



UNITED NATIONS EDUCATIONAL,
SCIENTIFIC AND CULTURAL ORGANIZATION

INTERNATIONAL HYDROLOGICAL PROGRAMME



**WATER INTERACTIONS: SYSTEMS AT RISK
AND SOCIAL CHALLENGES**

Issues and Strategies

***6th Phase of the International Hydrological Programme
2002-2007***

***IHP-VI
2002 – 2007***

The development of IHP-VI is based on the fundamental principle that freshwater is as essential to sustainable development as it is to life; that water, beyond its geophysical, chemical and biological functions in the hydrological cycle, has critically important social, economic and environmental values that are inter-linked and mutually supportive. The launching of this phase of the programme coincides with what is seen by many water planners and managers to be a genuine shift towards holistic concepts and environmental awareness in society's approach to water development and management.

**The text for this document was prepared by Hydro Tech International
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BACKGROUND

UNESCO's intergovernmental scientific cooperative programme in hydrology and water resources is presently the only broadly-based science programme of the UN system in this area. It was established because both the international scientific community and governments, realizing that water resources are often the primary limiting factors for the peaceful development in many regions and countries of the world, saw the need for an internationally coordinated scientific programme focusing on water. It has had a prime role as a catalyst in promoting cooperation in water science and water resources management.

With this in mind, the Fifth Phase, IHP-V (1996-2001) set out to stimulate a stronger interrelation between scientific research, application, and education. During that phase emphasis was placed on environmentally sound integrated water resources planning and management, supported by a scientifically proven methodology within the overall theme, "Hydrology and Water Resources Development in a Vulnerable Environment". While IHP-V is finished, its results are still influencing both research and practice.

The Sixth Phase of IHP (2002-2007) now emphasizes the societal aspects of our water resources. Its primary concern remains however to study the occurrence and distribution of water within the natural environment. Adding the social dimension underlines the need for improved, more efficient assessment and management of our water resources – which in turn requires a much more accurate knowledge of the hydrologic cycle.

As a result, the development of IHP-VI has been based on the fundamental principle that freshwater is as essential to sustainable development as it is to life; that water, beyond its geophysical, chemical and biological functions in the hydrological cycle, has critically important social, economic and environmental values that are inter-linked and mutually supportive. The launching of this effort coincides with what is seen by many water planners and managers to be a genuine shift in society's approach toward water development and management.

How has IHP-VI been developed?

IHP-VI has had a complex history of development. It was developed originally on the basis of a Concept and Outline discussion paper prepared by a high-level international Task Force. That paper was then discussed in detail, and revised, during the 13th session of the Intergovernmental Council of the IHP, following which comments and suggestions were requested from all of the IHP National Committees. After receiving those comments and suggestions it was then followed up by a two-day Outline Workshop held at UNESCO. The resulting suggestions from that Workshop were then used to modify the Outline, which was then presented for discussion at the Fifth UNESCO/WMO International Conference on Hydrology in 1999. Subsequently, a Draft Plan, based on all the discussions, was prepared by the IHP Secretariat and thoroughly considered and revised by the IHP Bureau at its 29th session in 2000. The revised version of the Draft Plan was adopted by the 14th session of the Intergovernmental Council of IHP in June 2000.

At the same time as the process was underway to develop the Draft Plan of IHP-VI, several IGOs and NGO partners together with several research institutions began the development of a new initiative called HELP (Hydrology for the Environment, Life and Policy), which was also presented at the Fifth UNESCO/WMO International Conference in 1999. The result was that UNESCO was requested to develop the initiative jointly with WMO. It was foreseen that HELP would attract extrabudgetary funding and would contribute to and provide a major stimulus for strengthening links between all five Themes of UNESCO's IHP-VI and WMO's Hydrology and Water Resources Programme (HWRP).

The detailed consultation process over the development of IHP-VI had revealed numerous interrelationships between the ongoing IHP-FRIEND (Flow Regimes for International Experimental and Network Data) projects with all Themes of IHP-VI. The 28th session of the IHP Bureau therefore decided to consider both HELP and FRIEND as cross cutting programme components (CCPC) instead of simply parts of particular focal areas of the programme. Yet another initiative that was recommended in 1999 during the Fifth UNESCO/WMO International Conference was presented by the IAEA entitled "International Programme for Isotopes in the Hydrological Cycle".

The Conference invited UNESCO and the IAEA to develop it further in collaboration with WMO and to submit it for approval to the relevant bodies of the organizations concerned. This was done, and the 28th session of the Bureau of the Intergovernmental Council of IHP recommended that UNESCO organize, in co-operation with IAEA, a Planning Group meeting to prepare a concept paper for a new long-term inter-agency programme. The developed concept stressed the need for a long-term inter-agency programme entitled the Joint International Isotopes in Hydrology Programme (JIIHP) that should be established under the auspices of the IAEA, in co-operation with UNESCO.

Figure 1 shows how IHP-VI is to be interlinked with joint and interagency programme components. Table 1 summarizes the core components of IHP-VI: five Themes containing 21 Focal Areas. In order to emphasize that HELP, FRIEND are relevant to virtually all five Themes of IHP-VI, Table 1 shows the inter-linkages of the cross-cutting program components.

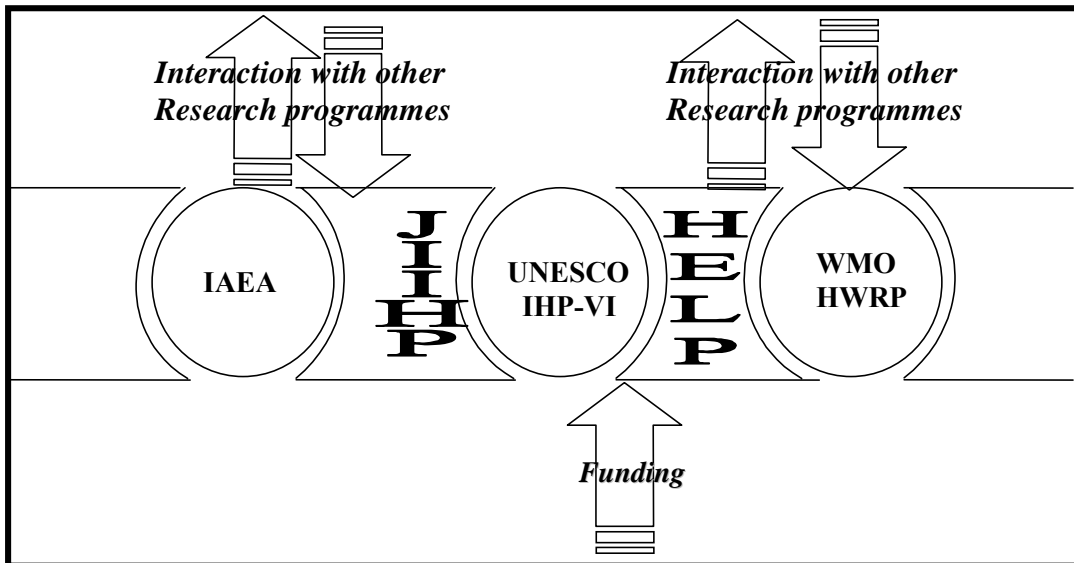


Figure 1. IHP-VI and its Interagency/Joint Programmes

Table 1. Overview of the core components of IHP-VI

Theme 1	Global Changes and Water Resources
Focal Area 1.1	Global distribution of resources: water supply and water quality ^{(*) (**)}
Focal Area 1.2	Global estimation of water withdrawals and consumption ^(**)
Focal Area 1.3	Integrated assessment of water resources in the context of global land-based activities and climate change ^{(*) (**)}
Theme 2	Integrated Watershed and Aquifer Dynamics
Focal Area 2.1	Extreme events in land and water resources management ^(*)
Focal Area 2.2	International River Basins and Aquifers ^(*)
Focal Area 2.3	Endorheic Basins ^(*)
Focal Area 2.4	Methodologies for integrated river basin management ^{(*) (**)}
Theme 3	Land Habitat Hydrology
Focal Area 3.1	Drylands ^{(*) (**)}
Focal Area 3.2	Wetlands ^(*)
Focal Area 3.3	Mountains ^{(*) (**)}
Focal Area 3.4	Small islands and coastal zones ^(*)
Focal Area 3.5	Urban areas and rural settlements ^(*)
Theme 4	Water and Society
Focal Area 4.1	Water, civilization and ethics
Focal Area 4.2	Value of water
Focal Area 4.3	Water conflicts – prevention and resolution ^(**)
Focal Area 4.4	Human security in water-related disasters and degrading environments ^{(*) (**)}
Focal Area 4.5	Public awareness raising on water interactions ^{(*) (**)}
Theme 5	Water Education and Training
Focal Area 5.1	Teaching techniques and material development ^{(*) (**)}
Focal Area 5.2	Continuing education and training for selected target groups ^(*)
Focal Area 5.3	Crossing the digital divide ^(*)
Focal Area 5.4	Institutional development and networking for W-E-T

(*) connections with FRIEND

() connections with HELP**

As decided by the IHP Intergovernmental Council at its 14th session, the Sixth Phase is to be executed in three two-year stages. Detailed activities and elements of activities have to be planned and specified in Implementation Plans for the duration of each stage.

The IHP Secretariat prepared the first of the rolling Implementation Plans for the first biennium as well as the Strategic Plan summarizing the overall thrust of IHP-VI as adopted at the 14th session of the IHP Intergovernmental Council.

The present document outlines the key issues addressed and the main components of the adopted Strategic Plan of IHP-VI. The Plan for the Sixth Phase of IHP has two basic functions:

- It identifies what are believed to be the most crucial water-related research issues emanating from the numerous water-related problems identified at the turn of the millennium, and
- It links the IHP-VI programme with major initiatives and the ongoing debate in the “Water World”.

The Plan has been conceived to guide programme activities and the development and testing of methods and procedures contributing to the solution of the identified water-related problems.

Why an IHP-VI?

Without question, water is an indispensable element to the proper functioning of the biosphere. In fact, it is such an important part of the environment that it impacts heavily on the socio-economic sectors. Human and economic developments are impossible without safe, stable water supplies. But water can also have destructive impacts, so these too must also be well understood.

Competing water uses (too often *misuses*) have often resulted in unsustainable situations such as depleted supplies, falling water tables, shrinking lakes, reduced streamflows and quality degradation. This has led to situations in which the water available is unsuitable for many potential uses. These problems are primarily the results of human activities, and are occurring

more and more frequently and in a much more widespread manner. In recent years, water issues have become very central in the international political agenda. This development is driven by the widely shared concern that the coming decades might be characterized by increasing water shortage in many parts of the world. As a result of competing uses and misuses, in recent years there has been an increasing conviction in many parts of the world regarding the existence of major water stresses and of looming water crises. In this respect, internationally shared water resources (about 50% of the world's freshwater) could become the source of competition or even conflict. The looming water crisis was tackled by a series of UN General Assemblies, inter-governmental and scientific conferences (1998 in Paris, 1999 at the IHP/World Water Council/IAHS conference in Paris and in 2001 Bonn (the International Conference on Freshwater) and World Water Forums: 1997 Marrakech, 2000 The Hague).

But awareness and subsequent good policy decisions should be based on sound scientific foundations. The need for a solid water science is a basic philosophy of IHP-VI. IHP has to face the political and social realities of the "Water World" and has to find proper interfaces to shape and be part of the mainstream development to address the actual water issues through research but also education and awareness raising. The Strategic Plan of the VIth Phase of IHP can be analysed; how it responds to the seven attributes of "Water Security for the 21st Century" as stipulated by the Ministerial Declaration of the 2nd World Water Forum:

- Meeting basic needs
- Securing the food supply
- Protecting the ecosystems
- Sharing water resources
- Managing risks
- Valuing water
- Governing water wisely

Unfortunately, in practice water resources have tended to be planned and managed in very fragmented manners. Surface water and ground water, for example, are too often considered separately in development activities, there being as yet an inadequate understanding of their common

interdependence. These water sources are all too regularly planned and managed without consideration of other resources.

The use of water resources often generates large amounts of waste water that also need consideration. Urban developments are commonly designed and built, especially in developing countries, without the necessary matching drainage networks and waste water treatment facilities. Quantity is generally managed separately from quality, as are water science and water resource policies. This fragmentation of approach impedes good hydrological analyses at regional, continental and global scales.

The need for proper planning and management of water resources calls for a process called *integrated water resources and management* (IWRM). There are numerous definitions of IWRM, often defined by individuals that are not experts in the field. But in general IWRM can be said to address the complex issues and changes of the physical, chemical and biological behavior of the entire hydrologic cycle including their interrelationships with various other natural phenomena and human activities. But “how” is the question.

The river basin/aquifer scale is broadly agreed to be normally adequate areal boundaries for water resources management in this integrated sense. The Ministerial Declaration of the 2nd World Water Forum endorsed IWRM as the comprehensive framework to tackle water resources related problems and development. But just how to go about the IWRM process is not clear. It seems obvious, therefore, that research on the subject is necessary. This requires not only the need for more inter- and multi-disciplinary approaches but also more cooperation and partnership in executing those research programmes. In that regard the water-related efforts of IGOs that have been offered as contributions to the international activities of the IHP should be synchronized with the programmes of the cooperating NGOs. It is expected that these synergies will be extremely important factors in the successful implementation of IHP-VI.

The Plan of IHP-VI has been designed to guide programme activities and the development and testing of methods and procedures contributing to the solution of the identified water-related problems. IHP-VI recognizes the need for a shift in thinking about water from fragmented compartments of scientific inquiry to a more holistic, integrated approach. Therefore, the general theme and title has been defined as *Water Interactions: Systems at Risk and Social Challenges*.

The combination of the above cited seven key issues of the “Water World” and the 21 Focal Areas of IHP-VI (subdivided into the 5 themes)

would yield 147 potential matches describing either explicit or implicit relevance of the respective research efforts. The analysis of the Strategic Plan of IHP-VI revealed 97 identified coincidences (both direct and indirect) showing that the IHP Phase VI will adequately address the scientific aspects of the actual agenda of the “Water World”. Consequently IHP-VI will provide substantial “policy relevant” research results.

How is IHP-VI organized?

In defining the critical research components for 2002-2007, it became clear that what had been missing before was a close investigation of water science and policy “*at the margins*”. What happens, for example, at the intersections of distinct geographical and/or thematic components of water resources management?

Within the general theme of IHP-VI some of the interactions believed to be in need of further investigation have been identified as those between:

- Surface water and ground water,
- Atmospheric and terrestrial parts of the hydrological cycle,
- Fresh water and salt water,
- Global watershed and river reach scales,
- Quantity and quality,
- Water bodies and aquatic ecosystems,
- Science and policy, and
- Water and civilization.

The apparent increase in worldwide human-induced and climatic change will be putting increasing pressures on water resources. The IHP-VI approach is that this requires a proactive, focused, integrated multidisciplinary way of addressing the scientific and societal issues. With the stated need for integrated management approaches it has been recognized that the underlying scientific base must also be considered by several relevant disciplines simultaneously.

Many of the results of present day research methodologies in water science were developed originally with limited data and using computational

procedures dating back several decades. With the development and improvement of modern earth observation technologies, the relevant data required can now be obtained and made available for research and investigation with a much higher spatial and temporal resolution. Furthermore, the development of information technology (IT) now provides access to a higher level of computational capability that often calls for the re-examination of the basic concepts for a better diversification of models for various uses. These trends call for the development of a new generation of water science modeling tools that will not only benefit from the available technology and data but also provide a more reliable analysis of interactions with consideration of areal scaling, the water chemistry/biology interface and the like. However, this is a gradual process. The reliable use of this new generation of models would still necessitate the maintenance and even improvement of the traditional “ground truth” observation networks.

IHP-VI will place emphasis on the interactions of these basic issues in order to help the water science and professional communities to better understand and use them properly. With this emphasis the reliability of data and models gain in importance. Due attention will be given to those aspects in the proposed activities and specific projects.

What is the IHP-VI programme?

The need for better consideration of water interactions, technological development of data acquisition and improved modeling of processes and interactions has been identified as being important. The relevant topics under IHP-VI have been identified and framed under five core Themes. The transition of interactions from the global scale to the watershed scale is a major requirement for considering the complex relationships between water and society.

The overall need for knowledge, information and technology transfer will, of course, always be a major consideration. The Themes of IHP-VI are:

Theme 1	Global Changes and Water Resources
Theme 2	Integrated Watershed and Aquifer Dynamics

Theme 3	Land Habitat Hydrology
Theme 4	Water and Society
Theme 5	Water Education and Training

Each of the five Themes is subdivided into Focal Areas (see Table 1), a total of 21 in all. These cover activities and activity modules (events, publications, etc.) contributing to the development of the Themes' topics.

In addition to the Themes there are two CCPCs of IHP-VI: FRIEND (Flow Regimes for International Experimental and Network Data), HELP (Hydrology for Environment, Life and Policy). These interact with all Themes through their operational concepts. But beyond the obvious symmetry with FRIEND, there is an expectation of substantial funding from external financial sources for HELP. Nevertheless, HELP is considered to be a fully integrated part of IHP-VI as far as scientific objectives, approach and knowledge transfer activities are concerned.

The interrelationships between the Themes and the two cross-cutting programme components are visualized in Figure 2.

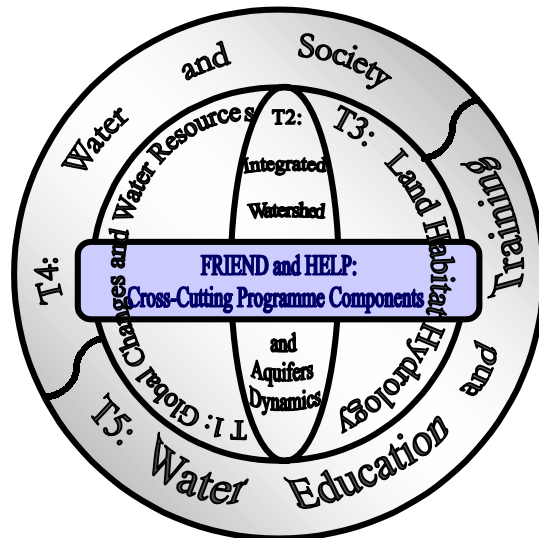


Figure 2. Relationships between Themes and the cross-cutting programme components FRIEND and HELP

Besides these two CCPCs IHP-VI has very strong linkages with the UN system-wide World Water Assessment Programme (WWAP), also hosted by UNESCO. It contributes actively to its challenge area: Shared water development. IHP-VI is actively involved in UNESCO's Interdisciplinary Initiative for Sustainable Development in the Volga-Caspian Basin initiated by the Steering Group of the Five Chairpersons of UNESCO international science programmes IGCP, IOC, IHP, MAB and MOST.

These involvements and several other key events and initiatives will be highlighted and briefly introduced in boxes under the respective themes of IHP-VI. The very nature of these, frequently multi – and interdisciplinary programme components imply that they interact with several themes of the IHP programme. Therefore the CCPCs FRIEND and HELP are introduced here.

Flow Regimes From International Experimental and Network Data (FRIEND)

The overall objective of the FRIEND project is to ease the problems of water resources assessment and management through applied research targeted at regionally identified problems. The project is an international collaborative study intended to develop, through the mutual exchange of data, knowledge and techniques at a regional level and a better understanding of hydrological variability and similarity across time and space. The advanced knowledge of hydrological processes and flow regimes gained through FRIEND helps to improve methods applicable in water resources planning and management.

FRIEND also provides support to researchers and operational staff of hydrological services in developing countries, thereby contributing to their capacity to assess and manage their own national water resources. It thus contributes to the goal of providing a reliable supply of fresh clean water to the world's poor.

With its features and structure developed during the earlier phases of IHP, FRIEND offers a particular contribution to IHP-VI by interacting with all five core Themes of the program. This special feature is characterized by its "cross-cutting program component" (CCPC) status.

The first FRIEND project was initiated in 1985 in Europe within IHP-III on the premise that improvements could be made if hydrologists were to exchange data and experiences with their counterparts in neighboring countries. To date, eight regional FRIEND projects have been established: in Northern Europe, in Southern Africa, in the Alpine and Mediterranean region, in Western and Central Africa, in the Hindu Kush – Himalayan region, in the Asian Pacific region, in the Nile basin and in the Caribbean. Several other regional FRIEND projects are being considered in Central Asia, South America and North America.

The scientific aspects of the FRIEND projects include studies in: low flows, floods, variability among regimes, rainfall/runoff modeling, processes of streamflow generation, sediment transport, snow and glacier melt and climate and land-use impacts.

Not only is the FRIEND network relevant to many of the projects within IHP-VI, its activities are also pertinent to several world scale environmental and health programs, such as WHYCOS, GEMS/Water and HELP.

Hydrology for the Environment, Life and Policy (HELP)

HELP is an initiative establishing a global network of basins to improve the links between hydrology and the needs of society. The vital importance of water in sustaining human and environmental health has been widely recognized by numerous national and international forums. However, no program has addressed key water resources management issues in the field and integrated them with policy and management. HELP is designed to change this by creating a new approach to integrated basins management. It is a problem and demand driven initiative that addresses five key policy issues:

- **Water and climate,**
- **Water and food,**
- **Water quality and human health,**
- **Water and the environment, and**
- **Water and conflict**

In order to emphasize the intended coherence of the HELP concept and approach and its relevance to virtually all five Themes of IHP-VI, HELP is also seen as a cross-cutting program component. Figure 2 reflects this decision showing the inter-linkages with the five themes of IHP-VI.

What are the details of the Themes and Aims of IHP-VI?

Following are descriptions of each Theme. The Focal Areas within each Theme are listed in Table 1. Their detailed objectives and envisaged activities are available in the Strategic Plan and relevant Implementation Plan of IHP-VI. Particular initiatives that are closely associated with a particular Theme are included under the respective Theme.

For complete documentation of the VIth Phase of IHP, including its particular initiatives please consult:

http://www.unesco.org/water/ihp/ihp_six.shtml

Theme 1: Global Changes and Water Resources

A reliable and clean supply of water is unquestionably critical to a human society as well as to the biosphere in general. However, with current technology it has been difficult to accurately assess the state of world's water resources and their response to the key agents of global change: namely, the greenhouse effect and climatic variability; land cover change; industrialization; population growth; and the modification of the natural water cycle through hydraulic engineering. It is poorly understood how, when and where such human-induced changes, together with weather and climatic extremes, will influence key ecosystems upon which humans depend heavily. Because there have been no carefully maintained and clear records of global hydrologic change the cumulative impact of human activities on the world's freshwater and marine support systems can not be judged with great precision. Given the deterioration of routine monitoring networks in many parts of the world, for all practical purposes, an accurate assessment is currently impossible. In contrast to the relatively well-mixed atmosphere, freshwater and coastal ecosystems have highly site- and regionally-specific

physical and water quality attributes that make such assessments extremely difficult.

It can be stated with reasonable certainty that process-based hydrological research, while highly productive at the small catchment scale, awaits success over continental and global domains. There is a critical need for synthesis studies of complex drainage basins because these collectively represent the primary domain over which impacts on water resources from human interventions have resulted. They have also been of primary concern of impacts on the sustainability of the biosphere. Indeed, this has provided the impetus for several major international and national observational and modeling programs such as GEWEX, IGBP-BAHC, and GCOS/GTOS. The initiatives of the two CCPCs of IHP-VI (FRIEND, HELP) have targets that will also contribute to the clarification of the inherent scientific issues at basin scale, in connection with various legal aspects and their resulting impacts on water management. Several opportunities do exist, however, for analyzing the global status of the land phase of the hydrological cycle and associated water resources. The recent emergence of improved models, high quality biophysical data sets, improved access to remote sensing imagery, and data assimilation schemes have provided a unique opportunity to monitor the state of the hydrologic cycle over broad domains, nearly in real-time. With this information appropriately prepared models can be used to provide improved understanding of many of the spatial and temporal aspects of global water resources.

Theme 1, through its scope and targeted scientific objectives will serve as one of the substantial science bases for the UN system-wide World Water Assessment Programme (WWAP). It will be implemented in current and future collaboration with international organizations and programmes (including UNESCO's environmental and social science programmes) such as WMO, IAEA, UNEP, IGBP, GEWEX, IGCP, IOC, MAB, and MOST.

The general Aims of Theme 1 are:

- **To estimate the time and space-varying nature of water supply and water demand at regional, continental and global scales (including the role of humans as agents of hydrological change) due to changes in land use, cover, and intensity; population growth; and water engineering and industrialization,**
- **To explore the effects of climate-induced forces on water resources,**
- **To encourage the adoption of emerging technical capabilities to perform broad-scale international, integrated, and multi-factor water resources assessments, and**
- **To support problem prevention and mitigation efforts with respect to water as a strategic resource.**

Three Focal Areas are considered within Theme 1:

- | | |
|-----------------------|---|
| Focal Area 1.1 | Global distribution of resources: water supply and water quality |
| Focal Area 1.2 | Global estimation of water withdrawals and consumption |
| Focal Area 1.3 | Integrated assessment of water resources in the context of global land-based activities and climate change |

World Water Assessment Programme (WWAP)

WWAP was created as a United Nations system-wide effort in response to the decision of the UN Commission on Sustainable Development. It involves 23 agencies and programmes of the UN system, to develop the tools and skills needed to better understand the basic processes, management practices and policies for improving the quality and supply of global freshwater resources. The Secretariat of WWAP is provided by UNESCO, based on the extra-budgetary support from the Government of Japan. Several other countries have joined as donors.

The programme's mission is to:

- Assess the state of the world's freshwater resources and ecosystems,
- Identify critical issues and problems,
- Measure progress toward achieving sustainable use of water resources,
- Help countries develop their own assessment capacity,
- Improve water resources planning, policy and management, and
- Document lessons learned and publish a World Water Development Report (WWDR) at regular intervals.

The World Water Development Report (WWDR)

The WWDR's main function will be to document basic processes, management practices and policies. Particular emphasis will be placed on developing-country situations to help lay the foundations for efficient and effective capacity-building in areas where stewardship challenges are great. One of the most original aspects of the report will be its use of international case studies as a testing ground for new methodologies. These will concentrate on water-related stresses in river basins, aquifers, cities and countries with regard to socio-economic circumstances and individual human needs.

The first WWDR will be published in March 2003 to coincide with the 3rd World Water Forum in Kyoto, Japan. It will take up the seven following challenge areas identified by the Hague Ministerial Declaration (2000):

- Meeting basic needs,
- Securing food supply,
- Protecting ecosystems,
- Sharing water resources,
- Managing risks,
- Valuing water, and
- Governing water wisely.

Four additional challenge areas have been added:

WWAP, cont.

- Water for industry,
- Water for energy,
- Ensuring a knowledge base, and
- Water for cities.

IHP-VI Theme 1 is the key scientific support area of WWAP, in particular in data collection and analysis. Besides Theme 1, all other Themes, in particular Themes 4 and 5 are also relevant to WWAP. The synergy of WWAP with IHP-VI is expected to be mutually beneficial in developing policy-relevant science.

From Potential Conflict to Cooperation Potential (PC→CP)

The PC→CP is the contribution of the IHP to WWAP. It is also supported by extra-budgetary funding. PC→CP focuses on the challenges of “sharing water resources” by promoting peace, and subsequently “water security”. Its aim is to turn areas of potential conflict into situations where cooperation is established and prove thereby that water can be a catalyst for peace rather than a source of armed conflict. During the first phase, which coincides with the first biennium of IHP-VI, the focus will be on international river basins. In the implementation of this project

UNESCO joined forces with the Water for Peace project of Green Cross International.

A history of conflict as well as cooperation concerning shared water resources and the legal and technical tools for negotiation and conflict prevention will also be reviewed and analysed in Theme 4 of IHP-VI.

Educational products constitute the major outputs of WWAP, as referred to in Theme 5 of IHP-VI. Teaching materials, educational modules, curricula, summer schools and internet-based dissemination are currently being prepared.

The PC→CP is expected not only to help strengthen IHP activities but also to draw on the scientific results generated within the different relevant focal areas.

Theme 2: Integrated Watershed and Aquifer Dynamics

Hydraulic, morphologic, biologic, chemical processes and human impacts on the hydrologic cycle are relatively well-known when studied in isolation at a small basin or aquifer scale. However, with increased pressure on natural systems resulting from population growth, large regions of the world are now subject to water-related stresses. There is therefore a need to develop the hydrologic and water planning and management strategies for ecological, social and economic sustainability over larger areas. The dynamics of the hydrologic cycle then bring into interaction all the elements of hydro-systems – combining the water fluxes with the fluxes of, for example, sediments, nutrients and polluting agents on and below the earth's surface. There are also dynamic interactions that must be considered between environmental (*e.g.*, climate change, extreme events, desertification), economic (*e.g.*, growth of agriculture, industries, energy needs), and social and cultural processes (*e.g.*, urbanization, human health). It becomes obvious, then, that water systems need to be analyzed in their whole complexity for proper water management if there is to be a truly integrated approach.

The new initiative, JIHP, is designed to improve on the use of isotopes in hydrology and to develop hydrologic process-oriented experiments using isotopes. Global implications from these initiatives and experimental aspects will be strengthened within the framework of IHP. New sets of high resolution data from earth observing systems and in-situ measurements at the basin-scale are expected to give more reliable descriptions of the processes governing the hydrologic cycle. It is expected that these will lead to new concepts for the representation of water resources and their associated fluxes.

The basin scale is normally appropriate for considering water fluxes (*e.g.*, precipitation, ground water, surface water) and water use or water demand (domestic, industrial and agricultural). The natural topographic approach is normal for natural hydrological processes. It is also a relevant approach for landscape and land-use mapping because of the topographically-driven organization of the typical watershed. But the evaluation of water resources at the larger basin scales more often than not needs to combine data from various sources. Mechanisms that govern water demand are not well outlined as of yet, nor are the relevant parameters yet to be suggested.

The General Aims of Theme 2 are:

- **To reduce the vulnerability of hydrologic systems and to improve the efficiency of water management when considered at the basin scale,**
- **To assess the impacts of extreme events (natural or man-induced) and proposed mitigation schemes,**
- **To enhance the modeling capabilities of all the relevant processes and fluxes at the interfaces of the hydrologic cycle, and**
- **To provide a comprehensive assessment of human/watershed/aquifer interactions combining all relevant human activities and physical and ecological processes.**

Four focal areas are considered within Theme 2.

Focal Area 2.1	Extreme events in land and water resources management
Focal Area 2.2	International River Basins and Aquifers
Focal Area 2.3	Endorheic Basins
Focal Area 2.4	Methodologies for integrated river basin management

The Joint International Isotopes In Hydrology Programme (JIIHP)

The initiative to establish the Joint Isotopes in Hydrology Programme was adopted by the 14th session of the UNESCO-IHP Intergovernmental Council (June 2000). Accordingly, the Joint International Isotopes in Hydrology Programme (JIIHP) was established under the auspices of IAEA in cooperation with UNESCO's IHP-VI. This joint endeavor is to develop activities integrating isotope methodologies into a broader range of water resources practices and improving the capacity for understanding hydrological processes and the dynamics of surface and groundwater systems.

International Sedimentation Initiative (ISI)

Erosion and sedimentation processes affect the management of catchments and river systems and reservoirs. They are increasingly important factors in all parts of the world because of their often conflicting socio-economic and environmental impacts. It has been said that within the next few decades more than 50% of the world's total reservoir storage capacity may be lost due to sedimentation. But even now a number of rivers and estuaries are subject to excessive aggradation and degradation that can often cause severe safety problems.

To overcome the existing and potential erosion and sedimentation problems sediment management practices must be improved. But if this is to be accomplished a better understanding of sediment production and transportation mechanisms and of relevant non-technical implications are necessary.

The 15th session of the Intergovernmental Council of IHP decided to set up an Advisory Group within this International Sedimentation Initiative. The terms of reference established for this Advisory Group are:

- To provide assistance to IHP-VI working groups related to sedimentation problems,
- To carry out workshops,
- To coordinate the development of a program action,
- To promote the establishment and implementation of pilot projects,
- To support the creation of a clearing house for reservoir sedimentation management, including an observatory where technical and non-technical documentation can be collected in real-time, and
- To collaborate with other organizations, agencies and specialized research institutes.

The resolution, as approved by Intergovernmental Council of the IHP, foresees that the IHP Secretariat incorporates the information developed by the Advisory Group of this International Sedimentation Initiative in the activities of the IHP-VI, through possible extra-budgetary funds and/or contributions from member states.

International Ground-Water Resources Assessment Centre **(IGRAC)**

In spite of enormous investments in exploiting ground-water resources for human use, insufficient attention has been paid to monitoring the condition of the resource and assessing its sustainable use in terms of quantity and in quality.

This situation needs to be corrected if more rational decisions on the use and conservation of this precious and strategic resource are to be made. IGRAC the International Groundwater Resources Assessment Center has been conceived with the aim to tackle the general lack of information and awareness about the status of groundwater resources. The Center will act as a catalyst for stimulating national and regional efforts in monitoring and assessment of aquifer systems. The Center will be established under the auspices of UNESCO and WMO as requested by the 14th Session of the UNESCO-IHP Intergovernmental Council, June 2000 and the 11th Session of the Commission for Hydrology of WMO, November 2000.

Internationally Shared Aquifer Resources Management **(ISARM)**

At present, international law does not adequately address issues concerning the flow of ground water beneath borders. Scientific correlation of the hydrogeology of such aquifers is often deficient and issues related to shared, sustainable management remain unaddressed because of poorly developed institutions and a lack of capacity and awareness. An international initiative on Internationally Shared/Transboundary Aquifer Resources Management (ISARM) has been conceived to address these issues. The initiative was endorsed by the Intergovernmental Council of the IHP, at its 14th session held in June 2000. ISARM (Internationally-Shared Aquifer Resource Management), is jointly implemented by UNESCO, IAH, FAO and UNECE, aims to set up a network of specialists and experts for compiling a world inventory of transboundary aquifers and developing wise practices and guidance tools concerning shared groundwater resources management.

The ISARM initiative is strongly linked to IHP-VI, Theme 2, Focal Area 2.2, as well as to the PC→CP project of WWAP.

Theme 3: Land Habitat Hydrology

Theme 3 offers a large number of interactions following the different climatic land form and land-use classes. “Habitat”, in the title of this Theme refers to a further dimension of interaction, that of the physical environment with the ecological one, emphasizing that landform, land use and climate determine habitats for humans, flora and fauna. Thus Theme 3 outlines the scientific challenges in these three-dimensional interactions.

Arid and semi-arid areas are normally under higher water stress than other regions. Together with the humid tropics, they have experienced high population growths. Over 90% of the world’s developing countries are located within these two climatic areas. The most common source of water supply in arid and semi-arid areas is ground water, surface water tending to be limited in space and time. The lack of sufficient water coupled with the high population growth rates has commonly resulted in serious water problems. The situation is likely to grow much worse in the coming years. It could reach a possible conflict stage, especially in the cases of shared water resources. There is, therefore, a need to develop projects that will help reduce the water problems experienced in these regions. But what would they be?

The humid tropics region plays a major role in the global hydrologic cycle. Thus the analysis of hydrologic processes at different scales is of great importance. Furthermore, the region constitutes a treasure trove of natural resources. It encompasses over 1,200 million hectares of tropical rain forest and a substantial part of the world’s estimated 30 million species of plants and animals. Estimates suggest that by the year 2005, one third of the global population will inhabit the equatorial belt. These considerations stress the complexity of environmental and social problems in the humid tropics, almost all of which are water-related in one way or another. As a result, understanding the complex mechanisms and interactions of different components of the humid tropic environment, and considering the special social and cultural dimensions, it is essential that these be understood and considered before the development of acceptable integrated water management schemes will be possible.

The successful application of integrated management techniques requires a flexible and proactive consideration of social, cultural and environmental dimensions. Management of the water resources in the humid tropics should be promoted in such a way that society’s needs are met while at

the same time the natural resources are protected, giving due consideration to both supply and demand. But proper water management can only be established on the basis of a clear understanding of the scientific principles that govern water-related processes.

Temperate zones, while normally associated with less dramatic hydrologic phenomena than those of the arid or humid tropical zones, remain in the focus of interest of IHP-VI, for along with the other climatic regions the temperate zones will also be affected by climate change. But the typical intensive land use, industrialization, infrastructure development and the like, give the temperate zones high priority for studies of the interactions of climate and anthropogenic influences and their joint impact on the hydrologic cycle. Having the most extensive long-term observation records and networks, temperate zone catchments can serve as excellent bases for research aiming to quantify impact-induced changes on the hydrologic regime.

Cold zones include high latitude and high altitude areas in which snow, ice and permafrost are the prevailing form of occurrence of water resources. Cold zones cover wide areas and influence global climate or global water/energy circulation to a large extent. In that respect, cold zones play significant roles in global and regional hydrology as well as being potential sources of water. Avalanches, ice-jam floods and other water-related disasters, typical of cold areas, must also be taken into account. The role of ice and ice jamming as an agent not only of damage, but also of replenishment of important northern habitats and their ecosystems, is only now beginning to be understood. Moreover, cold regions are among those that are likely to be most affected by climate change, according to simulation studies by global circulation models (GCMs) assuming a twofold increase of carbon dioxide concentration in the atmosphere.

Two major hydrologic problems that occur in most cold-zone applications are: (1) the prediction of hydrographs that are fully or partly generated by snowmelt, under a variety of atmospheric terrain, and river conditions, and (2) the prediction of ice formation, growth, and break-up processes in rivers, and their impacts on stage /discharge relationships.

Though there has been considerable scientific progress in these two areas, there remain significant gaps that prevent the application of physics-based modeling, and thus necessitate resorting to considerable empiricism. While that approach can be of some utility where site-specific processes and

stationary climatic conditions exist, it is inherently unreliable under those conditions that would prevail during a period of changing climate. Further studies are needed.

Apart from those general climatic regional classifications, one needs to consider specific hydrologic and water resources management problems of the fragile ecosystems of drylands, wetlands, mountains, coastal zones and small islands, irrespective of their geographic/climatic locations. Also important are the urban, peri-urban and rural settlement areas. The urban environments have emerged as the predominant living space of humanity, with the inherent social, ecological and water management challenges. Erosion and sedimentation, floods induced by encroaching urbanization, the problem of fresh and salt water intrusion both into the surface-water and into the ground-water environment, and the consideration and the development of appropriate water resources management strategies specific to small islands are some of the additional issues that will need to be addressed. The interference by rapidly developing urban developments along coastal zones, on islands and/or in mountainous areas further influence the magnitudes of the problems to be tackled.

Drylands are associated with deserts and semi-deserts, however in the sense of water interactions drylands can be considered all those areas which do not provide adequate quantity and year-round distribution of precipitation to sustain a society's activities without additional water resources management activities (*e.g.*, importation and water harvesting). Drylands are predominantly located in arid and semi-arid climatic zones, however they may also be found in temperate or cold zones, or even locally within predominantly humid zones.

Wetlands are identified as particular areas of concern, because they play an essential ecological role in a predominantly water-determined environment. Wetlands are increasingly endangered by both pollution and land reclamation. Water interactions are not well understood in wetlands, thus additional efforts are needed both for preservation and rehabilitation purposes.

Following the sequence set by Themes 1 and 2, moving from addressing global issues toward the consideration of the river basin or aquifer scale as the most appropriate unit of hydrological consideration, Focal Areas under Theme 3 are identified according to geographical (landform/land use) rather than climatic classifications. Consequently, five landforms/land use classes can serve to define the five focal areas under this Theme.

The general Aims of Theme 3 are:

- **To develop integrated approaches to the study of hydrologic systems as major constituents of environmental systems influenced by different climatic, geographic and human activities through interdisciplinary research to identify and model the interactions of the flow paths of water, sediments, nutrients and pollutants,**
- **To strengthen regional-scale understanding for integrated water resources management through the analysis of societal interactions,**
- **To enhance modeling capabilities of the interactions of physical processes of the water cycle at occurring at the regional and mesoscale within the framework of seasonal to decadal time scales,**
- **To develop methodologies for the proper management of urban water under different climatic conditions,**
- **To assess the impact of global change in the different climatic zones and landforms and to propose mitigation schemes to reduce the effects of extremes in the respective zones,**
- **To strengthen research networks on water in different climatic zones,**
- **To enhance the understanding of specific hydrologic processes characterizing certain climatic zones and landforms, particularly the recharge mechanism, evaporation and evapotranspiration and their interactions with water quality,**
- **To institute proper water resource assessment methodologies matching environmental and socio-economic features of climatic regions,**
- **To coordinate the hydrologic activities and to develop relevant tools for water-resources analyses and water-resources management at the regional level,**
- **To further develop ecohydrology as an interdisciplinary approach at the landform/land use scale,**
- **To improve knowledge on the functioning of terrestrial and aquatic environmental systems with respect to water as a primary habitat, storage and transport media, and**

- To help conserve habitats to maintain aquatic communities and biodiversity.

Five Focal Areas will be considered within Theme 3:

Focal Area 3.1	Drylands
Focal Area 3.2	Wetlands
Focal Area 3.3	Mountains
Focal Area 3.4	Small islands and coastal zones
Focal Area 3.5	Urban areas and rural settlements

Theme 4: Water and Society

All environmental problems are, by their very nature, also social problems. The Theme “Water and Society” focuses on the complex relationships between people and their water resources. The emphasis is on the human component of the equation, seeking to answer questions about attitudes, relationships, concepts and beliefs. In general, one’s approach to a watershed should incorporate these human aspects. They should seek answers to the following questions:

- How can human populations grow and develop in a sustainable manner?
- How should the needs, interests, and beliefs of a basin’s stakeholders be addressed?
- How best can disputes over use or quality be resolved or, better, prevented?
- How should one go about incorporating a water ethic into basin management? And,
- How do water issues impact the human/environmental security of the population?

This Theme will seek to address those questions in order to provide guidelines by which water resources can be managed in an equitable, sustainable, and ethical manner. As Figure 2 shows, the issues summarized under this Theme are relevant at all scales and in all aspects addressed by

IHP-VI. Thus, Theme 4 can be seen as the one with the most pronounced interface of all five core themes.

The general Aims of Theme 4 are:

- **To provide public awareness of the causes, impacts and trends in water scarcity and pollution, in connection with Theme 1,**
- **To study the relationship between safe water supply and appropriate public health sanitation as a contribution to poverty alleviation,**
- **To provide management methodologies and tools at different scales to assess and incorporate the water resources interests of the inhabitants of a basin,**
- **To identify possibilities for incorporating water valuation into the efficient management of water resources,**
- **To more fully understand social and ethical views of water users, and to incorporate indigenous knowledge in water management at different scales,**
- **To support problem prevention and mitigation considering water as a strategic resource, and**
- **To ensure both human and environmental security aspects of water resources at all levels.**

Five Focal Areas are considered within Theme 4:

- | | |
|-----------------------|---|
| Focal Area 4.1 | Water, civilization and ethics |
| Focal Area 4.2 | Value of water |
| Focal Area 4.3 | Water conflicts – prevention and resolution |
| Focal Area 4.4 | Human security in water-related disasters and degrading environments |
| Focal Area 4.5 | Public awareness raising on water interactions |

UNESCO Interdisciplinary Initiative for the Sustainable Development of the VOLGA-CASPIAN Basin

Given the economic, social and cultural importance of the basin to all countries sharing it, the rehabilitation and effective future management of the Volga-Caspian Basin is an urgent international task. It has been stated that no scientific effort should remain unexplored to increase the efficiency of investments in ecosystem restoration, monitoring and management restructuring.

Therefore, in October 1999, representatives of UNESCO's intergovernmental environmental programmes, the WMO, GIWA and the Project Leader of the Russian Federal Programme "Revival of the Volga" met in UNESCO, Paris. At this meeting, it was agreed to cooperate in initiating a project for the environmental and human sustainability of the Volga River and Caspian Sea Basin.

The second meeting of the Steering Group of the Chairpersons of UNESCO's five scientific programmes (IGCP, IHP, IOC, MAB and MOST) in May 2001 welcomed the initiative. The Chairpersons agreed that UNESCO should take the lead in the formulating and launching an interdisciplinary science project for the sustainable development of the Volga-Caspian Basin. They also agreed that in undertaking this project UNESCO should seek to engage other international organizations and programmes active in the region.

The most effective initial goal of the proposed project will be to prepare a science-based *Vision* for the effective future management of natural and human systems (*i.e.*, sustainable development) of the Volga Basin, its delta and immediate coastal areas. The *Vision* will focus on promoting human well-being through a better understanding of the people/environment interaction. In this sense, the "*Volga Vision*" can be interpreted as a framework document for future natural resource management.

While the *Vision* will develop interdisciplinary views and approaches to tackle these complex problems, part of the UNESCO approach will be to assist in the formulation of complementary project proposals, based on this *Vision*, suitable for funding by donor agencies. Institutions and scientists (drawn mainly from the basin) will participate in developing the *Vision*, and will develop new scientific concepts and approaches both reflecting and applicable to "*real world*" environmental, natural resources and social management issues. The completed *Vision* approach will facilitate the transferability of the concept to other large river basins worldwide.

In order to launch the *Vision* preparatory process, UNESCO has established a Volga Task Force within the Secretariat, with representations of all five intergovernmental programmes.

Theme 5: Water Education and Training

Water Education and Training (W-E-T) forms the overall support shell for IHP-VI (see Figure 2). It is thus not only inherently the priority Theme, but is also strongly interwoven with other Themes as shown in the respective objectives and suggested activity lists.

It is envisaged that each of the Themes within IHP-VI will aim at developing an output relevant to continuing education and training (CET), to strengthen its results with dissemination, training and awareness-raising activities. Besides these inherent activities, Theme 5 is conceived as a framework for all relevant aspects of water-related education and training. It gives opportunities for those institutions in the Member States that specialize in developing training material and running training courses to develop activities at various levels of human and institutional capacity-building. It is expected that the technology that will be made available during the period of the implementation of the IHP-VI will enable access by a much wider community to data, information and knowledge sources. Consequently, the transfer of information, knowledge and technology will be facilitated for both the water specialists and the general public.

W-E-T activities will cover all levels and aspects of education, information transfer and training. But a clear priority is to be given to higher education, education for research at the postgraduate level, continuing professional education and to activities targeting "training of trainers". Thus the multiplicative effect of IHP-VI efforts within the domain of education and training is facilitated.

The general Aims of Theme 5 are:

- To upgrade curricula and syllabi for hydrology and general water education and training,**
- To prepare programme tools for the comprehension of the fundamentals of water interactions among the environment, other disciplines of natural science and with society, as well as for the incorporation of the knowledge acquired in real world projects,**
- To enable a wide audience of professionals to have access to ever increasing computational and computer graphics power; and to**

enhance critical assessment capabilities in order to avoid a false confidence in problem solving,

- To strengthen IHP's involvement in W-E-T worldwide through the creation of a UNESCO-IHE Institute for Water Education, and
- To support capacity-building for integrated monitoring of hydro-meteorological and water quality variables necessary to achieve a proper understanding of global water resources management.

Four Focal Areas are considered within Theme 5:

Focal Area 5.1 Teaching techniques and material development

Focal Area 5.2 Continuing education and training for selected target groups

Focal Area 5.3 Crossing the digital divide

Focal Area 5.4 Institutional development and networking for W-E-T

The UNESCO-IHE Institute for Water Education

Human capacity is always a key factor in ensuring the sustainable use and management of water resources. Therefore Water Education and Training was and remains a key aspect of IHP's focus. In this context, the proposal of The Netherlands to host and financially support the UNESCO-IHE Institute for Water Education in Delft was welcomed by the member states. The statutes of the UNESCO-IHE Institute for Water Education in Delft, The Netherlands, were adopted by the 31st General Conference in October 2001. In close cooperation with other UNESCO water centres in various countries, the Institute enables UNESCO's IHP to improve the implementation of its international policy on water science and education. It is also instrumental in providing the human capacity-building component of WWAP. It will increasingly provide high-quality education, training and research, and will also act as an international reference centre for water-related education. It will be instrumental in strengthening and developing other universities and research centres in their efforts to increase the knowledge and skills of professionals working in the water sector. By making IHE an integral part of UNESCO, the IHP's long-term capacity for disseminating and sharing water-related knowledge is greatly enhanced. On a long-term basis, member states will have the knowledge and services of the UNESCO-IHE Institute in human and institutional capacity-building at their disposal. Recently, the Institute has launched a global network of human capacity-building institutions PoWER.

GOUTTE of WATER

A new concept approved by the International Council of the IHP as an effort within Theme 5 of IHP-VI is the Global Observatory of Units for Teaching, Training and Ethics of WATER (GOUTTE of WATER). This effort is intended to act as a stimulus for education, training, research and innovation through collaboration and exchange programmes extending new and existing partnerships. It will address four key areas of education, training and capacity building:

- The unity of education and research in higher education,
- The facilitation of high intensity networks,
- The assessment and assurance of quality, and
- The raising of public awareness as an obligation of water professionals and educators.

The mission of GOUTTE of WATER is the general mandate of UNESCO as applied to the field of the water environment. Thus it will:

- Promote UNESCO's mandate to build peace in the mind of man and environmental ethics as a basic concept of education, training and public awareness,
- Foster intellectual cooperation and the spirit of academic, scientific and professional solidarity in the domain of the water environment, and
- Link and strengthen new and existing networks as a major means of implementation.

Some of the activities foreseen for this effort include:

- The establishment of a useful classification of networking activities through definitions and general outlines,
- Suggesting recommendations for efficiency and quality assurance of cooperation schemes and networks,
- Organizing bi-annual international GOUTTE of WATER meetings and a virtual forum,
- Facilitating mutual assistance among participants,
- Promotion of activities in other conferences or congresses where GOUTTE of WATER objectives are fulfilled, and
- Setting up teams of experts upon request of donor agencies and beneficiaries.

ACRONYMS AND ABBREVIATIONS

BAHC	Biosphere Aspects of the Hydrological Cycle, ICSU/IGBP Core Project
CCPC	Cross-Cutting Programme Component of IHP
CET	Continuing Education and Training
FAO	Food and Agricultural Organization of the United Nations
FRIEND	Flow Regimes for International Experimental and Network Data, Project of IHP
GCM	Global Circulation Models
GCOS	Global Climate Observing System
GEMS/ WATER	Global Environment Monitoring System/Water
GEWEX	Global Energy and Water Experiment of the WCRP
GOUTTE of WATER	Global Observatory of Units for Teaching, Training and Ethics of WATER
GTOS	Global Terrestrial Observation System
HELP	Hydrology for the Environment, Life and Policy
HWRP	Hydrology and Water Resources Programme of WMO
IAEA	International Atomic Energy Agency
IAH	International Association of Hydrogeologists
ICSU	International Council of Scientific Unions
IGBP	International Geosphere-Biosphere Programme of ICSU
IGCP	International Geological Correlation Programme of UNESCO
IGO	Intergovernmental Organization
IHE	International Institute for Infrastructure, Hydraulic and Environmental Engineering
IHP	International Hydrological Programme of UNESCO
IGRAC	International Groundwater Resources Assessment Center (IHP)
IOC	International Oceanographic Commission of UNESCO
ISARM	Internationally Shared Aquifer Resources Management
ISI	International Sedimentation Initiative
IT	Information Technology
IWRM	Integrated Water Resources Management
JIIHP	Joint International Isotopes in Hydrology Programme
MAB	Man and the Biosphere Programme of UNESCO
MOST	Management of Social Transformations Programme of UNESCO
NGO	Nongovernmental Organization
PC→CP	From Potential Conflict to Cooperation Potential
PoWER	Partnership for Water Education and Research

UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
W-E-T	Water Education and Training (IHP)
WHYCOS	World Hydrological Cycle Observation System
WMO	World Meteorological Organization
WWAP	World Water Assessment Programme
WWDR	World Water Development Report