official correspondence as president of an association and to send copies of this correspondence to the Secretary-General.~~

Requests the Executive Council to include the following specific roles of the presidents and vice-presidents of the regional associations in the *Rules of Procedure for Regional Associations* (WMO-No. 1241):

(1) Specific role of the president of an association:

(a) Facilitate with the support of the Regional Offices the identification of key capacity gaps and priorities from the region supported by diagnostic databases of Member's capacities to inform the development of regional plans and serve as the foundation for the development of the strategic and operational plans of WMO in support to Members;

(b) Facilitate with the support of the Regional Offices the formulation of the regional association plan, based on capacity gaps of the Members in the region, including the definition of numerical indicators for monitoring implementation of the plan;

(c) Facilitate with the support of the Regional Offices the nomination of experts from the region to the subsidiary bodies of the Organization as well as their effective utilization in the substructures of the regional associations;

(d) With the support of the Regional Offices, l~~L~~ead the monitoring and evaluation of the activities of the regional association, including the activities of the WMO Regional Centres in collaboration with relevant technical commissions, the Chairs of working groups/expert teams, focal points and the Regional Office;

(e) Coordinate with the Regional Office the communication and facilitate the fulfilment of the requests to Members to keep relevant WMO platforms up to date;

(2) Specific role of the vice-president of an association:

(a) Assist the president in the fulfilment of duties specified in General Regulation 134;

(b) Act as Vice-Chair of the Management Group of a regional association;

(c) Carry out activities as delegated or requested by the president and the Management Group of the regional association;

Requests the presidents of the regional associations to take a leading role in the implementation of the aforementioned decisions;

Requests the Secretary-General to provide the required support for the effective implementation of the aforementioned decisions by:

(1) Providing the adequate orientation to the incoming presidents and vice-presidents of the regional associations in their respective roles;

(2) Developing a structured workplan and the operating plan of the Secretariat using adequate key performance indicators (KPIs) in coordination with the President and the presidents of the regional associations and by providing, through this workplan, a functional basis for the workplans and activities of the regional associations and the work of the presidents of the regional associations;

(3) Promoting enhanced collaboration and support by the Regional Offices, which act as the secretariats of the regional associations;

(4) Establishing a mechanism that will allow the presidents of the regional associations to guide the work of the Regional Offices so that they can provide the most effective support to the regional associations;

(5) Reporting to the regional associations on a quarterly basis on the support provided to the regional associations and to their presidents for the achievement of the KPIs;

Invites Members to take into consideration the above commitments required of the presidents and vice-presidents of the regional associations and to accord due support and the resources needed for them to fulfil their responsibilities.

Resolution 10 (Cg-Ext(2021))

Towards a structured WMO response to global crises

THE WORLD METEOROLOGICAL CONGRESS,

Noting Decision 5 (EC-73) – Impacts of COVID-19 and response of WMO, requesting the development of guidance for Members on how to maintain the operation and maintenance of systems,

Concerned by the challenges experienced by Members during the COVID-19 pandemic and **taking note** of existing arrangements and good practices already supporting business continuity and contingency planning as detailed in Cg-Ext(2021)/INF.4.3,

Recognizing that business continuity is a national responsibility that is planned and executed at the appropriate institutional level,

Recognizing further existing examples of business continuity and contingency planning good practices and the role of regional associations in further building on these,

Decides to review the principles and approaches related to Members' business continuity and contingency planning to maintain their essential operations, which are partly supported by regionally and globally coordinated networks and services;

Requests the technical commissions, in coordination with the Executive Council Capacity Development Panel, the regional associations, the Research Board, other WMO bodies and partners as necessary:

(1) To suggest approaches to the seventy-fifth session of the Executive Council on how to strengthen Members' business continuity and contingency planning as requested by the Members and as appropriate;

(2) To provide any additional support that may be required by Members within their respective national context;

Requests the Executive Council to review and provide feedback on the development of the aforementioned proposed approaches;

Further requests the Executive Council to include business continuity and contingency planning guidance development for Members in WMO's Capacity Development Strategy based on the aforementioned proposed approaches;

Requests the Secretary-General to provide Secretariat support to this initiative;

Calls on Members to engage in this initiative through the mobilization of their experts and by sharing their relevant expertise and knowledge;

Invites capacity development partners and other relevant agencies to include business continuity and contingency planning within their project plans and related activities.

Resolution 11 (Cg-Ext(2021))

Amendments to the General Regulations of the World Meteorological Organization

THE WORLD METEOROLOGICAL CONGRESS,

Recalling Resolution 75 (Cg-18) – Amendments to the General Regulations of the World Meteorological Organization, which updated and streamlined the General Regulations in order for them to serve their purpose as high-level rules for the Members, the officers of the Organization, the constituent bodies and other bodies of the Organization and the Secretariat to ensure the consistent, efficient and effective conduct of the Organization's convening and other activities,

Commending the Executive Council for the development and adoption of the rules of procedure for technical commissions, regional associations, the Research Board, the Executive Council and other bodies of the Organization,

Having considered the recommendation of the Executive Council to adjust the provisions of the General Regulations concerning terms of officers (Regulations 10 and 62), the credentials of individuals forming the delegations to constituent bodies (Regulation 20) and subsidiary bodies (Regulations 27–35) to adequately support the functioning of the new bodies of the Organization,

Adopts the amendments to the General Regulations, as provided in the annex to the present resolution;

Requests the Secretary-General to publish the 2021 edition of *Basic Documents No. 1* (WMO-No. 15) containing the amended General Regulations and to inform all concerned of this decision;

Requests the Executive Council to review respective rules of procedures and to adjust them, if needed, in line with the amended General Regulations.

Annex to Resolution 11 (Cg-Ext(2021))

Amendments to the General Regulations

The General Regulations (*Basic Documents No. 1* (WMO-No. 15, 2019 edition)) are amended as follows:

REGULATION 10

The term of office of the President and Vice-Presidents of the Organization ~~or of the president and vice-president of an association or president and vice-president(s) of a commission~~ shall be from the end of one ordinary session to the end of the succeeding ordinary session of Congress. The term of office of the president and vice-president(s) of an association or a commission shall be from the first ordinary session of the association or the commission following the ordinary session of Congress to the end of the next ordinary session of the association or the commission following the ordinary session of Congress.

However, they shall be eligible for re-election at the end of their term of office provided that, if any officer has already served for a continuous period covering more than one term of the same office, they shall not be eligible for a further term in the same office, unless they have served for less than five years which shall include the period they may have served in an acting capacity under the provisions of Regulations 11, 12 and 13. With regard to the offices of President and Vice-Presidents of the Organization and of the presidents and vice-presidents of the associations, successive Directors of the same Meteorological or Hydrometeorological Service shall not hold the same office for more than two consecutive terms.

REGULATION 62

Elections for all offices and places which a constituent body is required to fill shall be held at ~~each~~ an ordinary session of that constituent body at which an election of officers is to be held (in accordance with Regulation 10).

REGULATION 20

(a) Prior to a session of a constituent body other than the Executive Council, each Member concerned shall communicate to the Secretary-General the names of the persons composing its delegation to that body, indicating which of these shall be regarded as its principal delegate;

(b) Besides this communication, a letter giving these particulars and otherwise conforming with the provisions of the Convention and of these Regulations and signed by, or on behalf of, an appropriate governmental authority of the Member shall be sent to the Secretary-General or handed to the representative at the session and shall be regarded as appropriate credentials for the participation of the individuals named therein in the session. For technical commission sessions, the Secretary-General may accept the credentials of persons who are part of the Member's delegation provided that those credentials have been signed by the Member's Permanent Representative (in consultation with the Member's Hydrological Adviser in the case of hydrological experts);

(c) The same procedure shall apply as regards the credentials of observers representing non-Member countries;

(d) The credentials of observers representing international organizations shall be signed by the competent authority of the organization concerned.

Subsidiary bodies

REGULATION 27

Any constituent or additional body established according to Article 8 (h) of the Convention may establish subsidiary bodies to act during a prescribed period of time until the next session of that constituent or additional body. The terms of reference of such subsidiary bodies shall be established by the constituent or additional body and shall be within the terms of reference of that body.

REGULATION 28

A member of a subsidiary body selected by a constituent or additional body or its president (Chair) may be replaced on the subsidiary body only by decision of that constituent or additional body, except that, in case of urgency, the president (Chair) of the parent ~~constituent~~ body may do so. A member of a subsidiary body ~~selected~~ designated by a Member of the Organization may be replaced only by decision of that Member. A member of a subsidiary body~~selected~~ designated by an international organization may be replaced only by decision of that organization.

REGULATION 29

The president of the constituent body (Chair of additional body), after consultation with the Secretary-General in any case in which financial expenses for the Organization may be involved, may, at the request of the subsidiary body, invite technical experts to participate in the work of the subsidiary body.

REGULATION 30

An invitation to any technical expert in accordance with Regulations 28 or 29 to participate in the work of a subsidiary body shall be in accordance with Regulation 143. An invitation to any other individual to participate in the work of a subsidiary body shall require the prior concurrence of the Permanent Representative of the Member in which the individual lives, in consultations with the Hydrological Adviser (as relates to experts in hydrology), or of the competent authority of the United Nations or another international organization in which the individual works and with which the Organization has concluded arrangements or agreements. Invitations to individuals from these organizations shall be validated by the Secretariat.

REGULATION 31

Expenses of attendance of members of subsidiary bodies of constituent and additional bodies at sessions of these bodies shall normally be borne by the Members or the international organization to which those members belong. However, participation in a session of a subsidiary body ~~of a constituent body~~ may be financed by the Organization by decision of Congress or the Executive Council, provided that the questions to be dealt with:

(a) Are of general interest to the Organization;

(b) Are such as to necessitate the services of individual experts specially chosen in view of their specialized knowledge or to represent a regional interest rather than the interest of a Member or an international organization;

(c) Are such that they cannot be solved by correspondence; and

(d) Are considered by Congress or the Executive Council as having high priority.

REGULATION 32

Any constituent or additional body may recommend the establishment of joint subsidiary bodies between itself and one or more other ~~constituent~~ bodies. Such bodies shall only be established, and their terms of reference and number of members be determined, by Congress or the Executive Council and shall normally serve during a prescribed period of time until the next session of Congress.

REGULATION 33

Documents, reports and recommendations of subsidiary bodies shall have no status within the Organization until they have been approved by the responsible constituent or additional body. In case of joint subsidiary bodies, the recommendations must be concurred with the presidents of the constituent bodies (Chairs of additional bodies) concerned before being submitted to the designated constituent or additional body.

REGULATION 34

In the case of a recommendation made by a subsidiary body between sessions of the responsible constituent or additional body, either in a session ~~of a body~~ or by correspondence, the president of that constituent body (Chair of additional body) may, as an exceptional measure, approve the recommendation on behalf of the constituent or additional body when the matter is considered urgent, and does not appear to imply new obligations for Members. The president (Chair) may then submit this recommendation for adoption by the Executive Council or to the President of the Organization for action in accordance with Regulation 8 (5).

REGULATION 35

Notwithstanding Regulation 27, a subsidiary body may be dissolved at any time by the constituent or additional body that established it if that body considers that it has completed its task or is not able to proceed further.

Resolution 12 (Cg-Ext(2021))

Methods of work for the online extraordinary session of the World Meteorological Congress

THE WORLD METEOROLOGICAL CONGRESS,

Noting the successful experience of the conduct of virtual sessions of the regional associations, the technical commissions and the Executive Council in 2020–2021 and Decision 3 (EC-73) – Extraordinary session of the World Meteorological Congress in 2021, requesting the development of methods of work for online sessions of the World Meteorological Congress similar to those applied to the sessions of constituent bodies during 2020 and 2021 and in full respect of the provisions of the WMO Convention and General Regulations,

Adopts the methods of work for conducting the extraordinary session of the World Meteorological Congress (Cg-Ext(2021)) online as provided in the annex to the present resolution.

Annex to Resolution 12 (Cg-Ext(2021))

Methods of work for the online Extraordinary session of the World Meteorological Congress (Cg-Ext(2021))

1. Legal provisions

The Convention and General Regulations shall continue to apply in full, subject to consideration of any online practice that would be exceptionally required to conduct the online session, as identified in the attached table.

2. Registration

2.1 Representatives of WMO Members and invited observers shall notify the Secretary-General of the names of the persons who will participate in the session following the normal practice in accordance with the General Regulations.

2.2 Online registration will follow normal practice. Additional information is provided through the Cg-Ext(2021) website.

2.3 Guidance for identification of participants of online sessions is provided in the attached table.

3. Attendance and quorum

3.1 Attendance by representatives of WMO Members, invited observers, presidents of technical commissions, chairs of WMO bodies and all other participants shall be through a secured access to the videoconference.

3.2 The number of participants simultaneously connected may be limited depending on the capacity of the selected videoconference system.

3.3 Online attendance by representatives of WMO Members (or their alternates) shall be checked and registered in each meeting of the session to ensure the quorum of the presence of delegates of a majority of 193 Members.

4. Documents

4.1 Documents for the session will be made available and managed following normal practice through the Cg-Ext(2021) website.

4.2 To optimize discussions of documents in online sessions, representatives of Members are encouraged to submit comments on documents to plenary@wmo.int prior to the session, preferably one week before the opening of the session.

5. Interventions

5.1 During the online session, representatives of WMO Members, alternates, or delegates on their behalf shall be provided with the opportunity to take the floor. Individual statements are normally limited to three minutes.

5.2 Any representative of a Member wishing to take the floor should signal their wish to speak or to raise a point of order using the videoconference system, as indicated through the Cg-Ext(2021) website.

6. Recording of sessions

Pursuant to Regulation 95(c), audio and video recordings of online plenary meetings shall be made and retained for record-keeping purposes.

7. Decision-making

All decisions of the session should, as far as possible, be taken by consensus. Should certain matters require substantive debate, the President may propose the establishment of drafting groups, which will meet separately and report back to the plenary.

8. Committees

All business shall be conducted in plenary, except for committees that may be established, which shall meet separately, through an online platform that will be specified. All matters to be discussed by the committees shall be determined by the plenary.

9. Languages

General Regulation 97 shall continue to apply, whereby interventions made shall be interpreted into the other working languages of Congress.

Explanatory note on online practices in conducting the online session of the Extraordinary session of Congress (Cg-Ext(2021))

Procedure	Physical session	References	Online session
Delegates participation and credentials	(a) Prior to a session of a constituent body other than the Executive Council, each Member concerned shall communicate to the Secretary-General the names of the persons composing its delegation to that body, indicating which of these shall be regarded as its principal delegate; (b) Besides this communication, a letter giving these particulars and otherwise conforming with the provisions of the Convention and of these Regulations and signed by, or on behalf of, an appropriate governmental authority of the Member shall be sent to the Secretary-General or handed to the representative at the session and shall be regarded as appropriate credentials for the participation of the individuals named therein in the session; (c) The same procedure shall apply as regards the credentials of observers representing non-Member countries; (d) The credentials of observers representing international organizations shall be signed by the competent authority of the organization concerned.	GR[1]20	Same
Delegates and other participants registration,	In addition, online registration takes place through the Event Registration System.		Same

[1] General Regulations, *Basic Documents No. 1, 2019 edition* (WMO-No. 15)

attendance and identification, including presidents of technical commissions, Chairs of WMO bodies, invited experts and observers	One nameplate per delegation regardless of the size of the delegation. Representatives of observers (invited international organizations), non-Member States should be registered through the Event Registration System. The observer badge should indicate the Organization. The badge of representative of Member should indicate the Member State or Territory.		Specific naming convention will be determined by the Secretariat to facilitate the online identification of participants as follows: WMO Members: Principal Delegate (PD), Alternate (Alt), and Delegate (Del) • Principal Delegate (Principal): **Member name/PD/Surname** • Alternate: **Member name/Alt/Surname** • Delegate: **Member name/Del/Surname** President, Vice-Presidents of WMO • President of WMO: **P/WMO** • Vice-Presidents of WMO: **1st VP/WMO; 2nd VP/WMO; 3rd VP/WMO** Presidents and vice-presidents of regional associations, presidents and vice-presidents of technical commissions, Chairs of WMO bodies, Regional Hydrological Advisers and Invited Experts • Presidents of regional associations: **P/RA I** (II, …, VI) for presidents (acting presidents) • Vice-presidents of regional associations: **VP/RA (I, II….)** • Presidents of technical commissions: **P/INFCOM, P/SERCOM** • Vice-presidents of technical commissions: **VP/INFCOM/Surname, VP/SERCOM/Surname** • Chair, body acronym: **(C/HCP)**

			• Regional Hydrological Advisers: **HA/RA I** (II, …, VI) • Invited Experts: **Expert/Surname** Representatives of International Organizations/Non-Members • **Organization name/Surname** • **Non-Member name/Surname** Secretariat • **Secretariat/Surname** Number of participants simultaneously connected may be limited depending on the capacity of the selected videoconference system. Conference Officer (system administrator) will optimize the number of connections and capacity of the system.
Quorum	The presence of delegates of a majority of the Members shall be required to constitute a quorum for the meetings of Congress.	Article[2] 12	Same. Online presence shall be confirmed based on active connections. In the absence of a quorum, i.e. due to connectivity problems, the meeting could be: (i) suspended until connectivity is restored, provided this is within the agreed working hours of the session, (ii) postponed until the following working day, (iii) continued with those present to further adopt the decision by correspondence.

[2] WMO Convention, *Basic Documents No. 1, 2019 edition* (WMO-No. 15)

Interventions and submission of written comments	Request the floor by raising the nameplate. Principal delegates (or their alternates on their behalf) intervene first, followed by other delegates. Same applies to observers. Individual statements are normally limited to three minutes. Submit written comments on documents following the intervention to plenary@wmo.int.		Signal wish to speak using the videoconference system, as indicated through Cg-Ext(2021)/INF. 1.2. Same. In view of the limited time for online sessions and in order to optimize discussions during the meeting, WMO Members are encouraged to submit comments on documents to plenary@wmo.int prior to the session, preferably one week before the start of the session.
Recording of Sessions	Audio recordings of plenary meetings shall be made and retained for record-keeping purposes.	GR 95 (c)	Same
Conduct of business during sessions (i.e. points of order, motions, amendments)	A point of order may be raised by any delegation by means of a specific gesture from the floor. It shall be immediately addressed by the President in accordance with the Regulations.	GR 79	A point of order may be raised by any WMO Member through the chat function, writing "Point of Order". It shall be immediately addressed by the President in accordance with the Regulations.
Decision-making	All decisions of Congress should, as far as possible be taken by consensus. Should certain matters require substantive debate, the President may propose the establishment of drafting groups, which will meet separately and report back to the plenary.	Article 5, 11	Same
Committees	Congress will work in plenary throughout the session. Each constituent body, except the Executive Council may establish a Credentials Committee.	GR 22–24 and 26	Congress will work in plenary throughout the session. Congress will establish a Coordination Committee and may establish other committees for in-depth consideration of specific decisions in accordance with General Regulations 24. A Credentials Committee may

	Each constituent body may establish for the duration of its session, committees as it deems necessary. The WMO Hydrological Assembly shall be convened in accordance with General Regulation 26.		be established, if required, in accordance with General Regulations 22. The WMO Hydrological Assembly shall be convened in accordance with General Regulation 26.
Languages	Interventions are interpreted into the other working languages of Congress. Participants select their desired language from the device at their seat.	GR 97	Same. Participants will be able to select their desired language option from the online menu.

APPENDIX 3. LIST OF PARTICIPANTS

1. Officers of the session

Gerhard ADRIAN	President of WMO
Andrea Celeste SAULO	First Vice-President of WMO
Albert A.E. MARTIS	Second Vice-President of WMO
Agnes KIJAZI	Third Vice-President of WMO

2. Representatives of WMO Members

Algeria

Brahim IHADADENE	Principal Delegate
Djaouida NEGGACHE	Delegate
Salah SAHABI ABED	Delegate

Argentina

Andrea Celeste SAULO	Principal Delegate
Carla GULIZIA	Alternate
Claudia CAMPETELLA	Delegate
María Ines CAMPOS	Delegate
María Julia CHASCO	Delegate
Ramon DE ELIA	Delegate
Paula ETALA	Delegate
Lorena FERREIRA	Delegate
Mariano RE	Delegate
Maria Emilia RUIZ	Delegate
Yanina SKABAR	Delegate
Maria de los Milagros SKANSI	Delegate
Martina SUAYA	Delegate
Marcelo URIBURU QUIRNO	Delegate
Roxana VASQUES	Delegate
Elian WOLFRAM	Delegate

Armenia

Levon AZIZYAN	Principal Delegate
Valentina GRIGORYAN	Delegate
Amalya MISAKYAN	Delegate
Zarmandukht PETROSYAN	Delegate
Nunufar STEPANYAN	Delegate

Australia

Gilbert BRUNET	Principal Delegate
Louise WICKS	Alternate
Robert ARGENT	Delegate
Susan BARRELL	Delegate
Bryan HODGE	Delegate
Boris KELLY-GERREYN	Delegate
Karl MONNIK	Delegate
Sally MORGAN	Delegate
Narendra TUTEJA	Observer
Ruxandra VOINOV	Observer

Austria

Michael STAUDINGER	Principal Delegate
Andreas SCHAFFHAUSER	Alternate
Jutta EYBL	Delegate
Christoph WIELAND	Delegate

Bahamas

Arnold KING	Delegate

Bahrain

Basem ALASFOOR	Principal Delegate
Nader ABDULLA	Delegate
Khalid Hussain YASEEN	Delegate

Barbados

Sabu BEST	Principal Delegate
Brian MURRAY	Delegate
John MWANSA	Delegate

Belarus

Aliaksandr KANAVALCHYK	Principal Delegate
Sviatlana KUZMICH	Delegate
Hanna MATSEVILA	Delegate
Dmitry NIKALAYENIA	Delegate
Liudmila ZHURAVOVICH	Delegate

Belgium

Daniel GELLENS	Principal Delegate
Steven DEWITTE	Alternate

Belize

Ronald GORDON	Principal Delegate
Orlando HABET	Delegate

Benin

Didier KAKPA	Principal Delegate
Jules AZONGNIHOUN	Delegate
Dakpanon Félicien CHEDE	Delegate
Aurelien TOSSA	Delegate

Bhutan

Karma DUPCHU	Principal Delegate
Tayba Buddha TAMANG	Delegate

Bosnia and Herzegovina

Igor KOVACIC	Principal Delegate
Darko BOROJEVIC	Delegate
Sabina HODZIC	Delegate
Esena KUPUSOVIC	Delegate
Nada RUDAN	Delegate

Brazil

Helenir Trindade DE OLIVEIRA	Alternate
Jose Arimatea DE SOUSA BRITO	Alternate
Helges Samuel BANDEIRA	Delegate
Quilson DE ARAGÃO DOS SANTOS	Delegate
Camila A. LOPES CHRISOSTOMO	Delegate
Marcelo Jorge MEDEIROS	Delegate
Marcus Vinícius MENDES	Delegate
Fábio PEREIRA DE OLIVEIRA	Delegate
Gilvan SAMPAIO DE OLIVEIRA	Delegate

British Caribbean Territories

Arlene LAING	Principal Delegate
David FARRELL	Alternate
Shawn BOYCE	Delegate
Kathy-Ann CAESAR	Delegate
Jonathan COX	Delegate
Glendell DE SOUZA	Delegate
Mark GUISHARD	Delegate
Avalon PORTER	Delegate
Andrea SEALY	Delegate
John TIBBETTS	Delegate
Adrian TROTMAN	Delegate
Mark CODING	Observer
Yasmin JAMES	Observer

Brunei Darussalam

Muhamad Husaini AJI	Principal Delegate
Shahalmie EMRAN	Delegate

Bulgaria

Plamen NINOV	Delegate
Lora YOSIFOVA	Delegate

Burkina Faso

Guillaume NAKOULMA	Alternate
Amedee BAGA	Delegate
Joël ZOUNGRANA	Delegate

Burundi

Déogratia BABONWANAYO	Principal Delegate

Canada

Diane CAMPBELL	Principal Delegate
Jenifer COLLETTE	Alternate
Doris FORTIN	Alternate
Heather AUCOIN	Delegate
Veronique BOUCHET	Delegate
Shannon DEGRAAF	Delegate
David HARPER	Delegate

Wayne JENKINSON	Delegate
Christopher LINKLATER	Delegate
Samy PELERIN	Delegate
Alain PIETRONIRO	Delegate
Russ WHITE	Delegate

Chile

Reinaldo GUTIERREZ	Principal Delegate
Gaston TORRES	Alternate
Ricardo ALCAFUZ	Delegate
Pilar CARRILLO	Delegate
Gonzalo CONCHA	Delegate
Francisco LARRAIN	Delegate
Mercedes MENESES	Delegate
Juan QUINTANA	Delegate

China

Guotai ZHUANG	Principal Delegate
Yong YU	Alternate
Baogui BI	Delegate
Xiaodan NA	Delegate
Heng ZHOU	Delegate

Colombia

Yolanda GONZALEZ HERNANDEZ	Principal Delegate
Andres Felipe MARMOLEJO EGRED	Alternate
Fabio Andres BERNAL QUIROGA	Delegate
Claudia Yaneth CONTRERAS TRUJILLO	Delegate
Eliana FONSECA	Delegate
Helmer GUZMAN	Delegate
Laura Sofia HEREDIA CUELLAR	Delegate
Hugo SAAVEDRA	Delegate
Juan Manuel SALDAÑA BARAHONA	Delegate

Costa Rica

Werner STOLZ	Principal Delegate
José Alberto ZUNIGA MORA	Delegate

Côte d'Ivoire

Daouda KONATE	Delegate
Augustin NZUE	Delegate

Croatia

Branka IVANCAN-PICEK	Principal Delegate
Gordana BUSELIC	Alternate
Ivan GUETTLER	Delegate
Kristian HORVATH	Delegate
Kreso PANDZIC	Delegate
Vlasta TUTIS	Delegate

Cuba

Celso PAZOS ALBERDI	Principal Delegate

Curaçao and Sint Maarten

Albert Asinto Eleuterio MARTIS	Principal Delegate
Joseph ISCAAC	Alternate
Pedzi GIRIGORI	Delegate

Czech Republic

Jan DANHELKA	Alternate
Dominika BACHMANOVA	Delegate
Branislav GAL	Delegate
Eliska POLCAROVA	Delegate
Radim TOLASZ	Delegate
Karel VANCURA	Delegate

Democratic People's Republic of Korea

Jae Hyok KIM	Principal Delegate
Myong Hak JONG	Delegate
Hyon Min KIM	Delegate

Denmark

Marianne THYRRING	Principal Delegate
Ulrik Smith KORSHOLM	Alternate
Ellen Vaarby LAURSEN	Alternate
Kim SARUP	Delegate

Dominican Republic

Andres Miguel CAMPUSANO LASOSE	Principal Delegate
Renso HERRERA FRANCO	Delegate
Gabriela SANTONI BISONO	Delegate
Juana SILLE	Delegate

Ecuador

Jeaneth CARTAGENA	Principal Delegate
Rodrigo POMBOSA	Delegate

Egypt

Hesham TAHOUN	Principal Delegate
Abdelghafar ADAM	Alternate
Yasser ABDEL-GWAD ELSAYED MOHAMED	Delegate
Doaa AMIN	Delegate
Abdalla Abdelrahman BALIGH	Delegate
Samaa BAROUDY	Delegate
Abdelhamid ELAWADI	Delegate
Kamal FAHMY	Delegate
Amira GALAL	Delegate
Rabab Gaber HASSAN	Delegate
Marwa KHATAB	Delegate
Mohamed Husain KORANY	Delegate
Gehad Hasan MOHAMED	Delegate
Samira REFAAT	Delegate

El Salvador

Luis MENJIVAR	Principal Delegate

Estonia

Taimar ALA	Principal Delegate
Krabbi MIINA	Delegate
Jana POLDNURK	Delegate
Svetlana PUDOVA	Delegate
Kai ROSIN	Delegate

Fiji

Terry ATALIFO	Principal Delegate
Viliame VEREIVALU	Delegate

Finland

Jussi KAUROLA	Principal Delegate
Maria HURTOLA	Alternate
Sami NIEMELA	Alternate
Tarja RIIHISAARI	Alternate
Joanna SAARINEN	Delegate
Jari UUSIKIVI	Delegate

France

Virginie SCHWARZ	Principal Delegate
Catherine BORRETTI	Alternate
Laurence FRACHON	Alternate
Patrick BENICHOU	Delegate
Marie-Pierre MEGANCK	Delegate
Rachel PUECHBERTY	Delegate

Gambia

Lamin Mai TOURAY	Principal Delegate
Landing BOJANG	Delegate
Peter GIBBA	Delegate

Georgia

Ramaz CHITANAVA	Principal Delegate
Ioseb KINKLADZE	Delegate
Irakli MEGRELIDZE	Delegate
Lia MEGRELIDZE	Delegate

Germany

Gerhard ADRIAN	Principal Delegate
Karolin EICHLER	Alternate
Axel THOMALLA	Alternate
Stephan DIETRICH	Delegate
Charlotte HOPPE	Delegate
Julia KELLER	Delegate
Harald KOETHE	Delegate

Volker LEHMANN	Delegate
Ulrich LOOSER	Delegate
Florian TEICHERT	Delegate
Malte UPHOFF	Delegate
Philipp VON CARNAP	Delegate

Greece

Emmanouil ANADRANISTAKIS	Principal Delegate
Antonios EMMANOUIL	Alternate
Konstantina MITA	Alternate
Vasiliki KOTSALOU	Delegate
Artemis PAPAPETROU	Delegate
Konstantina PAPATSIMPA	Delegate
Panagiotis SMYRNIS	Delegate

Guatemala

Yeison SAMAYOA VELASQUEZ	Principal Delegate
Jorge David CHINCHILLA	Delegate

Guinea

Mamadou Lamine BAH	Principal Delegate
Mandiou CONDE	Delegate

Honduras

Francisco ARGENAL	Alternate

Hong Kong, China

Cho-ming CHENG	Principal Delegate
Sum-yee Sharon LAU	Alternate
Pak-wai CHAN	Delegate
Lap-shun LEE	Delegate
Shiu Wai Maxwell MAK	Delegate
Ming-keung OR	Delegate
Yu-fai TONG	Delegate

Hungary

Kornelia RADICS	Principal Delegate

Eszter LABO SZAPPANOS	Alternate
András CSIK	Delegate

Iceland

Arni SNORRASON	Principal Delegate
Jorunn HARDARDOTTIR	Alternate

India

Mrutyunjay MOHAPATRA	Principal Delegate
Ram Kumar GIRI	Alternate
D S PAI	Delegate
Kamaljit RAY	Delegate

Indonesia

Dwikorita KARNAWATI	Principal Delegate
Ardhasena SOPAHELUWAKAN	Alternate
Neng ALIA	Delegate
Anni Arumsari FITRIANY	Delegate
Dodo GUNAWAN	Delegate
Urip HARYOKO	Delegate
Iqbal IQBAL	Delegate
Wishnu KRISNAMURTHI	Delegate
Albert C. NAHAS	Delegate
Donaldi Sukma PERMANA	Delegate
Dasniari POHAN	Delegate
Agie Wandala PUTRA	Delegate
A. Fachri RADJAB	Delegate
Nelly Florida RIAMA	Delegate
Bagus Rachmat RIEVAN	Delegate
Rusgito RUSGITO	Delegate
Awidya SANTIKAJAYA	Delegate
Siswanto SISWANTO	Delegate
Maman SUDARISMAN	Delegate
Edward TRIHADI	Delegate
Yesi Christy ULINA	Delegate
Regina Yulia YASMIN	Delegate

Iran (Islamic Republic of)

Sahar TAJBAKHSH MOSALMAN	Principal Delegate

Ahad VAZIFEH	Alternate
Maryam HARATI	Delegate
Ladan JAFARI TEHRANI	Delegate
Sayed Masoud MOSTAFAVI DARANI	Delegate
Mehdi RAHNAMA	Delegate
Saviz SEHATKASHANI	Delegate

Ireland

Eoin MORAN	Principal Delegate
Sarah O'REILLY	Alternate
Josephine PRENDERGAST	Alternate
Sarah GALLAGHER	Delegate
Eoin SHERLOCK	Delegate

Israel

Guy RESHEF	Delegate
Tamara SZNAIDLEDER	Delegate

Italy

Luca BAIONE	Principal Delegate
Cristina BIINO	Alternate
Angela CORINA	Alternate
Adriano RASPANTI	Alternate
Marina BALDI	Delegate
Carlo CACCIAMANI	Delegate
Teodoro GEORGIADIS	Delegate
Giuseppe Angelo Antonio LEONFORTE	Delegate

Jamaica

Evan THOMPSON	Principal Delegate
Peter CLARKE	Delegate

Japan

Naoyuki HASEGAWA	Principal Delegate
Hidenori FURUICHI	Alternate
Jitsuko HASEGAWA	Alternate
Toshio KOIKE	Alternate

Naofumi MASUKO	Alternate
Mamoru MIYAMOTO	Alternate
Masanori OBAYASHI	Alternate
Akihiro SHIMASAKI	Alternate
Akihiko SHIMPO	Alternate
Naohisa KOIDE	Delegate
Masaru KUNII	Delegate
Masaki KUROIWA	Delegate
Kohei MATSUDA	Delegate
Hiroaki MORIKAWA	Delegate
Masakazu NAGATA	Delegate
Akira OKAGAKI	Delegate
Ryosuke SAKAKIBARA	Delegate
Kensuke SUZUKI	Delegate
Kazuki YASUI	Delegate

Jordan

Raed RAFID	Principal Delegate
Ibrahim ALSAIDAT	Delegate
Laila SHAHIN	Delegate
Aiman SUBEH	Delegate

Kazakhstan

Danara ALIMBAYEVA	Principal Delegate
Serik SAIROV	Alternate
Nurlan ABAYEV	Delegate
Ainur ABENOVA	Delegate
Svetlana DOLGIKH	Delegate
Bakhytzhan SAILYBAYEV	Delegate
Almas SHABDANOV	Delegate
Tursyn TILLAKARIM	Delegate
Didar ZHANIBEKULY	Delegate

Kenya

Stella AURA	Principal Delegate
Noah KERANDI	Delegate
Nicholas MAINGI	Delegate
Daniel MOGUSU	Delegate
Walter NGANYI	Delegate

Franklin OPIJAH	Delegate

Latvia

Ervins GREBESS	Delegate
Iveta INDRIKSONE	Delegate
Liga KLINTS	Delegate

Lesotho

Motoho MASEATILE	Alternate
Ntiea LETSAPO	Delegate
Tlhoriso MORIENYANE	Delegate
Retsepile NEKO	Delegate
Molefi PULE	Delegate

Libya

Ashour SASSI	Principal Delegate
Ali EDDENJAL	Delegate
Mohamed ELBSHENI	Delegate
Muftah KHADASH	Delegate

Luxembourg

Andrew FERRONE	Principal Delegate
Joerg BAREISS	Delegate
Christophe GILBERTZ	Delegate
Martina RECKWERTH	Delegate
Sven SCHMIT	Delegate

Macao, China

Weng Kun LEONG	Principal Delegate
Iu Man TANG	Alternate
Chan Vai TAM	Delegate

Madagascar

Nirivololona RAHOLIJAO	Principal Delegate
Tatiana ARIVELO	Delegate
Stephason KOTOMANGAZAFY	Delegate
Herinjanahary RALAIHARINORO	Delegate

Voahanginirina Anne Marie Pierrette RAMIANDRISOA	Delegate

Mali

Djibrilla MAIGA	Principal Delegate
Boubacar Ibrahima DJITTEY	Delegate
Adama KONATE	Delegate
Moussa TOURE	Delegate

Mauritius

Premchand GOOLAUP	Principal Delegate
Kumar Ram DHURMEA	Delegate

Mexico

Alejandra MÉNDEZ GIRÓN	Principal Delegate
Karen ARANDA GONZÁLEZ	Delegate
Miguel Ángel GALLEGOS BENÍTEZ	Delegate
María Eugenia GONZÁLEZ ANAYA	Delegate
Martín IBARRA OCHOA	Delegate
Reynaldo PASCUAL RAMÍREZ	Delegate
Ricardo PRIETO GONZÁLEZ	Delegate
Juan SALDAÑA COLÍN	Delegate
Raúl VARGAS JUÁREZ	Delegate

Monaco

Mariam TAVASSOLI-ZEA	Delegate

Mongolia

Lamjav OYUNJARGAL	Alternate
Ganbat AMGALAN	Delegate
Dashdondog BATDORJ	Delegate
Erdenemunkh BYAMBAA	Delegate
Dashzegve ULAMBAYAR	Delegate

Montenegro

Dusica BRNOVIC	Principal Delegate
Ivana ADZIC	Alternate
Branko MICEV	Alternate
Mirjana IVANOV	Delegate
Biljana KILIBARDA	Delegate

Morocco

Omar CHAFKI	Principal Delegate
Brahim ELMESSAOUDI	Alternate
Said ELKHATRI	Delegate
Karam ESSAOUINI	Delegate

Mozambique

Aderito ARAMUGE	Principal Delegate
Messias MACIE	Delegate
Francisco Raul NOSTADO	Delegate

Myanmar

Htay Htay THAN	Principal Delegate
May Khin CHAW	Delegate
Kyaw Moe OO	Delegate

Netherlands

Gerard STEENHOVEN	Principal Delegate
Hans ROOZEKRANS	Alternate
Frank LANTSHEER	Delegate
Nicole NIJHUIS	Delegate
Gé VERVER	Delegate

New Zealand

Norm HENRY	Principal Delegate
James LUNNY	Alternate
John FENWICK	Delegate
Stephen HUNT	Delegate

Niger

Katiellou Gaptia LAWAN	Principal Delegate
Mohamed Housseini IBRAHIM	Delegate
Mouhaimini MOUSSA	Delegate
Moussa SAADOU	Delegate

Nigeria

Mansur Bako MATAZU	Principal Delegate
Oluwaseun Wilfred IDOWU	Alternate
Abel Olatunji AKINYEMI	Delegate
Taiwo ASANIYAN	Delegate
Rabi Mohammed DAKU	Delegate
Ifeanyichukwu Clinton EZEKWE	Delegate
Clement Onyeaso NZE	Delegate
Peter ODJUGO	Delegate
Daniel Chibueze OKAFOR	Delegate
Haruna ZAKARI	Delegate
Abdulrasheed Darazo ZAKARIYAU	Delegate

North Macedonia

Suzana ALCINOVA MONEVSKA	Delegate
Nina ALEKSOVSKA	Delegate
Rada AVRAMOVSKA	Delegate
Vasko STOJOV	Delegate

Norway

Roar SKALIN	Principal Delegate
Bard FJUKSTAD	Alternate
Julie Louise AASERUD	Delegate
Lena ESKELAND	Delegate
Kristine GJESDAL	Delegate
Hege HISDAL	Delegate
Vibeke KRISTENSEN	Delegate
Jorn KRISTIANSEN	Delegate
Anne-Cecilie RIISER	Delegate
Cecilie STENERSEN	Delegate
Svein TAKSDAL	Delegate
Elise TRONDSEN	Delegate

Oman

Said Abdullah AL-HARTHY	Principal Delegate
Abdullahh Bin MUSTAHEL KASHOUB	Delegate

Paraguay

Raul Enrique RODAS FRANCO	Principal Delegate
Eduardo Jose MINGO VEGA	Delegate

Nelson Heriberto PEREZ TRIVEROS	Delegate

Peru

Ken TAKAHASHI	Principal Delegate
Romina CAMINADA	Alternate
Tania Katherine ITA	Delegate
Grinia AVALOS	Delegate
Anabel CASTRO	Delegate
Gustavo DE LA CRUZ MONTALVO	Delegate
Yury ESCAJADILLO	Delegate
Oscar FELIPE	Delegate
Godilia Teresa GARCIA VILCA	Delegate
Waldo LAVADO	Delegate
Luis Alberto METZGER	Delegate
Clara ORIA	Delegate
Karim QUEVEDO	Delegate
Kelita QUISPE	Delegate
Nelson QUISPE	Delegate
Gabriela ROSAS	Delegate
Bernardo Roca Rey ROSS	Delegate
Breat Sheylla SULLCA	Delegate
Luis VERA	Delegate
Esequiel VILLEGAS	Delegate

Poland

Miroslaw MIETUS	Principal Delegate
Janusz FILIPIAK	Alternate
Pawel PRZYGRODZKI	Delegate

Qatar

Abdulla Mohammed AL MANNAI	Principal Delegate

Republic of Korea

Dong-Eon CHANG	Alternate
Heekyu JUNG	Alternate
Yongseob LEE	Alternate
Kyungjeen PARK	Alternate

Seonyeong BAK	Delegate
Daeseok HAN	Delegate
Yunsun JUNG	Delegate
Insun KIM	Delegate
Sung KIM	Delegate
Hannah LEE	Delegate
Taesuk OH	Delegate
Jieun PARK	Delegate
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Mihail GRIGORAS	Principal Delegate
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Alexandru CORONOVSCHI	Delegate
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Romania

Elena MATEESCU	Principal Delegate
Sorin CHEVAL	Alternate
Marius MATREATA	Delegate
Andrei Mircea MIHAI	Delegate
Iuliana-Mona MUNTEANU	Delegate

Russian Federation

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Sergey BORSCH	Delegate
Alexander GUSEV	Delegate
Vladimir KATTSOV	Delegate
Dmitry KIKTEV	Delegate
Tatiana LABENETS	Delegate
Maria MAMAEVA	Delegate
Yury SIMONOV	Delegate
Vasily SMOLYANITSKY	Delegate
Sergey SOLDATENKO	Delegate
Sergey USPENSKY	Delegate
Sergei ZHURAVLYOV	Delegate

Rwanda

Aimable GAHIGI	Principal Delegate

Fidele MANIRAGUHA	Delegate
Mathieu MUGUNGA MBATI	Delegate
Alphonsine MUSANGANIRE	Delegate
Didace MUSONI	Delegate

Saudi Arabia

Ayman Salem GHULAM	Principal Delegate
Samirah Mansour M ALASIRI	Delegate
Anwar ALMATRAFI	Delegate
Abeer ASIRI	Delegate
Majed HAKAMY	Delegate

Senegal

Sidy GUEYE	Principal Delegate
Ousmane NDIAYE	Principal Delegate
Sadibou BA	Delegate
Bakary FATY	Delegate
Oumar KONTE	Delegate

Seychelles

Beryl ANDRADE	Delegate
Chantale BIJOUX	Delegate
Gerard BIJOUX	Delegate
Marie Eve DENIS	Delegate
Nelson LALANDE	Delegate
Egbert QUATRE	Delegate
Varunakumar RAJENDRAN	Delegate

Singapore

Chin Ling WONG	Principal Delegate
Lesley CHOO	Alternate
Darryl BOH	Delegate
Wee Kiong CHEONG	Delegate
Boon Ning CHEW	Delegate
Kwok Wah CHOW	Delegate
Jia Yan HUAN	Delegate
Vanessa LIM	Delegate

Cui Xian LIOU	Delegate
Aurel MOISE	Delegate
Raizan RAHMAT	Delegate
Sandeep SAHANY	Delegate
Jinny Claire SIM	Delegate
Cheryl TAN	Delegate
Thea TURKINGTON	Delegate
Songhan WONG	Delegate

Slovakia

Martin BENKO	Principal Delegate
Branislav CHVILA	Delegate
Jozef CSAPLAR	Delegate
Jana POOROVA	Delegate

Slovenia

Josko KNEZ	Principal Delegate
Mojca DOLINAR	Delegate
Saso PETAN	Delegate
Simona SPEHAR	Delegate

South Africa

Ishaam ABADER	Principal Delegate
Mnikeli NDABAMBI	Alternate
Gaborekwe KHAMBULE	Delegate
Tracey LABAN	Delegate
Samantha LINNERTS	Delegate
Zoleka MANONA	Delegate
Zacharia MASWUMA	Delegate
Francis MOSETLHO	Delegate
Jonas MPHEPYA	Delegate
Musariri MUSARIRI	Delegate
Ezekiel SEBEGO	Delegate
Bafentse SENGANE	Delegate
Kenosi SETLHAKO	Delegate

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Miguel Angel LOPEZ GONZALEZ	Principal Delegate
Julio GONZALEZ BRENA	Alternate

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Mario CARRERAS FERNÁNDEZ	Delegate
Elia DIEZ MUYO	Delegate
María Luisa MORENO SANTAENGRACIA	Delegate
Rosa ORIENT QUILIS	Delegate
Jose Pablo ORTIZ DE GALISTEO MARIN	Delegate
Javier SORIA QUINTANA	Delegate
Ricardo SQUELLA DE LA TORRE	Delegate
Jorge TAMAYO CARMONA	Delegate

Sri Lanka

Athula Kumara KRUNANAYAKE	Principal Delegate

Sudan

Hanan RABBAH	Principal Delegate

Sweden

Hakan WIRTEN	Principal Delegate
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Cristina ALIONTE-EKLUND	Delegate
Stefan NILSSON	Delegate

Switzerland

Peter BINDER	Principal Delegate
Fabio FONTANA	Alternate
Emmanuel BROCARD	Delegate
Pierre-André CORDEY	Delegate
Moritz FLUBACHER	Delegate
Fabrice FRETZ	Delegate
Estelle GRUETER	Delegate
Christian GUBSER	Delegate
Heike KUNZ	Delegate
Carlo SCAPOZZA	Delegate
Karine SIEGWART	Delegate
Donata DETTWILER	Observer
Jose ROMERO	Observer

Thailand

Thanasith IAMANANCHAI	Alternate
Nilobol ARANYABHAGA	Delegate
Phanumat LEWCHAROENTHRAP	Delegate
Fatah MASTHAWEE	Delegate
Wanchalearm PETSUWAN	Delegate
Sumalee PHUNGKHAM	Delegate
Prasarn SANGWALDECH	Delegate
Punjamaporn SIENGLERT	Delegate
Somkuan TONJAN	Delegate
Supinda WATTANAKARN	Delegate

Togo

Affoh ATCHA-DEDJI	Principal Delegate
Latifou ISSAOU	Delegate

Trinidad and Tobago

Shakeer BAIG	Principal Delegate

Tunisia

Hedi AGREBI JAOUADI	Principal Delegate
Hatem BAKOUR	Alternate
Farhat AOUNALLAH	Delegate
Fadhel GRAMI	Delegate
Ahmed HMAM	Delegate
Abderrahman OUASLI	Delegate

Turkey

Volkan Mutlu COSKUN	Principal Delegate
Murat ALTINYOLLAR	Alternate
Ozan CAKIR	Alternate
Hakan DOGAN	Delegate
Hikmet EROGLU	Delegate
Sezel KARAYUSUFOGLU UYSAL	Delegate
Ismail TEMIR	Delegate
Selami YILDIRIM	Delegate
Veysel YILDIZ	Delegate

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Festus LUBOYERA	Principal Delegate
David ELWERU	Alternate
Magaret NANKYA	Delegate
Bob Alex OGWANG	Delegate
Samuel SENKUNDA	Delegate
Benon ZAAKE	Delegate

Ukraine

Mykola KULBIDA	Principal Delegate
Viacheslav MANUKALO	Alternate
Denys BORDIIAN	Delegate
Olga DUBROVINA	Delegate
Natalia GOLENYA	Delegate
Oleksandr KAPUSTIM	Delegate

Illia PEREVOZCHYKOV	Delegate
Ruslan REVIAKIN	Delegate

United Arab Emirates

Abdullah A. AL MANDOOS	Principal Delegate
Mohamed A. AL EBRI	Alternate
Yousef N. AL KALBANI	Delegate
Kaltham A. MANGOOSH	Delegate
Monikumar RAMAKRISHNAN	Delegate

United Kingdom of Great Britain and Northern Ireland

Penny ENDERSBY	Principal Delegate
Sarah JACKSON	Alternate
Harry DIXON	Delegate
Abi DRAISEY	Delegate
Alan JENKINS	Delegate
Karen MCCOURT	Delegate
Simon MCLELLAN	Delegate
Nyree PINDER	Delegate
Steve STRINGER	Delegate
Jeremy TANDY	Delegate
Stewart TURNER	Delegate
Jon TURTON	Delegate

United Republic of Tanzania

Agnes KIJAZI	Principal Delegate
Mecklina BABYEGEYA	Delegate
Ladislaus CHANGA	Delegate
Hekima JOZANIA	Delegate
Hamza KABELWA	Delegate
Wilberfoce KIKWASI	Delegate
George LUGOMELA	Delegate
Samwel MBUYA	Delegate
Habiba Ismail MTONGORI	Delegate
Wilbert MURUKE	Delegate
Tunsume Gideon MWAMBONEKE	Delegate
Mathew NDAKI	Delegate
Robert K. M. SUNDAY	Delegate
Pascal WANIHA	Delegate

United States of America

Louis UCCELLINI	Principal Delegate
Courtney Jeanne DRAGGON	Alternate
Dominic ANDREWS	Delegate
Monique BASKIN	Delegate
Fredrick BRANSKI	Delegate
Donald CLINE	Delegate
Thomas CUFF	Delegate
Thomas GRAZIANO	Delegate
Mary Ann KUTNY	Delegate
Daniel MULLER	Delegate
Mark PAESE	Delegate
Aaron SALZBERG	Delegate
William Carl BOLHOFER	Observer
Alicia CHERIPKA	Observer
Peter COLOHAN	Observer
Shanna COMBLEY	Observer
Caroline CORVINGTON	Observer
Natalia DONOHO	Observer
Mary ERICKSON	Observer
Janice FULFORD	Observer
Angelica GUTIERREZ-MAGNESS	Observer
Paul KUCERA	Observer
Curtis MARSHALL	Observer
John NANGLE	Observer
Elizabeth PAGE	Observer
James PERONTO	Observer
Leah POPE	Observer
Alix ROLPH	Observer
Kari SHEETS	Observer
Sidney THURSTON	Observer
A. Sezin TOKAR	Observer
Susan WEST	Observer
Darren WRIGHT	Observer

Uruguay

Lucia CHIPPONELLI	Delegate

Yamandu MORAN	Delegate
Valentina SIERRA	Delegate
Jose VALLES	Delegate

Viet Nam

Tran Hong TAHI	Principal Delegate
Duc Cuong HOANG	Alternate
Thanh Mai DANG	Delegate
Tien Anh DO	Delegate
Phuc Lam HOANG	Delegate
Van Khiem MAI	Delegate
Vinh Thu NGUYEN	Delegate

Zambia

Edson NKONDE	Principal Delegate
Victor BUPE	Delegate
Christopher MUTAU	Delegate
Micah NAMUKOKO	Delegate

3. Representatives of non-WMO Members

Holy See

Jessica BARONI	Observer

4. Representative of international organizations and other bodies

European Centre for Medium-Range Weather Forecasts (ECMWF)

Fabio VENUTI	Observer

Economic interest grouping of the National Meteorological Services of the European Economic Area (ECOMET)

Willie MCCAIRNS	Observer

European Meteorological Services Network (EUMETNET)

Klemen BERGANT	Observer

European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)

Anne TAUBE	Observer

Group on Earth Observations (GEO)

Douglas CRIPE	Observer
Laurent DURIEUX	Observer
Yana GEVORGYAN	Observer
Steven RAMAGE	Observer

Global Water Partnership (GWP)

Valentin AICH	Observer

Association of Hydro-Meteorological Equipment Industry (HMEI)

Daisuke ABE	Observer
Joshua CAMPBELL	Observer
Brian DAY	Observer
Ilse GAYL	Observer
Alexander KARPOV	Observer
Shoichi TATENO	Observer

Tokiyoshi TOYA	Observer

International Association of Hydrological Sciences (IAHS)

Christophe CUDENNEC	Observer

International Union of Geodesy and Geophysics (IUGG)

Christophe CUDENNEC	Observer
Charles FIERZ	Observer

Association of Private Meteorological Services (PRIMET)

Andrew ECCLESTON	Observer

United Nations Office for Disaster Risk Reduction (UNDRR)

Ricardo MENA	Observer
Mami MIZUTORI	Observer

United Nations Educational, Scientific and Cultural Organization (UNESCO)

Anil MISHRA	Observer

World Federation of Engineering Organizations (WFEO)

Yvette RAMOS	Observer

5. Presidents and vice-presidents of constituent bodies and chairs of other bodies reporting to Congress

Daouda KONATE	President of RA I
Stella M.O. AURA	Vice-President of RA I
Abdullah Ahmed AL MANDOUS	President of RA II
Tran Hong THAI	Vice-President of RA II
Yolanda GONZÁLEZ HERNÁNDEZ	President of RA III
Raúl Enrique RODAS FRANCO	Vice-President of RA III
Evan THOMPSON	President of RA IV
Luz Graciela MORALES DE CALZADILLA	Vice-President of RA IV
Terry ATALIFO	Vice-President of RA V
Michael STAUDINGER	President of RA VI
Kornelia RADICS	Vice-President of RA VI
Michel JEAN	President of INFCOM

Silvano PECORA	Co-Vice-president of INFCOM
Ian LISK	President of SERCOM
Manola BRUNET INDIA	Co-Vice-president of SERCOM
Yuri SIMONOV	Co-Vice-president of SERCOM
Celeste SAULO	Chair of RB
Deon TERBLANCHE	Vice-Chair of RB
Gilbert BRUNET	Chair of SAP
Louis UCCELLINI	Co-Chair of JCB
Jan DANHELKA	Chair of HA/HCP
José Alberto ZÚÑIGA MORA	Vice-Chair of HA/HCP

6. Regional Hydrological Advisers

Jean-Claude NTONGA	Regional Hydrological Adviser of RA I
Sung KIM	Regional Hydrological Adviser of RA II
José Alberto ZÚÑIGA MORA	Regional Hydrological Adviser of RA IV
John FENWICK	Regional Hydrological Adviser of RA V
Angela Chiara CORINA	Regional Hydrological Adviser of RA VI

7. Invited experts

Dimitar IVANOV

Harry LINS

For more information, please contact:

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