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PROVISIONAL FIRST-ORDER DRAFT OF IHP-IX

Contents

Preamble

Water is an element that fulfills multiple functions, is found in different physical states and phases of the hydrological cycle, is not limited to the borders established by human societies, yet is essential for life and economic development. Faced with the diversity and transversality of water, UNESCO's work has been linked to the development of hydrological knowledge, with education and the creation of capacities at the forefront of their efforts to help all stakeholders respond in an effective and responsible way to the growing needs of long-term sustainable development. Logically, this includes promoting and favoring cooperation among diverse users, and participation and generation of alliances that enable Member States to comply with the multiple goals and indicators linked to water within the 2030 Agenda for Sustainable Development.

The UNESCO International Hydrological Program (IHP), which was founded in 1975, is currently implementing its Eighth Phase," Water Security: Responses to Local, Regional and Global challenges," during the period 2014 - 2021, which began one year prior to the launch of the 2030 Agenda. There have been important advances in the face of the evermore-complex challenges of water security, with multidisciplinary, innovative and environmentally friendly tools and approaches, capitalizing on scientific advances and reducing gaps in data fields. Additionally continued efforts to meet the eight indicators of Sustainable development Goal 6 (SDG6), along with other important and related water goals at various scales will underscore UNESCO's efforts during the Ninth Phase of the IHP (2022-2029).

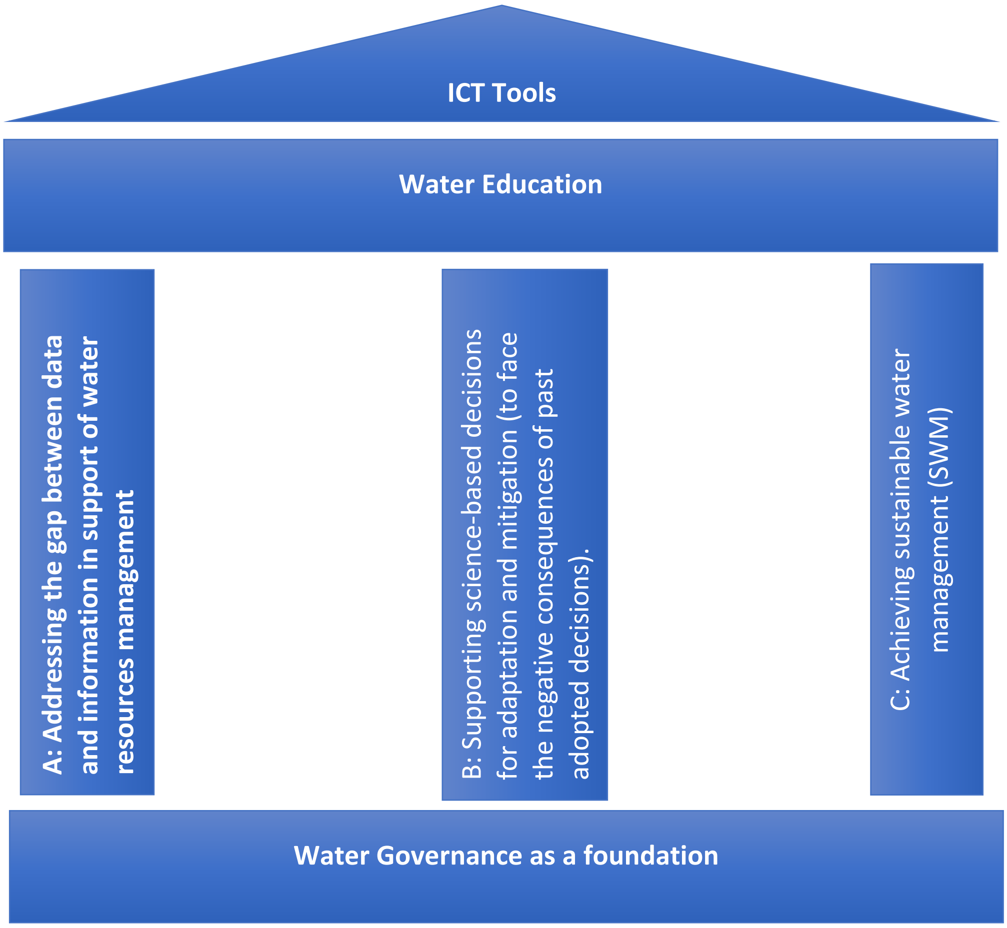
IHP is a long-term program executed in phases of an 8-year duration. Since IHP was established, its mode of implementation has gone through a profound transformation from a single discipline to a multi-disciplinary program. Recently, with the increased presence of the social science component, and now with the collaboration of citizen science, IHP has become a truly inter-disciplinary undertaking, capitalizing on the recognition that the solution of the world water problems is not just a technical or natural science issue.

In that spirit and as a follow-up action to the second meeting of the IHP-IX Task Force, the IHP Secretariat circulated first the zero-order draft and subsequently a first-order draft developed by the Task Force after consulting with all members of the UNESCO Water Family. The comments received were very diverse, but at the same time highlighting priority issues in many responses, with the clear understanding that an on-going effort is required for a deeper exchange of ideas involving all members of the UNESCO Water Family.

In September 2015 the UN adopted "Agenda 2030 for Sustainable Development" and the following year the General Assembly adopted the resolution "International Decade for Action – Water for Sustainable Development" (2018–2028) in support of the achievement of SDG 6 and other water and sanitation related targets.

Recognizing the importance of all processes underway, it is still essential to reinvent ourselves, deconstructing our certainties and approaches to water, in order to reconstruct, in a participatory and collaborative way, new orientations towards the consequences of our decisions in the face of an uncertain water scenario, globalizing the access and management of information about water resources, in order to achieve a sustainable water management, where economic growth is possible using less water while protecting its quality. And while we know that water is a renewable resource, that fact does not imply that it is an inexhaustible resource. Mother Nature, in all of its ramifications may be irreplaceable, but the presence of humans in the equation forces us to focus on deepening and expanding water knowledge, not only that of the experts, but also that of the all users and citizens, with an emphasis on the youth and women. This orientation is realistic given the challenges involved in development processes in an increasingly technological world, where the governance of water can make a difference in the quality of life of people and ecosystems, which are, finally, the basic components that the Task Force has selected to highlight in this Phase.

The current framework for IHP phase IX is therefore envisioned to support the major programs of UNESCO, where Water Governance is a foundation and simultaneously build on to construct the frame through time in three main pillars: (a) Defining the current status: Addressing the gap between data and information in support of water resource management, (b) Solving past induced problems: Supporting science-based decisions in a dynamic reality for adaptation and mitigation, and (c) Assuring a sustainable future: Achieving Sustainable Water Management (SWM). To cover these three pillars and finalize a secure construction, water education and ICT will drive a new era of water resource management and water professionals. The IHP Secretariat will manage this framework with support from UNESCO Chairs, Category 2 Centres, WWAP, IHP National Committees and all IHP initiatives, shortly, by the UNESCO Water Family.



The 3 main pillars of IHP Phase IX

Pillar A: Addressing the gap between data and information in support of water resources management.

An important step to enable water resources management is addressing the gap between available data and information required for decisions. As the High Level Panel on Water stated in their concluding report, you “cannot manage water if you cannot measure it”. Measurements in any hydrological system lead to information about the current state of the basin, knowing about water quantity, quality, distribution, access, risks, and use among many other factors; all essential information for effective decision making. Unfortunately, the lack of such data does not necessarily relieve decision makers of attempting to chart an effective way forward, many times leading to partial solutions – helping one problem while creating or exacerbating others. The Panel’s World Water Data Initiative aims therefore to improve generation of and access to better water data, specifically aimed at filling major gaps in the information needed to make informed decisions.

Water data can come from many sources: in-situ measurements, and real-time continuous sensor data, as well as new and innovative sources like remotely sensed information (satellites, drones), participatory monitoring (citizen science), and social media sources data.

However, the difficulty in collecting and understanding raw data and then applying it to a hydrological system in a decision context is often times much more complex than initially contemplated. There is also a gap to ensure that 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 issue is even more complex when a water resource is shared by more than one political jurisdiction, even in the same country.

Therefore there is a need to go beyond the data collection on its own and assist countries to commit to making evidence-based decisions about water management. This concept should include developing national water data policies and systems, using open data approaches, and logically unifying the experience of different generations, genders, cultures, among other skills and attributes.

To enable this transformation, IHP-IX is recommending different actions such as:

1. <u>Improving the quality and quantity of water data by enabling an increase in the density of collection stations and better validation of such data.</u>

Data is the most important tool in water resources management; without which management is severely handicapped. All analysis and modeling efforts, no matter how complicated in nature, are dependent on the quality of data (accuracy, scale, up-to date, and density -whether it contain too many gaps to be used). By enabling scientists to better validate the raw data using statistical methods, ground-truthing and so on, the basic quality of scientific research can be improved. By enabling scientists to combine different data sources to increase data quantity, scientific research can be based on larger and more complete data sets.

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

Centralized management of data is crucial to develop better decision support systems, water governance, water education and eventually sustainable management of water resources. Availability of accurate and credible data in a format that can be easily accessed and understood is 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.

Globally, professionals need to be able to find necessary data for their purposes, including validating the data collected for sake of comparison both scientifically and for understanding how such data was applied in a policy context. Whether this data is collected in traditional 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 make water data more accessible and understandable, platforms and quality assurance protocols should be improved or created, depending on the need. IHP VIII initiated programs like IHP-WINS, the International Water Quality Platform, the Global Network on Water and Development Information for Arid Lands (G-Wadi), and data platforms from the UNESCO Water Family like GEMS and GGWM (IGRAC Groundwater data platform) have been making a start on this task and will continue to improve their efforts overtime. Furthermore, considering the cost of data collection by traditional means, remote collection and analysis technologies must be promoted, especially via satellite and specialized Internet applications. Data from remote technologies should be placed on sites with international access to alleviate the differences between country resources and mismanagement of shared water resources.

Data collected by citizen science initiatives all over the world infrequently realize their full potential because their reach is small and collection methods and scales may inhibit comparisons with other data sets. Enabling people to collect data increases its potential use leading to an improvement in both the quality of science, critique by peers and overtime policy based on such information. Even when data is visible and comparable, there is no guarantee that professionals are able to collect it. For this reason developing user-friendly platforms and accepted matrices, outreach protocols, and capacity building exercises help to increase knowhow and the quality of data collected by civil society groups.

3. Enhance development and use of scientific research methods to correctly analyze and interpret the data, resulting in better scientific information.

To correctly analyze and interpret available data, scientific methods like modeling, forecasting, data assimilation, and data visualization need to be thoroughly understood. It is essential to know when to use which processing method, in order to use the correct way to interpret the data that is understandable by the broad scientific community. There is thus a need for building capacity in the professional ranks of the water community as it forms an integral part of planning future water projects and contributing to water goals including the SDGs. IHP-IX will therefore continue to support the FRIEND, the World Large River, and the International Sediment Initiatives.

But in a changing and uncertain world, developing new scientific methods to process data and utilizing cutting-edge technologies is also needed to help serve the SDGs and beyond (i.e. AI, big data processing methods). We will learn from methods used in other sectors, which can be more advanced than water sector specialists. The program will also make use of the multidisciplinary input from other UNESCO departments to combine different sciences related to Water Resources Management (social, economic, environmental) with hydrology to include the current influences on water resources in the Anthropocene, for example by looking into socio-hydrological scientific interpretation methods.

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. New opportunities associated with a data revolution from more innovative data sources can be leveraged to improve the knowledge base of water-related social-ecological functions, supporting sustainable management and resilience.

One way to focus data interpretation is on a basin scale. There is a need to incorporate the changes to the hydrological cycle (such as social influences, climate change or others) in different environmental settings (delta, arid, tropical, SIDS, etc.). Thus there is a need for experimental basins that can be used as examples for similar basins all over the world and with the help of the UNESCO Water Family, a chain of experimental basins could be managed and researched. In these basins, scientific information can be found to determine how much population can sustain an ecosystem (watershed), to strike a balance between supply and demand and to avoid increasing the vulnerability of ecosystems and the inability to serve a society emerging.

One additional way to go beyond the basin scale is to include data on virtual water processes at the global scale including trade data on food and other products and commodities, in essence moving water from water scarce areas to water rich areas and vice versa.

4. Enabling the accessibility, visibility and open-access of scientific information for the world to learn from each other.

Once data has been processed into scientific information and our published in journals, it needs to be shared with one another, enabling young professionals, experts, and other scientists to use it to further their work. Open access science should be enhanced as much as possible. Scientific information should be combined with indigenous knowledge and disseminated. It is important to recover long-standing information and customs, while making use of the new emerging digital technologies to open unsuspected possibilities.

5. Assist in disseminating and developing new interpretation methods of scientific information into a format usable for policy making.

Current methods for translating scientific information into information for decision making and policy formulation such as visualization methods, roadmaps providing implications for decision making, scenario development, etc. are lacking. These methods need to be disseminated (via workshops, meetings, trainings, platforms, etc.) to other professionals.

6. Demonstrate to all stakeholders the results to disseminate information, to increase public awareness of the risks facing society in relation to water.

It is very important to disseminate information to increase public awareness of the risks facing society in relation to water, and to enhance political discussion and understanding. One of the initiatives of UNESCO-IHP that has just been accepted is the Global Water Museum Network that can enable this dissemination to the public. By popularizing scientific results from IHP into information and activities for the public, the information found by water scientists will reach a broader audience. There is therefore a need to develop and start using methods to popularize water information.

Pillar B: Supporting science-based decisions for adaptation and mitigation to face the negative consequences of past adopted decisions.

Economic and industrial development frequently lead to decisions without considering the negative consequences on water resources, whether such impacts are of a short, medium or long-term. Additionally, population growth and its spatial and temporal dynamics have significantly increased the water-related risks. Water availability and quality are main concerns for societies under the evidences of global change. Accordingly, the 2030 Agenda indicates that the complexity surrounding water management is clearly interconnected with other factors such as economic development, hydro-political aspects and environmental changes.

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 for water management decisions needs to become common practice globally. Water must be managed and used sustainably, efficiently, and equitably, while recognizing and preserving its environmental, social, cultural, and economic values. Water 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.

IHP-IX is recommending two areas of action:

1. Adaptation to global changes.

The adaptation chain to global changes requires a series of measures including prevention, improving resilience, anticipation capacity, response, and recovery. To enable those measures, the negative impacts of global change need to be mapped. The probability of extreme events, which negatively affect lives, jobs and the socioeconomic status, is expected to increase because of human activities (i.e. deforestation, river draining, construction of reservoirs) and because the effects of climate change. However, the results of existing combined meteorological-hydrological models are still unreliable. Many shared basins and/or aquifers are poorly gauged and still lack the comprehensive assessment of environmental and socioeconomic impacts of projects.

Therefore, the adaptation chain for a resilient water sector requires the participation of multiple actors, political will and a sound scientific framework including strategic, tactical and operational decisions. This can be addressed by supporting the knowledge dissemination on resilience, which is extremely important for socio-economic development and potential investments. Research into risk levels should be intensified and data developed must be open-source among basin and/or aquifer countries.

The specific objectives of such an undertaking potentially include:

- Investigate the interaction between climate change with the hydrosphere in terms of data collection, and quantify projections and impacts on water supply, demand, quality, hazard and disasters;
- Link water resources management with socioeconomic and demographic growth in terms of water demand for various competing uses, such as agriculture, industry, and tourism;
- Compile, share, and analyze data on food security and socioeconomic vulnerabilities due to water-related hazards;
- Promote the reduction of high-water consumption by the agricultural sector through efficient irrigation equipment, applying volumetric water quota system, expanding use of drought and salt tolerant crops, and activating fair and social water tariff system;.
- Support cooperation among Member States sharing river basins to advance vulnerability studies and adaptation actions related to climate change and water-related projects;
- Support countries to improve cooperation and mutual understanding, strengthen their capacities and develop regulations for the sustainable management of transboundary aquifers;
- Identify priority adaptation measures for resilience of water-related infrastructure and restoration of ecosystemsDetermine the vulnerability of both rural areas (water scarcity, desertification, loss of productivity and agricultural employment), as well as urban areas (the human right to water and sanitation, threats and water risks) to climate change and extreme events among other water related problems;
- Promote uncertainty analysis of water-related hazards and risks among governmental agencies, river basin authorities, and research entities; and
- Promote community participation in undertaking vulnerability and resilience assessments.

2. Mitigation of environmental degradation.

There is a continuing and increasing tendency to dispose pollutants into lakes, rivers, streams water recharge zones; clearly a result of inadequate and/or poor management and a lack of enforcement. There are, of course, other contributing factors such as inadequate investment in recycling and water treatment in reuse infrastructure, and other consequences of continuing urban population growth. Water quality deterioration makes water unfit for use and hence contributes to water scarcity.

An In-depth assessment of the anthropogenic and natural contamination of the environment, accumulation of existing pollutants to water bodies, and emissions of GHGs and other components to the atmosphere must be undertaken at various scales to fully understand the problem and develop solutions. It is also mandatory to support the interaction with ecosystems and environmental flows, the promotion of adequate water pollution control policies, and mitigation policies of global warming and atmospheric pollution.

The specific objectives of such an undertaking potentially include:

- Working on target 6.3 of Water SDG 6, to improve, by 2030, water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally;
- Outline the basic criteria for the assessment of groundwater quality and vulnerability;
- Support coordination efforts in the management of watersheds and on the ocean coast to mitigate environmental consequences in one by mismanagement in the other;
- Inter-connect marine with freshwater and mitigate the human negative impacts on ecosystems from land and rivers to near-shore coastal zones and in marine environments;
- Promote GHGs mitigation measures by applying solar energy to well pumps for human consumption and irrigation, and for the transport and conduction of anti-gravity water when necessary, in regions with high levels of solar radiation;
- Enhance legal, policy and institutional frameworks for improved water quality management;
- Develop robust analytical techniques and methodological standards across sectors in support of integrated decision support systems that can be adapted to a variety of environments and political contexts;
- Improve scientific research, knowledge and data on risk assessment, regulations, and pollution control/attenuation;
- Link water quality with economic approaches including cost recovery principle for wastewater treatment and the polluters-pay principle; and
- Advance the socio-ecological system approaches identifying feedbacks between water and society.

Pillar C: Achieving sustainable water management (SWM)

Humanity, in order to improve its quality of life, pursues development. Unrestricted development can lead to social inequity, environmental damage and affect the quality of life of future generations. This is particularly relevant when it comes to water. Sustainable water management requires understanding the relationships between supply and water demand, avoiding over-use of natural resources and use levels that can be sustained over time. This goal becomes even more complex due to climate change and direct anthropogenic impacts. Therefore, SWM can be considered as an allocation problem in a highly complex system that includes natural and social components and various synergies and trade-offs between them.

There is little disagreement that, an integrated, cross-sectoral approach is mandatory. IWRM can form the backbone of such a strategy, yet it must be complemented with tools and approaches that enable the necessary cross-sectoral assessment and solution of water problems. What was proposed in this area by SDG 6, target 6.5 on water and its integrated management, constitutes a floor to be consolidated for long-term management. An innovative and holistic approach to water management should enrich IWRM, through including the mainstreaming of circular economy and ecohydrology, demand management, non-conventional water resources and the Water-Environment-Food-Energy (WEFE) nexus. In this regard, IHP offers an opportunity to foster a science-based approach to current and future water issues: sustainable management of water resources may be regarded as the ultimate outcome of the strategy of IHP-IX.

Due to the complexity and cross-sectoral nature of SWM, a nexus approach should be used to identify synergies and tradeoffs between interdependent sectors to address the complex global development and security challenges and support the implementation of SDGs in all scales ranging from river basins to a global scope. The interrelations in the 2030 Agenda show that SDG 6 cannot be achieved independently of other goals, yet it is also obvious that most of the others SDGs (e.g. SDG 1,2,4, 5, 8,10, 11, 12, 13, 15 and 16) need SWM. The synergistic relationships between different SDGs and water are case-specific and should be evaluated to design and implement SWM. This requires fluid communication through the interface between different dimensions of science, domestic and international policy (if applicable) and its regulatory and institutional frameworks.

Particular attention needs to be paid to water management models and strategies developed by Member States, the UN system, NGOs and the research community, which may have direct applicability to the work of IHP. To avoid SWM being captured by certain water sectors, evaluation against international benchmarks is also a must and a potential field of leadership for IHP.

IHP-IX is recommending two areas of action:

1. The use of non-conventional water resource tools (NCWR).

The use of NCWR, through cost-effective and replicable practices could ensure water availability and address water scarcity challenges at a local level. NCWR includes the reuse of treated grey-water and wastewater, rainwater harvesting & storm water collection, desalination of marine and groundwater brines, ice shields, fog harvesting, permafrost, smart and nature-friendly water storage systems, and geo-engineering among others. The reuse options of NCWR are parts of a water chain approach to SWM, pointing towards a circular economy for water and wastewater management.-NCWR require local knowledge on the operation and maintenance and can be replicable by developing technical expertise at a local level and also, they can act as field labs for further implementation.

2. Adopting/adapting sustainable water management principles and tools (SWM).

SWM implies a profound change in consumption patterns at all levels and in all sectors. Demand management is connected to the need for more active social participation and more water responsibility. Regulatory, administrative and economic measures provide tools to encourage water users towards valuing water and increasing their utilization efficiency. Demand management can also assist in promoting the use of NCWRs.

The basis of SWM is the sustainability of resources and attached ecosystem services. To ensure this, eco-hydrology, ecosystem services, and environmental flow assessments must be performed. Finally, natural and nature-based solutions should be considered during SWM planning and implementation.

IHP-IX would support a holistic approach on SWM focusing on technical, regulatory, awareness raising and capacity developing interventions, which should involve local authorities, institutions, the private sector, technical experts and local people. The specific objectives of such undertakings potentially include:

- Problem assessment, helping to understand its complexity;
- Evaluating the sustainability of proposed solutions;
- Raising awareness for non-conventional solutions and their advantages;
- Informing authorities of small scale solutions;
- Knowledge sharing and capacity development; and
- Assisting stakeholders, especially women and young people, to fully grasp the interactions of their activities with the natural resources and ecosystems.

The Three Cross- Cutting Tools

A. Water Governance as a Foundation.

Water governance refers to the political, social, economic and administrative systems in place that influence water's use and management. It determines the equity and efficiency in water resource and services allocation and distribution, and balances water use between socio-economic activities and ecosystems. Water governance includes formulation, establishment and implementation of water policies, legislation and institutions, and roles and responsibilities of all stakeholders.

Water resources availability is a complex paradox globally due to its hydrological characteristics, scarcity, uneven distribution and land use changes combined with climate changes that are altering the water map. These factors therefore translate into various management challenges. Good governance thus is a prerequisite in addressing most of these challenges, building a strong foundation for the IHP-IX strategy and to the successful implementation of SDG 6 of the 2030 Agenda.

The value of water and the services that freshwater ecosystems provide in all affected sectors should be stressed. Coherent policies, legal frameworks, planning, partnership and adequate financing are fundamental to achieving the SDGs. This must include creating effective, accountable and transparent institutions, to ensure responsive, inclusive, participatory and representative decision-making, at all levels.

The management of transboundary waters continues to be a very important issue. The majority of the global rivers, lakes and aquifers are shared by two or more nations, and a complex web of environmental, political, economic and security interdependencies link these transboundary water resources issues. The interdependencies extend not only across national borders, but also between the different water systems, underlining the need for integrated management of these resources within a common legal and regulatory framework whenever possible. A joint basin or aquifer-wide approach for water resources assessment, management, and mitigation of water conflict and stresses is required.

The IHP VIII Strategic Plan included recommendations related to water governance at the national and transboundary scales, including:

- Strengthening a joint cross-border diagnosis with a scientific basis;
- Understanding water resources by outlining the boundaries of watersheds and streams, determining water renewable rates and recharging mechanisms;
- Analyzing existing institutions and advising on appropriate institutional setup, mandate/roles standardized protocols and strategic change;
- Advising on Policy and legal issues, alignment of national policies and legislation to international law and to the desired accepted objectives;
- Offering expertise in mapping, analysis, stakeholder participation, in policies formulation and decision making; and
- Carrying out stakeholders' awareness and capacity building exercises.

An important challenge is to define how to use previous work as a basis for further improving water governance through better decision-making and understanding of the role of power and politics as important components to have accountability in all governance dynamics.

Resource mismanagement, corruption, inappropriate 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.

Public participation in decision affecting water access and use are vital to long-term acceptance by the beneficiary community. Particular attention must be paid to vulnerable groups notably women, indigenous groups, youth, refugees, immigrants, and disabled groups whose opinions are often sidelined.

River Basin Management Plans not only incorporate a cooperative framework but should also include open access internet-based databases that can enhance cooperation and shed light on water-related conflicts among countries that share transboundary waters. 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 specific objectives to realize such lofty goals in IHP-IX potentially include:

- Further research is needed on the sustainability of former IHP-influenced works, as it was project-based putting financing as key for compliance to the system in place;
- There is need to increase the number of trans-boundary basins that IHP collaborates on, together with the World River Initiative, PCCP, G-Wadi and the remainder of the UNESCO water family; and
- Coordinating IHP-IX goals with those of SDG6 would have the added benefit of showcasing UNESCO technical skills and its willingness to collaborate with other parts of the UN system.

B. Water Education in the fourth industrial revolution.

It is undeniable that the success of the SDG goals and targets depends on a profound transformation in human values. The most efficient way to catalyze this evolution in thinking is through education on a number of technical levels and 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 K-12 programs as well as in 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.

Water education enhances the ability of everyone to observe and question the role of water and emphasizes an increased understanding of how the quality and quantity of water are directly related to its sustainable management as well as their individual quality of life.

Water education, in a formal sense, is a prerequisite to implement the development agenda of countries, as it provides a critical mass of experts that will translate the developmental needs to water sector-related targets and help develop a strategy to achieve them. In this regard, there is a need to link tertiary water education curricula with that of Technical and Vocational Education and Training (TVET). It is also important to recognize the contribution of youth and young professionals to gain an understanding of the importance of water in their lives by developing all types of innovative science programs to ensure that future generations of water leaders are in the making.

Since every country has different water issues and priorities, the alignment of water education programs with formal curricula should be sensitive to local needs. Opportunities for educating the global population and water experts about water go far beyond the formal curriculum though. There are diverse ways to acquire knowledge: social media, training, lifelong learning, in-field workshops, exchange programs, refresher courses, summer schools, etc.; thus raising awareness for various audiences (community, decision-makers, experts etc.)

There are also numerous experts, teachers, young professionals, and governmental officials who require on-the-job training on water related topics that will improve their 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. IHP-IX has a strategic role to play in ensuring a more trans-generational dialogue in the water sector by building the capacity of youth as leaders to participate in the governance of water.

Multiplying the number and quality of trainers should also be a high priority. Since human resources and the budget are limited, the strategy needs to rely on creating multipliers, who will be thousands of water and non-water professionals. One of these multipliers is the WAMU-NET initiative, where water museums act as hubs for water knowledge.

Specific objectives in support of this issue should include:

- Enhancing opportunities to train-the-water trainer education programs as well as specific education programs for women and youth;
- Expanding linkages with IHE-Delft in providing tailor-made refresher courses for water professionals as well as in undertaking priority research efforts aligned with the SDGs and IHP-IX priorities;
- The IHP is committed to developing, monitoring and reporting on water education efforts and strengthening reciprocal links between targets 6.1, 6.2 and 6.3 with targets 4.1; 4.5; 4.7 and 4.a, as part of the joint efforts between water and education within the 2030 Agenda;
- Continue to support UNESCO efforts to enhance K-!2 science programs, particularly those that include water among the topics to be addressed;
- Support programs related to building a water-wise citizenry; and
- A Water education program for and by youth should be developed. Youth focused activities can includes supporting the implementation of local projects, encouraging mentorship, volunteerism and career development and facilitating their understanding of water

C. Information Communication Technologies (ICTs): Driving a New Era of Water Resources Management.

ICTs include a wide array of new technologies some of which have current application to water management and some that will undoubtedly play an important role in the future.

ICTs include Internet and cell phone technologies, cloud data storage and cloud-to-cloud communication technologies, open-source information, artificial intelligence (AI), robotic and remotely sensed data, etc. These technologies will most assuredly impact efficient and effective use of water resources, timely disaster forecast, groundwater governance, evidence based planning, conflict resolution among the actors and trust building, effective decision support systems, use of lesser resources and time and above all achieving sustainable management of water resources under an integrated water resources management framework.

The contribution of ICTs to the evolution of scientific and technological disciplines, such as satellite earth observations, real time monitoring networks, geographic information systems, and cloud-based geo-information systems and their interconnection to integrated water resources management will all be important tools for future generations of water managers to adapt to problem solving. Customizing novel ICT tools for the water sector may indeed help reach the objectives of the three main pillars of IHP Phase IX.

A seemingly unending number of remotely sensed products, including products of data assimilation, from the next-generation satellites, including CubeSats (nanosatellites) for Earth observation, are going to provide us much more data with greatly improved quality and hence the potential of more and broader applications than ever before. Products of other airborne platforms such as UAVs producing video data is also going to be an evermore important part of those products, particularly as the quality of digital photography and the sophistication of the related computer applications increases.

Operation hydrological real-time forecasts (i.e., river discharge forecast) on global and regional scales will soon be available and accessible to the public in a similar fashion to that of forecast, available and accessible for several decades. This will change the ways of water resources management and flood disaster mitigation in various parts of the world. It will be information very easily on a personal mobile device such as smartphone.

Simultaneously with this proliferation of technological possibilities already described is the fact that many people, both in developed and developing societies, already use and will be using more personal mobile devices such as smartphones exceeds even the impact that wide spread acquisition of small computers has had on the data and information marketplace. Now the inclusion of sensors to both phones and computers a new increment in data access, 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 may be deployed and connected along with personal mobile devices. Artificial Intelligence (AI) will also be of great help in the development and implementation of those networks systems, particularly in a developing society with a de-centralized communication and transmission system.

In decades past 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 will play an increasingly key role in the future to managing water resources. Open source decision support systems (generic and problem-driven) should be accompanied by comprehensive manuals and guides to ensure their effective and appropriate use. Open source software and data sharing for real-time management of a water system offers an opportunity to sustainable water resources managers as well as citizens and scientists to share data on an unprecedented basis.

The so-called "Internet of things" (IoT) is the extension of Internet connectivity into physical devices and everyday objects. Embedded with electronics, Internet connectivity, and other forms of hardware (such as sensors), these devices can communicate and interact with others over the Internet, and they can be remotely monitored and controlled. IoT could therefore bring substantially more information for water resources management. 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 and make available such data.

Specific objectives in support of this issue should include:

- The benefits of the latest generation of ICT tools to the water resources sector should be investigated, perhaps with the assistance of the Hydroinformatics Department at IHE-Delft and other water research institutions, particularly in manners that will interface with the goals outlined in the three thematic areas of IHP-IX;
- Access to and use of water resource data should be encouraged to reduce or prevent conflicts, and enhance dialogues and promote cooperation;
- The use of ICT tools should be effectively utilized in education, capacity building and awareness raising projects and programs;
- Strong support should be given to increased education in hydro-informatics – fundamental to using AI and a range of ICTs to better manage water resources;
- It is also suggested to put a focus on institutional and legal barriers to the adoption of ICT tools and related technologies for water resources management. IHP-IX strategy should address inter institutional cooperation at all levels (basin, regional, national and international) in order make ICT and AI operational and used in a routine way, identifying legal, institutional and financial barriers and ways to overcome them;
- Data assimilation techniques for adequately combining data from various sources should become ever increasingly important.

In entering a new ICT-driven era as described above, numerical models (hydro-informatics) of hydrology for simulation, assessment and forecast which have been developed and used in the “old” era might better be substantially improved or fundamentally remodeled. It is also important to note that these tools should be developed with a focus on meeting user needs; and

In addition, social sciences should that play an increasingly important role for effective deployment of technology and methods involving “co-innovation” and “co-design” are proving to be an effective and appropriate manner in which to introduce new technologies in less developed regions and smaller villages.