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2ND-ORDER DRAFT OF THE STRATEGIC PLAN OF THE 9TH PHASE OF IHP (IHP-IX, 2022-2029)

Sub-item 4.6 of the provisional agenda

Summary

This document contains the 2nd-order draft Strategy for the ninth phase of the IHP (2022-2029), elaborated by the Task Force and Experts designated by the Members States.

United Nations Educational, Scientific and Cultural Organization · Intergovernmental Hydrological Programme

IHP-IX

The ninth phase of the Intergovernmental Hydrological Programme 2022-2029

2nd ORDER DRAFT 28 September 2020

Title (alternatives)

Holistic Science for-based Water Security to Sustain Development in a Changing World

A Water Secure World: Science and Education for Sustainable Living

Holistic Science for Water Security in a Changing World

Science for a Water Secure World in a Changing Environment

Finding solutions for people and nature through water in an uncertain world (proposal from IHP-VIII mid-term evaluation)

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Title

The Strategic Plan for the ninth phase of the Intergovernmental Hydrological Programme (IHP-IX) covering 2022-2029 identifies priority areas in support of Members States to achieve the SDGs focusing on SDG6 and other water related global agendas such as the Paris agreement on climate change, Sendai Framework on Disaster Risk Reduction (DRR) and the New Urban Agenda (NUA).

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

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

Preamble

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

We live in a time of unprecedented risks, but also of great opportunities for the future of our planet. Natural systems that support life are affected by what many scientists consider the supreme challenges of our time such as changing lifestyle consumption patterns, population increase, urbanization, and climate change, and their impact on hydrological behaviors, the availability of freshwater for human consumption and for sustainable development and their combined effects on extreme climatic events. The current COVID-19 global pandemic posed additional limitations to the boundary conditions, restricting the capability of humans to interact and to learn how to deal with synchronous and / or cascading hazards. However, if this pandemic has taught us anything it is the fundamental importance of the relationship between clean water and basic sanitation and the need for cooperation and transparency in sharing data and lessons learned to the collective benefit of the global community.

The ever-increasing pace of environmental changes intertwined with human dimensions calls for better understanding of hydrology. The interaction between human activities and water systems needs to be considered to develop scenarios for water resources management. IHP-IX will provide a platform and venue to address those scenarios in cooperation with the international scientific community including soliciting ideas for holistic science for hydrology, which will also contribute to address many unsolved problems in hydrology (Blöschl et al., 2019[1]).

The purpose of this strategic plan is to outline a compelling and strategic focus for the Intergovernmental Hydrological Programme for the 2022-2029 period, rather than an exhaustive diagnosis of the water sector. The approach and prioritization presented aligns with UNESCO's principal mandates in Sciences and Education as well as its comparative advantage in responding to the needs of Member States supporting them to capitalize on scientific and technological advances as they face water related global challenges.

Global water challenges and opportunities

Global Water Challenges

Although water is mostly a renewable resource, it is increasingly scarce due to the presence of the human factor, particularly in the large metropoles, productive centres, agricultural latitudes, arid and semi-arid regions. The impact of economic and demographic growth on the water balance and the quality of freshwater, forces us to deepen and expand our comprehensive knowledge of hydrology and management of water, not only among experts, but also with all users, citizens and decision makers. 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 understanding the use of water through holistic scientific research, together with education and training for its sustainable management, constitute unavoidable keystones for leading 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

Despite the intrinsic value of freshwater to human health, prosperity and security, challenges of water scarcity and quality, poor sanitation and water-related disasters confront billions worldwide. Almost half of the world's population will be living in high water stress areas by 2030 (WWDR, 2019). Water-related risks will further upsurge because of increasing climate instability, demographic growth and human migration putting pressure on the water resources. Indeed, more than 65 million people were involuntarily displaced at the end of 2016 (UNHCR, 2017) and unfortunately the trend has continued to increase in severity.

One of the greatest challenges for the hydrological community is to identify appropriate and timely adaptation measures in a continuously changing environment. Optimizing ecosystem services and enhancing the resilience of river basins to climatic and anthropogenic stress can greatly contribute to reaching these goals.

Clean water for human and ecosystem health

In 2019 the World Water Development Report estimated that three out of ten people do not have access to safe drinking water and according to WHO (2017) around 4.2 billion people lacked safe sanitation services. The degradation of water quality directly affects the health of people and the environment, as well as the economy, and the increasing costs associated with cleaning contaminated water make it unavailable in many corners of the world. Clear evidence includes eutrophication (high loads of nutrients, such as phosphorous and nitrogen) and acidification of surface- and groundwater systems. Further complicating the cocktail of pollutants traditionally present in insufficiently treated surface water or untreated wastewater, emerging contaminants related to pharmaceuticals and hospital wastes, micro-plastics, complex pesticides and other industrial and household chemicals, metals, surfactants, industrial additives and solvents have all reached levels that necessitate research and new approaches on the way to address them.

Water related disasters

Disasters triggered by hydro-meteorological events surpass in number all other disasters combined. Floods, droughts, and windstorms have been the most frequently occurring disaster events since 1900, accounting for 88.5% of the thousand most disastrous events. In the last decade, floods and extreme rainfall events have surged globally by more than 50% now occurring four times more often than in 1980s. During the two decades from 2000 to 2020, floods and droughts killed more than 166,000 people, affected another three billion and inflicted total economic damage of close to US$700 billion (EM-DAT, 2019; UNESCO World Water Assessment Programme, 2020).

Public understanding about the value of water

Changing established societal habits and productive models with respect to water is an overwhelming challenge, but necessary and urgent, since if it does not happen, our bad habits, especially in urban areas, will continue to degrade the quality and quantity of water available. Aquifers are often subject to irreversible damage when affected by excessive withdrawals, surface hardening, saline intrusion, or contamination which overtime reaches the groundwater table, and their recharge areas are diminished.

Education at all levels is vital to catalysing understanding and interest in improving water management in all of ramifications, including fostering wide acceptance of water conservation measures, pro-active involvement of citizens´ water groups, and greater concern for water pollution. Despite increasing international recognition of education for sustainable development (ESD) and education for sustainable consumption (ESC), mainstreaming of water education for sustainable consumption in formal education curricula as well as in informal education remains a challenge. Various networks, initiatives, and tools, which have been developed in different regions, have not yet succeeded in having a significant impact on educational policies and practices. More efforts are needed to validate and disseminate an experience-based model for institutional strengthening of ESD through policymaking and implementation at a national level.

Expanding acceptance of holistic water management

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

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

Such a model faces many difficulties in terms of temporal and spatial scales and the complexity of model formulation, data quality and calibration, results interpretation and dissemination, the increasing importance and necessity of citizen science inputs, as well as the issues surrounding comprehensive data collection and handling. Collaborative strategies for managing water data between scientific organizations and UN agencies, Member States and stakeholders also present a major challenge.

Opportunities

It is not sufficient to simply recognize and understand the problems water managers are facing. Effective solutions must be identified and included in the programmes proposed for IHP-IX, primarily organized as part of scientific, education and technology related strategies and responses. In 2019 there are 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; in short, water stewardship. UNESCO's Operational Strategy on Youth will provide the basis upon which the involvement of young experts will be founded. The role of women and girls should not be overlooked as agent of change for improved water culture and better water management and governance.

Investing in scientific research and innovation

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

There are several opportunities for investing in science that will be supported by IHP-IX including hydrological research and its relationship with citizen science. This will allow the combined efforts of scientists and the public to better understand the water cycle and the behaviour of the people who use it. Furthermore, social hydrology provides an interdisciplinary field studying the dynamic interactions between water and people and an opportunity to showcase UNESCO's comparative advantage of interdisciplinarity when conducting

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

scientific research on water. *Enhancing scientific research and cooperation can help bridge data and knowledge gaps.*

Additionally, IHP's support to ecohydrology research, innovating and expanding its boundaries and improving Integrated Management of Water Resources (IWRM) will continue, as will its collaboration in investigations on the effects of climate change, reducing the impacts of natural hazards and improving adaptation to global changes.

New water conservation technologies

In areas where surface water is more polluted increasing the cost of treatment, where aquifers are drying up, and where rainwater is increasingly unpredictable, innovation and investment in research at scale is needed. Additionally, partnerships with private entrepreneurs and NGOs to build the knowledge base and trust of the community could multiply the positive impacts of employing new technologies, particularly in rural and traditional societies.

Improving water catchment and harvesting methods, recycling wastewater and reducing capital investment and maintenance costs for membrane technology as well as developing creative ways to purify and reuse grey water for agriculture and even human consumption, improving irrigation and agricultural practices, upgrading old infrastructure and technologies, promoting energy efficient desalination technologies such as solar-powered plants, and improving water catchment and harvesting techniques, are all examples where opportunities exist to strengthen our scientific knowledge for the benefit of humanity and of the environment.

Water education for sustainable production and consumption

Education is still the foundation upon which behaviours can change and consensus can be built for sustainable water resource decisions. *Enhanced capacity and public awareness towards a sustainable water culture and water management is required.* Coping with water scarcity will require a major overhaul of all forms of production and consumption, from individual use to manufacturing and supply chains as well as education at all levels, formal, non-formal and informal. This is our best hope for improving what has obviously become a dire situation in large parts of the world.

Sustainable production is about decoupling economic growth from environmental degradation, increasing resource efficiency, and promoting sustainable lifestyles, doing more and better with less. The water, energy and food nexus is the key element to consider if we have any hope of making such substantive changes in how we live. IHP-IX will link with the Man and Biosphere (MAB) programme, the Geopark and Geoscience programmes, the LINKS programme and also with UNESCO's Education Sector and UNEP's efforts on "Education for Sustainable

Consumption" in its proposed actions in this area building on the UNESCO designated sites.

Education can likewise foster development of international frameworks and institutional cooperation. Catalysing international agreements for natural resource issues is difficult to achieve but can benefit from the input of the IHP experience, especially in transboundary water bodies, comprehensive water management planning, and water conflict negotiations.

Investing in water governance

To enhance the resilience of societies, decisions should be made based on evidence. Improving the effectiveness of water governance is strongly supported as a cornerstone to IHP-IX to enable Member States to implement decisions based on science to build more resilient and peaceful communities. It is recognized as a long-term activity that includes master plans, financing structures, and implementation of projects based on science, as well as partnerships of all stakeholders in building and maintaining sustainable water systems, the foundation of long-term resilience. Encouraging the development of community-based governance partnerships at the grassroots level can lead to effective policy changes at the national or even regional levels, particularly in transboundary basins.

A major push in educating water managers to new technologies has substantially reduced the skill-gap prohibiting adequate water governance. However, enhancement of legal, policy and institutional frameworks to support water governance has lagged. This reality provides IHP with an opportunity to apply the principles of the "from Potential Conflict to Cooperation Potential" (PC-CP) programme in conflict negotiation as well as the skill sets of water diplomacy.

Global Water Landscape: framework and global agendas

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.

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

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

IHP Vision

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

IHP-IX Mission

Our mission for the period 2022-2029 is to support the Member States to accelerate the implementation of water-related SDGs and other relevant frameworks through water science and education.
To this end IHP-IX will:

a. Promote international scientific research and cooperation for improved knowledge to address water and climate challenges incorporating the interaction between human and water systems.
b. Mobilize and disseminate effectively scientific and policy relevant expertise and knowledge for informed decisions in addressing water challenges.
c. 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.
d. Raise awareness and promote a water culture at all levels for conserving, protecting and valuing water.

e. Support Members States in better understanding, valuing, and managing their water resources.
f. Support the SDG6 Global Accelerator Framework including the associated water and climate coalition in terms of understanding and implementing solutions to global water problems.

Strategic Objectives, Outcomes and Priority Areas

The ninth phase of IHP has two strategic objectives, three outcomes (plus an enabling outcome) and five priority areas that were defined according to the main challenges and opportunities identifies by the Member States. Each of these priority areas are linked with the SDGs/Agenda2030 highlighting their outputs.

Strategic Objectives

Strategic Objective 1 (SO1): Improve evidence-based water management and governance

This Strategic Objective shades light to the importance and relationship of both quality science and long-term sustainable governance. Sound science is required to avoid mismanagement of the resource and corruption in decision processes; good management and governance is manifested through water policies that lead communities to water stewardship. Together they form the basis for sustainable development, as water is often noted as the thread that ties all sectors together. If the link is broken through poor science or poorly communicated science, then decisions are made on incomplete or even false assumptions and data and achieving good governance is unattainable.

Strategic Objective 2 (SO2): Enhance resilience of societies under global change

Population growth and changes in production and consumption patterns have affected the availability and quality of water. Furthermore, climate change and variability, which in turn has a measurable effect on the water cycle, altering the quantity, distribution, time of rainfall, with serious consequences for water security.

The human factor is an essential component of climate and global change, but it is also a key component in responding to that challenge through adaptation and the development of a culture of resilience. To enhance the resilience of societies and adapt to the ongoing global changes, decisions must be made based on evidence and the participation of all water stakeholders. It is not possible to decree resilience, it must be built based on education and founded on a culture of water; by sensitizing people and enhancing their understanding and knowledge of the multiple functions of water in supporting livelihoods, ecosystems and productive development, generating better practices of participatory management and new opportunities for the future of our planet.

Outcomes

Outcome 1: Enhanced capacity development and public awareness towards a sustainable water culture and water management.

Water education and the expansion of knowledge about water make it possible to improve capacity development and expand public awareness towards a sustainable water culture, change behaviours and build consensus for sustainable production that results from decoupling economic growth from environmental degradation. Using citizen science inputs provides new opportunities like water awareness, capacity development and pro-active support. In addition, open source decision support systems built on open software platforms play an increasingly important role in managing water resources. Therefore, the fulfilment of this outcome implies a strategic lever to achieve both, the strategic objective of increasing the resilience of societies in the face of the challenges of global change, and the objective of having water governance based on reliable data and knowledge.

Outcome 2: Water-related data and knowledge gaps bridged by enhancing scientific research and cooperation

Bridging the water data and knowledge gaps through improved science and cooperation will result in improved water management decisions and governance fulfilling Strategic Objective 1. The quality of water data collected, and knowledge generated are without a doubt directly reflected in the sustainability of policies developed. Enhancing the level of cooperation among scientists and citizen scientists is vital to bridging the gap between existing data and those who must understand and subsequently interpret and apply this technical information in the policy arena. However, for this cooperation to become a reality, data collection and analysis methodologies must be validated and sufficient time must be invested to develop comprehensive data at different scales and in distinct geographic and political settings, all contributing to better evidence-based water management.

Replicable data derived from sound water research is the foundation for building resilient communities. 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. If progress is to be made and subsequently prove sustainable, a willingness to listen to other opinions is of paramount importance. It is equally important that decision-makers understand the necessity of adapting decisions made overtime as the science improves and environmental conditions change. This is especially the case in settings where different objectives may be supported or where a decision framework cannot be reached, but where resilience is a strategic objective.

Outcome 3: Enhanced evidence-based water-decisions for resilient societies by reinforcing the science-policy interface.

Water science, particularly data streams that have been collected and validated over a number of years, and the mechanisms to facilitate transferring such data to decision-makers in a palatable form is the link between environmental conditions and resilience. Educating the next generation of water planners, scientists and practitioners along with a water sensitized public, at all levels of sophistication is the other half of successful societies. Thus, implementing this outcome directly contributes to the realization of Strategic Objective 1.

Complementarily, this outcome also makes possible the realization of Strategic Objective 2 since building communities and societies that are resilient in the face of changing and evermore complex environmental conditions requires that science inform policy. Improving this aspect of the decision process permits greater involvement of citizen science and pro-active NGO community partners with government, including the ability of decision makers to benefit from the use of indigenous knowledge. Strategies and activities addressing climate change that are science-based and inclusive of all sectors of civil society in the context of the long-term resilience of decisions taken, enhance the overall resilience of societies to the inevitable changes in climate.

Enabling Outcome: Strengthening the capacities of cooperation and partnerships with UNESCO Water Family members and in particular the National IHP committees and focal persons.

The Strategic Plan presented herein originated from and was developed by the UNESCO Water Family Members with the support of the Secretariat. The mid-term evaluation of IHP-VIII recommends that during the execution of IHP-IX, roles, and responsibilities for the implementation of the Plan are taken up by the UNESCO Water Family Members. This allows the Organization to take advantage of the combined knowledge of its 36 Category 2 Centres, more than 60 water related Chairs linked to academic centres, and also, in a special way, the 169 IHP National Committees and focal persons to ensure that they have adequate capacity to contribute to the implementation of the Programme.

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

That is why the importance of IHP's National Committees must continue to develop so that their bodies contain the principle of sustainable water management, that is, that they become meeting spaces between public water bodies, academic and scientific centres and increasingly, citizen water organizations.

To demonstrate a significant capacity to contribute to the implementation of IHP-IX, it is necessary for the water family to strengthen its insertion and contribution in the debate and proposals with the Member States and, simultaneously, to do so in other internationally agreed instruments such as the Agenda 2030, Sendai Framework, Paris Agreement and the New Urban Agenda. Consequently, expected results are:

1. Capacities and means of IHP National Committees and / or focal persons strengthened, with focus on developing countries.
2. Partnerships between UNESCO Family Members have been established and or strengthened.

Theory of Change

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

As aforementioned several challenges arise from achieving water security, which range from the effects of global change such as water related disasters to operational aspects such as understanding of the value of water as this is expressed by local water rates [3]. The Intergovernmental Hydrological Programme's approach to these challenges is to expand the 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"[4].

[3] INTERNATIONAL HYDROLOGICAL PROGRAMME (IHP) EIGHTH PHASE "WATER SECURITY: RESPONSES TO LOCAL, REGIONAL, AND GLOBAL CHALLENGES" STRATEGIC PLAN IHP-VIII (2014-2021)
[4] IHP, 2011. THE IMPACT OF GLOBAL CHANGE ON WATER RESOURCES: THE RESPONSE OF UNESCO'S INTERNATIONAL HYDROLOGY PROGRAMME. Page 2.

IHP-IX building on its expertise on scientific cooperation on water research, expects to contribute to achieve a water secure world where people and institutions have adequate capacity and scientific knowledge for informed decisions on water management and governance to attain sustainable development and to build resilient societies. IHP-IX will do so by providing support for its Member States to strengthen their capacities to “Improve evidence based water management and governance” and to “Enhance resilience of societies under global change including climate change”, which comprise its two Strategic Objectives.

Expected outcomes

The ninth phase of IHP has three identified outcomes:

1. Outcome 1: Enhanced capacity development and public awareness towards a sustainable water culture and water management.
2. Outcome 2: Water-related data and knowledge gaps bridged by enhancing scientific research and cooperation
3. Outcome 3: Enhanced evidence-based water-decisions for resilient societies by reinforcing the science-policy interface.

Each of these Outcomes will contribute to the achievement of the two Strategic Objectives, which in turn will support Member States to achieve IHP-IX’s Vision. Five priorities, streams of action have been identified as the key elements to materialize these Outcomes and are presented in detail hereafter. UNESCO’s Member States identified Science, Research and Innovation (Priority 1), Water Education for the Fourth Industrial Revolution (Priority 2) and Bridging the data and knowledge gaps (Priority 3), as intertwined elements that feed of each other and formulate the basis for Inclusive Water Management (Priority 4) and Water Governance based on science for mitigation, adaptation and resilience (Priority 5). Each Priority consists of several identified Outputs that along with sample activities, will be further developed within an operational document to be elaborated in a later stage by UNESCO’s water family and its partners. The document will be used to monitor the implementation progress of the strategy.
The following table presents a summarized version of the expected flow of actions and resources to achieve the impact sought by IHP:

Challenges & Opportunities

Challenges	Opportunities
1. Clean water for human and ecosystem health 2. Water related disasters 3. Public understanding about the value of water 4. Expanding acceptance of holistic water management	1. Investing in scientific research and innovation 2. New water conservation technologies 3. Water education for sustainable production and consumption 4. Investing in water governance

Inputs

Human Resources (UNESCO Water Family)	Financial Resources (UNESCO Water Family)
1. UNESCO Secretariat 2. C2Cs & UNESCO Chairs 3. IHP NCs production and consumption	1. Regular Programme 2. Extrabudgetary funding 3. In-kind

Activities

Specific Activities per Output to be defined in the Operational Plan document water

Expected outputs (sample)

1.1. Integration of citizen science in hydrological research promoted, allowing
1.2 The interaction between human and water systems in line with socio-hydrology is scientifically assessed to develop adaptive pathways and scenarios for water management.
1.3 International scientific cooperation enhanced to address unsolved problems in hydrology, improving scientific understanding of hydrological cycles across river and aquifer basins.
1.4 Uncertainty in hydrological predictions and forecasting communicated to decision makers and the public for better adaptive water management strategies. the combined efforts of scientists and the public to understand the behavior of water and of the people who use it.

2.1 Outreach and awareness raising materials prepared and disseminated allowing public at all levels to expand their awareness of the important multi-functions of water in domestic life, ecosystems, and productive development
2.2 Tertiary and vocational education and training for water-related enhanced for adapted skilled professionals capable of identifying the main gaps for sustainable water management, providing appropriate tools to governments and societies to address those gaps and the Agenda 2030 targets.
2.3 Capacities of decision makers, water managers and users enhanced allowing them to take advantage of new technologies and research to make better decisions, and to design and implement inclusive and efficient water policies.
2.4 Water education for children and young people enhanced enabling a better understanding of the importance of water in their lives and in their communities.

3.1 Data on water quantity, quality and use are available, accessible, comparable, and validated in a format easy to understand and utilized by all users on open access databases.
3.2 Development and use of scientific research methods to correctly collect, analyze, and interpret the data supported utilizing cutting-edge technologies resulting in better scientific information.
3.3 Development, dissemination, and capacity building on scientific tools like modeling, forecasting, data assimilation and visualization, quality assurance protocols to connect existing databases and outreach protocols reinforced.
3.4 Experimental basins for hydrological research and holistic water management identified and promoted.
3.5 New methods for translating scientific information into a format for decision-making and policy formulation developed and disseminated.

4.1. Knowledge developed, disseminated and capacities strengthened on water management at watershed level using the nexus and source-to-sea approaches particularly in transboundary watersheds.
4.2. Upstream-downstream river uses, and socio-economic and ecological consequences are better analyzed and disseminated with respect to hydropower, navigation and flood risk management.
4.3. Assessment of ecosystem services and environmental flows to achieve water security improved through pilot sites, research, and capacity building.
4.4. Understanding and knowledge on pollutants fate and transport in freshwater systems improved underpinning water resources management strategies based on the source-to-sea approach.
4.5. Assessment and monitoring methods of changes in snowpack, glacier, reservoirs, such as mountains lakes or aquifers, and their related water resources.
4.6. Methodologies and tools in mainstreaming global changes within water management plans developed and disseminated.
4.7.Inclusive approaches ensuring participation of youth, local and indigenous communities with gender equality, enabling all stakeholders to be part of the water management process are researched and disseminated.
4.8.Capacities enhanced and acceptance improved on non-conventional Water Resources (NCWRs) such as wastewater reuse, desalination and rainwater harvesting as an important underpinning of Water Cycle Management.

5.1. Awareness raised at all levels on the importance of science-based water governance.
5.2. Capacities on new frameworks and tools such as Climate Risk Informed Decision Analysis (CRIDA) enhanced to underpin water governance and building resilience.
5.3. Novel approaches of adaptive water management to support sound water governance developed and capacities of Member States enhanced.
5.4. Water governance legal, policy and institutional frameworks assessed and proposals for their improvement made to ensure that they are context-dependent, location-based, reflecting adaptation to climate change and IWRM integrating both surface water and groundwater.
5.5. Cooperative frameworks and open access

Priority areas

1. Scientific research and innovation	2. Water Education in the Fourth Industrial Revolution	3. Bridging the data-knowledge gap	4. Inclusive water management under	5. Water Governance based on science for mitigation, adaptation, and resilience

(Intermediate) Outcomes

Outcome 1: Enhanced capacity development and public awareness towards a sustainable water culture and water management	Outcome 2: Water-related data and knowledge gaps bridged by enhancing scientific research and cooperation	Outcome 3: Enhanced evidence-based water-decisions for resilient societies by reinforcing the science-policy interface

Enabling Outcome: Strengthening the capacities of cooperation and partnerships with UNESCO Water Family members

Strategic Objectives (Outcomes)

Strategic Objective 1: Improve evidence-based water management and governance	Strategic Objective 2: Enhance resilience of societies under global change including climate change

(Impact) Vision: a water secure world where people and institutions have adequate capacity and scientific knowledge for informed decisions on water management and governance to attain sustainable development and to build resilient societies

Priority Areas

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

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

Developing and implementing each of these five priority areas with their expected outputs implies advancing and adding value to sustainable water management not only from each of these thematic axis, but because they also explain and make possible the outcomes: "enhanced capacity development and public awareness towards a sustainable water culture and water management"; "water-related data and knowledge gaps bridged by enhancing scientific research and cooperation" and "enhanced evidence-based water-decisions for resilient societies by reinforcing the science-policy interface". In addition to the above, the deepening and implementation of each of the priority areas contributes to achieve the Agenda 2030, its 17 SDGs and 169 targets, since all of them are governed by the principles of comprehensiveness, balance, sustainability, equity, universality and indivisibility. Since the conclusion of IHP-IX (2029) coincides with the threshold of the Sustainable Development Agenda, it is essential that the contributions of these priority areas be fully implemented and translated into improvements in the three dimensions of sustainable development: economic growth, social inclusion and environmental protection prior to the end of the decade.

1. Scientific research and innovation

Scientific research incorporating human interactions with nature in the context of complex water sciences and management problems provide fundamental feedback for water resources management, along with the application of new tools, approaches and technologies. By 2029, the Member States have the knowledge, sound scientific and research capacity, new and improved technologies, and the management skills that allow them to secure water resources for human consumption and the maintenance of the balance of ecosystems within a sustainable development context.

Expected outputs:

1.1. Integration of citizen science in hydrological research promoted, allowing the combined efforts of scientists and the public to improve understanding of water cycle and behaviour of the people who use it.
1.2 The interaction between human and water systems in line with socio-hydrology is scientifically assessed to develop adaptive pathways and scenarios for water management.
1.3 International scientific cooperation enhanced to address unsolved problems in hydrology, improving scientific understanding of hydrological cycles across river and aquifer basins.
1.4 Uncertainty in hydrological predictions and forecasting communicated to decision makers and the public for better adaptive water management strategies.
1.5 Nature based solutions for Integrated Water Resource Management (IWRM) and services at all scales promoted through ecohydrology research and innovation at UNESCO designated sites.
1.6 Scientific understanding, research, methodologies, and solutions promoted in improving water quality and reducing water pollution.
1.7 Knowledge base relating to the impacts of global change (including climate change) on river basins, aquifer systems, cryosphere and human settlements improved.
1.8 Research on non-conventional water including treatment technologies (for potable water, wastewater reuse and desalination) promoted.
1.9 Scientific knowledge, methodologies, and tools in addressing water related disasters such as flood and drought enhanced for timely forecasting.
1.10 New technologies are promoted and improved hydrological planning, assessment, and water distribution networks worldwide.

<u>Relation between this priority area and the Agenda 2030</u>

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

The need to bridge the gap between scientific research and its application through innovation on one hand, and policy on the other is obvious given the complexity of environmental and social issues being confronted. Further discussion on this topic has also promoted understanding that knowledge-based action requires an increase in the resources available to scientists and research institutions. UNESCO is on the correct path in that science, research, technology and innovation are all critical components of IHP-IX achieving its SOs and providing an important contribution to the UN Decade of Action (2020-2029).

Innovation and partnerships

IHP-IX will cover a period (2022-2029) when the human race is entering an unprecedented tech-driven and big-data era for innovation, numerical models (hydro-informatics) of hydrology for simulation, assessment and forecasting. Concurrently, new monitoring techniques including optimal estimation techniques such as data assimilation and sparse-modelling will be further developed across scales by utilizing new instruments, the latest ICT technologies, and big-data. This new generation of modelling is at the nexus of geo-informatics, cyber-infrastructure in watersheds and remote measurements for scientific studies and water resources assessment. IHP–IX will provide scientific connectivity and cooperation to address unsolved problems in hydrology. Furthermore, IHP in partnership with professional scientific organizations will work on interfaces between hydrology and other disciplines to stimulate scientific and innovative undertakings required to address questions related to water resources at different spatial and temporal scales. IHP-IX will therefore focus on issues with which UNESCO and its partner organizations have a substantive history, but which will greatly benefit from applying new technologies. This strategy will then inform research efforts of partner organizations in a collaborative fashion and respond to priorities of the Member States through its programme of activities.

Further research in hydrological cycles, ecohydrology and groundwater

Supporting research in ecohydrology has been a priority for UNESCO since IHP-VI. In that regard scaling and heterogeneity issues in hydrological processes have engendered debate in both the water research and management communities for decades. Scientists still struggle with the relationship between various physical factors and spatial homogeneity and heterogeneity in hydrological variables and fluxes. It is also an open question how hydrological principles should be applied at different scales (e.g., point-scale, hill-slope-scale, catchment-scale, and continental-scale) and further how to relate such data when scales change over space and time.

Additionally, the principles of ecohydrology provide a framework as to the use of ecosystem processes as basin management tools, but many research questions remain unanswered. For example, the interfaces between standing vegetation and ground water recharge and availability provide many research possibilities for IHP-IX to explore, particularly as surface water becomes scarcer and more contaminated. This will be achieved by applying the three main principles of ecohydrology: the quantification of both hydrological and biological processes, the characterisation of threats, and the harmonization of grey and green infrastructures to achieve sustainability of ecosystems closely related with IWRM.

Reducing uncertainty in water management

Variability in the hydrological cycle, including extremes such as floods and droughts is a research area that attracts publicity due to a high level of public concern. Investments in new field stations, monitoring and generation of information and in research to forecast such events should be further enhanced to encompass anthropogenic activities that influence climate change models. Research on melting snow reserves, mountain glaciers, permafrost, and groundwater should also be carried out to provide additional information to complex and integrative management models with the aim of reducing the impacts of natural disasters. The results of conducting research in this area within the framework of IHP-IX will improve water management and governance for mitigation and adaptation of natural hazards under global change.

Innovative techniques for addressing water quality, involving social sciences

We are witnessing new questions from human interactions with nature in the context of complex water management problems. These are questions where hydrology can make important contributions, but hydrological scientists alone cannot address them. Socio-hydrology, which portends a marriage of hydrology with humanities, social and behavioural sciences, is an emerging research direction. Socio-hydrology research provides an insight into how populations and power-relations influence the water cycle and watershed, particularly in a time of global change. IHP should build capacity within the Member States on the results of such research to enable them to consider human influence in water management plans.

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. Tools should be developed in a way that encourage citizen science and other social applications that can improve water management, such as integrating modern science with indigenous and local knowledge. 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, considering that a sustainable society will deliver equitable solutions to achieve water security.

One prime example of the need for merging natural and social sciences in addressing problems is that of maintaining or recovering a consistent supply of high-quality freshwater. In many places water quality has been deteriorating due to increased volumes of point and non-point pollution and mixing fresh water with untreated or inadequately treated wastewater, agricultural drainage, industry cooling water, as well as runoff from hardened surfaces. Non-point source pollution, from for example, agricultural production processes and waste is particularly difficult to monitor or successfully model. Research within the framework of IHP-IX should focus on the low-cost, innovative, sustainable, and socially acceptable treatment technologies to address these social and technical problems.

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. We will also have a better foundation for decision-making in adapting to more devastating hydrological disasters, better management of the water-energy-food-ecosystem nexus and better management of water scarcity and transboundary water systems.

Integrated River Research and Management from the watershed to the local scale is needed in order to unify isolated analysis of specific topics such as floods, droughts or sediments. Rivers are the lifelines in the landscape and have a central function in the water-energy-food-nexus as well as the UN SDGs, 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 they are endangered by overuse, interruption of sediment continuity or spatial restriction as well as water quality. There should be an integrated river research focus on the fundamental processes in river hydrology, hydraulics, sediment transport and morphodynamics, water quality and river management (focusing on usages) as well as socioeconomics while maintaining the health of river ecological environment. The outcome of this research will be a global overview of the status and future of rivers as contribution to an improved water management.

Improving Citizen Science

Citizen science has fast become an important research approach applied to hydrological research, enabling the combined efforts of scientists and the public to collect and interpret data for research and decision-making. Advances in user-friendly technology also facilitates communication, training and online data visualization and data collection. Using citizen science inputs provides new opportunities for society, like water awareness and capacity development, a sense of belonging to decision and management processes, unexpected insights, and pro-active support. From a science perspective, citizen science widens spatial and temporal data collection possibilities. Many citizen science initiatives and research projects already exist and add to the big data available already in the world. Unfortunately, citizen science data is still not fully accepted due to data quality uncertainties and related issues. There is therefore a need to create the enabling environment and assist citizens and scientists, through enhanced water education programs to ensure scientific methods are used when participating in and applying citizen science.

Innovation and use of technologies

While desalination and wastewater reuse technologies have advanced in important ways, investments in further developing these technologies is necessary, as they will become increasingly important as urban populations increase and water demand grows.

There are seemingly an unending number of ICT innovations and AI-related technologies impacting efficient and effective use of water resources. Many related issues such as timely disaster forecasting, the use of cubesats (nano-satellites), groundwater governance, evidence based planning, conflict resolution and trust building, real-time monitoring, and effective decision support systems, optimizing the use of resources and time, will all benefit from new technologies. 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. Hundreds, thousands or even millions of inexpensive small sensors will be deployed and connected along with personal mobile devices and IoT.

IHP-IX will work to support and field-test these advances and how they can improve sustainable water security for future generations and the preservation of ecosystems.

Accurate and adequate monitoring

Accurate and adequate monitoring of hydrological systems is still lacking in many parts of the world making it harder to assign equitable sharing of these limited resources. In recent years, great innovation has been made in the field of Internet of things (IoT), especially in consumer, commercial, infrastructure and military applications. To date, water monitoring and planning have received limited attention in this regard but the potential for applications at local, regional, and global scales is great. This is particularly the case in very remote places with poor communication and transportation infrastructure making it hard to obtain vital environmental real-time measurements for improved monitoring, planning and disaster prevention. Therefore, appropriate tools and platforms for improved data visualization, analysis, understanding and communication for improved monitoring and planning need to be tested and applied where appropriate.

In recent decades scientists generally protected their data; today transparency, whether desired or not, has all but replaced privacy including that of scientific data. While original data is still considered to be “proprietary” and falling under the "intellectual property" concept in an academic sense, open source decision support systems built on open software platforms will play an increasingly key role in the future to managing water resources. Information exchanged on social networking services (SNSs) by citizen scientists can also contribute to water resources management, if effective tools are developed to capture, organize, quality control, and make available such data. There is also an urgent need for the development and application of AI techniques that can merge different sources of data obtained from IoT, remote sensing, and citizen observatories.

2. Water Education in the Fourth Industrial Revolution

Both sustainable water management and water security are key objectives that UNESCO and other UN agencies, as well as other relevant institutions, have proposed in different navigation charts and action programs. Without a doubt, water education has been a strategic and critical platform to achieve these purposes in a context of global change.

<u>Expected outputs:</u>

2.1 Outreach and awareness raising materials prepared and disseminated via Member States, allowing public at all levels to expand their awareness of the important multi-functions of water in domestic life, ecosystems, and productive development.

2.2 Water-related tertiary and vocational education and training for enhancing and adapting the skills of professionals, capable of identifying the main gaps for sustainable water management, providing appropriate tools to governments and societies to address those gaps and the Agenda 2030 targets.

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

2.4 Water education formal, non-formal and informal, for children and young people enhanced, enabling ownership and an improved understanding of the importance of water in their lives and in their communities.

<u>Relation between this priority area and the Agenda 2030</u>

It is clear that IHP-IX priority area water education in the fourth industrial revolution is connected to SDG6 and its targets (ensure availability and sustainable management of water and sanitation for all), SDG9 and several of its targets (industry, innovation and infrastructure), and given the widely circulated "blue thread" concept, to SDG4 (quality education), as well as water related targets of all of the SDGs. The sanitation aspects of SDG6 (particularly target 6.2 on gender equity) are often times undervalued, as compared to providing freshwater, but the fact that the lack of clean running water for pubescent girls in large parts of Africa is the principle reason for their not completing primary or middle school speaks directly to the connection with SDGs 1-5 (no poverty, zero hunger, good health and well-being, quality education and gender equity) and so many of their respective targets. The loss in contribution to communities due to just this single issue has been estimated in millions of productive hours. 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.

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 social classes. It is a commonly stated statistic that Africa needs a near 200% increase in the number of water professionals, Latin America a 100% increase and Asia a 50% increase if the SDGs, once achieved, are going to be sustainable. We must have a cadre of new scientists, planners, and practitioners ready to assume positions of responsibility in a fourth industrial revolution setting in the water sector by the end of this decade. It is undeniable that the success of Agenda 2030 for Sustainable Development, the SDGs and the associated targets depends on a profound transformation in human values and, consequently, human actions, directly impacting how we live our lives. Achieving that end can only be envisioned when society recognizes the need to reintegrate itself with nature in ways that embrace a common understanding of the importance and limits of our natural resource base to improving the quality of life.
IHP-IX will pursue the development and use of a water education related indicator under target 6a.

<u>Education for a better understanding of the role of water</u>

Education is normally delivered in 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. It needs to employ the most relevant technology and to ensure the quality of outputs as well as reaching all people; overtime engendering a pro-active and inter-generational water stewardship context. It is therefore incumbent on scientists to help interpret their findings to be understandable and useful for educators and the students and publics they interact with. 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. Without such overlap in understanding, the impact of science on decision-making and policy development and the level of understanding and acceptance by beneficiary communities is severely compromised.

The most efficient way to catalyse this evolution in thinking is through education to all sectors of civil society leading to a greater understanding of the role that water plays in every individual's life. 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. Therefore, a broad water education strategy with a strong scientific basis is a determinant factor to shaping a water conscious future for everybody.

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 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. To enable this transformation, IHP-IX will collaborate with other parts of UNESCO, particularly the Educational Sector.

Implementation of Water Education for Sustainable Development in the official development agendas of Member States

In general, many people have only a vague understanding of the relationship of their daily lives with the availability of water. Given the complexity of water-related issues confronting society, increasing the number and quality of programs and trainers should be a high priority at all jurisdictional levels. Since human resources and budgets are limited, strategies in support of this goal need to rely on creating multipliers resulting in a many-fold increase in the numbers of formal and informal water educators/trainers and champions, being sensitive to national contexts and local needs. There are many ways to acquire water-related knowledge: lifelong learning, community story-telling as a form of ancestral knowledge, training in-field workshops, exchange programs, refresher courses, summer schools, graduate degrees, social media, UNESCO-related initiatives such as WINS (Water Information Network), TVET (Technical and Vocational Education and Training), WAMU-NET (Global Network of Water Museums), UNESCO Chairs and Category 2 Centres such as IHE-Delft.

Developing and applying new tools to improve education

A key challenge is to develop international training and sharing of experiences using (open) e-learning, with contributions from experts globally and reaching water professionals, water technicians, schools, and the public. Tools and mechanisms to overcome this challenge can be in the form of short instruction videos, e-classrooms, and meetings, and even potentially including on-line graduate degree programmes. There are also numerous experts, teachers, young professionals, and government officials who require on-the-job training related to generating public awareness on water-related topics that will improve their capacity in the field, lab and classroom skills and enable them to perform their tasks in a more effective manner. Moreover, while good policy requires informed citizens, good decision-making requires sound science, which in-turn requires knowledgeable experts in a range of natural and social science disciplines.

Understanding the value and difficulty of behavioural transformation towards a more eco-conscious society

Effective education normally leads to better understanding and subsequent application of new knowledge, either directly accruing to the students or indirectly to those influenced by those students as they take positions of responsibility; change being the output of such a process. However, change can be difficult and impeded by any number of obstacles, be they human resistance or customary social mores, financial or technological impediments, among others. However, it is clear that anyno proposed solution will not be fully effective if imposed on a community without their understanding and support. This is particularly the case for societies 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. It is therefore crucial to emphasize that water education must embrace strategies and techniques that will support people to expand their consciousness and be able to adopt better practices towards equilibrium in interacting with the natural world and in improving their emotional health. In consequence, IHP-IX will continue to encourage a broad conception of 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. It is also important to emphasize the contributions of youth and young professionals to improving water management and governance by gaining an understanding of the importance of water in their lives through becoming involved in the development of innovative science programs to ensure that future generations of water leaders are in the making. Therefore, the opinions of young people should actively be sought-out as inputs to decision-making processes related to water.

Water education in support of governance success

Several different strategies need to be implemented to address the needs and interests of all sectors active within community decision-making processes. This suite of approaches will provide decision-makers and citizens, including youth, with the necessary tools for boosting the transition from an economy based solely on consumption to an economy based on stewardship and conservation. In this way, there will be actions corresponding to the underlying causes of priority problems. Decision makers will therefore have the necessary societal support to design and implement policies that will associate economic success with stewardship of the natural resource base, obviously including water resources.

3. Bridging the data-knowledge gap

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

Expected outputs:

3.1 Data on water quantity, quality and use are available, accessible, comparable, and validated in a format easy to understand and utilized by all users on open access databases.
3.2 Development and use of scientific research methods to correctly collect, analyse, and interpret the data supported.
3.3 Development, dissemination, and capacity building on scientific tools (like modelling, forecasting, data assimilation and visualization, quality assurance protocols to connect existing databases and outreach protocols) reinforced.
3.4 Experimental river basins for hydrological research and holistic water management identified and promoted.
3.5 New methods for translating scientific information into a format for decision-making and policy formulation developed and disseminated.

Relation between this priority area and the Agenda 2030

Scientific data must be available in an understandable form by target audiences for science to advance, particularly in the case where IWRM is a desired outcome. Additionally, the increase in the number of citizen scientists and interested NGOs, which is strongly supported in the IHP-IX strategic plan, requires that water data collection methods and metrics be standardized to facilitate long-term data series and determining trends overtime. While most of the SDGs and their related targets can benefit from improved water data, which helps bridge the gap in what is collected and how it is applied in the policy arena to improve water management, SDG 17 (strengthening partnerships) is of particular importance in this regard. What is clear is that partnerships are the fundamental tool to achieve any of the specific sectoral goals found in the SDGs and their targets.

Strong partners, particularly those that understand and embrace the SOs and expected results of IHP-IX will likely be able to determine how they can best contribute to their realization in a pro-active partnership. Generally, these partnerships would be engendered at the National level but that does not exclude the opportunity for specialized groups to assist in the implementation of the IHP-IX strategy in terms of their expertise in financing, technology development and sharing, data monitoring and accountability, standardization of data collection and handling methods, and policy and institutional capacity building exercises. Many partners will do so in projects funded from multiple sources as they utilize

IHP-IX as a project framework or guideline. Additionally, multi-stakeholder partnerships are of particular importance in that they frequently provide an opportunity and promote effective public, public-private and civil society alliances, building on the experience and resourcing strategies of partnerships involving several sectors.

The importance of open science and data accessibility

Transparency and accessibility of data are among the main pillars that sustain the advancement of open science. Hydrological measurements provide information about the current state of a basin, the main hydrological unit, and are essential for decision-making and sustainable water resources management. While the absence or inaccessibility of comprehensive or long-term data about water quantity, quality, distribution, access, risks, use, etc. does not preclude decision-making, it often leads to partial or ineffective decisions and investments. Therefore, both sufficient data and its accessibility need to be ensured and, in many cases, improved. This was the main recommendation of the UN Mar del Plata conference in 1977; yet the desired level of compliance has not been achieved, more than forty years after it was agreed to.

Water data comes from many sources: manual measurements, real-time continuous sensors, as well as new and innovative sources like remotely sensed information (satellites, drones) or autonomous monitoring buoys. Data generators include public and private research and educational institutions, participatory monitoring groups (citizen science), and social media. 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 useful knowledge can only be bridged if such data is collected in a manner that it can be replicated by other scientists, understood, interpreted and applied at the scale and level of detail required by policy makers. The challenge of data gathering, sharing, and interpretation becomes more complex when a water resource is transboundary, even within the same country.

Therefore, there is a need to go beyond the call of promoting data collection, to ensure data quality and to fill local gaps and add value to information. Countries often require assistance in making evidence-based decisions about water, including management and development of water master plans or schemes for the integrated use and protection of water resources based on the river basin principle. This concept should include developing national policies based on reliable quantitative and qualitative characteristics of renewable surface and underground water resources (formation, exchange across borders, temporal variability, usage). The scope of these policies determines data required to be collected and, in many cases, how it should be organized.

Considering that water science cannot exist without data, IHP initiated cooperative programs like IHP-WINS, the International Water Quality Platform, the Global Network on Water and Development Information for Arid Lands (G-Wadi) and Flow Regimes from International Experimental and Network Data (FRIEND-Water) all of which harvest knowledge and information to support science and decision making that contributes to bridging the data-knowledge gap. UNESCO programs are also making essential contributions to the data platforms of the UN Water Family like the Global Environment Monitoring System for freshwater (GEMS / Water by UNEP), the Hydrology and Water Resources Programme (HWRP by WMO) and their centres of global water data; such as the Global Precipitation Climatology Centre (GPCC), Global Terrestrial Network - Hydrology (GTN-H), Global Runoff Data Centre (GRDC), GEMS/Water Data Centre (GWDC), the Global Groundwater Information System (GGIS) and Global Groundwater Monitoring Network (GGMN) both by IGRAC, Global Cryosphere Watch (GCW) and the World Glacier Monitoring Service (WGMS). The IHP Secretariat has been strengthening these linkages in recent years and should continue these efforts in institutional outreach. IHP-IX will continue to support capacity building through the FRIEND-Water, ERB, the World Large Rivers, EauMega, and the International Drought, Flood, and Sediment, among others. Bridging the data-knowledge gap through these cooperative programmes supports inclusive water management under conditions of global change.

To realize the vision of open-access science, IHP-IX is promoting data-related priorities in line with the open science recommendation in preparation by UNESCO on the request of Its Members States

<u>Improving the quantity, quality, and validation of water data in a broad collaborative effort.</u>

Credible data is the most important basis for water resources management, without which implementation of decisions is severely handicapped. All analysis and modelling efforts are dependent on the quantity, quality, coverage, and accessibility of data. Data quantity should be maintained by reversing the current decline in the numbers of monitoring stations and sampling frequencies. Data quality determines the quality of scientific research outputs. The diversification of data sources allows scientific research to be based on larger and more complete data sets, increasing the confidence-levels of results.
However, water data should not be limited to water quantity and quality parameters. Rather water use trends, and other human interactions with surface and ground water should be monitored as well. IHP-IX will logically promote the exchange of experiences in data collection strategies and analytical methodologies along with free access to data, especially in transboundary water resources, and to create / strengthen new capacities and collaboration at local, regional and global levels. Metadata are essential for data validation and should form an integral part of databases.

Enabling data accessibility and visibility, comparable and usable data series, and open-access data

Centralized management 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. Availability of accurate and credible data in a format that can be easily accessed and understood is also fundamental for the sake of any of these interventions. Therefore, this aspect must be placed on highest priority and its maintenance should be a continuous process.

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

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

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

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.

Enhance development and use of scientific research methods to correctly analyse, complete, and interpret the data, resulting in better scientific information

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 UN-Water SDG-6 Synthesis Report suggests the need for understanding more 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. IHP-IX encourages the use of multidisciplinary inputs from other UNESCO departments to combine natural and social sciences related to Integrated Water Resources Management (social, economic, environmental) with hydrology to include the current influences on water resources in the Anthropocene.

IHP will work as a catalyst for international, inter-disciplinary cooperation in many aspects of water-related disaster risk reduction in collaboration with global and regional programs, networks and initiatives, including the International Flood Initiative (IFI), the International Drought Initiative (IDI), and the International Consortium on Landslides (ICL). Historical data form the basis for understanding trends and rare (extreme) events. Countries and international organizations should collect, digitize and make available on the web historical data, reports, proceedings, and other documentation that will assist in a broader grasp of such events.

There is a need to understand and incorporate the changes to the hydrological cycle (such as social influences, climate change or others) in different environmental settings (delta, arid, tropical, SIDS, etc.). Experimental field hydrological studies in small catchments remain an indispensable source for the development of hydrological knowledge and methods for calculating and forecasting hydrological, meteorological and biochemical processes in river catchments. Additionally, monitoring of natural and anthropogenic changes in hydro-meteorological characteristics and regimes including climate change benefit from studies at this scale.

Thus, a chain of experimental basins could be managed and researched with the help of the UNESCO Water Family as examples for similar basins all over the world. In these basins, methodologies can be developed and tested, and scientific information can be gathered on sustainable management. The basins will be selected based on existing initiatives like HELP and to the extent possible within UNESCO designated sites, like WHS, Biosphere Reserves and Global Geo-parks. To go beyond the basin scale, water processes at the global scale should be analysed, including trade data on food and other products and commodities using the concept of virtual water.

Assist in disseminating and developing new interpretation methods of scientific information into a format usable for water education and policymaking

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

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

4. Inclusive water management under conditions of global change

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

Expected outputs:

4.1. Knowledge developed, disseminated and capacities strengthened on water management at watershed level using the nexus and source-to-sea approaches particularly in transboundary watersheds.
4.2. Upstream-downstream river uses and socio-economic and ecological consequences are better analysed and disseminated with respect to hydropower, navigation and flood risk management.
4.3. Assessment of ecosystem services and environmental flows to achieve water security improved through pilot sites, research, and capacity building.
4.4. Understanding and knowledge on pollutants fate and transport in freshwater systems improved underpinning water resources management strategies based on the source-to-sea approach.

4.5. Assessment and monitoring methods of changes in snowpack, glacier, reservoirs, such as mountains lakes or aquifers, and their related water resources.
4.6. Methodologies and tools in mainstreaming global changes within water management plans developed and disseminated.
4.7. Inclusive approaches ensuring participation of youth, local and indigenous communities with gender equality, enabling all stakeholders to be part of the water management process are researched and disseminated.
4.8. Capacities enhanced and acceptance improved on non-conventional Water Resources (NCWRs) such as wastewater reuse, desalination and rainwater harvesting as an important underpinning of Water Cycle Management.

<u>Relation between this priority area and the Agenda 2030</u>

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

From this perspective, it is possible to identify at least those targets related to universal and equitable access to drinking water, sanitation and hygiene (6.1 and 6.2), improving water quality (6.3), implementing integrated water resources management at all levels (6.5.1), including transboundary cooperation (6.5.2) and protecting and restoring water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes (6.6 and 15.1). Other targets are, among others, 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).

<u>Global issues concerning water management practices</u>

Freshwater sustains life on earth, access to it is a human right and a social need, and it underpins all economic development. Healthy rivers, lakes, wetlands, aquifers, and glaciers do not just supply safe drinking water and maintain all ecosystems on the planet; they also support agriculture, hydropower, industry, recreation, communications, and transportation of goods. Although water is considered the core of sustainable socio-economic development, this knowledge is often not considered when decisions are being made. Water is frequently considered to be a 'given' in the development / investment debate. And as water management is not considered in an integrated, inclusive manner, its management is frequently disbursed; considered a shared responsibility among many different governmental institutions.

This reality is further complicated when one considers that the voices of women, youth, indigenous groups, racial or cultural minorities, less-educated social classes or migrants are not consistently sought-out in consultation and decision processes related to investments affecting water resources.

Economic and demographic growth impact the availability, quantity & quality of freshwater. We require deepening and expansion of the knowledge on and management of water, in an integrated manner that includes all sectors of society. However, there is a continuous gap when it comes to understanding the complete watershed and water cycle, especially under the challenging conditions of climate change. Water is a finite resource, and it is only renewable if it is managed efficiently and equitably. When effectively managed, it plays a key and enabling role in strengthening the resilience of socio-economic and environmental systems in the light of rapid and unpredictable changes. Furthermore, transboundary management of these resources is a continuously increasing dilemma, where rivers, watersheds and aquifers do not take country borders into account.

We are living in a time of unprecedented risk, but also unprecedented opportunity for the future of our planet. The natural systems that sustain life are in danger from what many people consider the greatest challenge of our time: climate change and its effects on hydrometeorology and sea level rise. At the same time, population growth, urbanization, the increase in extractive activities, changes in land use and lifestyles translate into a sustained increase in the demand for water. The impacts of these 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.

IHP-IX will identify, promote, and implement innovative solutions that will support Member States achieving the Sustainable Development Goals set in Agenda 2030 and specifically SDG-6.

<u>Increasing inclusive water management</u>

To tackle ineffective and inefficient water management practices, IHP will work towards enhancing participatory management practices. Water management efforts should be implemented through inclusive approaches, ensuring that young minds are considered, that indigenous and local knowledge are the starting point and that all stakeholders are included in the process. Many water-related inequalities are due to power-relations.

Social participation is a means of improving water accountability and responsibility and, when properly achieved, can lead to conscientious and inclusive resource management. A central component of participation is gender equity and equality in all decision-making instances. Participatory management also includes the enabling of citizen science, user-centred design, youth participation, serious gaming, participatory modelling, and other empowering activities in water management. By working together in partnerships, more wide-reaching impacts can be achieved.

While not a new concept, more emphasis needs to be placed on capacity building in the use of integrated water resource management and eco-hydrology tools in organizing future investments in the water sector. Successful management of freshwater resources requires an assessment of ecosystem services and environmental flows.

The use of the nexus approach should be further implemented into daily water management practices. Here, there is still much to learn which is linked to the Science, Research and Innovation part of this strategy 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. This requires capacity building and fluid communication through the interface between different dimensions of science, domestic and international policy, and its regulatory and institutional frameworks. Water management requires a systemic, multi and inter-disciplinary approach.

The interrelations implicit in achieving Agenda 2030 goals and targets demonstrate how SDG 6 cannot be achieved independently of the other goals, all of which require water. The synergistic relationships between different SDGs and water are case-specific and should be evaluated to design and implement SWM using a nexus approach.

Enhancing water cycle management

The need to enhance the use of water cycle management (WCM) methods by Member States is obvious if they are charged with implementing holistic management of their water resources. When applying WCM methods, one can satisfy both human and environmental objectives in a sustainable manner while aiming towards water security.

For Member States to start addressing water resource management at the watershed level, the source-to-sea approach is a particularly useful method that is still not applied sufficiently. This is particularly helpful in transboundary watersheds. The source-to-sea approach reflects inclusive water management under conditions of global change in several dimensions.

First, most ocean pollution originates from land-based activities, with pollutants and debris (such as plastics and micro-plastics) transported through rivers and waterways to coastal areas and then to deeper outfalls. Therefore, improving understanding and knowledge on pollutants fate and transport in freshwater systems underpins water resources management strategies based on the source-to-sea approach. Secondly, 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. Thirdly, better understanding the relationships between river flow, soil water and groundwater is becoming more important as surface water sources dry up or become too polluted to economically clean up. A fourth aspect is a temporal one; better understanding trajectories of change over time e.g. in water, pollutants and sediment transport and erosions processes from source-to-sea. Finally, a fifth dimension is the upstream–downstream integration of river usages and socio-economic and ecological consequences with respect to energy (hydropower), transport (navigation) or flood risk management.

IHP-IX can help build capacity on these components of WCM and support fundamental research using existing IHP initiatives with the aim of providing scientifically sound and practically usable data to the larger community. IHP will also contribute to enhance organizations that govern transboundary watersheds.

Non-conventional Water Resources (NCWRs) are an important underpinning of WCM, including such as wastewater reuse, desalination, and rainwater 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-convention water resource, while reducing water pollution and allowing for the recovery of useful by-products such as nutrients and energy. Yet, there is a need to improve knowledge and management practices to ensure safe water reuse, in particular with regard to health and environmental risks of pollutants. Desalination provides a constant source of water in countries that face extreme scarcity and have access to the most abundant form of water found in seas and oceans.

Managing Water Resources while recognizing global change

Managing our water resources requires understanding, acknowledgement, and inclusion of the influences of global changes on our water management plans, using tools like scenarios development. It is necessary to both, focus on mitigating global warming, as well as on adapting to it and increasing resilience.

When doing this, risk sensitive areas such as SIDS, semi-arid regions, coastal hinterlands, and mountainous areas should receive extra attention.

Mitigation water management can be achieved by utilizing water in innovative ways, by for example using tidal changes, wave energy, and small sustainable hydropower dams and better wetlands management. Adaptive water management considers that extreme conditions occur more often and with higher intensities and how to limit the effects of extreme conditions and build a resilience framework to optimize water management.

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

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

Expected outputs:

5.1. Awareness raised at all levels on the importance of science-based water governance.
5.2. Capacities on new frameworks and tools such as Climate Risk Informed Decision Analysis (CRIDA) enhanced to underpin water governance and build resilience.
5.3. Novel approaches of adaptive water management to support sound water governance developed and capacities of Member States enhanced.
5.4. Water governance legal, policy and institutional frameworks assessed and proposals for their improvement made to ensure that they are context-dependent, location-based, reflecting adaptation to climate change and IWRM integrating both surface water and groundwater.
5.5. Cooperative frameworks and open-access internet-based databases for water data collection and monitoring developed and / or promoted to improve water governance.
5.6. Capacities and skills strengthened in water cooperation and diplomacy as well as in the application of the principles of the "from Potential Conflict to Cooperation Potential" (PC-CP) initiative in conflict negotiation.

Relation between this priority area and the Agenda 2030

Water Governance is directly linked to several targets of SDG6 (ensure availability and sustainable management of water and sanitation for all), water-use efficiency (6.4); integrated water resources management (6.5.1), including transboundary cooperation (6.5.2) ; international cooperation and water capacity-building support (6A); and participation of local communities in decision processes (6B). Progress in governance also impacts the fight against poverty (SDG1) and hunger (SDG2), building resilience and reducing exposure to extreme weather-related events; doubling productivity and the income of small food producers; and implementing resilient practices that strengthen capacity to adapt to climate change (targets 1.4, 1.5, 2.1, 2.3 and 2.4).

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

This priority area also 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. SDG 16 (peace, justice and strong institutions) is especially related to transboundary water cooperation (target 6.5) and SDG17 (partnerships for sustainable development). Any successful sustainable development program, including water governance, 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.

Good water governance is essential for sustainable water management

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 and water democracy, including water ethics, legislation and institutions, and the roles and responsibilities of all stakeholders.

The UN-Water SDG-6 Synthesis Report suggests that adequate or good governance is essential for sustainable water management focusing on a bottom-up framework with multiple stakeholders. Water governance is understood as a cornerstone to enable Member States and the multiple stakeholders in water to adopt and implement decisions based on information and knowledge to build more resilient and peaceful communities and governance structures, without leaving anyone behind.

Maintaining access to sufficient quantities of clean water poses an interesting and complex challenge globally due to power-relations and a number of hydrological characteristics - scarcity due to global change, uneven distribution and land use changes, an increase in contamination levels and the complexity of emerging pollutants, in addition to unsustainable decision-making, inadequate management, and poor conservation policies. These factors combined with local water cultures that expect government to provide water based simply on increasing demand are altering the water map, translating into various managerial challenges. Water governance is a long-term activity that calls for water master plans, long-term financing structures, and implementation projects based on science. Good governance is therefore a prerequisite in addressing most of the aforementioned challenges, building a successful implementation of SDG 6 of the 2030 Agenda.

One of UNESCO's priorities is to ensure that decisions and actions on water, (surface and groundwater), are made on the basis of scientific, multidisciplinary and accessible information, and this is why we insist on promoting water education and research as the best tools to understand water and manage it.

Water governance requires the ability to understand what happens to the water resource in a basin and its related aquifer, both in terms of the hydrological cycle (of precipitation, evapotranspiration, infiltration and runoff flows) and where and how the main modifications of ecosystems take place in order to address those hot spots (human settlements, agricultural use, industrial activity, etc.) and to intervene to avoid unwanted modifications or to rehabilitate ecosystems to a suitable state.

The comprehensive nature of Water Governance

Economic development, population growth, urbanization, the evidence of variations and climate change and the further deterioration of the environment are integral aspects of water governance at different spatial scales and time periods. These elements significantly increase water-related risks, compromising the availability and the quality of water and, in general, the sustainability of the resource. Inadequate management skill can further compromise the implementation of adequate water governance.

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

There is a need to develop and implement new paths to achieve sustainable urban water management that goes beyond physical engineering and implementing IWRM. Such policies must ensure conservation of the resource and protection of watersheds, raise awareness for the reduction of water consumption, ensure compliance with the law, promote water reuse, manage aquifer recharge, and recycle storm water and wastewater, provide circular economy incentives, especially in megacities, all of which can only be achieved with the cooperation of the national governments, local authorities and non-governmental organizations, with well-coordinated efforts.

Science: the foundation for sustainable water governance

Decisions to deal with water challenges require a holistic, coherent, and inter-sectoral vision as well as science-based policies in order to address all aspects of water uncertainty. The sound scientific underpinning of water management decisions needs to become common practice globally. Water use, protection, mitigation, and adaptation measures are considered to underpin the sustainability of societies. 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.

The characteristics of groundwater as an 'unseen', a largely open-access resource extremely vulnerable to contamination from many diverse sources, and usually developed in a largely unregulated way (private, unregistered exploitation is predominant), and the comparatively very lengthy processes of discovering negative or irreversible impacts to the aquifer, merit special attention and governance provisions. Groundwater still lags behind surface water with respect to effective governance and therefore great efforts are still required to close this gap.

Adaptive governance based on science as a key to future management

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. Therefore, 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.

Tackling problems due to the mismanagement of water requires adaptation to global changes and mitigation of environmental degradation. Adaptation measures for a resilient water sector require the participation of multiple actors, political will and a sound scientific framework including strategic, tactical, and operational decisions. This can be addressed by supporting knowledge development and dissemination on resilience, which is extremely important for socio-economic development and potential investments. Linking resilience-promoting activities with community livelihoods and encouraging community participation in resilience assessments are indispensable for the spreading and effectiveness of these measures.

Good water governance also requires the promotion of additional research to address the challenges of food security and adaptation to climate change as well as on the recycling and re-use of wastewater, managed aquifer recharge, and to develop affordable technologies for water desalination, by developing research for renewable energy utilization. Improving scientific research, knowledge and data on risk assessment, regulations, and pollution control/attenuation, and linking water quality and quantity with economic approaches, advancing socio-ecological system approaches, and identifying feedback between water and society are some actions to improve water governance.

Participation and partnership for Water Governance

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"[5] (EEA, 2015, 12). Understanding and ensuring the role of accountability, transparency and participation of all stakeholders, including those vulnerable groups (~~women, indigenous communities, youth and children, refugees, immigrants, and disabled groups~~) whose opinions are often side-lined, is core for effective and equitable water governance.

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. Water Governance should not only incorporate a cooperative framework but should also use open access internet-based databases that can enhance cooperation and shed light on water-related conflicts. As local demand for water rises above supply in many regions, the effective governance of available water resources will be key to achieving water security, fairly allocating water resources and settling related disputes.

The value of water and the services that freshwater ecosystems provide in all affected sectors should be stressed. Coherent policies, legal frameworks, planning, partnerships, adequate financing, and justice are fundamental to achieving the SDGs, and thus are required for good governance. This must include ethics creating effective, accountable, and transparent institutions, to ensure participatory decision-making, at all levels. The elements of coherence and integration also need to be stressed, avoiding the silo approach. A multi-stakeholder platform can work effectively to realize such decision contexts.

Twenty-eight years after the Dublin principles identified the critical situation of world water resources and the interdependence of all countries, water has yet to reach the highest level of governance. However, progress has been made. For example, there is a growing recognition that the scope and complexity of water-related challenges extend beyond national and regional boundaries and therefore, cannot be adequately addressed solely by national or even regional policies. This is especially true, as widespread water scarcity and lack of access to water supply and sanitation threaten socio-economic development and national security for countries throughout the world.

Water cooperation and diplomacy

It is important to strengthen the cooperation and the leadership IHP, as an Intergovernmental Programme provides, with an emphasis on transboundary and groundwater resources based on principles of water cooperation and diplomacy, not only in terms of negotiation and cooperation, but via the concrete mechanisms identified in IHP-IX. In that regards, IHP-IX will continue to provide co-leadership in supporting Members States on the monitoring of SDG 6.5.2.

Faced with climatic instability and the effects of demographic and economic growth to the world economy, the global landscape and biodiversity, it is necessary to reverse the degradation of water resources and halt the decline in biodiversity and carbon storage capacity. Water governance should facilitate adaptation, mitigation and resilience processes including, through eco-hydrology, the regulation of the hydrological and nutrient cycles in ecosystems altered by the human factor. Ultimately, adequate water governance is a fundamental and solid pillar to guarantee sustainable water security for all.

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

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

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

Through this network, UNESCO water programmes have established credibility around water resources management cooperation, as technically competent, neutral, and trusted conveners. They have also established excellent working relationships with global and regional partners at various levels including policy and decision makers from countries and regional water institutions, as well as other UN agencies through UN-Water. Additionally, IHP has developed a very dense matrix of private sector and NGO partners who are regularly consulted on the development and implementation of its work programme.

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

While substantive advances have been made in both science and its application to decision processes, many of the issues that were addressed in IHP-VIII are still unresolved and relevant. IHP-IX will therefore follow in this dynamic tradition by addressing five priority areas, all interconnected and related to water security and sustainable water management. In this manner, water education becomes a main axis of continuity and transition from phase VIII to phase IX, with increased importance on the relationship between new technologies and education. In the same way, unresolved issues from other five themes of the eighth phase of the IHP, are reflected in IHP-IX with an intertwined, holistic approach and steering away from the silo approach of the past.

An additional critically important transition element from IHP-VIII to IHP-IX will be the 17 to date Flagships and Initiatives s, 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. IHP-IX will also continue to support capacity development through various flagships, initiatives, and other UNESCO water family programmes.

Partnerships

The aforementioned cooperative initiatives and the overall implementation of IHP-IX will be led by UNESCO's Water Family and will benefit from existing partnerships with the United Nations and other organizations of the United Nations system, Scientific Unions, and entities with which UNESCO has concluded mutual representation agreements.- In addition to strengthening the partnerships among the UNESCO Water family, other existing partnerships will be strengthened, those from UN-Water and its members, academic and scientific organizations and associations, Intergovernmental organizations, Non-Governmental organizations and with global funds.

Further to that, partnerships will be pursued with other UN-water members, global, regional, or national organizations, research / academia, the private sector, non-governmental organizations.

Outreach and Communication

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.

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.

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.