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Science for a Water Secure World in a Changing Environment

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Science for a Water Secure World in a Changing Environment

The Strategic Plan for the ninth phase of the Intergovernmental Hydrological Programme (IHP-IX) covering 2022-2029 identifies priority areas in support of Members States to achieve the Sustainable Development Goals (SDGs) focusing on the United Nations (UN) 2030 Sustainable Development agenda and other water related global agendas, such as the Paris agreement on climate change, Sendai Framework on Disaster Risk Reduction (DRR) and the New Urban Agenda (NUA).

The process of preparing the strategic plan has been intensely participatory, collecting in successive consultation stages the inputs of regional experts, the IHP Bureau and Council members, the UNESCO Water Family, partner organizations and UN agencies, whose observations were substantial and complex.

The implementation of the IHP-IX phase will be guided by two interrelated documents: i) a Strategic Plan, presented herein, identifying water-related priorities for Member States, and ii) an Operational-Implementation Plan, to be elaborated at a later stage, which will be used to track the progress in implementing the strategic plan through proposed actions and monitoring related indicators.

Preamble

The UNESCO Intergovernmental Hydrological Programme (IHP), founded in 1975, is a long-term programme executed in phases of an 8-year duration. Its programmatic focus has gone through a profound transformation from a single discipline mode, to a multi-disciplinary undertaking, aimed at advancing hydrological knowledge through supporting scientific research and education programmes. Recently, with the increased presence of social science components, including important growth in the quality and quantity of citizen science inputs, IHP is evolving into a truly transdisciplinary undertaking. This progress has capitalized on the recognition that solutions to the world's water related problems are not just technical, engineering or natural science issues, but have strong human and socio-cultural dimensions, where social sciences play a and increasingly important role. The IHP is a mature program with the capacity of addressing critical and immediate future water challenges.

We live in a time of unprecedented risks, but also of great opportunities for the future of our planet. Natural systems that support life are affected by what many scientists consider the supreme challenges of our time such as changing lifestyle consumption patterns, population increase, urbanization, and climate change, and their impact on hydrological behaviours, the availability of freshwater for human consumption and for sustainable development and the combined effects of extreme climatic events. The COVID-19 global pandemic posed additional limitations to the boundary conditions, restricting the capability of humans to interact and deal with synchronous and / or cascading hazards. This pandemic has demonstrated the importance of science, research and technology as well as the need for cooperation and transparency

regarding the sharing of data and lessons learned for the collective benefit of the global community.

The ever-increasing pace of environmental changes intertwined with human dimensions calls for better understanding of hydrology. The interaction between human activities and water systems needs to be considered to develop scenarios for water resources management. IHP-IX continues to offer a platform and venue to extend cooperation within the international scientific community, and thus contribute to address many unsolved problems in hydrology¹.

The purpose of this strategic plan is to outline a compelling and strategic focus for the Intergovernmental Hydrological Programme for the 2022-2029 period. The ninth phase represents a methodological response towards transdisciplinarity aimed to generate solutions for a water secure world in a complex context. The approach and prioritization presented aligns with UNESCO's principal mandates in Sciences and Education, with the comparative advantage of being responsive to the needs of Member States and supporting them to capitalize on scientific and technological advances as they face water related global challenges.

Global water landscape: challenges and opportunities

Although water is mostly a renewable resource, it is increasingly scarce due to the presence of the human factor, particularly in the large metropolises, production centres, agricultural latitudes, arid and semi-arid regions. The impact of economic and demographic growth on the water balance and the quality of freshwater deems it necessary to deepen and expand our comprehensive knowledge of hydrology and management of water, not only among experts, but also by all users. Furthermore, climate change exacerbates the gravity of the described challenges and increases the urgency of bringing the water agenda to the forefront of global attention.

The challenges we are currently facing are interconnected and cannot be met if we continue a business as usual, sectoral-silo approach. That is why optimizing the use of water through transdisciplinary scientific research, together with education and training for its sustainable management, constitute necessary keystones leading to sustainable water governance for global change and to water security.

Despite the intrinsic value of freshwater to human health, prosperity and security, challenges of water scarcity and quality, poor sanitation and water-related disasters confront billions worldwide. Almost half of the world's population will be living in high water stress areas by 2030 (WWDR, 2019). Water-related risks will further upsurge because of increasing climate change and demographic growth. Furthermore, human migrations are putting pressure on the water resources. Indeed, more than 65 million people were involuntarily displaced at the end of 2016 (UNHCR, 2017) and unfortunately the trend has continued to increase in severity. Also, migration within countries due to relocation of people from rural areas to urban areas is increasing globally. Currently more than 50% of the world population lives in cities.

¹ Blöschl, G. et al. (2019) Twenty-three unsolved problems in hydrology (UPH) – a community perspective, *Hydrological Sciences Journal*, 64:10, 1141-1158

However, it is not sufficient to simply recognize and understand the problems water managers and overall stakeholders are facing, it is important to ascertain the present and potential future opportunities that are available to project IHP into its ninth phase and beyond. Effective solutions must be identified and included in the programmes proposed for IHP-IX, primarily organized as part of scientific, education and technology related strategies and responses.

It is equally important to distinguish the various players and their role in the implementation of the transdisciplinary program envisioned for the 2022-2029 period. In 2019 there were about 1.2 billion persons between the ages of 15 and 24, about one in every six persons in the world. This number, which is projected to grow by 7 percent by 2030², makes youth engagement essential for building a generation of future leaders committed to an evolved water culture, water security and achieving the SDGs; in short, water stewardship. UNESCO's Operational Strategy on Youth will provide the basis upon which the involvement of young experts will be founded. Similarly, the role of indigenous groups considering their ancestral knowledge, as well as that of women and girls should not be overlooked as agent of change for improved water science, culture and better water management and governance.

Meeting the SDGs and other water related International Agendas

A major challenge confronting Members States is meeting the Sustainable Development Goals (SDGs) that conform the UN Agenda 2030 for Sustainable Development. Despite the efforts and resources dedicated to this task, the SDGs are off track. The United Nations World Water Development Report (WWDR, 2020) emphasizes that water is the 'climate connector' that allows for greater collaboration and coordination across most targets for sustainable development, climate change, and disaster risk reduction.

Certainly, the majority of the global frameworks are directly related to water while others are connected indirectly and any improvement in the achievement of SDG6 results in having secondary effects on them. The on-going process of UN reform with SDGs country-oriented support provides a greater opportunity for IHP through its national IHP committees and Chairs and Centres for more engagement at country and regional levels.

The IHP-IX programmatic content is designed with the objective to maximize the support to Member States in attaining SDG 6 and other water related goals and targets. Being the co-custodian of SDG 6.5.2 provides a unique opportunity to IHP to play a major role in identifying and implementing actions to help countries achieve the required benchmarks pertaining the improvement of operational arrangements for water cooperation related to the management and conservation of transboundary aquifers.

² United Nations Department of Economic and Social Affairs (UNDESA 2019)

The IHP-IX strategic plan is positioned within the context of the global water related policy landscape to provide opportunities of alignment with other initiatives and in contributing to their achievement. This landscape consists of, among others, the following key frameworks: the Sustainable Development Goals (SDG) framework and its 2030 Agenda including specifically SDG6 on ensuring availability and sustainable management of water and sanitation for all and its connecting role to all the other SDGs, the associated High-Level Political Forum on Sustainable Development and updated monitoring of progress towards SDG targets, the SDG6 Global Accelerator Framework, the Paris Agreement within the UN Framework Convention on Climate Change, the Sendai Framework for Disaster Risk Reduction, the Addis Ababa Action Agenda for Financing Development, the New Urban Agenda, the Human Rights Framework with reference to the human right to safe drinking water and sanitation, and the Global Strategic Framework for Food Security and Nutrition. Other important frameworks include the UNGA declaration on the Water Action Decade 2018-2028 and the Decade of Action to Deliver SDGs by 2030, the UN Decade on Ecosystem Restoration (2021-2030), the Decade of Ocean Science for Sustainable Development (2021-2030), the Global Commission on Adaptation's Year of Action, and the outcome document of the Small Island Developing States' Accelerated Modalities of Action (SAMOA) Pathway.

Advance water science while expanding towards transdisciplinarity

Changes taking place in the environment are increasing faster and demand a better understanding of hydrology. One of the greatest challenges for the hydrology scientific community is to identify appropriate and timely adaptation measures in a continuously changing environment. Furthermore, the interaction between human and water systems needs to be analysed from new perspectives to develop a comprehensive picture of the inherent feedbacks and coevolving processes and scenarios³. To address these challenges, water science needs to develop a new vision. IHP IX will take advantage of the increasing computational power, new monitoring techniques, enhanced modelling capabilities, new opportunities for sharing information, and the enhanced international and transdisciplinary cooperation.

The basic premise of IHP-VIII is its commitment to quality science for informed water decisions and its impact to improving the quality of life, commitment to continue during IHP-IX. The 2019 Global Sustainable Development Report: "The Future Is Now: Science for Achieving Sustainable Development" has clearly highlighted that scientific evidence is a prerequisite for designing and implementing transformations to sustainable development requiring Member States to work with the scientific community (e.g. research consortiums, universities, centres). The High Level Panel on Water report (Every drop counts) and the report of the High level panel on water and peace (Water a matter of survival) have also clearly stressed the crucial need for evidence based decisions in addressing complex water challenges.

Among the several opportunities for investing in science that will be supported during IHP-IX are those that relate to citizen science. This emerging modality will allow to combine the efforts of scientists and the public to better understand the water cycle and the behaviour of the people who use it. Similarly, encouraging Open Science provides an opportunity for scientific information, data and outputs to be more widely

³ Montanari, A., J. Bahr, G. Bloeschl, X. Cai, D. S. Mackay, A. M. Michalak, H. Rajaram, and G. Sander (2015), Fifty years of Water Resources Research: Legacy and perspectives for the science of hydrology, *Water Resour. Res.*, 51, 6797–6803, doi:10.1002/ 2015WR017998

accessible and more reliably harnessed with the active engagement of all the stakeholders (scientists, policy-makers and citizens), Furthermore, disciplines, such as socio-hydrology, provide an interdisciplinary field studying the dynamic interactions between water and people and an opportunity to showcase UNESCO's transition towards transdisciplinarity when conducting scientific research on water. Additionally, partnerships with water users, private entrepreneurs and NGOs to build a knowledge base and the trust of communities could multiply the positive impacts of applying innovative scientific findings and employing new technologies, particularly in rural and traditional societies. *Enhancing scientific research and cooperation can help bridge data and knowledge gaps.*

Water education for a sustainable future

Education is still the foundation upon which behaviours can change and consensus can be built for sustainable decisions on water resources. Despite increasing international recognition of education for sustainable development (ESD), mainstreaming of water education for a sustainable future during the fourth industrial revolution in formal education curricula as well as in informal education remains a challenge. Various networks, initiatives, and tools, which have been developed in different regions, have not yet succeeded in having a significant impact on educational policies and practices. More efforts are needed to validate and disseminate an experience-based model for institutional strengthening of ESD through policymaking and implementation at a national level. Similarly, enhanced capacity and public awareness towards a sustainable water culture and water management is required. Coping with water scarcity will entail a major overhaul of all forms of production and consumption, from individual use to manufacturing and supply chains and consequently will require innovation in educational programs.

A major push in educating water managers on new technologies has substantially reduced the skill-gap prohibiting adequate water governance. However, educational undertakings aimed to enhance legal, policy and institutional frameworks to support water governance has lagged, which constitutes a challenge. This reality provides IHP with an opportunity to identify and pursue science base capacity building activities to provide Member States with skills for water based cooperation.

The water, energy, ecosystem, and food nexus is a key element to consider for making substantive changes towards sustainable development. Therefore, the understanding of the nexus and its integration approaches should be incorporated in educational programs at all levels, formal and informal. IHP-IX will use the opportunity of linking with the Man and Biosphere (MAB) programme, the Geopark and Geoscience programmes, the LINKS programme and also with UNESCO's Education Sector and UNEP's efforts on "Education for Sustainable Consumption" to undertake actions to advance water education and capacity building activities, aimed to contribute to the creation of a sustainable future. During its ninth phase, IHP will work closely with the UNESCO water family and other branches of UNESCO to enhance participatory and cross-disciplinary knowledge building and dissemination. Likewise, IHP-IX will advance educational programmes aimed to strengthen and support Member States in the development and implementation of international frameworks and institutional cooperation.

The data-knowledge gap

The increase of information and knowledge requires new ideas and models that will allow to profit from these. The capacity of individual Member States to monitor hydrological processes, manage, store and analyse data and information, and ultimately develop and apply models is very heterogeneous. Thus, ensuring that data exchange between states is reliable and shared appropriately so that it can be factored into decision-making is still a major challenge. This fact jeopardizes the exchange of information and knowledge among countries and regions. Furthermore, collaborative strategies for managing water data between scientific organizations and UN agencies, Member States and stakeholders also present a major challenge. UNESCO is well positioned to contribute to other data related initiatives across the UN- water constituency such as those of WMO, FAO, UNEP-GEMS, SDG-IMI etc.

Notwithstanding, the development and application of new monitoring techniques, and in particular remotely sensed data, are providing the opportunities for observing hydrological processes across a wide range of scales, both temporal and spatial. Similarly, global-scale modeling is presenting stimulating opportunities for acquiring a more comprehensive understanding and mapping of water resources availability and identification of water threats. However, uncertainties in global-scale modeling are still a challenge, but they are being reduced by growing global data sets. Consequently, working on larger spatial scales puts forward new ways to address global water challenges⁴. IHP IX will build on these opportunities to expand the efforts of the Programme aiming to support Member States develop and gain access to data and information and to provide a platform to further increase data sharing and knowledge transfer.

Investing in water governance

To enhance the resilience of societies, decisions should be made based on evidence. Improving the effectiveness of water governance is a major challenge which needs to be strongly supported as a cornerstone within IHP-IX to enable Member States to implement decisions based on science in order to build more resilient and peaceful communities. Similarly, there is a need to promote the recognition of sustainable water governance as a long-term activity that includes water management master plans, financing structures, and implementation of projects based on science, as well as partnerships of all stakeholders to build and maintain sustainable water systems, which is the foundation of long-term resilience. Therefore, encouraging the development of community-based governance partnerships at the grassroots level can lead to effective policy changes at the national or even regional levels, particularly in transboundary basins.

⁴ Montanari, A., J. Bahr, G. Blöschl, X. Cai, D. S. Mackay, A. M. Michalak, H. Rajaram, and G. Sander (2015), Fifty years of *Water Resources Research*: Legacy and perspectives for the science of hydrology, *Water Resour. Res.*, 51, 6797–6803, doi:10.1002/2015WR017998.

The COVID-19 global health crisis has served as a trigger for re-thinking governance for sustainable futures. The pandemic has opened a window of opportunities for change and for “bouncing forward” through adaptation and transformation. In an endeavour for the implementation of plans to enhance the resilience of individuals and communities, new people-driven governance models have been advocated. Some of these models can be adapted to the water sector. Managing and preventing public crises and other disasters show that without whole-of-society engagement policies and measures may turn out to be ineffective or ignored. Therefore, the importance for the need of the civil society and private sector to be involved in governance mechanisms to the extent feasible or needed (IIASA, 2020)). In this context, coping with hydrometeorological disasters provides an opportunity to expand and enhance under IHP-IX, more inclusive water governance schemes involving a wider spectrum of stakeholders.

Sustainable water resources management

Freshwater is “the thread” that ties all aspects of society together. It supports life on earth and it also supports sustainable economic development. Healthy rivers, lakes, wetlands, aquifers, and glaciers not only provide drinking water and maintain valuable ecosystems; they also support agriculture, hydroelectric power, and flood mitigation around the world. Therefore, sustainable water management must be an integrated undertaking – one that involves all productive sectors if it is to be successful.

A transdisciplinary based approach, which IHP-IX will help promote, integrates water sciences and economic and social aspects into a model, with the objective of maximizing ecosystem goods and services outputs as well as more traditional economic outputs in various productive sectors. This approach supports convergence between natural and behavioural sciences and leads to "co-innovation" and "co-design" of projects.

Such a model faces many difficulties in terms of temporal and spatial scales and the complexity of model formulation, data quality and calibration, results interpretation and dissemination, the increasing importance and necessity of citizen science inputs, as well as the issues surrounding comprehensive data collection and handling.

Water management is a long-term process that requires a vision that goes beyond decades. Such a vision can be reached by preparing Water Management Master Plans in which natural conditions, technological solutions and social realities are considered.

Water security in a changing world

To attain water security, a population must have access to adequate quantities of water of acceptable quality for sustaining human and ecosystem health, and the capacity to safeguard the resource and related systems and infrastructure. However the definition of the full extend of ‘water security’ depends mostly on how the complexity of water-society challenges is analyzed. The main challenge of water security resides in the uncertainty of water availability and demand in the future in the midst of complex natural and social systems⁵

⁵ Maria C. Donoso, 2021. Water Security, Evolution and Challenges in Transboundary Basins. Submitted. Springer Nature

The contributions and results obtained during the implementation of the IHP VII Phase, provides a unique opportunity for the IHP IX to build on and mainstream these in to newly structured programmatic content to be presented later in this document. Similarly, the partnerships built over the past 8 years by IHP and the UNESCO Water Family offer the opportunity for the activities of IHP-IX to be carried out by a group of experienced entities and professionals that have worked in promoting and advancing water security for various years. While the entire UNESCO Water Family has contributed significantly towards the achievement of water security, two category II Water Security Centres under the auspices of UNESCO and a UNESCO Chair on Sustainable Water Security were established in the Republic of Korea, Mexico and the United States of America, respectively during the implementation of IHP-VIII. The UNESCO Water Family will continue to promote and carry out research and capacity building activities related to water security, and will extend the support of their specialized expertise to the Member States.

The comparative advantage of UNESCO and its Intergovernmental Hydrological Programme (IHP)

UNESCO employs a unique transdisciplinary approach to natural resources management. Through its five sectors and related science programmes, UNESCO can leverage a wide range of expertise and information in complementary fields, such as the natural and social sciences, education, culture, communication, and information. Furthermore, the Organization has accumulated more than 50 years of experience on water having a unique global scientific water network comprising the Intergovernmental Hydrological Programme (IHP) and the World Water Assessment Programme (WWAP).

The Intergovernmental Hydrological Programme (IHP) is devoted exclusively to advancing water research and management, and the related education and capacity development efforts considered essential to foster sustainable water management. UNESCO-IHP has one of the most structured intergovernmental platforms related to water, enabling other complementary network initiatives that bring together research institutes, museums, industry, innovation centres, scientists, policy makers, government officials, youth and others, to share knowledge and integrate different points of view. IHP together with its “UNESCO Water Family” comprises of the 169 IHP National Committees and focal persons, UNESCO’s Division of Water Sciences, including the World Water Assessment programme and Regional Hydrologists posted in field offices, its 36 Category 2 Centres, and more than 60 thematically grouped water related Chairs, offers the international community the most comprehensive grouping of water scientists, managers and practitioners in this evermore contentious and complex water arena. *It is thus of primary importance to facilitate the cooperation and partnerships of UNESCO Water Family members and ensure that National IHP committees and focal persons have adequate capacity and means to contribute to the implementation of the Programme.*

Through this network, UNESCO water programmes have established credibility around water resources management cooperation, as technically competent, neutral, and trusted conveners. They have also established excellent working relationships with

global and regional partners at various levels including policy and decision makers from countries and regional water institutions, as well as other intergovernmental and international organizations. Additionally, IHP has developed a very dense matrix of private sector and NGO partners who are regularly consulted on the development and implementation of its work programme.

Furthermore, within the context of the UN Water platform and through excellent inter-agency relations, UNESCO-IHP develops and undertakes a myriad of collaborative activities and programmatic initiatives with other organizations and agencies of the United Nations system. Among these actions, it is important to highlight those aimed to accelerate the 2030 UN Sustainability Agenda in support of Member States to meet the SDGs.

Assuring Continuity with Change

To date IHP has developed and implemented 8 phases, each one building on the prior phase while addressing issues of global importance, as clearly expressed by Member States. This evolution represents an institutional growth from hydrological sciences to integrated sciences, policy and society.

While substantive advances have been made in both science and its application to decision processes, many of the issues that were addressed in IHP-VIII are still unresolved and relevant.

IHP-IX will address five priority areas, all interconnected and related to water security and sustainable water management. In this manner, water education becomes a main axis of continuity and transition from phase VIII to phase IX, with increased importance on the relationship between new technologies and education. In the same way, unresolved issues from other five themes of the eighth phase of the IHP, are reflected in IHP-IX with an intertwined transdisciplinary approach and steering away from the silo approach of the past.

An additional critically important transition element from IHP-VIII to IHP-IX will be the 17 to date Flagships and Initiatives, which will be deepened or complemented with other initiatives contributing to improve the water science and capacities required for water security. Through the IHP-Water Information Network System (IHP-WINS), efforts will be made to connect all IHP flagships and initiatives data related platforms as well as other relevant water data platforms.

Similarly, the drought observatories established in different regions and the flood early warning systems developed and deployed in Africa will be continued to improve stakeholder capacity and enhance resilience to extreme hydro-meteorological phenomena. The developed Climate Risk Informed Decision Analysis (CRIDA) methodology will be applied in new study sites around the world for identifying water security risks. In addition, IHP's support of ecohydrology innovative research and applications in present and new sites will continue during the ninth phase to provide nature-based urban development alternatives. The IHP-VIII phase considered key aspects of groundwater governance, with a particular focus on transboundary cooperation, by establishing governance guidance, assessment at multiple levels, and

scientific cooperation. During phase IX, IHP will further develop activities dedicated to research and scientific cooperation on the essential role of groundwater to support resilient water use and will continue to assist Member States in improving the scientific knowledge on groundwater and in strengthening groundwater governance frameworks at domestic and transboundary level. Furthermore, the IHP-VIII phase has promoted research and enhanced the knowledge base on emerging pollutants and microplastics. IHP will continue to play a leading role in promoting further research and scientific cooperation on emerging pollutants and microplastics in order to respond to this new global water challenge. Whereas a number of state-of-the-art reviews of existing urban water systems, approaches to macro urban water management, water sensitive urban design and urban metabolism have been conducted during IHP-VIII, gaps identified will be pursued in IHP-IX, while the promotion of Smart Water Management Systems, researching the role of water in urban planning and circular economy will continue. These are examples of some of the flagships that will continue from phase IHP into phase IX.

Building on the lessons learned from previous stages and the experience gained from the current IHP VIII phase, the implementation of IHP-IX will adopt an adaptive approach by country and region and a strong global coordination among the IHP family at all levels (Council, National IHP Committees, Centres, Chairs, regional consultation units, etc.). The IHP programmatic undertakings will transition from IHP VIII to IHP IX, via a dynamic pathway, while assuring continuity.

IHP Vision

IHP envisions a water secure world where people and institutions have adequate capacity and scientifically based knowledge for informed decisions on water management and governance to attain sustainable development and to build resilient societies.

IHP-IX Mission

Our mission for the period 2022-2029 is to support the Member States to accelerate the implementation of water-related SDGs and other relevant agendas through water science and education.

To this end IHP-IX will:

- a. Leverage intersectorality for peace and sustainable water security;
- b. Promote international scientific research and cooperation for improved knowledge to address water and climate challenges incorporating the interaction between human and water systems.
- c. Mobilize and disseminate effectively scientific and policy relevant expertise and knowledge for informed decisions in addressing water challenges.

- d. Reinforce institutional and human capacities and train the present and upcoming generation of water professionals capable of providing water solutions for SDGs and building climate resilience through water.
- e. Raise awareness and promote a water culture and water ethics at all levels for conserving, protecting and valuing water.
- f. Support Members States in better understanding, valuing, and managing their water resources.
- g. Support the UN SDG6 Global Accelerator Framework implementation including the associated water and climate coalition in terms of understanding and implementing solutions to global water challenges.

Outcomes and Priority Areas

As several challenges arise from achieving water security, which range from the effects of global change such as water related disasters to operational aspects such as understanding of the value of water as this is expressed by local water rates⁶. The Intergovernmental Hydrological Programme’s approach to these challenges is to expand the human capital, scientific base and knowledge at all levels to “understand the impacts of global changes on water systems and to link scientific conclusions to policies for promoting sustainable management of water resources”⁷.

IHP-IX will do so by providing support for its Member States to “practice inclusive and evidence-based water governance and management based on improved scientific data, research, knowledge, capacities and science-policy-society interfaces towards sustainable resilient societies.”.

The above identified outcome of IHP-IX is aligned with UNESCO’s overall Medium Term Strategy, 41 C4 (2022 – 2029) and will serve two of its Strategic Objectives:

Strategic Objective 2: Work towards sustainable societies by preserving the environment through the promotion of science, technology and the natural heritage and Strategic Objective 1: Reduce inequalities and promote learning and creative societies in the digital age through quality education for all.

A prerequisite to evidence based water governance and management is available, accessible and current scientific knowledge provided by trained and aware human resources.

Enhancing the level of cooperation among scientists, policy-makers and practitioners, as well as with citizen scientists is vital to bridging the gap between existing data and those who must understand and subsequently interpret and apply this technical information in the policy arena. However, for this cooperation to become a reality, data collection and analysis methodologies must be validated and sufficient time must be

⁶ INTERNATIONAL HYDROLOGICAL PROGRAMME (IHP) EIGHTH PHASE “WATER SECURITY: RESPONSES TO LOCAL, REGIONAL, AND GLOBAL CHALLENGES” STRATEGIC PLAN IHP-VIII (2014-2021)

⁷ IHP, 2011. THE IMPACT OF GLOBAL CHANGE ON WATER RESOURCES: THE RESPONSE OF UNESCO’S INTERNATIONAL HYDROLOGY PROGRAMME. Page 2.

invested to develop comprehensive data at different scales and in distinct geographic and political settings, all contributing to better evidence-based water management.

Developing capacity for current generation and educating the next generation of water planners, scientists, policy makers and practitioners along with a water sensitized public, at all levels of sophistication is the other half of successful societies. Water education and the expansion of knowledge about water make it possible to improve capacity development and expand public awareness towards a sustainable water culture, change behaviours and build consensus for sustainable production that results from decoupling economic growth from environmental degradation. In addition, open source decision support systems built on open software platforms play an increasingly important role in managing water resources.

Bridging the water data and knowledge gaps through improved science and cooperation will result in improved water management decisions and governance. The quality of knowledge generated is without a doubt directly reflected in the sustainability of policies developed. Water policies that stand the test of time, particularly in the context of global change, is an example of the type of societal resilience required to address the complex water issues facing society today.

Strategies and activities addressing global changes that are science-based and inclusive of all sectors of civil society in the context of the long-term resilience of decisions taken, enhance the overall resilience of societies. Building communities and societies that are resilient in the face of changing and evermore complex environmental conditions requires that science inform policy. Improving this aspect of the decision process permits greater involvement of citizen science and pro-active NGO community partners with government, including the ability of decision makers to benefit from the use of indigenous knowledge.

The following performance indicators have been identified to monitor progress towards the achievement of the desired result (Outcome 1):

- PI 1: Number of Member States/stakeholder use improved water science, research and apply the strengthened capacities to expand knowledge and better manage services and related risks at all levels
- PI 2: Number of Member States with enhanced water informal, formal and non-formal education at all levels
- PI 3: Number of Member States which use scientific data and knowledge to better manage their water resources
- PI 4: Number of Member States practice inclusive water management to addressing global challenges
- PI 5: Number of Member States implementing mechanisms and policies based on science to strengthen water governance for mitigation, adaptation and resilience

The Enabler:

The Strategic Plan presented herein originated from and was developed by the UNESCO Water Family Members with the support of the Secretariat. The mid-term evaluation of IHP-VIII recommends that during the execution of IHP-IX, roles, and

responsibilities for the implementation of the Plan are taken up by the UNESCO Water Family Members (36 Category 2 Centres, more than 60 water related Chairs linked to academic centres, and 169 IHP National Committees).

Through this network, UNESCO water programmes have established credibility in water resources management cooperation as technically competent, neutral, and trusted conveners. It is thus essential that its strengths are put in the service of fulfilling the expected outcome.

It is thus important that IHP National Committees continue to develop so that their bodies contain the principle of sustainable water management and become meeting spaces between public water bodies, academic and scientific centres and increasingly, citizen water organizations.

To demonstrate a significant capacity to contribute to the implementation of IHP-IX, it is necessary for the water family to strengthen its insertion and contribution in the debate and proposals with the Member States and, simultaneously, to do so in other internationally agreed instruments such as the Agenda 2030, Sendai Framework, Paris Agreement and the New Urban Agenda. Consequently, a sixth performance indicator is dedicated in monitoring the contribution of IHP NC's towards achieving the proposed Outcome via their role at multiple levels:

- PI 6: N° of water family members leading the water agenda at national, regional and global levels

Results Chain / Theory of Change

Achieving water security is gradually being understood and is becoming a global concern because of increasing water scarcity and the effects of global changes have, on human health, nature and well-being as well as the environment, peace and security. The primary driver for these challenges is human activity, which, along with economic growth, has increased the pressures on water supplies quite often in the detriment of the environment.

The ninth phase of IHP has one identified outcome:

1. Member States practice inclusive and evidence-based water governance and management based on improved scientific data, research, knowledge, capacities and science-policy-society interfaces towards sustainable resilient societies.

It is expected that this Outcome will contribute to the achievement of UNESCO's Strategic Objectives, which in turn will support Member States to achieve IHP-IX's Vision. Five priorities, streams of action have been identified as the key elements to materialize this Outcome and are presented in detail hereafter. UNESCO's Member States identified Science, Research and Innovation (Priority 1), Water Education for the Fourth Industrial Revolution (Priority 2) and Bridging the data and knowledge gaps (Priority 3), as intertwined elements that feed of each other and formulate the basis for Inclusive Water Management (Priority 4) and Water Governance based on science for mitigation, adaptation and resilience (Priority 5).

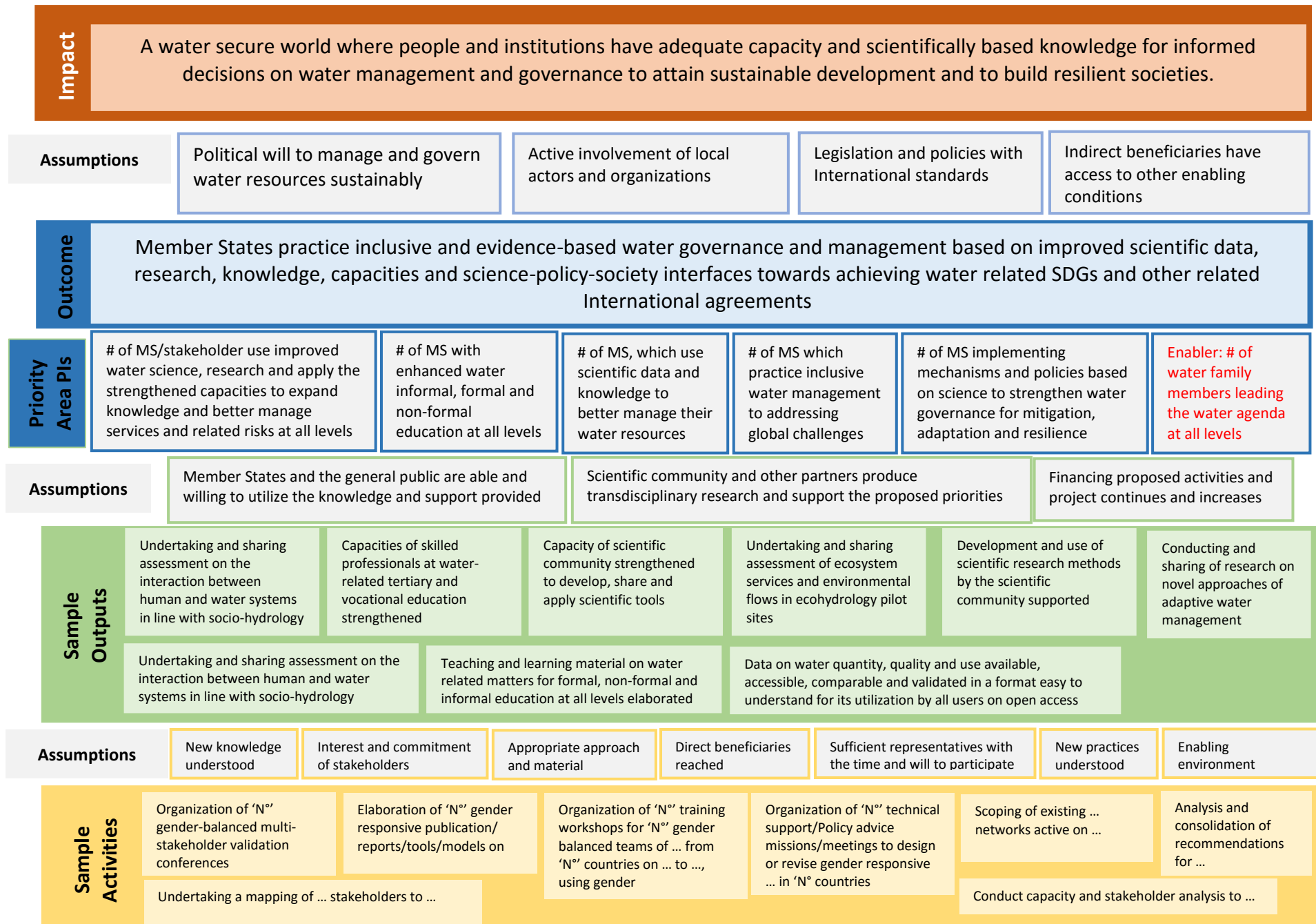
Each Priority consists of several identified Outputs that along with sample activities, will be further developed within an operational document to be elaborated in a later stage by UNESCO's water family and its partners. The document will be used to monitor the implementation progress of the strategy.

Numerous activities related to research, assessments, creation of baselines to generate knowledge based on validated data collected via commonly agreed protocols and analysed via commonly agreed and used methodologies and approaches are planned. Activities related to strengthening the human capital at all education levels (secondary, vocational, tertiary, life-long) and for all education types (formal, informal, non-formal), will benefit from the new knowledge developed and from the technological opportunities offered by the fourth industrial revolution. The trained scientists, teachers, and other knowledge brokers, the informed public and decision makers will become agents of change towards a new water culture that supports sustainable development and environmental protection. These activities aim at informing management and policy decisions, reform institutional settings to align them with the needs as they become more complex due to the effects of global change.

The activities will respond to expressed MS states needs and require human and financial resources, cooperation and collaboration with the scientific community at large, sister UN Agencies, scientific and professional associations, NGOs and the general public. Understanding and uptaking of the new knowledge tools & products produced is a prerequisite. Reaching the direct beneficiaries and use of customized, appropriate materials will facilitate the knowledge transfer required for change. The willingness of the public and decision makers to use the knowledge and support provided will be necessary in implementing activities and render them into results. Similarly, the availability of finances and the willingness and support of the scientific community and other partners producing transdisciplinary research are invaluable in achieving the desired result.

The impact of all efforts will be to achieve "a water secure world where people and institutions have adequate capacity and scientifically based knowledge for informed decisions on water management and governance to attain sustainable development and to build resilient societies".

Theory of Change diagram



Risks:
 Political instability (elections, coup, war etc.)
 Financial instability (global financial crises)
 Health related risks (pandemics etc.)
 Political willingness for data access and sharing

Inputs:
 1. Expressed MS states needs
 2. Human and financial resources from the Secretariat, Member States, UNESCO Water Family, Scientific community and partners
 3. UN and other partners work (to enhance complementarity)
 4. Financial support from new and existing donors
 5. Research and knowledge tools & products
 6. Assessments
 7. Scientific Networks
 8. Education related tools and products

Priority Areas

The IHP-IX priority areas, identified and elaborated by UNESCO's Member States, are presented as five transformative tools that will enable water security to sustain development in a changing world for the period 2022-2029:

1. Scientific Research and innovation
2. Water education in the Fourth Industrial Revolution
3. Bridging the data-knowledge gap
4. Inclusive water management under conditions of global change
5. Water governance based on science for mitigation, adaptation, and resilience

Developing and implementing each of these five priority areas with their expected outputs implies advancing and adding value to sustainable water management not only from each of these thematic axis, but also through their interlinkages and synergies to achieve the expected outcome: "Member States practice inclusive and evidence-based water governance and management based on improved scientific data, research, knowledge, capacities and science-policy-society interfaces towards sustainable resilient societies". In addition, the deepening and implementation of each of the priority areas contributes to achieve the Agenda 2030, its 17 SDGs and 169 targets, since all of them are governed by the principles of comprehensiveness, balance, sustainability, equity, universality and indivisibility. Since the conclusion of IHP-IX (2029) coincides with the threshold of the Sustainable Development Agenda, it is essential that the contributions of these priority areas be fully implemented and translated into improvements in the three dimensions of sustainable development: economic growth, social inclusion and environmental protection prior to the end of the decade.

The UN-Water SDG 6 Synthesis report coordinated by WWAP, stated that we are not on track in achieving the agreed goal. As a response, the UN agreed to an SDG 6 Global Acceleration Framework, which envisions country level interventions and which in combination with the Delft 2020 Capacity Development Agenda, comprise means in achieving the expected outcome.

Priority Area 1: Scientific research and innovation

The development of hydrological science and research has provided practical knowledge and information for society about water fluxes, transport and management, however ever increasing and uncertain environmental changes demands for a continued effort on research innovation and application. Scientific research incorporating human interactions with nature in the context of complex water sciences and management problems provide fundamental feedback for water resources management, along with the application of new tools, approaches and technologies. By 2029, the Member States have the knowledge, sound scientific and research capacity, new and improved

technologies, and the management skills that allow them to secure water resources for human consumption and the maintenance of the balance of ecosystems within a sustainable development context.

Relationship between this priority area and the Agenda 2030

The link between priority area “scientific research and innovation” and the SDGs was clearly defined in the 2019 Global Sustainable Development Report produced by an independent group of scientists appointed by the United Nations Secretary-General informing the High-Level Political forum (HLPF) “The Future is Now: Science for Achieving Sustainable Development”. This document stresses that scientific innovation is indispensable for addressing climate change (SDG13 Climate Action), reducing inequalities in access to the resources that sustain life (SDG6 Clean Water and Sanitation, SDG7 Affordable and Clean Energy, and SDG9 Industry, Innovation and Infrastructure) and achieving the SDGs in general. Also the SDG12 (Sustainable Consumption and Production) is paramount in reducing pollution and its impacts on water and in enhancing efficiency in the use of water. You cannot solve poverty (SDG1) or hunger (SDG2) without the underlying science and a thorough understanding of the problem and specifically in relation to water.

Expected outputs:

1.1. Conducting and sharing of research on integrating citizen science in the hydrological discipline by the scientific community and other stakeholders supported, to improve understanding of the water cycle enabling science based decision making.

It is necessary to explore the potential of citizen science to complement more traditional ways of scientific data collection and knowledge generation for hydrological sciences and water resources management. These data have a significant potential to create new hydrological knowledge, especially in relation to the characterization of hydrological processes, heterogeneity, remote regions, and human impacts on the water cycle. Water related information generated through low cost sensors and smartphones embedded with web-based mapping tools and global positioning systems exchanged on social networking services (SNSs) by citizen scientists can contribute to water resources management, if effective tools are developed to capture, organize, quality control, and make such data available. There is an urgent need for the development and application of AI techniques that can merge different sources of data obtained from IoT, remote sensing, and citizen observatories.

Citizen science has become an important research approach applied to hydrological research, enabling the combined efforts of scientists and the public to collect and interpret data for research and decision-making. Advances in user-friendly technology including those in the virtual arena, also facilitates communication, training and online data visualization and data collection. From a science perspective, citizen science widens spatial and temporal data collection possibilities, particularly at the local scale.

Many citizen science initiatives and research projects already exist and may add to the big data available already through open science and open access initiatives. Unfortunately, citizen science data is still not fully accepted due to data quality uncertainties and related issues.

IHP-IX will support the development of methods and tools that promote inclusive knowledge generation processes, such as participatory monitoring and citizen science.

IHP-IX will therefore create the enabling environment and assist citizens and scientists, through enhanced water education programs to ensure scientific methods are used when participating in and reporting their findings and also to develop new approaches for data processing to increase the contribution of citizen science in hydrology research

1.2. Undertaking and sharing assessments on the interaction between humans and water, in line with socio-hydrology by the scientific community supported to develop adaptive pathways, scenarios and strategies for water management.

Water- humans nexus, has become very pertinent considering the impacts on the water resources based on anthropogenic induced changes. The continuum of human interactions with that of complex water management problems being confronted, lead us to many new questions and possibilities, that hydrological scientists alone cannot address.

Social sciences play an increasingly important role for effective deployment of technology and methods involving “co-innovation” and “co-design” and are proving to be an effective manner to introduce new technologies in less developed regions and smaller villages.

Socio- hydrology provides two-way feedbacks between human and water systems that result in a wide range of phenomena that arise in different places around the world and in different contexts.

Supporting greater overlap in social and natural sciences creates better conditions for the design and implementation of projects to address complex issues such as the variability and change in the hydrological cycle under global changes and its social impacts. It provides a better foundation for decision-making in adapting to more devastating hydrological disasters, better management of the water-energy-food-ecosystem nexus, urban-regional water metabolism and better management of water scarcity and transboundary water systems.

IHP-IX will facilitate the resolution of water related societal problems by enhancing the understanding of the dynamics of water–societal interactions, underpinned by scientific findings supporting equitable solutions to achieve water security. IHP-IX will also support identifying synergies and tradeoffs between societal goals related to water management. IHP will build capacity within the Member States on the results of such research to enable them to move towards a paradigm shift and consider human influence in water management research plans and policies. Research should focus on the low-cost,

innovative, sustainable, and socially acceptable technologies to address the understanding of the dynamics of water–societal interactions, assisting with data gathering and dissemination efforts.

Additionally, tools should be developed to encourage citizen participation and other social applications that can improve water management, such as integrating modern science with ancestral, indigenous and local knowledge.

1.3. International scientific cooperation strengthened and fostered to address unsolved problems in hydrology,⁸ improving scientific understanding of hydrological cycles across river basins and aquifers.

Since societal problems related to water have become ever more complex, streamlining a community science agenda is more important than ever as recognized by international scientific community. IHP's role is increasingly important to facilitate scientific platform and foster scientific cooperation to address Unsolved Problem in Hydrology (UPH) in coordination with scientific institutions, professional organization and water professional. Addressing UPH requires fundamental understanding of human water nexus and coevolution of hydrologic processes and scenarios.

IHP–IX will facilitate provide scientific platform and support cooperation to address UPH, in partnership with scientific institutions, professional scientific organizations such as IAHS, IHA and other relevant UN organizations, such as WMO.

IHP-IX will emphasize the use of new monitoring techniques, and in particular, the latest ICT technologies, remote sensing and bigdata which offering exciting opportunities for observing hydrological processes across a wide range of spatial and temporal scales.

Furthermore, IHP will mobilize international scientific community to advance hydrological research including working on interfaces between hydrology and other disciplines to stimulate scientific and innovative undertakings required to address questions related to water resources at local, regional and global level,.

1.4. Research on uncertainty in climatic scenarios, hydrological predictions and forecasting and water use scenarios conducted and recommendations communicated to decision makers and the general public to elaborate adaptive water management strategies.

A proper understanding of the sources and effects of hydro-climatic uncertainty, with the reconsideration of stationarity of historical trend, is required to develop reliable hydrological prediction and forecasting as the basis for decision making in water resource management and planning. Furthermore, the recent past has demonstrated that, societies are also constantly facing socio economic and non-environmental

⁸ Blöschl et al. [Twenty-three unsolved problems in hydrology \(UPH\) – a community perspective](https://doi.org/10.1080/02626667.2019.1620507). HYDROLOGICAL SCIENCES JOURNAL 2019, VOL. 64, NO. 10, 1141–1158. <https://doi.org/10.1080/02626667.2019.1620507>

uncertainties which will have impact on water resources system. Both climatic and non-climatic uncertainties need to be addressed through risk assessment including stakeholder engagement to develop adaptive water management strategies.

Based on the previous work on uncertainties of water-related risk IHP-IX will continue to support application of recent advances in uncertainty analysis, and probabilistic mapping of water-related risks among government agencies, and river basin authorities. Moreover, uncertainty in hydrological prediction and risk communication and stakeholder participation will be further promoted as an integral part of strategies for managing water-related risks.

IHP will promote application of methodologies to assess the impact of climatic and non-climatic uncertainty on water resources and to work towards effective adaptation strategies for planning for robustness and adaptability under uncertainty as such, when knowledge about the past is not sufficient to predict the future.

Furthermore, IHP-IX will also emphasize the application of several resilient water management tools and approaches which assess hydro-climatic and non-climatic uncertainties integrated in hydrological predictions and forecasting and water use scenarios to support decision support system in water resources planning and management.

1.5. Scientific knowledge, methodologies and tools in addressing water related disasters, such as flood and drought elaborated and/or enhanced towards timely forecasting.

Water-related disasters accounted for 90% of the 1,000 most severe disasters that have occurred since 1990, according to the final outcome document 'Making Every Drop Count of the High Level Panel on Water'. The Report by the Secretary-General of the United Nations at the 2019 UN High-Level Political Forum on Sustainable Development (HLPF)⁹ emphasizes that the higher ratio of economic loss caused by disasters in the poorest countries is an obstacle to eradicating poverty. The Report also highlighted that "all risk-management measures must be human-centered and ensure a whole of society approach" in the chapter of responding to gaps and accelerating implementation.

Multidisciplinary approaches are needed to better understand these changes in hydrological processes. The 9th phase of IHP will enhance and develop multidisciplinary knowledge base to better understand mechanism of hydrological processes and extremes and analyze trends of hydro-climatic variables and provide interpretation of climate model projections considering in situ and remotely sensed observations. IHP-IX will further develop scientific methodology on drought and flood early warning (EWS) systems and vulnerability assessment to increase resilience to floods and droughts; strengthening policy and institutional capacity for integrated flood and drought management at the local, national and trans-boundary levels to ensure risk informed decision-making.

⁹ UN Department of Economic and social Affairs and the World Bank. 2018. Making Every Drop Count: An Agenda for Water Action - High Level Panel on Water Outcome. Washington, D.C. 34 pp.

1.6. Ecohydrology research and innovation at UNESCO designated sites conducted and shared by the scientific community and UNESCO Water Family, communicated to assess the impact of NBS on water cycles and include such solutions in Integrated Water Resource Management (IWRM) and services at all scales and in Sites' management

Scaling and heterogeneity research in hydrological processes has engendered a spirited debate between scientists and managers for decades. Scientists still struggle with the relationship between various physical factors and spatial homogeneity and heterogeneity in hydrological variables and fluxes. It is also an open question how hydrological principles should be applied at different scales (e.g., point-scale, hill-slope-scale, catchment-scale, and continental-scale) and how to relate such data when scales change over space and time.

Nature-based solutions contribute to the improved management of water and enabling protection of ecologically sensitive environments, providing critical services, such as wetlands for sewage treatment and flood mitigation, or mangroves to reduce the impact of waves, storm surge and coastal erosion. The principles of ecohydrology provide a framework as to the use of ecosystem processes as basin management tools, but many research questions remain unanswered. Greater understanding of these complexities will be achieved by applying the three main principles of ecohydrology: the quantification of both hydrological and biological processes, the characterisation of threats, and the harmonization of grey and green infrastructures to achieve sustainability of ecosystems closely related with IWRM.

Supporting research in ecohydrology has been a priority for UNESCO since IHP-VI and will continue being so in IHP-IX. Using an expanding number of UNESCO designated sites, IHP-IX will support conduct of ecohydrology research, share and communicate its results to provide solutions in Integrated Water Resource Management (IWRM) and services at all scales.

1.7. Development and sharing of knowledge-base on the impacts of global change on river basins, aquifer systems, coastal areas, cryosphere and human settlements by the scientific community supported so as to embed it in water resources and services management plans.

Knowledge systems need to be developed for assessing past, current, and future changes in the Source-to-Sea interconnection trajectory incorporating the cryosphere, the terrestrial hydrological water cycle, groundwater, sediment and erosion processes and deposition in littoral zones, deltas and coasts where numerous human settlements lay. Rivers and aquifers serve as lifelines in the landscape and have a central function in the water-energy-food-nexus, Global changes related effects apply pressure on these valuable resources affecting not only their quantity, but also their quality. Changes in

snow and glaciers have changed the amount and seasonality of runoff and water resources in snow dominated and glacier-fed river basins and have widespread consequences for high mountain and lowland ecosystems of global relevance for biodiversity and ecosystem services. The processes of erosion and sediment transport and deposition both naturally or increased by human activity, have many important implications for society, particularly in terms of the sustainable development and management of water resources. Sea level rise may lead to salt water intrusion into coastal aquifers affecting groundwater quality and contaminating drinking water sources and leading to desertification of fertile land. Land subsidence caused by excessive abstraction of groundwater effects negatively infrastructure in human settlements.

IHP-IX will provide an integrated research in the source-to-sea interconnections and trajectory focusing on fundamental processes in cryosphere, hydrology, hydraulics, sediment erosion, transport and deposition , surface water and groundwater interaction, water quality and river management incorporating socioeconomics challenges and global change drivers. . It will assess the state of the snow, glacier and permafrost impacted by climate change and strengthen cooperation among scientists and institutions and formulate adaptation strategies. It will continue to promote the development of an improved understanding of sediment mobilization, transport and storage and sediment budgets at local, regional and global scales, to support effective sediment management; IHP-IX will continue developing a scientific knowledge base on groundwater integrating considerations of global change effects for a rational and equitable management of the groundwater resources that include depended ecosystems. . It will support research to better understand the water demand associated with the response to the effects of global changes in both urban and rural context and the role of Integrated Urban Water Management (IUWM), Water Sensitive Urban Design (WSUD) and other approaches and tools to mitigate them.

1.8. Development and sharing of knowledge and innovative solutions on improving water quality, and reducing water pollution by the scientific community supported and communicated to support science-based decision-making, improve knowledge, services and reduce health related risks

It is essential to strengthen the knowledge base on the state and health of the world's water resources. There is a need for comprehensive water quality assessments at basin, national and regional levels in order to underpin management and policy priorities to improve and restore water quality. Research is needed to enhance the scientific understanding and knowledge on the impact of climate change on water quality, which is an under-researched area where data and scientific information are lacking. Innovative tools to water quality monitoring and assessment need to be developed and promoted. The scientific underpinning of water quality regulations, standards and criteria is necessary to develop effective water quality monitoring, assessment and management strategies.

IHP-IX will continue supporting comprehensive water quality assessments and will enhanced knowledge and research promoting an ecosystem-based approach to water quality management, in particular to understand better changes in water quality-related ecosystem goods and services such as the ecosystem degradation and biodiversity loss caused by water quality deterioration. This knowledge will be used to provide guidance to policy-makers in valuing water quality-related ecosystem goods and services and in developing water quality restoration strategies.

1.9. Development and sharing of new technologies using, EO, AI and IoT by the scientific community and service providers are communicated to and/or used for capacity strengthening of water stakeholders to increase their use in hydrological planning and assessment as well as monitoring and distribution networks

There are seemingly an unending number of ICT innovations and AI-related technologies impacting efficient and effective use of water resources and realizing several SDGs related to access to drinking water, sanitation and hygiene.

The inclusion of sensors to personal mobile devices and the “Internet of things” (IoT) enables us to develop and implement a new generation of observation, data-acquisition, and data-distribution networks globally. Many related issues such as timely disaster forecasting, groundwater governance, the use of CubeSats (nano-satellites), evidence based planning, real-time monitoring, and effective decision support systems optimizing the use of resources and time, will all benefit from new technologies.

IHP-IX will work to support and field-test these advances and how they can improve sustainable water management for future generations and the preservation of ecosystems. Human and institutional capacity remains the major bottleneck to advancing e-learning and digitally supported particularly in developing countries. IHP-IX will maximise its efforts to build a community of practice and enable the sharing of digital educational e-content

1.10. Conducting scientific research on the exploration of new business models, the role of water utilities, broadening engagement and partnerships, and infrastructure by the scientific community supported to accelerate the circular economy transition of the water sector

Linear water management (Take-Use-Discharge) is still commonly adopted in the water sector and in the majority of watersheds today, and it is at the base of an unsustainable production and consumption pathways of water worldwide. The circular economy transcends conventional administrative, political and geographical boundaries and requires an approach beyond traditional boundaries, also considering urban-rural interlinkages and the urban water systems within their biological regions.

The transition to a circular economy should consider the consumption and production of resources across the entire value chain, creating synergies within the water cycle for

more just and efficient integrated water management. The use of a circular metabolic approach can further facilitate a more systemic and integrated water management across scales, particularly through the use of nature-based solutions, and appropriate consideration of integrated eco-system services, to better align the human water cycle with the natural water cycle, in enhancing and protecting resources, particularly facing climate mitigation and adaptation challenges.

IHP-IX will support such transition by researching several enabling factors including: system oriented scientific and technological advances, new business models and the role of water utilities, broad-based engagement and partnerships to favour a just transition, and re-thinking by design the retrofitting of existing and new infrastructures, to optimize water use and generate co-benefits, for example in relation to water-energy-food-ecosystem nexus. Existing infrastructure will need to be designed to fully enable resource efficiency and recovery and optimised to reduce energy consumption and decrease wastage, sharing infrastructure across sectors.

Leading science, research and innovation in cooperation with other UN Agencies and scientific partners

In line with its Mandate on science, IHP-IX will provide leadership in advancing actionable scientific research and innovation for addressing complex interlinkages water challenges building on achievements from previous phases. IHP-IX will continue to promote scientific cooperation and building partnership with other UN organizations, such as WMO on monitoring and hydrological forecast and UNEP on water quality for complementary and synergy, UN-HABITAT and WHO on urban water challenges and with professional scientific organizations such as IAHS, IAH, IAHR and other international scientific water programmes. . Additionally, IHP-IX will continue partner with academic institutions and research centres in developing research initiatives, validating results and disseminate these results to Member States. IHP-IX will continue to broaden and deepen different collaboration and coordination strategies, working on interfaces between hydrology and other disciplines to address the challenges.

Priority Area 2: Water Education in the Fourth Industrial Revolution

It is undeniable that the success of Agenda 2030 for Sustainable Development and water related SDGs and associated targets depends on a profound transformation in human values and, consequently, human behaviour and actions, directly impacting how we live our lives. Achieving that end can only be envisioned when society recognizes the need to reintegrate itself with nature in ways that embrace a common understanding of the importance and limits of our natural resource base to improving the quality of life.

Water education at all levels for an improved water culture, in a context of global change, is undoubtedly a formidable tool for Member States to practice inclusive, evidence-based water governance and management in order to move towards resilient and sustainable societies.

Water education must therefore begin at an early stage in life and continue to be offered in a variety of ways to build a water stewardship mentality at all ages and in all communities. We must have a cadre of new scientists, planners, and practitioners equipped with appropriate skills for addressing complex interconned water challenges and ready to assume positions of responsibility in a fourth industrial revolution setting in the water sector by the end of this decade.

Relation between this priority area and the Agenda 2030

Water education is connected to SDG 6 and all of its targets (ensuring the availability and sustainable management of water and sanitation for all) and all other water related SDGs' targets, as they all require trained and aware human resources to be achieved.

Education for Sustainable Development allows every human being to acquire the knowledge, skills, attitudes and values necessary to shape a sustainable future. There is also a direct link to the SDG 4 on ensuring inclusive and equitable quality education and promote lifelong learning opportunities for all and especially to the target 4.7 to ensure that all learners acquire the knowledge and skills needed to promote sustainable development.

Similarly, this Priority Area is related to various targets of SDG 9 (industry, innovation and infrastructure), and given the widely circulated "blue thread" concept, as well as water related targets of all of the SDGs. The behavioural and manufacturing transformation aspects of SDG 12 and its targets (sustainable consumption and production patterns) are also directly connected with this priority area.

Additionally, the Member States of the IHP recognizing a gap in the 2030 Agenda, have requested the Secretariat to pursue in cooperation with WHO, UNEP and OECD the development and use of a water education-related indicator under target 6a.

Expected outputs:

2.1 Public's awareness at all levels raised towards better understanding their contribution to the important multi-functions of water in domestic life, ecosystems and productive development.

Change can be difficult and impeded by any number of obstacles, be the human resistance or customary social mores, financial or technological impediments, among others. It is clear that no proposed solution will be fully effective if imposed on a community without their understanding and support. This is particularly the case for traditional societies and those under duress from conflicts or any number of

environmental or personal stressors; their daily life patterns being logically focused on daily survival strategies and further complicating change.

Many people have only a vague understanding of the relationship of their daily lives with the availability of water and often considering water for granted. Effective education leads to better understanding and subsequent application of new knowledge by the public, either directly or indirectly to those influenced by those whose awareness was raised, as they take positions of responsibility; change being the output of such a process. It is important to emphasize the contributions of women, youth and young professionals as agents of change to improving water management and governance by gaining an understanding of the importance of water in their lives through becoming involved in the development of innovative science programs to ensure that future generations of water leaders are in the making. Therefore, the opinions of young people should actively be sought-out as inputs to decision-making processes related to water.

It is therefore crucial to emphasize that water education must embrace strategies and techniques that will support people to expand their consciousness and be able to adopt better practices towards equilibrium in interacting with the natural world and in improving their emotional health. People who are aware of the value of water for their livelihoods, economic development and protection of the environment, will demand its conservation contributing to it sustainable management and governance.

There are many ways to acquire water-related knowledge including among others lifelong learning, community story-telling as a form of ancestral knowledge, training in-field workshops, exchange programs, refresher courses, summer schools, graduate degrees and social media. Additionally, the COVID-19 pandemic caused a profound change in educational modes based on technological tools. IHP will continue to utilize the plethora of modalities borne out of this necessity to increase its reach and benefit all people, urban and rural, in attaining a more profound understanding of their dependency on and relationship to water resources,

IHP-IX will continue to encourage a broad conception of water education, along with conditions in the regulatory frameworks of the Member States that favour a change in behaviour towards a society with greater eco-social awareness via awareness raising activities. IHP-IX will support the development of interdisciplinary materials, such as guidelines, briefing papers, and case studies on leading practices in water education for mass media contributing raising awareness of public at large. UNESCO-designated sites and network of water Museums will be mobilized in raising awareness and improving water culture of citizens. IHP-IX in partnership with water youth networks will strengthen the capacities of youth as agent of change and promote their involvement in water decision making processes.

2.2 Development and implementation of promote transdisciplinary research collaborations and educational approaches by UNESCO Water Family promoted to enhance participatory socio-hydrology practices.

Connecting research to educational initiatives builds both research capacity and promotes greater public support and understanding of water science. Water science advocacy in the public realm is inherently a collaborative undertaking involving a variety of constituencies and stakeholders. Moreover, in an increasingly globalized and diversifying world, putting the water science sector to work in advancing the development of skills, training leaders, growing public awareness, transferring technologies and technical knowledge, is critical to achieving a sustainable and water secure future. Activities, such as exhibitions, jargon-free and easily accessible publications, online platforms, and other public events all offer important avenues to broaden and enhance the impact of water science.

With the support of the UNESCO secretariat and IHP, the UNESCO water family is well positioned to engage in public outreach and education that diversifies the social impact of water science and advances inclusive water security initiatives. The UNESCO water family consists of both water and social scientists and as such it is well positioned to collaborate with other UNESCO divisions, members of the IHP, and governmental entities to increase participatory ecohydrological practices and learning.

2.3 Teaching and learning materials on water related matters for formal, non-formal and informal education at all levels elaborated towards a better understanding of the importance of water in lives and communities.

Education is normally delivered in formal, non-formal and informal settings. Regardless of the delivery context - curricula and transfer mechanism employed - in order for water education to have the greatest impact on improving water management and governance, it must be based on quality science. The linkage between quality science, credible data and technology and the ability of educators/trainers to communicate such information is fundamental for all education processes. Additionally, education needs to employ the most relevant technology and to ensure the quality of outputs as well as reaching all people; over time engendering a pro-active and inter-generational water stewardship context. Therefore, a broad water education strategy with a strong scientific basis is a determinant factor to shaping a water conscious future for everybody.

The most efficient way to catalyse this evolution in thinking is through education to all sectors of civil society leading to a greater understanding of the role that water plays in every individual's life. Along with this needed transformation, our society is experiencing a fourth industrial revolution, characterized by the emergence of a new broad range of technologies in fields like biotechnology, big data, drones and artificial intelligence, among others, that will reshape the economy, research and professional water practice. Hence, water education must use those technologies to help prepare professionals and technicians to make the best management decisions and to better focus needed research and capacity-development activities.

A key challenge is developing state-of-the-art training programs and materials using new technologies and innovative learning processes, such as (open) e-learning in the form of short instruction videos, e-classrooms, and meetings, even potentially including on-line graduate degree programmes.

UNESCO has a long history in the field of water education including support to Open Educational Resources (OER) programmes as well as in professional and tertiary education and research to garner new water knowledge.

IHP-IX will mobilize the UNESCO Water Family and will collaborate with other parts of UNESCO, particularly the Education Sector and will focus on the design, planning and implementation of teaching and learning materials on water for all types of education, including the development of improved tools for the teaching of water issues in the K-12 curriculum.

2.4 Development and sharing of methods and tools based on new practices by the scientific community supported to translate scientific information into a format facilitating education, decision-making and policy formulation.

Accessibility and visibility of scientific information are prerequisites for open science. Once data has been processed into scientific information and published in journals, it needs to be shared and disseminated, allowing it to be used by citizens, professionals, scientists, and authorities. Scientific information should be combined with indigenous/local knowledge and widely disseminated in scientific journals, education sources and other widely consulted media and digital outlets.

The current methods for translating scientific information into a format for decision-making and policy formulation, such as visualization methods, roadmaps that provide implications for decision-making or scenario development are, in general, limited. Therefore, it is necessary to develop new ideas, disseminate new methods through multiple media and involve all stakeholders at the basin level in this process.

IHP IX will assist in development and dissemination of new data visualization methods to facilitate science based decision making.

2.5 Capacities of skilled professionals and technicians at water-related tertiary and vocational education strengthened to identify the main gaps for sustainable water management towards providing appropriate tools to governments and societies to address those gaps and the Agenda 2030 targets.

Given the complexity of water-related issues confronting society, increasing the number and quality of water programs and trainers should be a high priority at all jurisdictional levels.

There are numerous water technicians and experts, teachers, young professionals, and professors who require on-the-job training that will improve their capacity in the field, lab and classroom skills and enable them to perform their tasks in a more effective manner in the context of Agenda 2030.

The offers of water-related vocational programs to train water technicians has declined steadily and the rapid transformation and innovation of technologies require the enhancement of existing human resources at the technical level in the water sector. Within UNESCO Water Family and in partnership with other UN system agencies and programmes, efforts are needed for maintaining and expanding the training of technicians in water-related fields (e.g. hydrometeorological monitoring, irrigation systems, sanitation, water supply systems). To address complex and interconnected water challenges and accelerate implementation of SDG 6 and other water-related SDGs, Members States will need to enhance tertiary water education aiming at the training of scientists to further develop water sciences, as well as to educate the new generations of water professionals, managers, and decision makers.

IHP IX will mobilize and strengthen partnership among UNESCO Water Family, WWAP, UNESCO Chairs and Category 2 Centres such as IHE-Delft and also ICTP (International Centre for Theoretical Physics) for cutting-edges educational programmes in meeting the needs of the Member States.

IHP-IX will develop interdisciplinary materials, such as guidelines, briefing papers, prototype professional development programmes and case studies and best practices connected with water education and support enhancement of vocational and tertiary water education capacities, particularly in developing countries by increasing the numbers of formal and informal water educators/trainers and champions, being sensitive to national water contexts and local needs..

2.6 Capacities of decision makers and water managers strengthened allowing them to take advantage of new technologies and research to make better decisions, and to design and implement inclusive and efficient water policies.

While good policy requires informed citizens, good decision-making requires sound science, which in-turn requires knowledgeable experts in a range of natural, technological and social science disciplines. For decision-makers to be able to count on the social support necessary to design and implement efficient and sustainable water policies, it is essential that they have access to specialized training, based on their needs and the impact that information and knowledge can have on the governance and management of water.

IHP-IX will mobilize UNESCO Water Family in developing adapted training materials and providing technical assistance for the development of interdisciplinary support materials, such as guidelines, briefing papers, and case studies on leading practices in capacity building for decision makers and water managers. IHP-IX will co-lead the effort of UN-Water on providing capacity development support to countries to accelerate implementation of SDG 6.

Leading Water Education in cooperation with other UN Agencies and partners

In line with its mandate as the principal UN educational organization UNESCO through its Water Family and partnership with Education Sector will provide leadership on this priority area in providing support on curriculum development, life-long learning and formal, informal and non-formal water education activities from primary levels to post-graduate education. In addition of co-leading the UN-Water efforts on capacity development under UN SDG 6 Global Acceleration Framework in support to Member States, cooperation will be sought with other UN Agencies for complementary or joint training initiatives (case of WMO for example on building capacity of national hydrological services) and other relevant partners including water related NGO and professional associations and private sector.

Priority Area 3: Bridging the data-knowledge gap

By the year 2029, significant advances will have occurred in transparency and accessibility of water data, which made possible further development of open-access science platforms and generated facilitating instruments for integrated watershed management, particularly in the case of transboundary water resources.

Transparency and accessibility of data are among the main pillars that sustain the advancement of open science – a coming commitment of UNESCO. Hydrological measurements are essential for decision-making and sustainable water resources management. The absence or inaccessibility of comprehensive or long-term data about water quantity, quality, distribution, access, risks, use, etc. often leads to partial or ineffective decisions and investments. Therefore, both sufficient data and its accessibility need to be ensured and, in many cases, improved, as recommended by the UN Mar del Plata conference already in 1977.

Water data comes from various sources and data generators have a comparable diversity. However, the difficulty in collecting and understanding raw data and then applying it to a hydrological system in a decision context is often much more complex than initially contemplated. The gap between data and knowledge can only be bridged if data is collected in a transparent, comprehensible manner and can be scaled to the level of detail required by policymakers. The challenge of data gathering, sharing, and interpretation becomes more complex when a water resource is transboundary. Therefore, there is a need to go beyond promoting data collection, to ensure data quality and to fill local gaps and add value to information.

Relation between Priority Area 3 and the Agenda 2030

Sufficient and credible data is an absolute must for IWRM and in general for any kind of science and policymaking. Improving the accessibility of data therefore indirectly supports all water-related SDGs. Specifically, all the SDG6 targets will benefit for the monitoring various related indicators and for supporting decision making on actions to be taken to accelerate implementation. The better availability and comprehensibility of scientific data to the target audiences can only be achieved through strengthening partnerships (SDG17) and especially improved transboundary cooperation.

To realize the vision of open-access science, IHP-IX will be promoting and contributing to, among others, the following data-related outputs in line with the request of its Members States.

3.1 Development and use of scientific research methods by the scientific community supported to correctly collect, analyse, and interpret the data.

Credible data is the most important basis for water resources management, without which implementation of decisions is severely handicapped. All analysis and modelling efforts are dependent on the quantity, quality, coverage, and accessibility of data. Data quantity should be maintained by reversing the current decline in the numbers of monitoring stations and sampling frequencies. Data quality determines the quality of scientific research outputs. The diversification of data sources allows scientific research to be based on larger and more complete data sets, increasing the confidence-levels of results. Scientific information should be combined with indigenous/local knowledge if available.

However, water data should not be limited to water quantity and quality parameters. Rather water use trends, and other human interactions with surface and groundwater should be monitored as well. Additionally, metadata are essential for data validation and should form an integral part of databases.

IHP-IX aims at improving the quantity, quality, and validation of water data in a broad collaborative effort and will promote the exchange of experiences in data collection strategies and analytical methodologies along with free access to data, especially in transboundary water resources. It will further create new / strengthen capacities and collaboration at local, regional and global levels.

3.2 Establishment of harmonized experimental basins by Member States, scientific and research communities, supported to collect scientific data and gain knowledge for hydrological research and holistic water management

There is a need to understand and incorporate the changes to the hydrological cycle (such as social influences, climate change or others) in different environmental settings (delta, arid, tropical, SIDS, etc.). Experimental field hydrological studies in small catchments remain an indispensable source for the development of hydrological

knowledge and methods for calculating and forecasting hydrological, meteorological and biochemical processes in river catchments. Additionally, monitoring of natural and anthropogenic changes in hydro-meteorological characteristics and regimes including climate change benefit from studies at this scale.

Thus, a chain of experimental basins should be managed and researched with the support of the UNESCO Water Family as hubs of knowledge creation all over the world. In these basins, methodologies can be developed and tested, and scientific information can be gathered on sustainable management. The basins will be selected based on existing initiatives like HELP and to the extent possible within UNESCO designated sites, like WHS, Biosphere Reserves and Global Geo-parks.

UNESCO Water Family will assist the establishment of a network of experimental basins all over the world.

3.3 Comparing and validating open access data on water quantity, quality and use and their sharing by the scientific community supported, for its utilization by all users.

Availability of data at an appropriate scale, to undertake planning and management processes, is crucial to develop better decision support systems, improve water governance, advance water education, and eventually attain sustainable management of water resources. Besides availability, accuracy, credibility and an easily accessible and comprehensible format are also fundamental. Therefore, this aspect must be placed on highest priority and its maintenance should be a continuous process.

Global access to data is fundamentally important for comparative research and decision-making especially in transboundary water resources. Professionals need to be able to access necessary data for their purposes, including validating the data collected for comparison reasons both scientifically and for understanding how such data can be applied in a policy context. Whether this data is collected using traditional field techniques or using state-of-the-art technology, whether it is local data or data on a larger scale, it all needs to be accessible. To facilitate data access, emphasis should be put on connecting existing web databases, developing data access Application Programming Interfaces (API) and removing obstacles to connectivity (incompatibilities between platforms, business and national security interests), as well as in improving web-based platforms and quality assurance protocols.

Besides data collection by traditional means, remote collection, Internet of Things sensors and citizen science must also be promoted. Data from these technologies should be placed on globally accessible portals to alleviate the differences between country resources and mismanagement of transboundary water resources, among other issues.

Data collected by the increasing number of citizen science initiatives often times do not realize their full potential because of the limited reach of their efforts and the compatibility of such data collected across political jurisdictions. Solving these issues would lead to better science and sound policies on a larger scale. To enable accurate interpretation of citizen science data, user-friendly platforms, outreach protocols, and capacity building exercises need to be developed to better inform NGOs and other citizen groups as to how to engage with the decision makers more effectively.

Historical data form the basis for understanding trends and rare (extreme) events. Countries and international organizations should collect, digitize and make available on the web historical data, reports, proceedings, and other documentation that will assist in a broader grasp of such events.

Public and private companies are also collecting data on the operation of the existing water infrastructure for various objectives. These data should ideally be posted in a publicly accessible database, at various jurisdictional scales, according to prevailing 'open access' policies.

IHP-IX encourages the inclusion of multidisciplinary data from other UNESCO departments to combine natural and social sciences related to Integrated Water Resources Management (social, economic, environmental) with hydrology to highlight influences on water resources in the Anthropocene. IHP IX will promote open access data and the development of tools for data accessibility, visibility and connectivity, including platforms targeting citizens and NGOs.

3.4 *Capacity of scientific community strengthened to develop, share and apply scientific tools for data processing (like data assimilation and visualization methods, quality assurance protocols to connect existing databases and outreach protocols).*

The UN-Water SDG-6 Synthesis Report suggests the need for innovative scientific methods to enable the use of data from remote technologies and citizen science. Developing new scientific methods to process data and utilizing cutting-edge technologies from other sectors are also needed to help serve the SDGs and beyond. Artificial intelligence and big-data technologies will play a key role in this process.

To correctly collect, analyse, and interpret available data, scientific concepts like modelling, forecasting, data assimilation, and data visualization need to be thoroughly understood and practiced. Selection and correct use of any methodology is essential to be able to interpret the data in a way that is understandable by the broad scientific community. Additionally, creating capacities for better understanding by citizens, professionals and political authorities is vital to plan and implement water projects and to contribute to the achievement of water security. The current methods for translating scientific data into an intelligible format for decision-making and policy formulation are,

in general, limited. Therefore, it is necessary to develop new ideas, disseminate new methods through multiple media.

IHP IX will work as a catalyst for development and dissemination of data assimilation and visualization tools, quality assurance protocols, database links and outreach protocols within the scientific community. IHP IX will enhance scientific research methods to map data into better scientific information and widen the science-policy interface by sharing new methods and tools translating scientific data into a format facilitating decision-making and policy formulation.

Cooperating with other UN Agencies and partners

IHP-IX will cooperate with various UN agencies and partners in contributing to bridging the data-knowledge gap for better water management. UNESCO water programs/initiatives connected under the UNESCO Water Information Network Systems (WINS) are and will be making essential contributions to the data platforms of the UN Water Family like the Global Environment Monitoring System for freshwater (GEMS / Water by UNEP), the Hydrology and Water Resources Programme (HWRP by WMO) and their centres of global water data; such as the Global Precipitation Climatology Centre (GPCC), Global Terrestrial Network - Hydrology (GTN-H), Global Runoff Data Centre (GRDC), Global Cryosphere Watch (GCW) and the World Glacier Monitoring Service (WGMS). UNESCO will closely cooperate with WMO in contributing to the Water and Climate coalition as contribution to the data and information component of the UN SDG6 global accelerator framework. UNESCO will also continue to cooperate with UN agencies custodians of the different SDG6 indicators under the Integrated Monitoring Initiatives (IMI) for sharing data related SDG6 monitoring.

Priority Area 4: Inclusive water management under conditions of global change

By 2029, most societies have managed to adapt to or mitigate water risks derived from, among others, climate change and the human factor, such as global pandemics, generating better participatory management practices and new opportunities for the future of our planet.

Healthy rivers, lakes, wetlands, aquifers, and glaciers do not just supply safe drinking water and maintain all ecosystems on the planet; they also support agriculture, hydropower, industry, recreation, communications, and transportation of goods. Although water is considered the core of sustainable socio-economic development, it is frequently ignored in the investment debate. Additionally, water management is not

considered in an integrated, inclusive manner and it is frequently disbursed; considered a shared responsibility among many different governmental institutions.

Global change is simultaneously a threat and an opportunity for inclusive water management. Inclusiveness is about water management that creates and strengthens all the mechanisms that enable the participation of all water stakeholders, with an integrative perspective using the nexus and source - to - sea approaches. It also means achieving water security while protecting water quality, the environmental flows and its ecosystems services, including all fresh water, independent of its diverse sources, all interests, all levels of government, and the widest possible range of relevant disciplines.

The development and implementation of this Priority Area complements those targets of the Agenda 2030 related to universal and equitable access to drinking water, sanitation and hygiene (6.1 and 6.2), improving water quality (6.3), implementing integrated water resources management at all levels (6.5.1), including transboundary cooperation (6.5.2) and protecting and restoring water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes (6.6 and 15.1).

Other targets are related to combating desertification, restoring degraded land and soil, including land affected by drought and floods, and achieving a land degradation-neutral world (15.3), significantly reducing the number of deaths and of people affected by water-related disasters (11.B) while strengthening the participation of local communities in improving water and sanitation management (6.B), and enhancing the global partnership for sustainable development. All these targets are complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology, and financial resources, to support the achievement of the SDGs in all countries (SDG 17).

Expected outputs:

- 4.1 *Conducting and sharing of research on inclusive and participatory approaches by the scientific community, to ensure open, active, meaningful gender responsive engagement of youth, local and indigenous communities supported to enable all stakeholders to be part of the water management process.*

The gap between water policies and its management, where it is not always considered in an integrated and inclusive way, becomes even greater when the voices of women, youth, indigenous groups, racial or cultural minorities, lower income social classes or migrants are not included in decision making processes related to investments that affect water resources in their daily lives.

Social participation is a means of improving water accountability and responsibility and, when properly achieved, can lead to conscientious and inclusive resource management.

A central component of participation is gender equality in all decision-making instances. Participatory management also includes the enabling of citizen science, user-centred design, youth and community participation.. Special attention should also be given to the actual water resource user groups that in the end have to deal with the resulting water management decisions and practices. Many water-related inequalities are due to power-relations. By working together in partnerships, more wide-ranging and accepted impacts can be achieved.

To tackle ineffective and inefficient water management practices, IHP will work towards enhancing participatory management methodologies promoting the concept that water management efforts should be implemented through inclusive approaches and ensuring that young minds, indigenous and local knowledge are the starting point, having all stakeholders are included in the process. Capacity of experts will be strengthened on the gender disaggregated data for gendered water management.

4.2 Research on upstream-downstream river uses for hydropower, navigation and flood risk management conducted and shared by the scientific community and UNESCO Water Family to minimize socio-economic and ecological consequences.

The need to enhance research on Water Cycle Management (WCM) methods by Member States is obvious if they are to implement holistic management of their water resources at the watershed level. When applying WCM methods, one can satisfy both human and environmental objectives in a sustainable manner while aiming towards water security. In order to effectively implement WCM, a system that can evaluate the hydrological circulation process in the watershed must be established

Holistic approach reflecting water management from the perspective of the upstream–downstream integration of river usages and socio- economic and ecological consequences with respect to energy (hydropower), transport (navigation) or flood risk management is crucial. This is particularly helpful in addressing transboundary water issues.

IHP-IX will build capacity on the WCM approach and support fundamental research and identification of best practices using existing IHP initiatives with the aim of providing scientifically sound and usable data to the larger community.

4.3 Conducting and sharing of research on non-conventional Water Resources (NCWRs) such as wastewater reuse, desalination, rainwater harvesting, and the Management of Aquifer Recharge (MAR) by the scientific community supported for improving Water Cycle Management (WCM) and capacities of local, regional

and national decision-makers strengthened and acceptance of general public enhanced

Non-conventional Water Resources (NCWRs) are an important underpinning of WCM, including such as wastewater reuse, desalination, rainwater harvesting and fog harvesting. The most widespread use of NCWRs is using treated wastewater for agricultural irrigation. The safe and beneficial use of treated and untreated wastewater offers an alternative non-conventional water resource, while reducing water pollution and allowing for the recovery of useful by-products such as nutrients and energy. Yet, there is a need to improve knowledge and management practices to ensure safe water reuse, in particular with regard to health and environmental risks of pollutants. Desalination provides a constant source of water in countries that face extreme scarcity and have access to the most abundant form of water found in seas and oceans. However, the 3 E issues (Ecosystems/Environment, Energy and Economics) should be taken into consideration in scientific and innovation development, as desalination requires energy and produces secondary effects with negative impacts on the environment (brines for example).

IHP will continue its efforts to promote better implementation of the WCM by collaborating in the development and implementation of NCWRs based on different regional realities with a particular emphasis on new technologies with lower costs. Best practices will be identified and shared between the Global North and Global South concerning for example recycling, wastewater treatment, MAR and desalination technologies. It will further raise awareness and train experts to enhance acceptance of the general public in using such resources.

4.4 Development and sharing of knowledge on using the source-to-sea and nexus approaches by the scientific community supported, and capacities strengthened to improve water management, particularly in transboundary watersheds.

Water flows from Sources in the highest mountains to the sea or ocean through river basins and aquifers. The source-to-sea approach contributes to better management of near-shore landscapes reduces flood risk, allows for protection of groundwater recharge zones, and maintains healthy ecosystems as well as estuarine zones. Additionally, this approach improves understanding of the relationships between river flow, soil water and groundwater, which is becoming more important as surface water sources dry up or become too polluted to economically clean up.

IHP IX will provide the knowledge base to develop a comprehensive scientific understanding of the Source-to-Sea phenomena and will contribute to global knowledge generation on Source-to-Sea interconnections, particularly related to water resources and as well in proposing options for adaptation to the member states. IHP will further promote and support additional research and case studies in using the source-to-sea approach, benefiting from direct cooperation with UNESCO's Intergovernmental

Oceanographic Commission (IOC) and other partners of the international source to sea platform.

It is necessary that water food energy and ecosystems should be viewed not as separate entities, but rather complex and inextricably intertwined to address interconnected resources, challenges as well as responses. The use of the nexus approach provides an all sector encompassing way of considering user requirements and should be further implemented into daily water management practices. There is still much to learn, related to the science, research and innovation part of nexus approach, to identify synergies and trade-offs between interdependent sectors to address the complex global development and security challenges and support the implementation of the SDGs at all scales ranging from watersheds to a global scope.

To address these challenges IHP IX will support an integrated approach that concretely addresses the most relevant interlinkages among sector beyond and within water such as food, and energy, considering that these interlinkages can increase efficiency, reducing trade-offs and building synergies while improving governance across sectors.

IHP-IX will support informed decision on nexus by providing evidence, scenarios, and supporting stakeholder engagement. Furthermore, IHP IX will promote in coordination with other partners such as FAO and JRC the nexus approach for coordination across sectors and stakeholders to enable synergies and managing often competing interests while also ensuring the integrity of ecosystems.

4.5 Understanding and knowledge on pollutants sources, fate and transport in freshwater systems, including surface waters (rivers, lakes, lagoons) and groundwater improved by the scientific community and UNESCO Water Family to prevent and reduce water pollution and underpin water resources management strategies.

Freshwater resources pollution is worsening throughout the world, calling for urgent action in order to reduce negative effects on human health and aquatic ecosystems. Water pollution is also one of the main direct factors that cause ecosystem degradation and biodiversity loss. Emerging and new pollutants such as pharmaceuticals and microplastics pose a particular concern due to the lack of knowledge on their potential health and ecotoxicological risks.

IHP-IX will focus on improving the scientific understanding and assessments of all types of pollutants in the aquatic environment providing thus a fundamental basis for evidence-based management decisions and appropriate science-based policy responses. Measures to prevent, reduce and control discharges of all types pollutants to the aquatic environment will be promoted at all stages of the life cycle of pollutants—from awareness raising on sustainable production and consumption, to improving wastewater treatment, reuse and management. Research on emerging pollutants (pharmaceuticals

and chemicals), in particular on their toxicity and environmental effects, is essential to enhance the scientific basis of risk assessment in relation to their potential health and ecological risks in the freshwater environments and will be pursued. Appropriate 'end-of-the-pipe' pollution abatement solutions, including low-cost technologies for wastewater treatment, will be identified and promoted. Partnership with other UN agencies such as UNEP will be sought for complementary and synergy.

4.6 Undertaking and sharing assessment of ecosystem services and environmental flows in ecohydrology pilot sites by the scientific community supported, to improve integrated water resources management.

Successful management of freshwater resources requires an assessment and enhancement of ecosystem services, with special emphasis on environmental flows to fully implement this approach. Ecohydrology creates green solutions for increasing challenges in the sustainable management of water ecosystems. It combines hydrology, biota and engineering for water security, to enhance both water quality and quantity. The integration and harmonisation of Ecohydrological Nature Based Solutions with hydrotechnical infrastructure at catchment level, improves efficiency of measures at lower costs, thus helping to avoid conflicts for water resources management and water allocation.

The UNESCO-IHP network of ecohydrology and especially the demonstration sites (26 in 19 countries) have developed the understanding of water-ecosystems-society interactions, translated into innovative Nature Based Solutions and used as laboratory for training of professionals and for society education/involvement, are fundamental for enhancement of the catchment sustainability potential through WBSRCE (Water, Biodiversity, ecosystem Services for Society, Resilience to impacts, social, Cultural and Educational components).

IHP aims at improving the understanding of the relationships between ecosystem processes such as the water-plants-soil-groundwater interactions, to better manage catchment landscapes by reducing flood risks, allowing for protection of groundwater recharge areas, and maintaining healthy ecosystems as well as estuarine zones.

While not a new concept, IHP-IX will give more support to capacity building activities in the use of integrated water resource management and ecohydrology tools in organizing future investments in the water sector.

4.7 Undertaking assessments and developing and sharing of methods to monitor changes in the cryosphere system (snow, glacier, and permafrost), runoff formation from melting glaciers erosion and sediment transport, glacier fed reservoirs, such as mountains lakes, and aquifers, by the scientific community supported for improved understanding of their potential use to inform decision makers at all levels.

Over the last decades, global warming has led to widespread shrinking of the cryosphere, with mass loss of glaciers and reductions in snow cover and increased permafrost temperature created profound risks for societies that depend on cryosphere for water resources. Similarly, aquifers, as the major sources of potable water, have been experiencing increased abstractions that often cause irreversible effects.

IHP will promote scientific research to enhance understanding of water availability from cryosphere and in aquifers and call for science-based policy decisions. IHP IX will strengthen the adaptation capacity of countries to climate change impacts through assessment, promotion of regional cooperation, and stakeholder engagement.

IHP IX will support strengthening national and regional capacities to monitor and assess aquifers and GLOF hazards. Scenarios of changes in the available groundwater and cryosphere in response to climate change for several regions will be implemented.

4.8 Development and sharing of methodologies and tools in mainstreaming global changes within water management by the scientific community supported for improved planning by decision makers at all levels.

The impacts of global changes on the management of freshwater resources are hardly recognized, therefore, theory and practice of water resources management will have to continue to adapt to current and future trends facing the planet. It is necessary to both, focus on mitigating global warming, as well as on adapting to it and increasing resilience in risk sensitive areas such as SIDS, semi-arid regions, coastal hinterlands, and mountainous areas, which should receive major assistance in the development and sharing of new methodologies and tools.

IHP-IX will give more emphasis to develop and share methodologies, guidelines and tools to address these challenges, particularly related to environmental sensitives natural resources.

4.9 Implementing integrated water resources management at all levels, through transboundary cooperation as appropriate by Member States, supported in coordination with UN-Water and UNECE, to achieve SDG target 6.5

Currently, 263 transboundary river basins and the more than 600 transboundary aquifers have been identified. Shared resources need to be managed in a mutually beneficial manner by all riparian states. The Agenda 2030 through Target 6.5 emphasizes the importance of transboundary cooperation. Monitoring of transboundary cooperation provides impetus for countries to assess the current status of cooperation with neighbouring countries, and set targets for improved coordination. UNESCO, as

the co-custodian agency of SDG 6.5.2 indicator, will continue, together with UNECE, to support monitoring and support Member States to assess and develop their transboundary cooperation, tackling the main gaps in the national capacity, especially regarding groundwater resources and their management. This will help and equip countries to negotiate cooperative arrangements where they are now lacking.

Cooperating with other UN Agencies and scientific partners

UNESCO has an important role, together with UNECE as custodian agencies for 6.5.2, the only target in the 2030 Agenda explicitly related to transboundary water cooperation.

UNESCO will mobilize and complement the work of various partners including different UN agencies members of UN-Water such as UNEP, UNDP, WMO and FAO, etc, academic and research institutions as well as NGOs such as GWP in contributing to promote inclusive water management. The contribution of IHP-IX will be mainly on capacity development, provision of science based knowledge, tools, methodologies and guidelines.

Priority Area 5: Water Governance based on science for mitigation, adaptation, and resilience

Water governance refers to the political, social, economic, legal, and administrative systems in place that influence water's access and use, protection from pollution, and management in general. It determines the equity and efficiency in water resource and services allocation and distribution, and balances water use between socio-economic activities and the goods and services provided through ecosystem preservation. It includes formulation, establishment, and implementation of water policies, with clear and practical standards based on science, including water ethics, legislation and institutions, and the roles and responsibilities of all stakeholders.

By 2029, Member States have significantly reduced water governance gaps, generating greater equity and efficiency in the allocation, distribution and conservation of water resources and services, and designing and implementing water policies in an inclusive and participatory way with standards based on science while developing ongoing efforts addressing the adaptation and mitigation to climate change.

Good Water Governance is fundamental to the entire concept of setting global goals such as the SDGs and is therefore directly linked to several targets of SDG6 (ensure availability and sustainable management of water and sanitation for all), water-use efficiency (6.4); integrated water resources management (6.5.1), including transboundary cooperation (6.5.2); international cooperation and water capacity-

building support (6A); and participation of local communities in decision processes (6B). Progress in governance also impacts the fight against poverty (SDG1) and hunger (SDG2), building resilience and reducing exposure to extreme weather-related events; doubling productivity and the income of small food producers; and implementing resilient practices that strengthen capacity to adapt to climate change (targets 1.4, 1.5, 2.1, 2.3 and 2.4).

There is an important link between SDG3 (good health and well-being) and water governance, specifically with target 3.9 related to reducing the number of deaths and illnesses from hazardous chemicals, air and water, and contamination. There is also an important connection between this priority area and SDG4 (quality education), particularly targets 4.1 and 4.5, which aim to eliminate gender disparities and all discrimination in education. Following the same logic, the link with SDG5 (gender equality) underscores the development of targets to end all forms of discrimination against women and girls and enhance the use of enabling technology to promote the empowerment of women (5.1 and 5.B). It is also linked to SDG8 (inclusive and sustainable economic growth, employment and decent work for all), specifically with the goal of achieving higher levels of economic productivity through diversification, technological upgrading and innovation and endeavour to decouple economic growth from environmental degradation (targets 8.2, 8.3, 8.4 and 8.9).

This priority area strengthens the fulfilment of SDG10 (reduce inequality within and among countries), SDG 11 (make cities inclusive, safe, resilient and sustainable) and SDG 13 (action to combat climate change and its impacts) and their targets 13.1, 13.2 and 13.B. Sound Governance underpins SDG 16 (peace, justice and strong institutions) and is related to transboundary water cooperation (target 6.5) and SDG17 (partnerships for sustainable development). Any successful sustainable development program, requires partnerships between governments, the private sector and civil society. Inclusive alliances are built on principles and values, sharing a vision that place people and the planet at the centre of decisions reached. All of this adds up to the fundamental nature of open and good governance as a prime driver in attaining the ambitious targets associated with the SDGs.

5.1 Awareness of decision makers at all levels raised on the importance of science-based water governance by the UNESCO Water Family supported, to improve and update Member States' policies and institutional frameworks that enhance the overall resilience of communities to effects of global change.

Water governance is understood as a cornerstone to enable Member States and the multiple stakeholders in water to understand, adopt and implement decisions based on information and knowledge to build more resilient and peaceful communities and governance structures, without leaving anyone behind.

Water governance requires the ability to understand what happens to the water resource in a basin and its related aquifer, both in terms of the hydrological cycle (of precipitation,

evapotranspiration, infiltration and runoff flows) and where and how the main modifications of ecosystems take place in order to address those hot spots (human settlements, agricultural use, industrial activity, etc.) and to intervene to avoid unwanted modifications, inequities or unfairness in accessing water or to rehabilitate ecosystems to a suitable state.

Due to its particular characteristics, groundwater still lags behind surface water with respect to effective governance and therefore great efforts are still required to close this gap.

Water governance should therefore facilitate adaptation, mitigation and resilience processes including, through eco-hydrology, the regulation of the hydrological and nutrient cycles in ecosystems altered by the human factor based on scientific facts. Ultimately, adequate water governance is a fundamental and solid pillar to guarantee sustainable water security for all.

IHP-IX will disseminate scientific results and organize sessions to raise awareness so that policy instruments, tools, decisions and actions on water (surface and underground) are made on the basis of scientific, multidisciplinary knowledge and taking into consideration global change effects.

5.2. *Science-based assessments on water governance, legal, policy and institutional frameworks undertaken and recommendations communicated ensuring that they are context-dependent, location-based, reflecting adaptation to climate change and IWRM, integrating surface and groundwater for their uptake to decision makers.*

Governance addresses the role of institutions and relationships between organizations and social groups involved in water decision-making, both horizontally across sectors and between urban and rural areas, and vertically from local to international levels. Governance needs to be adaptive, context-dependent, and location-based to take into account historical and territorial specificities and challenges. It is widely accepted that governance is much broader than government as it also seeks to include the private sector, civil society, and the wide range of stakeholders with a stake in water use and management.

The fast-increasing rate of urban populations and development of megacities and massive migration is a challenge to the achievement of SDG 6, and thus may jeopardizes good governance. Resource mismanagement, corruption, inappropriate and malfunctioning legal and institutional arrangements, non-convergence between hydrographic boundaries and administrative boundaries, bureaucratic inertia, insufficient human capacity, and a shortage of funding for investments all undermine the effective governance of water in many places around the world.

IHP-IX will promote science-based assessments of water governance, so that Member States can have efficient legal, political and institutional frameworks that make it

possible to implement participatory, contextualized and location-based water policies. It will further organize sessions to share the results of the assessments and propose and disseminate recommendations to decision makers. In addition, the UNESCO Water Family will provide scientific knowledge to support Member States to improve and update their regulatory and institutional frameworks so that they are solid and flexible instruments to respond with mitigation, adaptation and resilience to global changes.

5.3. Conducting and sharing of research on novel approaches of adaptive water management by the scientific community supported and capacities of Member States strengthened to enhance sound water governance.

Adaptation measures for a resilient water sector require new paths to achieve sustainable urban water management that goes beyond physical engineering and implementing IWRM. They further require the participation of multiple actors, political will and a sound scientific framework including strategic, tactical, and operational decisions. These in turn require the development of strategies, action and monitoring plans.

Policies must ensure conservation of the resource and protection of watersheds, raise awareness for the reduction of water consumption, ensure compliance with the law, manage aquifer recharge, and recycle storm water and wastewater, provide circular economy incentives, especially in megacities. This requires cooperation of the national governments, local authorities and non-governmental organizations, as well as other public and private stakeholders.

Good water governance also requires the promotion of additional research to address the challenges of adaptation to climate and other global changes as well as to develop affordable technologies for providing solutions to all.

Scientific hydro analyses on the impact of implemented sustainable solutions in terms of water resources (environment, soil, surface and groundwater bodies) and economics in watersheds, considering a multi-disciplinary approach based on water positive multi-benefit impact of solutions/actions, for water, environment, biodiversity and people, should be performed.

IHP-IX will continue conducting and sharing of research on novel approaches of adaptive water management, paying special attention to improving scientific research, knowledge and data on risk assessment, regulations, pollution control/attenuation, linking water quality and quantity with economic, societal and ecological approaches. IHP will further build capacity of national experts and organize awareness raising sessions to sensitize decision makers of UNESCO's Member States in the results of this research.

5.4. *Capacities of the scientific community and decision makers strengthened on new frameworks and tools, to underpin water governance and build resilience*

The UN-Water SDG-6 Synthesis Report suggests that good governance is essential for sustainable water management focusing on a bottom-up framework with multiple stakeholders. It's necessary to improve decision-making processes through public participation that "can ensure that decisions are based on shared knowledge, experiences and scientific evidence, are influenced by the views and experience of those affected by them, that innovative and creative options are considered and that new arrangements are workable, and acceptable to the public"¹⁰ (EEA, 2015, 12).

Decisions to deal with water challenges require further to a holistic, coherent, and inter-sectoral vision, science-based policies to address all aspects of water uncertainty. Building resilience to uncertainty and future risks requires a continuous partnership of all stakeholders in Member States, working within an enabling legal, scientific, and institutional framework.

A multidisciplinary science approach (Hydrological, Social Socio-Economics sciences etc.) will provide a new holistic framework for water governance at all levels. Sharing scientific knowledge and understanding of water issues to all stakeholders, in urban areas and in rural areas in a watershed will allow the development of a common vision and implementation of science-based solutions.

IHP-IX will continue to develop new and strengthen existing frameworks and tools with a participatory approach, such as Climate Risk Informed Decision Analysis (CRIDA), Water Sensitive Urban Design, etc. taking into consideration the challenges posed by global changes, to underpin water governance and build resilience of the scientific community and decision makers. It will further organize training and raising awareness sessions to strengthen the capacities of scientists and decision makers to enhance the uptake and implementation of these innovative approaches, frameworks and tools.

5.5. *Sciences-based assessment and development of guidelines, for strengthening water related content in Nationally Determined Contributions and National Adaptation Plans, conducted to strengthen water-based climate policy-action nexus for adaptation and mitigation*

Climate Governance is essential for Water Governance just as water governance is essential for climate governance. The Intergovernmental Panel on Climate Change (IPCC) has reflected on the need to understand this concept from a broader and different perspective that allows addressing solutions to climate change based on the constant changes that are carried out at a scientific technological and social level. World Water

Development Report 2020 on water and climate change has clearly shown that water is part of the solution to climate change both for adaptation and also for mitigation.

Therefore climate mitigation and adaptation policies should better consider water and make synergy with water policy. A systematic analysis of how water is included in Nationally Determined Contributions and National Adaptation Plans and how countries can benefit from a better water management is still missing;

IHP-IX will support evidence-based climate policy making by providing a science-based analysis of current inclusion of water related content within the NDCs and NAPs, developing also recommendations and guidelines for better integrating water and supporting the increased ambition in the periodical re-submission of NDCs and new submissions of NAPS, at the same time supporting the Measuring, Reporting and Verification mechanism of the Paris Agreement.

Cooperating with other UN Agencies and scientific partners

UNESCO's role in water governance is to reinforce the scientific base upon which decisions and policies are framed by providing scientific knowledge, which will take into consideration the effects of global change.

IHP-IX will cooperate with other UN agencies and other partners including Scientific Unions, Intergovernmental organizations, Non-Governmental organizations and global funds in contributing to improve water governance based on science for building resilient societies

IHP will provide scientific knowledge and research skills cooperating with existing initiatives and Organizations such as OECD, SIWI, UNEP, WMO, UNFCC and UNDP as well as UNECE, GWP and others especially in the case of transboundary waters.