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Draft IHP-IX Strategic Plan

Science for a Water Secure World in a Changing Environment

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Science for a Water Secure World in a Changing Environment

1. The Strategic Plan for the ninth phase of the Intergovernmental Hydrological Programme (IHP-IX) covering 2022-2029 identifies key water priority areas to support Members States to achieve Agenda 2030 and the Sustainable Development Goals (SDGs), specially water related SDGs 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).

2. The process of preparing the strategic plan has been highly 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 useful.

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

Preamble

4. The UNESCO Intergovernmental Hydrological Programme (IHP), founded in 1975, is a long-term programme executed in successive eight-year phases. 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 educational programmes. Ever since the early 2000s, with the increased presence of social science components, including growth in the quality and quantity of citizen science inputs, IHP has been 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 an increasingly important role

5. The IHP is an intergovernmental cooperation programme aimed at addressing national, regional and global water challenges and building a sustainable and resilient society by expanding the scientific understanding of water, improving technical capabilities, and enhancing education. To attain these aims, it is important to innovatively develop science and technology, generate integrated scientific knowledge based on various data, knowledge, experience and objective facts obtained so far and share this knowledge widely, and implement it. Furthermore, IHP aims at developing human resources who will be responsible for these endeavours. As a result, it will become possible to support governance whereby decisions are made based on science and technology by building mechanisms enabling all stakeholders to participate.

6. 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 lifestyles and 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. Disasters such as the COVID-19 global pandemic caused additional limitations to boundary conditions, restricting the capability of humans to interact and deal with synchronous and/or cascading impacts of disasters. This example has demonstrated the utmost importance of science, research and technology as well as the need for rapid cooperation and full transparency regarding the sharing of data and lessons learned for the collective benefit of the global community.

7. The ever-increasing pace of environmental changes intertwined with human behaviours calls for better understanding of hydrology. The interaction between human activities and water systems needs to be considered to develop scenarios for Integrated Water Resources Management (IWRM). IHP-IX continues to offer a platform and venue to extend cooperation within the international scientific community, and thus contribute to addressing many unsolved problems in hydrology[1].

8. 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 the Sciences and Education, and aims to be responsive to the needs of Member States and support them to capitalize on scientific and technological advances as they face water-related global challenges.

Global water landscape: challenges and opportunities

9. Although water is mostly a renewable resource, it is increasingly scarce due to human activity, particularly in large metropoles, 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 means it is necessary to deepen and expand our comprehensive knowledge of hydrology and management of water, not only among experts, but also among all users. Furthermore, climate change exacerbates the gravity of water-related challenges and increases the urgency of bringing the water agenda to the forefront of the global community.

10. 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 for sustainable institutional development and water governance for global change and water security.

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

11. Freshwater is essential to human life, health, food security and biodiversity, 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 increase because of climate change and demographic growth. Furthermore, human migrations are putting pressure on water resources. Indeed, more than 65 million people were involuntarily displaced as of the end of 2016 (UNHCR, 2017) and unfortunately the trend has continued to increase. Also, migration within countries due to relocation of people from rural to urban areas is increasing globally, putting more pressure on urban services. Currently more than 50% of the world's population lives in cities.

12. 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, as part of scientific, education and technology related strategies and responses.

13. 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 2030[2], makes youth engagement essential for building a generation of future leaders committed to an evolved water culture, water security and achieving the SDGs (water stewardship). UNESCO's Operational Strategy on Youth will provide the basis upon which the involvement of young experts will be founded. Similarly, women and girls play key roles as agents of change for improved water science, culture and better water management and governance. The role of indigenous groups, considering their ancestral knowledge on water issues will also be essential.

Meeting the SDGs and other water-related International Agendas

14. A major challenge confronting Members States is meeting the Sustainable Development Goals (SDGs) that comprise the UN Agenda 2030 for Sustainable Development. Despite the efforts and resources dedicated to this task, the SDGs are off track with an alarming trend for SDG6. 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.

15. Certainly, the majority of the global agenda 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 committees, Chairs and Centres for more engagement at country and regional levels.

16. The IHP-IX programmatic content is designed with the objective to maximize the support to Member States in attaining SDG 6 and its related UN SDG 6 Global Accelerator Framework, UN Water Decade for Action (2018-2028) and other water-

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

related goals and targets by strengthening scientific knowledge, data availability and enabling informed decision-making. In addition, being the co-custodian of SDG 6.5.2 with UNECE, provides a unique opportunity to IHP to play a major role in identifying and implementing actions to help countries, within the framework of SDG 6 and international conventions, achieve the required benchmarks pertaining the improvement of operational arrangements for water cooperation related to the management and conservation of transboundary aquifers.

17. To date water management and water engineering were focused on water supply to agriculture, industry, navigation, and domestic use. However, intensive water exploitation, catchment modification and climate change have amplified the stochastic character of the hydrological process and both the intensity and frequency of floods and droughts. This will in turn further negatively impact the water resources per capita ratio.

18. In a broader context, attaining the SDG implies recognizing the complex relation between humans and the biosphere, and in particular the role of water as a key driver of bio-productivity, biodiversity, and nutrient cycles, all fundamental life supporting processes, thus the urgent need to harmonize the demand with enhanced water resources. Consequently, the most important challenge for water management is how to increase water resources quantity and quality, and in parallel to increase biodiversity, ecosystem services for society, and resilience to impacts (WBSR)[3]. The answer is through a holistic approach which incorporates the innovative nature-based and ecohydrological solutions methods (NBS) and catchment scale systemic solutions, based on understanding the water ecosystems interplay, as both recipients and producers of water, as well as promoting society involvement through culture and education of water and sustainability (CE). Culture is deeply embodied in societal behaviour patterns, defining perception and actions, efficiency and effectiveness.

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 (applicable for the signatory Member States): 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 rights to safe drinking water and sanitation (UNGA Resolution A/RES/64/292 and A/RES/70/169) and the Global Strategic Framework for Food Security and Nutrition, the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Helsinki 1992), the Convention on the Law of the Non-navigational Uses of International Watercourses (New York, 1997), and the Resolution A/RES/68/118 on the Law of Transboundary Aquifers. 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.

3 WBSRCE: Zalewski M. 2014 Ecohydrology and Hydrologic Engineering: Regulation of Hydrology-Biota Interactions for Sustainability. Journal of Hydrologic Engineering. A4014012-1

Advancing water science while expanding towards transdisciplinary

19. Environmental changes are and demand a better understanding of hydrology as a key factor of these changes. One of the greatest challenges for the hydrologic science community is to identify appropriate and timely adaptation and mitigation measures in a continuously changing environment. There is a need to study the physics of hydrological processes under conditions of non-stationary climate change, and then adaptation mechanisms under these conditions. 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 scenarios[4]. To address these challenges, IHP needs to develop a new vision. IHP IX will take advantage of the increasing computational power, and new monitoring techniques, enhanced modelling capabilities, new opportunities for sharing information, non-traditional data sources and greater international and transdisciplinary cooperation to achieve its vision.

20. The basic premise of IHP-VIII was its commitment to quality science for informed water decisions and its impact to improving quality of life. This commitment will continue and be built on 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). Similarly, the High-Level Panel on Water report (Every drop counts) has also clearly stressed the crucial need for evidence-based decisions in addressing complex water challenges.

21. Among the several opportunities for expanding and sharing scientific knowledge that will be supported during IHP-IX are those that relate to citizen science. This emerging field combines the efforts of scientists and the public to better understand the water cycle, including the effects of human behaviour. Similarly, encouraging Open Science and Open Data provides an opportunity for scientific information, data and outputs to be more inclusive, more widely 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.

Strengthening water education for a sustainable present and future

[4] 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

22. 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, utilities 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 are 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.

23. A major push in educating water managers on new technologies has substantially reduced the skill-gap limiting adequate water governance. However, educational undertakings aimed to enhance legal, policy and institutional frameworks to support water governance have lagged, which constitutes a challenge. This reality provides IHP with an opportunity to identify and pursue science-based capacity building activities to enable Member States towards enhanced water governance from local to basin levels.

24. The water, energy, food, and ecosystem (WEFE) nexus is a key element to consider to achieve sustainable development. Therefore, the understanding of the nexus and its integrative 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 programme (MAB), the International Geoscience and Geopark Programme the Local and Indigenous Knowledge Systems (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 development activities, for a sustainable future. During its ninth phase, IHP will work closely with the UNESCO water family other branches of UNESCO and UN Agencies and Organizations to enhance participatory and cross-disciplinary knowledge building and dissemination. Likewise, IHP-IX will advance educational programmes aimed at strengthening and supporting Member States in the development and implementation of international frameworks and institutional cross-sectoral cooperation.

25. UNESCO is dedicated to Open Education Resource (OER). OER provide a strategic opportunity to improve the quality of learning and knowledge sharing as well as improve policy dialogue, knowledge-sharing and capacity-building globally.

Closing the data-knowledge gap

26. The increase of information and knowledge requires new ideas and models that will allow us 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. Ensuring that data information and knowledge exchange among states and regions, is reliable so that it can be factored into decision-making is still a major challenge. Furthermore, elaboration of collaborative strategies for managing water data between scientific

organizations and UN agencies, Member States and stakeholders also is very much needed. 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.

27. Notwithstanding, the development and application of new monitoring techniques, and in particular remotely sensed data, are providing opportunities for observing hydrological processes across a wide range of scales, both temporal and spatial. Similarly, global-scale modelling is presenting stimulating opportunities for acquiring a more comprehensive understanding and mapping of water resources availability and identification of water threats. Uncertainties in global-scale modelling 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 challenges[5]. New initiatives on global level (like the WMO Global Hydrometry Support Facility (WMO HydroHub) aim at supporting access to end-users of hydrometeorological data and services from various economic sectors as tailored services. IHP IX will build on these opportunities to expand the efforts of the Programme aiming to help Member States develop and gain access to data and information and to provide a platform to further increase data sharing and knowledge transfer.

<u>Working towards sustainable and inclusive integrated water resources management</u>

28. 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, flood mitigation and drought prevention around the world. Therefore, sustainable water management at the basin level must be an integrated undertaking – to be successful it needs to involve all water users (civil society, institutions, public authorities and private sector).

29. A transdisciplinary approach, which IHP-IX will help to 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.

30. Such a model faces many difficulties in terms of temporal and spatial scales and the complexity of model formulation, data collection, quality, handling and calibration, results interpretation and dissemination, the incorporation of citizen science inputs.

31. 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 at national and subnational levels in which natural conditions, technological solutions, nature-based solutions and social realities are considered.

[5] 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.

Scientific support to water governance

32. To enhance the resilience of societies, decisions should be evidence-based. Improving the effectiveness of water governance is a major challenge which needs to be strongly supported as a cornerstone of IHP-IX to enable Member States to implement evidence-based decisions to build more resilient and prosperous communities. Similarly, there is a need to promote sustainable water governance as a long-term activity through sound data, capacitated human resources, and increased partnerships. Therefore, encouraging the development of community-based governance partnerships at the grassroots level can lead to effective policy changes at the national level.

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

Attaining water security in a changing world

34. UNESCO's Member States defined water security as, the capacity of a population to safeguard access to adequate quantities of water of an acceptable quality for sustaining human and ecosystem health on a watershed basis, and to ensure efficient protection of life and property against water-related hazards such as floods, landslides, land subsidence, and droughts. However, the definition of the full extent of 'water security' depends mostly on how the complexity of water-society challenges is analysed. 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 systems.[6]

35. The contributions and results obtained during the implementation of the IHP-VIII, provide a unique opportunity for the IHP-IX to build on and mainstream these into the newly structured programmatic content. Similarly, the partnerships built over the past eight 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 2 Water Security Centres under the

[6] Maria C. Donoso, 2021. Water Security, Evolution and Challenges in Transboundary Basins. Submitted. Springer Nature
See also: Varady, R. G., T. Albrecht, A. K. Gerlak, A. A. Zuniga-Teran, and C. Staddon (in press; exp. pub. date: March 2021). The water security discourse and its main actors. In Handbook of Water Resources Management, ed. by J. J. Bogardi, T. Tingsanchali, K. D. Wasantha Nandalal, J. Gupta, L. Salamé, R. R. P. van Nooijen, A. G. Kolechkina, N. Kumar, A. Bhaduri. SpringerNature. 84 pp.

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

36. UNESCO's transdisciplinary approach is accomplished 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, as well as communication, and information. Furthermore, the Organization has accumulated more than 50 years of experience on water through the Intergovernmental Hydrological Programme and since 2000 through the World Water Assessment Programme (WWAP).

37. The Intergovernmental Hydrological Programme is devoted exclusively to advancing water research and management, and the related education and capacity development efforts considered essential to foster sustainable and integrated water resources management. UNESCO-IHP offers a scientific and education platform related to water, enabling other complementary network initiatives that bring together research institutes, museums, industry development facilities, innovation centres, scientists, Member States representatives policy makers, government officials, youth and others, to share knowledge and integrate different points of view. IHP together with its "UNESCO Water Family" comprises the 169 IHP National Committees and focal persons, UNESCO's Division of Water Sciences, including the World Water Assessment Programme, Regional Hydrologists posted in field offices, its 36 Category 2 Centres, and more than 65 thematically grouped water-related Chairs, offers the international community the most comprehensive grouping of water scientists, managers and practitioners in the water arena. It is thus of primary importance to facilitate the cooperation and partnerships of UNESCO Water Family members and ensure that IHP National Committees and focal persons have adequate capacity and means to contribute to the implementation of the Programme. Furthermore, it is crucial that the establishment of water related Category 2 Centres and Chairs will be supported particularly in Africa, a UNESCO priority and a region where strengthening human capacity for science, research and innovation is needed.

38. Through this network, UNESCO has established. working relationships with global and regional partners at various levels, including other intergovernmental and international organizations. Additionally, IHP has developed partnerships with the private sector and NGO partners aimed to advance the results of scientific research and innovation into practical uses and to promote knowledge sharing at all levels.

39. Furthermore, within the coordination mechanism of UN-Water and through inter-agency relations, UNESCO-IHP develops and undertakes 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 at accelerating the UN 2030 Agenda and the SDGs.

Assuring Continuity with Change

40. To date IHP has developed and implemented eight 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, supporting policy and society.

41. 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.

42. 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 the other five themes[7] 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.

43. An additional critically important transition element from IHP-VIII to IHP-IX will be the 17 Flagships and Initiatives (see annex), 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.

44. 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 innovative ecohydrological 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 in collaboration with the Water Conventions, 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. It will further 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

[7] Theme 1: Water-related Disasters and Hydrological Changes; Theme 2: Groundwater in a Changing Environment; Theme 3: Addressing Water Scarcity and Quality; Theme 4: Water and Human Settlements of the Future; Theme 5: Ecohydrology, Engineering Harmony for a Sustainable World

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 VIII of IHP into phase IX.

45. 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, IHP National Committees, Centres, Chairs, regional consultation units, etc.). The IHP programmatic undertakings will transition from IHP VIII to IHP IX, via a dynamic and adaptive pathway, while assuring continuity.

IHP Vision

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

IHP-IX Mission

47. 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 in cooperation with partners and other UN agencies active in the water sector.

To this end IHP-IX will, in its ninth phase:

a. Leverage intersectorality for a water secure world;
b. Promote international scientific research and cooperation for improved knowledge to address water challenges and climate changes incorporating the interaction between human and water systems.
c. Mobilize and disseminate effectively scientific and policy relevant expertise, knowledge and tools 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 the protection and conservation of water resources and the promotion of sustainable integrated water resources.
f. Support the achievement of UN SDG6 and the implementation of the Global Acceleration Framework, taking into account interrelated water and climate issues.
g. Strengthen transdisciplinary water research, by supporting research on methods for stakeholder involvement and transdisciplinary knowledge integration.

Outcome and Priority Areas

48. 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 the value of water as this is expressed by local water rates[8]. The Intergovernmental Hydrological Programme's approach to these challenges is to expand the human potential, 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"[9].

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

50. The above identified outcome of IHP-IX is aligned with UNESCO's overall Medium-Term Strategy, 41 C/4 (2022-2029) and will serve two of its Strategic Objectives:

51. Strategic Objective 1: Ensure quality, equitable and inclusive education and promote lifelong learning opportunities for all, in order, inter alia, to reduce inequalities and promote learning and creative societies, particularly in the digital era and Strategic Objective 2: "Work towards sustainable societies and protecting the environment through the promotion of science, technology, innovation and the natural heritage.

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

53. Enhancing the level of cooperation among scientists, policy-makers and practitioners, and the contributions of citizens to scientific activities (to data collection and the definition of problems to be solved - citizen science) 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 and effort must be invested to develop comprehensive data at different scales and in distinct geographic and political settings, all contributing to better evidence-based water management.

54. Developing capacity for the 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 the equation. 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 and consumption that results from decoupling economic growth from environmental

[8] INTERNATIONAL HYDROLOGICAL PROGRAMME (IHP) EIGHTH PHASE "WATER SECURITY: RESPONSES TO LOCAL, REGIONAL, AND GLOBAL CHALLENGES" STRATEGIC PLAN IHP-VIII (2014-2021)

[9] IHP, 2011. THE IMPACT OF GLOBAL CHANGE ON WATER RESOURCES: THE RESPONSE OF UNESCO'S INTERNATIONAL HYDROLOGY PROGRAMME. Page 2.

degradation. In addition, open source decision support systems built on open software platforms play an increasingly important role in managing water resources.

55. 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.

56. Strategies and activities addressing global changes that are science-based and inclusive of all sectors of society, enhance the overall resilience of these 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 involvement of citizen science and pro-active NGO, civil society and community partners with government, including the ability of decision makers to benefit from the use of indigenous knowledge.

57. The following performance indicators (PI) have been identified to monitor progress towards the achievement of the desired Outcome:

- 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, develop and encourage scientific and quality-controlled data and knowledge to sustainably manage their water resources
- PI 4: Degree of integrated water resources management addressing global challenges practice by number of Member States
- PI 5: Degree of mechanisms, policies and tools based on science implementation to strengthen water governance for mitigation, adaptation and resilience by number of Member States

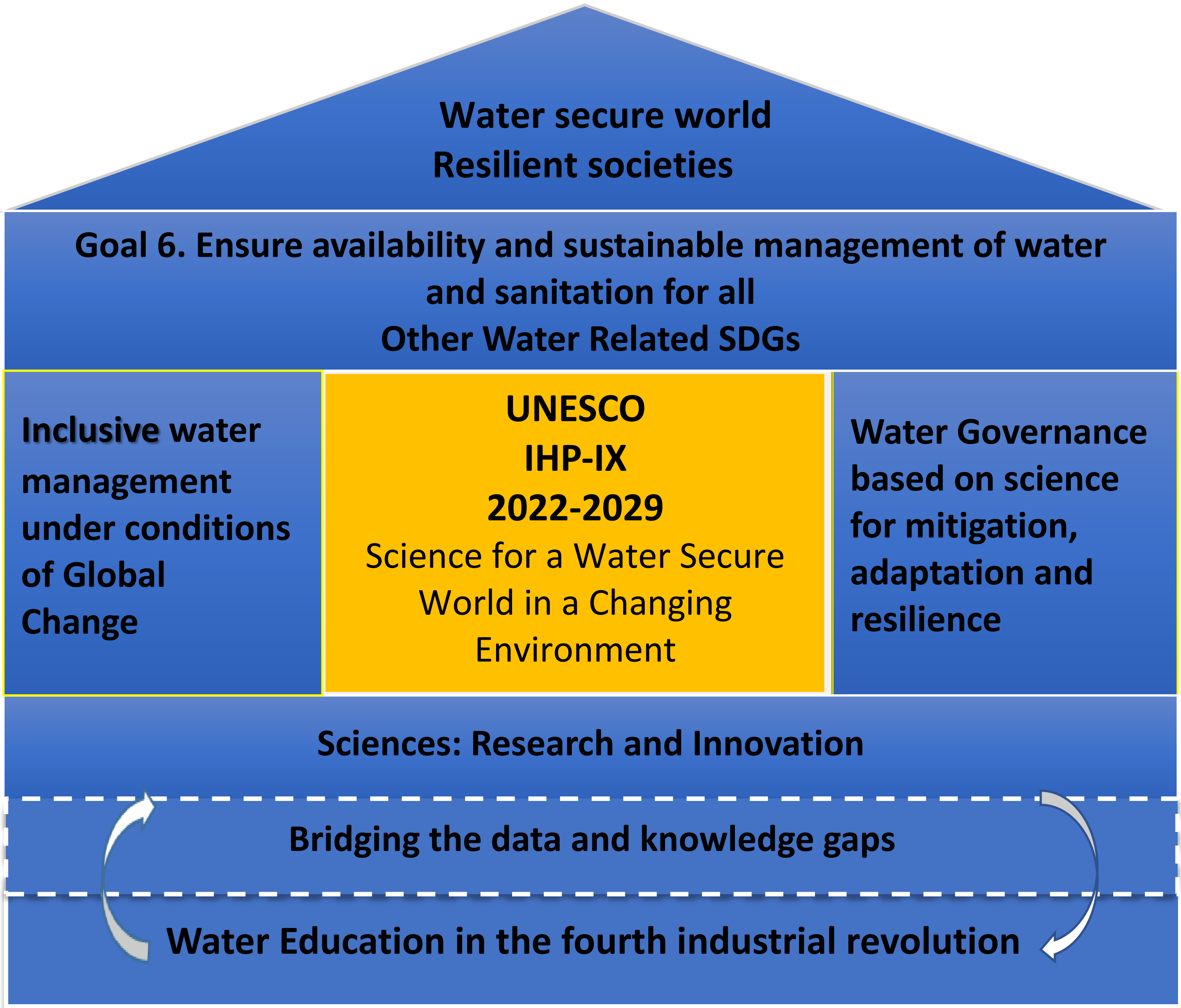
58. The Strategic Plan presented herein originated from and was developed by Member States and the UNESCO Water Family Members with the support of the Secretariat. The mid-term evaluation of IHP-VIII recommends that during the execution of IHP-IX, roles, and responsibilities for the implementation of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

59. It is essential that IHP National Committees continue to develop so that their bodies act as meeting spaces between public water bodies, academic and scientific centres and increasingly, non-governmental water organizations.

60. 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 Agenda 2030, the Sendai Framework, the

Paris Agreement and the New Urban Agenda and other relevant instruments. Consequently, a sixth performance indicator is dedicated to 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

61. Achieving water security is gradually being understood and is becoming a global concern because of increasing water scarcity, degrading water quality, increase intensity and occurrence of extreme weather events such as floods and droughts and the effects of global changes have, on human livelihoods, health, environment, and potential impacts on peace and security. The primary driver for these challenges is human activity, which, along with economic growth, has increased the pressures on water resources and supply and quite often to the detriment of the environment.

62. The ninth phase of IHP has one identified outcome, as noted above:

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

63. It is expected that this Outcome will contribute to the achievement of UNESCO's Strategic Objectives, and 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 as Priority Areas Science, Research and Innovation (Priority 1), Water Education for the Fourth Industrial Revolution including Sustainability including Sustainability (Priority 2) and Bridging the data and knowledge gaps (Priority 3), as intertwined elements that feed of each other and formulate the basis for Integrated and Inclusive Water Resources Management (Priority 4) and Water Governance based on science for mitigation, adaptation and resilience (Priority 5).

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

65. 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. These activities aim at informing management and policy decisions, and reform institutional settings to align them with the needs as they become more complex due to the effects of global change.

66. The activities will respond to expressed Members States needs and require human and financial resources, cooperation and collaboration with the scientific community, other 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 transform 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.

67. 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”.

Priority Areas

68. 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 including Sustainability
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

69. 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 axes, 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 Agenda 2030 and its 17 SDGs, 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 end of Agenda 2030, 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.

Priority Area 1: Scientific research and innovation

70. 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.

71. **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 development and healthy of ecosystems within a sustainable development context**.

Relationship between this priority area and Agenda 2030

72. 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. Moreover, 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. International scientific cooperation strengthened and fostered to address unsolved problems in hydrology[10]*, improving scientific understanding of hydrological cycles across river basins and aquifers.*

73. Since societal problems related to water have become ever more complex, streamlining a science community 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 Problems in Hydrology (UPH) in coordination with scientific institutions, professional organization and water professionals. Addressing UPH requires fundamental understanding of human water nexus and coevolution of hydrologic processes and scenarios.

74. One of the UPH is scaling and heterogeneity research in hydrological processes that has engendered a spirited debate between scientists and managers for decades. Scientists still struggle with the relationship between various physical and biological 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. 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, IAHR, WASER and other relevant UN organizations, such as WMO.

75. IHP-IX will emphasize the use of new monitoring techniques, and in particular, the latest ICT technologies, remote sensing and big data which offering exciting opportunities for

10 Bloeschl el al. Twenty-three unsolved problems in hydrology (UPH) – a community perspective. HYDROLOGICAL SCIENCES JOURNAL 2019, VOL. 64, NO. 10, 1141–1158. https://doi.org/10.1080/02626667.2019.1620507

observing and modelling hydrological processes across a wide range of spatial and temporal scales.

76. Furthermore, IHP will mobilize the 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.

1.2. Ecohydrology [11] research and innovation at UNESCO-designated sites conducted and shared by the scientific community and UNESCO Water Family, communicated to assess the impact of ecohydrological and nature-based solutions on water cycles and include such solutions in Integrated Water Resource Management (IWRM) and services at all scales and in Sites' management

77. Nature Based Solutions (ecohydrology) 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, use ecosystem properties and services as a tool in water management (Ecohydrology and Nature-based Solutions) and the harmonization of grey and green infrastructures to achieve sustainability of ecosystems closely related with IWRM.

78. 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.

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

79. 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 projection 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 uncertainties which will impact

11 Ecohydrology: Zalewski M., Janauer G. A., Jolánkai G. 1997. Ecohydrology A New Paradigm for the Sustainable Use of Aquatic Resources. International Hydrological Programme, UNESCO, Paris

water resources systems. Both climatic and non-climatic uncertainties need to be classified and addressed through risk assessment including stakeholder engagement to develop adaptive water management strategies.

80. 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 projection and risk communication and stakeholder participation will be further promoted as an integral part of strategies for managing water-related risks.

81. 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.

82. 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 projections and water use scenarios to support decision support system in water resources planning and management.

1.4. 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

83. 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 is an important part of integrated water resources management, also considering urban-rural interlinkages and the urban water systems within their biological regions.

84. 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.

85. 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.

1.5. 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.

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

87. 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.

88. 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.

89. 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 water systems, including transboundary water systems, as appropriate.

90. 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 trade-offs between societal goals related to water management. IHP will build capacity within 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 be pursued 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.

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

91. 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 (2018)’. The Report by the Secretary-General of the United Nations at the 2019 UN High-Level Political Forum on Sustainable Development (HLPF)[12] 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.

92. Multidisciplinary approaches are needed to better understand these changes in hydrological processes. The IXth phase of IHP will enhance and develop multidisciplinary knowledge base to better understand the mechanisms 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. In close collaboration with the World Meteorological Organization, 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; providing appropriate tools and capacity building to ensure risk informed decision-making and allow Member states to strengthen policy and institutional capacity for integrated flood and drought management at the local, national and trans-boundary levels.

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

93. 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, lakes and aquifers serve as lifelines in the landscape and have a central function in the water-energy-food-ecosystem nexus, supplying people with drinking water, renewable energy or transport means but are as well of central importance related to flood risk and droughts. They form the hotspots of biodiversity and reflect immediately climate and land use changes. At the same time rivers are endangered by overuse, interruption of sediment continuity or spatial restriction. Global changes related effects apply pressure on these valuable resources (rivers and aquifers) 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 sedimentation including sediment transport and sediment

[12] 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.

deposition both naturally or due to human activity, including sand and gravel mining, 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.

94. IHP-IX will provide an integrated river, lake and aquifer research and management in the source-to-sea interconnections and trajectory focusing on fundamental processes in river hydrology, hydraulics, sediment dynamics including erosion, transport and deposition, morphodynamics, surface water and groundwater interaction, water quality and river management incorporating socioeconomics challenges and global change drivers while maintaining the health of river ecological environment. As contribution to an improved integrated water management, one output will be a global overview of the status and future of large rivers with the participation of Member States on a voluntary basis. 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 and integrated 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 dependent ecosystems.

95. 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

96. 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 water and sanitation 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 and linked with Sanitation initiatives. The scientific underpinning of sanitation, water quality regulations, standards and criteria is necessary to develop effective water quality monitoring, assessment and management strategies.

97. IHP-IX will continue supporting comprehensive water quality assessments and will enhance knowledge and research promoting an ecosystem-based approach to water quality management, in particular to better understand 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 contribute in providing 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, earth observation, Artificial Intelligence and Internet of Things 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

98. There are seemingly an unending number of Information and Communication Technologies (ICT) innovations and Artificial Intelligence (AI)-related technologies impacting efficient and effective use of water resources and realizing several SDGs related to access to drinking water, sanitation and hygiene, and disaster mitigation.

99. 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. The increasing number of Earth Observations satellites also provide large pool of information on hydrology. 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.

100. 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 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.

101. Exploring the potential of citizen science to complement more traditional ways of scientific data collection and knowledge generation for hydrological sciences and water

resources management might 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 though satellites, low cost sensors and smartphones embedded with web-based mapping tools and global satellite navigation systems exchanged on social networking services (SNSs) by citizen scientists can contribute to water resources management, if effective tools are developed following scientifically valid methodologies to capture, organize, quality control, and make such data available. There is an urgent need for the development and application of proper techniques, including AI, that can merge different sources of data obtained from IoT, remote sensing, and citizen science projects.

102. Citizen science has become one of the tools for hydrological research, enabling the efforts of scientists and citizens to collect data for research to be interpreted by scientists for 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.

103. 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. Concerns about the accuracy and quality of data generated through citizen science hamper full acceptance of such data. There is a need to further elaborate on how and where quality problems in citizen science data can arise, on validation mechanisms and on guidelines, in order to improve the accuracy and quality of such data.

104. IHP-IX will support the development of scientifically valid methods and tools that promote inclusive knowledge generation processes, such as citizens' contribution to scientific research.

105. IHP-IX will therefore create the enabling environment and assist citizens and scientists, through enhanced water knowledge and education programmes to ensure scientific methods are used when participating in and reporting their findings to increase the contribution of citizen science to hydrology research. Training, in particular, will contribute to enhancing accuracy and validity of data. Additionally, scientific 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.

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

106. In line with its Mandate on science, IHP-IX will provide leadership in advancing actionable scientific research and innovation for addressing complex interlinked water challenges building on achievements from previous phases. IHP-IX will continue to promote scientific cooperation and building partnerships 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, Wetlands international and the Ramsar convention on wetlands, 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 disseminating 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 including Sustainability

107. 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 our quality of life.

108. 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. It is a tool that encourages the engagement of all sectors of society to adopt sustainable consumption and production patterns that are in tune with the regeneration pace of ecosystems.

109. 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, awakening critical and emancipatory awareness in citizens in relation to their rights and duties so that they can be active citizens. We must have a cadre of new scientists, planners, and practitioners equipped with appropriate skills for addressing complex interconnected 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.

110. By 2029, a critical mass of decision makers, educators and citizens worldwide will be trained, have their awareness raised and their knowledge enriched on water related challenges and opportunities based on sound scientific and research information to facilitate sustainable water management and governance and governance. Networks of scientists will be strengthened to develop and disseminate related material and conduct the training / raising aware sessions

Relation between this priority area and the Agenda 2030

111. 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.

112. 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 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.

113. 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.

114. 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.

115. Change can be difficult and impeded by any number of obstacles, be it 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.

116. Many people have only a vague understanding of the relationship of their daily lives with the availability of water and often consider 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 programmes 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.

117. It is therefore crucial to emphasize that water education must embrace strategies and techniques that will support people to enhance their awareness and be able to adopt better practices towards protection and sustainable water use and ecosystems. 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 its sustainable management and governance.

118. 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 new possible 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 while keeping in mind the inequality of internet access.

119. 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 the 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 agents of change and promote their involvement in water decision making processes.

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

120. 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.

121. 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. 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.

122. 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.

123. The most efficient way to catalyse this evolution in thinking is through education to all sectors of 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.

124. A key challenge is developing state-of-the-art training programmes 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.

125. 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.

126. 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[13] 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.

127 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.

128 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.

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

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.

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

131 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.

132 The offers of water-related vocational programmes 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 the UNESCO Water Family and in partnership with other UN system agencies and programmes, efforts are needed for maintain and expand the training of technicians

[13] The letter K stands for Kindergarten and 12 for 12th grade. K-12 covers the years from Kindergarten through 12th grade and includes Kindergarten, Primary, Secondary, High-School and Pre-University education

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, Member 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.

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

134 IHP-IX will develop/support development of interdisciplinary materials, such as guidelines, briefing papers, curricula and 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 and key water sector institutions strengthened allowing them to take advantage of new technologies and research to enhance better decisions, design and implementation of integrated and efficient water policies.

135 Even though bottom-up approaches are very important to raise awareness among people, it is crucial to acknowledge that the actions of the decision makers such as governments or big companies have the biggest impacts on society and environment. Therefore, several different strategies need to be implemented to address the needs and interests of all sectors active within community decision-making processes. While good policy requires informed citizens, good decision-making requires sound science, which in-turn requires knowledgeable experts and institutions 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.

136 This suite of approaches will provide decision-makers and institutions with the necessary tools for boosting the transition from an economy based solely on consumption to an economy based on stewardship, sustainability and conservation.

137 IHP-IX will mobilize the UNESCO Water Family in developing adapted training materials and providing technical assistance for the development of interdisciplinary support materials, such as guidelines, information documents, 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 under UN SDG 6 Global Acceleration Framework.

<u>Coordinating Water Education in cooperation with other UN Agencies and partners</u>

138 In line with its mandate as the principal UN educational organization UNESCO through its Water Family and in partnership with the Education Sector will provide leadership on this priority area by providing support on curriculum development, life-long learning and formal, informal and non-formal water education activities from primary schools 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 (with WMO for example on building capacity of national hydrological services) and other relevant partners including water-related NGOs and professional associations and private sector.

Priority Area 3: Bridging the data-knowledge gap

139 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 management and investments. Therefore, both sufficient data and its accessibility need to be ensured and, in many cases, improved.

140 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 necessary to address specific issues. Appropriate data networks among riparian countries need to be established that enable data access from transboundary sources to all interested users. 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.

141 Bridging the data-knowledge gap asks for availability, intergration and processing of data from various disciplines and sources; IHP-IX will take a full use of data and knowledge repositories available within the UNESCO water family, such as a Global

Groundwater Information System (GGIS, since 2004) developed at the International Groundwater Resources Assessment Centre (IGRAC), a Category 2 UNESCO centre.

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

Relation between Priority Area 3 and Agenda 2030

143 Sufficient and reliable 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 be reached through monitoring various related indicators and will support 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 through transboundary cooperation, as appropriate (SDG 6).

144 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 Member States.

<u>Expected outputs:</u>

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

145 Reliable 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.

146 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.

147 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 and exchange strategies and analytical methodologies along with free access to data for all water resources, including transboundary ones. It will further create new / strengthen existing capacities and collaboration at all levels. Strong link to the WMO systems, including WMO Hydrological Observing System (WHOS), World Hydrological Cycle Observing System (WHYCOS), WMO Integrated Global Observing System (WIGOS) and WMO Information System (WIS) is envisaged.

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

148 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, wetlands, arid, tropical, Small Island Developing States 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.

149 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 World Heritage Sites, Biosphere Reserves and Global Geo-parks.

150 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 sustainable water management.

151 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, its maintenance should be a continuous process.

152 Access to reliable and consistent data is fundamentally important for comparative research and decision-making in all water resources, including in transboundary ones. 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 needs to be as accessible as possible. Therefore, data sharing of different data stakeholders will be encouraged. To facilitate data access, where applicable, emphasis should be put on connecting existing web databases, including cloud-based ones, developing data access Application Programming Interfaces (API) and removing technical obstacles to connectivity (e.g. incompatibilities between platforms), as well as in improving web-based platforms and quality assurance protocols.

153 Besides state-of-the-art data collection and exchange protocols by traditional means, remote sensing, Internet of Things (IoT) collection, IoT sensors, the private sector and citizen science can also be encouraged.

154 However, citizen science initiatives often times do not realize their full potential because of the limited reach of their efforts and the compatibility of the data collected. 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 concerned citizens as to how to engage with decision makers more effectively.

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

156 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 of Member States.

157 IHP-IX encourages the inclusion of multidisciplinary data from other UNESCO divisions and sectors 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 era. IHP IX will encourage open access data and support the capacity building of Member States in the development of tools for data accessibility, visibility and connectivity, including platforms targeting citizens and NGOs through scientific programmes.

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).*

158 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.

159 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 and disseminate new methods through multiple media.

160 IHP will work during its ninth phase as a catalyst for development and dissemination of knowledge about 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

161 IHP in its ninth phase will cooperate with various UN agencies and partners in contributing to bridging the data-knowledge gap for better water management. UNESCO water programmes/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), the WMO Hydrological Observing System (WHOS), the World Hydrological Cycle Observing System (WHYCOS), the Global Hydrometry Support Facility (WMO HydroHub) and various global water data centres under auspices of different UN organisations and various global water data centres under auspices of different UN organisations and programmes such as the Global Precipitation Climatology Centre (GPCC/WMO), Global Runoff Data Centre (GRDC/WMO), International Data Centre on Hydrology of Lakes and Reservoirs (HYDROLARE), International Soil Moisture Network

(ISMN), AQUASTAT and WaPOR (FAO), GWDC (GEMS/Water Data Centre/UNEP), Global Cryosphere Watch (GCW/WMO), the World Glacier Monitoring Service (WGMS), all federated in the Global Terrestrial Network Hydrology (GTN-H) hosted at the International Centre of Water Resources and Global Change (ICWRGC), a UNESCO Category 2 Centre (C2C). 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 acceleration framework. The excellent cooperation with WMO on the Global Groundwater Monitoring Network (GGMN, since 2007) implemented by UNESCO's C2C, IGRAC, will be used as an example to follow. 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: Integrated water resources management under conditions of global change

162 Healthy rivers, lakes, wetlands, aquifers, and glaciers do not just supply safe drinking water, safeguard biodiversity 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 manner and is frequently considered a shared responsibility among many different governmental institutions.

163 Global change is simultaneously a threat and an opportunity for integrated water management. Water management should be inclusive to strengthen 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.

164 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.

Relationship between Priority Area 4 and Agenda 2030

165 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 as appropriate (6.5.2) and protecting and restoring water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes (6.6 and 15.1).

166 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.

167 The gap between water policies and its integrated management can become great, if it is not always considered in an integrated and inclusive manner, including in consultative and decision-making processes.

168 Social participation of vulnerable and minority groups, (inter alia of women, youth, indigenous groups, national minorities) may lead to 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.

169 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 ensured 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, fishery, leisure activities, water supply, drought risk management and flood risk management conducted and shared by the scientific community and UNESCO Water Family to minimize socio-economic and ecological consequences.

170 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. Furthermore, an Integrated River Research and Management (IRM) is needed to improve upstream-downstream river uses, minimize Global Change effects and improve ecosystem services of rivers.

171 A 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. The upstream-downstream integration includes the research and improved river management concerning water, sediment and ecological continuity being affected by river uses and better understanding trajectories of change over time.

172 IHP-IX will build capacity on the WCM approach and IRM 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, in support of improving Water Cycle Management (WCM), strengthening capacities of local, regional, and national decision-makers, and enhanced acceptance of public.

173 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 regarding 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).

174 IHP will continue its efforts to promote better implementation of the WCM by collaborating in it the development and implementation of NCWRs based on different regional realities with a particular emphasis on new technologies with lower costs. IHP will explore how NCWR can be incorporated when planning sustainable use of water demand. 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 integrated water resources management for all watersheds, including transboundary ones.

175 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.

176 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.

177 It is necessary that water, food, energy, and ecosystems be viewed not as separate entities, but rather as complex and inextricably intertwined sectors needed 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 the 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.

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

179 IHP-IX will support informed decision on nexus by providing evidence, scenarios, concrete tools to implement nexus approach 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, wetlands) and groundwater improved by the scientific community and UNESCO Water Family to prevent and reduce water pollution and underpin water resources management strategies.

180 Freshwater resources pollution is worsening throughout the world, calling for urgent action 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.

181 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 of 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), 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 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 complementarity 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.

182 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 solutions and 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.

183 The UNESCO-IHP ecohydrology network and especially the demonstration sites (26 in 19 countries) has developed the understanding of water-ecosystems-society interactions, translated into innovative ecohydrological solutions and nature-based Solutions 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).

184 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.

185 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 mountain lakes, and aquifers, by the scientific community supported for improved understanding of their potential use to inform decision makers at all levels.

186 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.

187 IHP will promote scientific research to enhance understanding of water availability from the 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.

188 IHP IX will support strengthening national and regional capacities to monitor and assess aquifers and Glacial Lake Outburst Flood (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.

189 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. Further to spatial-temporal optimization of water resources management based on ecohydrological soundness, 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, wetlands, coastal hinterlands, and mountainous areas, which should receive major assistance in the development and sharing of new methodologies and tools.

190 The spatial-temporal optimization reflects the ‘regional-specific condition’ considering the seasonality and the hydraulic and hydrologic factors of each study area. It is essential to consider the ecological and hydrological factors and effects in achieving the spatial-temporal optimization. The strategy focusing on the human benefit alone may destroy the ecosystem and cause a food and agricultural problem in the long-term perspective.

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

192 Currently, over 260 transboundary river basins and more than 600 transboundary aquifers have been identified. Transboundary water resources need to be managed in a mutually beneficial manner by all riparian states. Agenda 2030 through Target 6.5

emphasizes the importance of transboundary cooperation. Monitoring of transboundary cooperation provides impetus for countries to assess the 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 Member States in monitoring and 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 countries to negotiate cooperative arrangements.

Cooperating with other UN Agencies and scientific partners

193 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.

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

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

195 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. The UNGA resolution A/RES/68/118 on the Law of Transboundary Aquifers, is an example of how UNESCO's scientific support can help in the preparation of water governance related work. The Resolution calls encourages the IHP of UNESCO to continue its contribution by offering further scientific and technical assistance to the States concerned;

196 **By 2029, Member States use science-based tools, capacity and knowledge addressing adaptation and mitigation to climate change**. **to significantly reduced water governance gaps.**

Relationship between Priority Area 5 and Agenda 2030

197 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 as appropriate (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).

198 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).

199 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 the implementation of integrated water resource management at all levels, including through transboundary cooperation as appropriate (target 6.5) and SDG17 (partnerships for sustainable development). Any successful sustainable development programme, 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.

<u>Expected outputs:</u>

5.1 Awareness raising of decision makers at all levels on the importance of science-based water governance by the UNESCO Water Family supported, to enhance the overall resilience of communities to effects of global change.

200 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 prosperous communities and governance structures, without leaving anyone behind.

201 Water governance requires the ability to understand and take into consideration 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, to promote equitable and improved access to water or to rehabilitate ecosystems to a suitable state.

202 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.

203 Water governance should therefore facilitate adaptation, mitigation and resilience processes considering the human factor, including climate change, impact on the hydrological and nutrient cycles in ecosystems and based on scientific facts. Ultimately, adequate water governance is a fundamental and solid pillar to guarantee sustainable water security for all.

204 IHP-IX will disseminate scientific results, best practices and will consider various tailored and targeted methods including among other events (thematic discussions, roundtables, seminars, webinars, workshops, conferences, debates, exhibitions etc.), campaigns, engaging with media 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. Integration of sound science in water governance instruments improved reflecting adaptation to climate change and IWRM, integrating surface and groundwater for their uptake by decision makers.

205 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.

206 The fast-increasing rate of urban populations and development of megacities and massive migration and other factors are challenges to the achievement of SDG 6, and thus may jeopardizes good water governance. Among them are resource mismanagement, corruption, inappropriate and malfunctioning legal and institutional arrangements, lack of cooperation within river basins, bureaucratic inertia, insufficient human capacity, and a shortage of funding for investments.

207 The UNESCO Water Family will provide scientific knowledge to support Member States to shape, improve and update (if necessary) their water governance frameworks so that they are scientifically based and flexible to respond to the water challenges associated with mitigation, adaptation and resilience to global changes. Building on the scientific knowledge produced within relevant and various outputs and existing best practices, methodologies and guidelines for better integration of reliable science in water governance instruments will be produced and disseminated, and Member States capacity enhanced.

5.3. 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.

208 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. The 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.

209 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;

210 IHP-IX will support evidence-based climate policy making by providing a science-based analysis of current inclusion of water-related content into the global climate change regime under the UNFCCC, including within Nationally Determined Contributions (NDCs) and National Adaptation Plan (NAPs), developing also recommendations and supplements to the UNFCCC work on guidelines for better integrating water and supporting the increased ambition in the periodical re-submission of NDCs and new sub-missions of NAPs, at the same time supporting the Measuring, Reporting and Verification mechanism of the Paris Agreement. These activities will be realized in liaison with UNFCCC Secretariat and in collaboration with relevant UN bodies (agencies and programs) who are also involved in the development of such supplements, to ensure appropriate harmonization of actions and to avoid duplication of efforts.

5.4. 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.

211 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.

212 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.

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

214 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.

215 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 within UNESCO's Member States to the results of this research.

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

216 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" (EEA, 2015, 12).

217 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.

218 A multidisciplinary science approach (Hydrological, Social and 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.

Cooperating with other UN Agencies and scientific partners

219 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.

220 IHP-IX will cooperate with other UN agencies and other partners including Scientific Unions, intergovernmental organizations, Non-Governmental organizations and international financial institutions and others in contributing to improve water governance based on science for building resilient societies

221 IHP will provide scientific knowledge and research skills cooperating with existing initiatives and Organizations, such as UNDP, UNECE, UNEP, UNFCCC, IAEA, WMO, OECD, SIWI as well as GWP and others, in the case of all water resources, including transboundary ones.

Outreach and Communication

222 Effective communication and outreach are integral key components of IHP-IX. The communication flow among the implementing actors of IHP-IX is a prerequisite for the Programme's impactful realization. The proactive cooperation of the members of the UNESCO Water Family and its partners requires reliable networking and communication capacities as key tools for IHP-IX. IHP-WINS provides a pivotal asset in this regard.

223 Communication and outreach of IHP-IX endeavour, simultaneously, the strengthening of the collaborative engagement of IHP's family network and other stakeholders and partners and increased public visibility and recognition of IHP-IX and its role in contributing to global water security.

224 IHP-IX systematically integrates communication and outreach in its implementation at all levels, including feedback mechanisms which will allow harnessing the Programme's outputs and outcomes both to enhance and demonstrate impact. Effective implementation of the IHP outreach and communication strategy is crucial in increasing the visibility of IHP-IX and contributing to mobilize more partnerships and funding for an impactful implementation of the programme.

Way forward

225 This ninth phase of IHP-IX will cover the next eight years almost until the end of agenda 2030. It is designed to support Members States in achieving SDG6 and other water-related SDGs and international water-related agendas towards a water secure world and resilient societies. Its implementation will among others contribute to the UN SDG6 Global Accelerator Framework and the UN Water Action Decade (2018-2028). Its success should be measured based on the progress made by Members States in addressing global complex interlinkages and water challenges by people and institutions having adequate capacity and scientifically based knowledge to make informed decisions on water management and governance to attain sustainable development and to build resilient societies.

226 The overall implementation of IHP-IX will be led by UNESCO's Water Family and will benefit from partnerships with UN-Water and its members, academic and scientific organizations and associations, Intergovernmental organizations, regional, or national organizations, Non-Governmental organizations, global funds, research / academia and the private sector.

227 The implementation of this strategic plan will be guided by an Operational-Implementation Plan, to be elaborated after the approval of the strategic plan by the IHP council. It will guide the incremental achievements of the strategic plan, grounded in key lessons learned during implementation and adjustments to changing contexts, capacities and resource availability. Specific activities and deliverables including milestones in line with each of the outputs under each priority areas will be identified.

228 The operational plan will also identify the entities responsible for the respective outputs/deliverables. Specific measurable indicators will be developed for each of the specified outputs/deliverables and the means of verification to enable the different stakeholders capture the relevant information and data for a clear monitoring and evaluation. Regular reviews of the operational plan will be performed to be presented at the bureau and IHP council meetings to take stock of the achievements and challenges, and to draw lessons allowing adjustments in the remaining part of the plan.

229 All Members States and the UNESCO Water Family, comprising the national IHP committees, the centres, chairs, flagships/initiatives and WWAP and key partners will be mobilized in the preparation of the operational-implementation plan. In line with the intergovernmental nature of IHP and the recommendations of the mid-term external evaluation of IHP-VIII, Members states and their related UNESCO water family entities should play a key role in the implementation of the operational plan by identifying outputs for which they can actively contribute to and/or provide (co-)leadership. A clear implementation framework will be proposed by the secretariat in that regard in line with the new IHP statutes including among others the establishment of thematic implementation working groups to be discussed and approved by the IHP council. A Financing Strategy will also be prepared to ensure implementation of IHP-IX.

Glossary

Term	Definition
Citizen Science	**With reference to and in line with the UNESCO Open Science Recommendation, para. 10 [exact reference to be included]: Citizen Science** is the voluntary participation of citizens in scientific research and data collection, frequently under the direction of professional scientists and/or in association with scientific institutions or formal scientific programmes, following scientifically valid methodologies.
Ecohydrology	A branch of hydrology, which highlights the relationships between hydrological, biological and ecological processes at different scales and translates them into nature-based solutions to improve water security, enhance biodiversity and create opportunities for sustainable development by harmonizing socio-economic needs and environmental potential. https://en.unesco.org/themes/water-security/hydrology/ecohydrology
Holistic Water Management	Water management practices and solutions where one deals with or treats the whole of the water system, cycle and its resources, not just a part.
Hydro-informatics	A mathematical model-based field of study of the flow of information and the generation of knowledge related to the dynamics of water in the real world, through the integration of information and communication technologies for data acquisition, modeling and decision support, and taking into account the consequences for the aquatic environment and society and for the management of water-based systems (UNESCO-IHE, currently IHE-Delft, www.unesco-ihe.org)
Hydro (water) policy	Water resource policy encompasses the policy-making processes that affect the collection, preparation, use and disposal of water to support human uses and protect environmental quality. Water policy addresses provision, use, disposal and sustainability decisions. (https://www.wikiwand.com/en/Water_resource_policy)
Hydrotechnical Engineering	A branch of science and technology concerned with the study of water resources and their use for various purposes, as well as the prevention of the damaging effect of water; https://www.epictraining.ca/course-catalogue/civil/10453/hydrotechnical-engineering-for-non-hydrotechnical-engineers

Inclusive Water Management	Integrated water (resources) management practices aiming to include, integrate, and have the participation of all diverse people and groups in its activities, organizations, political processes, etc., with special attention to those who are disadvantaged, have suffered discrimination, or are living with disabilities
Integrated Water Resources Management	(1) Development and operation of regional water resources, taking into account hydrological and technical aspects, as well as socio-economic, political and environmental dimensions. (WMO UNESCO Glossary) (2) A process which promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (Global Water Partnership) (3)
Nature-Based Solutions (NBS)	Actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits, with climate change, food security, disaster risks, water security, social and economic development as well as human health being the common societal challenges (Cohen-Shacham, E., G. Walters, C. Janzen, S. Maginnis (eds). 2016. Nature-based solutions to address global societal challenges. Gland, Switzerland: IUCN. Xiii + 97 pp. Downloadable from https://portals.iucn.org/library/node/46191)
Non-conventional water resources	Water resources that are generated as a by-product of specialized processes such as desalination; or that need suitable pre-use treatment; or pertinent on-farm management when used for irrigation; or need a special technology to collect/access water. (https://inweh.unu.edu/projects/unconventional-water-resources/)
Open Science **Open Data**	The idea behind Open Science is to allow scientific information, data and outputs to be more widely accessible (Open Access) and more reliably harnessed (Open Data) with the active engagement of all the stakeholders (Open to Society) https://en.unesco.org/science-sustainable-future/open-science
Socio-hydrology	An interdisciplinary field studying the dynamic interactions and feedbacks between water and people, in areas such as the historical study of the interplay

	between hydrological and social processes, comparative analysis of the co-evolution and self-organization of human and water systems in different cultures, and process-based modelling of coupled human-water systems. (Sivapalan, Murugesu; Savenije, Hubert H. G.; Blöschl, Günter (2012-04-15). "Socio-hydrology: A new science of people and water: INVITED COMMENTARY". Hydrological Processes. 26 (8): 1270–1276. doi:10.1002/hyp.8426.)
Sustainable water management	Sustainable water management means the ability to meet the water needs of the present without compromising the ability of future generations to do the same https://www.aquatechtrade.com/news/water-treatment/sustainable-water-essential-guide/#what-is-water-sustainability
Transdisciplinarity/Transdisciplinary research	A research mode for generating knowledge about complex societal problems by integrating knowledge of multiple scientific disciplines and various stakeholders from outside of academia. Transdisciplinary research on a jointly defined problem generates knowledge that is both valuable for society and science. It aims at three types of knowledge, 1) system knowledge about the human-environment system, 2) goal knowledge about the envision state of the system and 3) transformation knowledge about how to reach the envisioned state. Transdisciplinary research requires context-specific methods and a self-reflexive approach. (Jahn, T. Bergmann, M., Keil, F. (2012): Transdisciplinarity: Between mainstreaming and marginalization. Ecological Economics, Vol. 79, 1–10)
Urban metabolism	Urban Metabolism is defined as "the sum total of the technical and socio-economic process that occur in cities, resulting in growth, production of energy and elimination of waste… [taking into account] four fundamental flows or cycles, those of water, materials, energy, and nutrients". (Kennedy, Cuddihy et al. 2007) Circular urban metabolism refers to the combination of circular economy principles to the urban metabolism approach.
Water culture	(1) the way of relations to water in life, especially the general customs and beliefs, of a particular group of people at a particular time

	(https://dictionary.cambridge.org/dictionary/english/culture) (2) The definition of cultural water means the values and demands of specific water sources that relate to a specific geographic area, a cultural group, a religion or heritage requirement, etc. (https://www.yourdictionary.com/cultural-water) (3) *The growing of plants in water, (in later use) especially in an artificial system with or (usually) without a solid substrate. (https://www.lexico.com/definition/water_culture)
Water Governance	(1) The range of formal and informal political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society (GWP. GLOBAL WATER PARTNERSHIP. www.gwpforum.org/servlet/PSP) (2) Water governance is the set of rules, practices, and processes (formal and informal) through which decisions for the management of water resources and services are taken and implemented, stakeholders articulate their interest, and decision-makers are held accountable (OECD, 2015a).
Water Management Master Plan	Water Master Plan is to establish a basic framework for: orderly and integrated planning and implementation of water resources programmes and projects; and a rational water resources management consistent with overall national socioeconomic development objectives. (Guidelines for the preparation of National Water Master Plans, Water Resources Series No. 65, UN, N.Y. 1989)
Water Stress & **Water Scarcity**	The amount of available renewable water resources per capita per year based on estimates of water requirements in the household, agricultural, industrial and energy sectors, and the needs of the environment. Countries whose renewable water supplies cannot sustain 1700 m^3 are said to experience water stress. When supply falls below 1,000 m^3 a country experiences water scarcity, and below 500 m^3 absolute scarcity. Falkenmark, Lundqvist and Widstrand, 1989 UNESCO 2011: Ethics and Climate Change in Asia and the Pacific (ECCAP) Project, Working Group 14 Report, Water Ethics and Water Resource Management, 2011; https://unesdoc.unesco.org/ark:/48223/pf0000192256 Rijsberman, F. R. 2005. Water Scarcity: Fact or Fiction? Proceeding of the 4th International Crop Science

	Congress, 26 September - 1 Octobor 2004. Brisbane, Australia. Published in CD-Rom. Website: www.cropscience.org)
Water Stakeholder	An institution, organization or group that has some interest in a particular sector or system or outcome of a project, program or policy initiative related to water (EEA. European Environmental Agency. www.eea.eu.int/; glossary: eea.eu.int/EEAGlossary/)

Indicative List of Partners

(provisional)

UN entities, Intergovernmental Organizations:

FAO; GEF; UNDESA; UNDP, UNDP-GEF; UNDRR ; UNECE; UNEP, UNEP-GEF ; UN-HABITAT ; UNICEF; UNOOSA; UNU; WHO; WMO, UN Economic Commission for Africa (UNECA), UN Economic Commission for Europe (UNECE), UN Economic and Social Commission for Asia and the Pacific (UNESCAP), UN Economic Commission for Latin America and the Caribbean (UNECLAC), UN Economic and Social Commission for Western Asia (UNESCWA)

The African Ministers' Council on Water (AMCOW); OECD

National and international organizations:

National and international river basin Organizations

Professional scientific organizations:

IACS; IAH; IAHR; IAHS; IUGG; IWRA; WGMS

Academic institutions, research centres and programmes:

All 36 Category 2 water related Centres and 66 UNESCO Water related Chairs

AGRHYMET; Global Water Future (GWF); HWISE; SIWI, Global Energy and Water Exchanges (GEWEX); IWMI

Conventions:

Convention on the Law of the Non-navigational Uses of International Watercourses (New York, 1997); Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Helsinki, 1992); UNFCCC; UNCCD; Convention on wetlands of international importance (Ramsar, 1971)

Non-governmental Organizations:

World Water Council (WWC), Alliance for Global Water Adaptation (AGWA); Future Water; GWP, GWP-Med; W-SMART

Private sector:

Gallup; various water utilities

Annex 1: Theory of Change diagram

Impact

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.

Assumptions

- Political will to manage and govern water resources sustainably
- Active involvement of local actors and organizations
- Legislation and policies reflecting local socio-economic condition and aligned with with International standards
- Indirect beneficiaries have access to other enabling conditions

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 achieving water-related SDGs and other related International agreements

Priority Area PIs

- # of MS/stakeholder use improved water science, research and apply the strengthened capacities to expand knowledge and better manage services and related risks at all levels
- # of MS with enhanced water informal, formal and non-formal education at all levels
- # of MS, which use scientific data and knowledge to better manage their water resources
- Degree of inclusive water management to addressing global challenges practice by # of MS
- Degree of implementation of mechanisms and policies based on science to strengthen water governance for mitigation, adaptation and resilience by # of MS
- Enabler: # of water family members leading the water agenda at all levels

Assumptions

- Member States and the general public are able and willing to utilize the knowledge and support provided
- Scientific community and other partners produce transdisciplinary research and support the proposed priorities
- Financing proposed activities and project continues and increases

Sample Outputs

- Undertaking and sharing assessment on the interaction between human and water systems in line with socio-hydrology
- Capacities of skilled professionals at water-related tertiary and vocational education strengthened
- Capacity of scientific community strengthened to develop, share and apply scientific tools
- Undertaking and sharing assessment of ecosystem services and environmental flows in ecohydrology pilot sites
- Development and use of scientific research methods by the scientific community supported
- Conducting and sharing of research on novel approaches of adaptive water management
- Undertaking and sharing assessment on the interaction between human and water systems in line with socio-hydrology
- Teaching and learning material on water-related matters for formal, non-formal and informal education at all levels elaborated
- Data on water quantity, quality and use available, accessible, comparable and validated in a format easy to understand for its utilization by all users on open access
- Data access and data sharing mechanisms and systems are enhanced

Assumptions

- New knowledge understood
- Interest and commitment of stakeholders
- Appropriate approach and material
- Direct beneficiaries reached
- Sufficient representatives with the time and will to participate
- New practices understood
- Enabling environment

Sample Activities

- Organization of 'N°' gender-balanced multi-stakeholder validation
- Undertaking a mapping of … stakeholders to …
- Elaboration of 'N°' gender responsive publication/ reports/tools/models on
- Organization of 'N°' training workshops for 'N°' gender balanced teams of … from 'N°' countries on … to …, using gender
- Organization of 'N°' technical support/Policy advice missions/meetings to design or revise gender responsive … in 'N°' countries
- Scoping of existing … networks active on …
- Conduct capacity and stakeholder analysis to …
- Analysis and consolidation of recommendations for …

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

Annex 2: Main questions of modern hydrology*

Time variability and change

1. Is the hydrological cycle regionally accelerating/decelerating under climate and environmental change and are there tipping points (irreversible changes)?

2. How will cold region runoff and groundwater change in a warmer climate (e.g. with glacier melt and permafrost thaw)?

3. What are the mechanisms by which climate change and water use alter ephemeral rivers and groundwater in (semi-) arid regions?

4. What are the impacts of land cover change and soil disturbances on water and energy fluxes at the land surface, and on the resulting groundwater recharge?

Space variability and scaling

5. What causes spatial heterogeneity and homogeneity in runoff, evaporation, subsurface water and material fluxes (carbon and other nutrients, sediments), and in their sensitivity to their controls (e.g. snow fall regime, aridity, reaction coefficients)?

6. What are the hydrologic laws at the catchment scale and how do they change with scale?

7. Why is most flow preferential across multiple scales and how does such behaviour co-evolve with the critical zone?

8. Why do streams respond so quickly to precipitation inputs when storm flow is so old, and what is the transit time distribution of water in the terrestrial water cycle?

Variability of extremes

9. How do flood-rich and drought-rich periods arise, are they changing, and if so why?

10. Why are runoff extremes in some catchments more sensitive to land-use/cover and geomorphic change than in others?

11. Why, how and when do rain-on-snow events produce exceptional runoff?

Interfaces in hydrology

12. What are the processes that control hillslope-riparian-stream-groundwater interactions and when do the compartments connect?

13. What are the processes controlling the fluxes of groundwater across boundaries (e.g. groundwater recharge, inter-catchment fluxes and discharge to oceans)?

14. What factors contribute to the long-term persistence of sources responsible for the degradation of water-quality?

15. What are the extent, fate and impact of contaminants of emerging concern and how are microbial pathogens removed or inactivated in the subsurface?

Measurements and data

16. How can we use innovative technologies to measure surface and subsurface properties, states and fluxes, at a range of spatial and temporal scales?

17. What is the relative value of traditional hydrological observations vs soft data (qualitative observations from lay-persons, from data mining etc.), and under what conditions can we substitute space for time?

18. How can we extract information from available data on human and water systems in order to inform the building process of socio-hydrological conceptualisations and models?

Modelling methods

19. How can hydrological models be adapted to be able to extrapolate to changing conditions, including changing vegetation dynamics?

20. How can we disentangle and reduce model structural/parameter/input uncertainty in hydrological prediction?

Interfaces with society

21. How can the (un)certainty in hydrological predictions be communicated to decision makers and the general public?

22. What are the synergies and tradeoffs between societal goals related to water management (e.g. water-environment-energy-food-health)?

23. What is the role of water in migration, urbanisation and the dynamics of human civilisations, and what are the implications for contemporary water management?

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