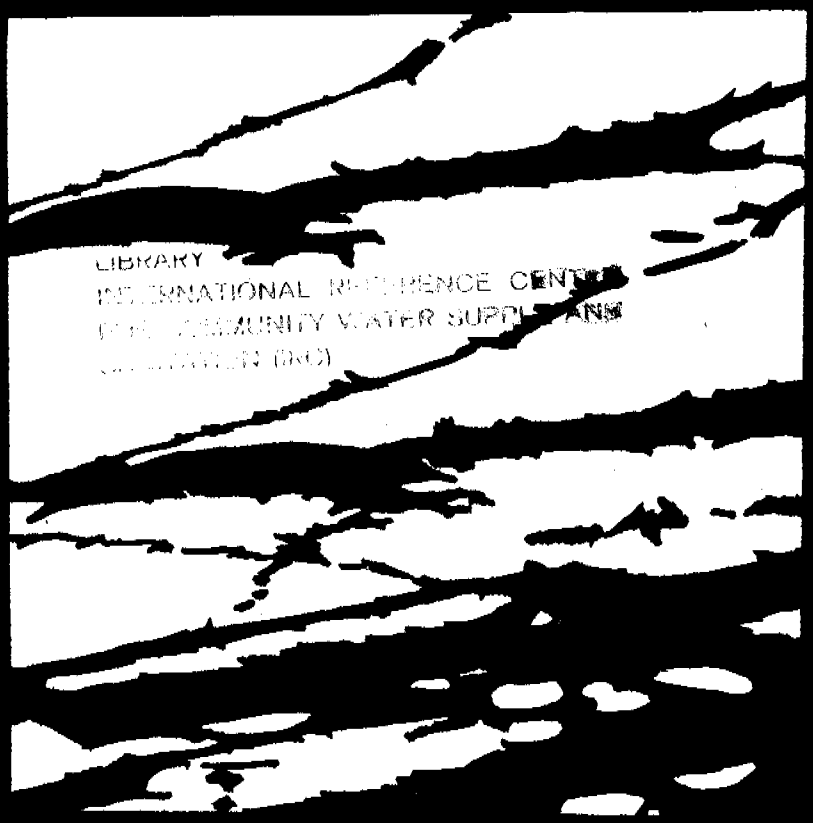
NATIONAL HYDROLOGICAL PROGRAMME

Hydrology and water resources development in a vulnerable environment

Detailed Plan of the fifth phase (1996-2001) of the IHP



UNESCO, Paris, 1996

IHP-V

INTERNATIONAL HYDROLOGICAL PROGRAMME

HYDROLOGY AND WATER RESOURCES DEVELOPMENT IN A VULNERABLE ENVIRONMENT

Detailed Plan of the Fifth Phase (1996-2001) of the IHP

UNESCO, Paris, 1996

IHP-V

Cover Artwork by Judith Nemes, 1995

SC-96/WS/24

ACRONYMS

ACSAD	The Arab Center for the Studies of Arid Zones and Dry Zones
AGCM	Atmospheric Global Circulation Models
ALECSO	Arab League Educational, Cultural and Scientific Organization
AMHY	Alpine and Mediterranean Hydrology component of FRIEND
ASCE	American Society of Civil Engineers
ASCEND 21	An Agenda of Science for Environment and Development into the 21st Century, ICSU Conference, Vienna, November 1991
BAHC	Biospheric Aspects of the Hydrological Cycle, ICSU/IGBP Core Project
BALTEX	The Baltic Experiment
Blue Plan/MEDO	UNEP/Mediterranean Action Plan Regional Activity Center/MEDO (Mediterranean Development and Environment Observatory)
CAL	Computer Aided Learning
CATHALAC	Water Centre for the Humid Tropics of Latin America and the Caribbean
CD-I	Interactive Compact Disc Technology
CHR	Commission internationale de l'hydrologie du bassin du Rhin (International Commission for the Hydrology of the Rhine Basin)
ECLAC	United Nations Economic Commission for Latin America and the Caribbean
EIA	Environmental Impact Assessment
ERB	Experimental and Research Basins
EU	European Union
FRIEND	Flow Regimes from International Experimental and Network Data (IHP-IV Project H-5.5)
GCIP	GEWEX Continental-scale International Project
GCTE	Global Change and Terrestrial Ecosystems, ICSU/IGBP Core Project
GEWEX	Global Energy and Water Experiment
GIS	Geographic Information System
GRDC	Global Runoff Data Center
IAH	International Association of Hydrogeologists
IAHR	International Association for Hydraulic Research
IAHS	International Association of Hydrological Sciences
IAHS/ICGW	International Commission on Groundwater of IAHS
ICASVR	International Committee on Atmosphere-Soil-Vegetation Relations of IAHS
ICCE	International Commission for Continental Erosion of IAHS
ICCORES	International Coordinating Committee on Reservoir Sedimentation
ICID	International Commission on Irrigation and Drainage
ICRSDT	International Committee on Remote Sensing and Data Transmission of IAHS
ICSI	International Commission on Snow and Ice of IAHS
ICSU	International Council of Scientific Unions
ICSW	International Commission on Surface Water of IAHS
ICT	International Committee on Tracers of IAHS
ICWE	International Conference on Water and the Environment: Development Issues for the 21st Century, Dublin, January 1992
ICWRS	International Commission on Water Resources System of IAHS
IDNDR	International Decade for Natural Disaster Reduction
IGBP	International Geosphere-Biosphere Programme of ICSU
IGO	Intergovernmental organization
IGWMC	Intergovernmental Groundwater Modeling Center
IHE	International Institute for Infrastructural, Hydraulic and Environmental Engineering

IHP	International Hydrological Programme of UNESCO
IHP-IV	The fourth phase (1990-1995) of IHP
IHP-V	The fifth phase (1996-2001) of IHP
IIASA	International Institute for Applied Systems Analysis
ILO	International Labour Organization
INECEL	Instituto Ecuatoriano de Electrificacion
IRTCES	International Research and Training Center on Erosion and Sedimentation
IRTCUD	International Research and Training Center on Urban Drainage
IWRA	International Water Resources Association
KIT	Knowledge, Information and Technology
LBA	Large Scale Biosphere and Atmosphere Experiment in Amazonia
LCBC	Lake Chad Basin Commission
MAB	Man and the Biosphere Programme of UNESCO
NC	National Committee
NGO	Non-Governmental Organization
NOPEX	Northern Hemisphere Climate Process Land-Surface Experiment
ROST	Regional Office for Science and Technology of UNESCO
SCOWAR	ICSU Scientific Committee on Water Research
SHI	State Hydrological Institute, St. Petersburg, Russia
UNCED	United Nations Conference on Environment and Development, Rio de Janeiro, June 1992
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization
UNIFEM	United Nations Development Fund for Women
USGS	United States Geological Survey
WCP	World Climate Programme
WCRP	World Climate Research Programme
WHO	World Health Organization
WMO	World Meteorological Organization

CONTENTS

1. POINT OF DEPARTURE

During the preparation for the United Nations Conference on Environment and Development (UNCED) a number of international meetings were held which were either directly or indirectly related to hydrology and water resources.

The International Conference on Water and Environment (ICWE), held in Dublin, from 26-31 January 1992 provided the major input on freshwater problems to UNCED calling attention to the serious problems of optimizing the use of freshwater resources in the years ahead.

The Dublin Statement on Water and Sustainable Development
(Excerpts)

" Scarcity and misuse of fresh water pose a serious and growing threat to sustainable development and protection of the environment. Human health and welfare, food security, industrial development and the ecosystems on which they depend, are at all risk, unless water and land resources are managed more effectively in the present decade and beyond than they have been in the past."

" The problems highlighted are not speculative in nature; nor are they likely to affect our planet only in the distant future. They are here and they affect humanity now. The future survival of many millions of people demands immediate and effective action."

" The Conference participants call for fundamental new approaches to the assessment, development and management of freshwater resources, which can only be brought about through political commitment and involvement from the highest levels of government to the smallest communities. Commitment will need to be backed by substantial and immediate investments, public awareness campaigns, legislative and institutional changes, technology development, and capacity building programmes. Underlying all these must be a greater recognition of the interdependence of all peoples, and of their place in the natural world."

The Conference also stated that concrete action is needed to reverse the present trends of overconsumption, pollution and rising threats from droughts and floods. Recommendations for action at local, national and international levels were set out based on four guiding principles:

The Dublin Principles

Principle No. 1: Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.

Principle No. 2: Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels

Principle No. 3 Women play a central part in the provision, management and safeguarding of water

Principle No. 4 - Water has an economic value in all its competing uses and should be recognized as an economic good

Based on these principles the Conference developed a series of recommendations which also formed a framework for the planning of the International Hydrological Programme of UNESCO.

Freshwater issues also came up at the International Conference on an Agenda of Science for Environment and Development into the 21st Century (ASCEND 21) which was convened by ICSU in Vienna in November 1991 in order to make a contribution to the formulation of the future directions of world science as well as to the preparation of UNCED. Amongst the major problems that effect the environment and hinder sustainable development and are to be of the highest scientific priority the problem of water scarcity was also pinpointed. ASCEND recommended, *inter alia:*

- Strengthened support for international global environmental research and observation of the total Earth System;
- Research and studies at the local and regional scale on: the hydrologic cycle, impacts of climate change; coastal zones; loss of biodiversity; vulnerability of fragile ecosystems; impacts of changing land use, of waste and human attitudes and behaviour;
- Special efforts in education and in building up of scientific institutions as well as involvement of a wide segment of the population in environment and development problem-solving.

Concerning research and monitoring of the Earth System the Conference recommended that there is a need for research directed towards improved understanding at the local and regional scales, of the **hydrological cycle** including its interaction with soil and vegetation, and its response to changing land use and pollution, environmental degradation and rising industrial, agricultural and domestic demands, particularly in semi-arid regions.

The recommendations of the above-mentioned major international conferences, together with the Chapter 18 (Protection of the quality and supply of freshwater resources: Application of integrated approaches to the development, management and use of water resources) of the UNCED Agenda 21 formed the basis for planning the Fifth Phase of the International Hydrological Programme.

If future water resources development and management schemes are to be sustainable they will have to deal effectively with the following four major issues:

(i) Environmental and social consequences

These consist of the effects of major water development projects on the natural environment and on the social well-being of people living in areas affected by these developments. Surface water and ground water quality and the preservation and enhancement of aquatic and terrestrial ecosystems must also be considered.

(ii) Land-water linkages

Closely related to the preceding issue is the need for water resources management to deal effectively with the important land-water linkages in the river basin or watershed. An important facet is the need to integrate the effective management of watersheds for erosion and sedimentation control and water conservation with water developments. Although the importance of such integrated management of river basins has been recognized for more than 50 years, good examples of its implementation are rare. The need for integration has become especially urgent as the need for developing countries to exploit their available water and land resources increases.

(iii) Allocation of water among competing uses and users

This issue is becoming increasingly important due to the growing pressures of population and economic activity. As the development of water resources becomes increasingly costly and may involve adverse environmental and social consequences, the need for efficient use of existing supplies for all relevant purposes becomes especially important. Water conservation and nonstructural management measures become more and more relevant. Competing national and international pressures on the limited available water resources force water managers to deal with the rational allocation of water to achieve goals of efficiency, equity and environmental quality.

(iv) Achieving effective implementation

For a number of reasons there can be considerable differences between the planned targets of projects and the results actually achieved. In addition, the follow-through on plans for handling social and environmental impacts of projects has often been neglected. As the potential gap between available supplies and increasing demands on water resources becomes critical, the importance of effective implementation and system operation becomes greater and greater. The need for flexibility in policies, institutional settings and procedures, for example, must be maintained.

Although the degree of environmental, economic and social consequences is different in the various climatic zones, especially in the arid, semi-arid and humid tropical zones, more serious problems than ever before must be faced. The alarming trend of desertification of the arid regions is continuing with frequent intensive droughts contributing to economic devastation of entire nations. In the humid tropics, growing population is forcing the continuous destruction of tropical forests for agricultural, energy and forest product demands. This region is frequently subject to severe flooding, but drought periods are not uncommon.

2. FRAMEWORK AND GENERAL OUTLINE OF IHP-V

In general, IHP-V is set out to stimulate a stronger interrelation between scientific research, application and education. The emphasis will be on environmentally sound integrated water resources planning and management supported by a scientifically proven methodology.

In order to tackle the four major issues listed in Section 1, the following principal areas of concern will be included:

- **The role of scales in hydrological processes;**
- **Vulnerability of the environment;**
- **Integrated water resources management;**
- **Education, training and transfer of technology.**

The four are briefly described and defined below.

2.1 The role of scales in hydrological processes

Understanding the complex interactions of the hydrological and biogeochemical cycles is of prime importance for both their quantitative and qualitative role. This must be understood at global, regional and local scales. Each has specific characteristics. The climatic zones of the humid tropics and the arid and semi-arid regions are quite different, for example, in the quantitative characteristics of their hydrologic cycles and thus require very different water and land management approaches from those developed for and used in temperate zones. Considering that the countries within these zones will contain nearly 70 percent of the total world population by the year 2000, special emphasis should be given to their water research and management programmes.

At the same time, the temporal scales must be considered in the hydrologic and biogeochemical processes. Time scales in ground-water flow may involve thousands of years while precipitation processes change within minutes or even shorter time scales.

To successfully predict the behaviour of hydrologic systems it is essential to be able to transpose information among different spatial and temporal scales.

One of the objectives of IHP-V is to promote comparative hydrological studies and water management case studies at different scales. This will improve the knowledge about and the understanding of the hydrological and biogeochemical processes and their relationships at different scales. This information should contribute substantially to improved water management. Special emphasis will be placed on the scale aspects of the hydro-bio-geo-chemical processes in the humid tropics and in arid/semi-arid zones.

2.2 Vulnerability of the environment

Water resources developments should preserve or enhance the buffering capacity of the environment against unexpected shocks or long-term trends. Options for the future must be developed to serve future requirements. However, water resources projects are planned, designed and operated under various sources of uncertainty. Their inadequate consideration in the decision-making process can lead to poor results.

As the carrying capacity of the environment is increasingly stressed due to growing needs and improper use of the resources, the vulnerability of the environment also increases. To assess the vulnerability in a decision-making context, appropriate criteria must be identified and the sequence of hydrological processes understood in order to link actions with their respective outputs.

Clearly, the interactions between land-water-biosphere-atmosphere have to be analyzed in more detail to properly trace the consequences of change. The system is a highly nonlinear and random environment. Relevant indicators, considering the scales and the climatic region, have to be identified to assess impacts. Methodologies have to be developed which adequately consider the various sources of uncertainties in the planning and management phases. The knowledge gained will constitute an important input to the environmentally sound management of water and water-related resources.

2.3 Integrated water resources management

Water resources management is understood to be a set of actions taken to use and control natural resource inputs (including water), to obtain outputs and natural systems conditions useful to society.

To be effective the management approach must be able to accommodate a number of important physical, economic and social linkages and interactions, such as:

- The major physical quantity and quality linkages between surface water and ground water. In terms of management, this implies conjunctive planning and operation of these water bodies;
- The complex interactions between land and water ecosystems;
- The current and projected human activities, including their temporal and spatial patterns, as such activities affect water resources;
- The relationship between the water resources sector and other sectors at different scales;
- The complex political, governmental and institutional context or milieu within which human activities take place, and within which water resources management must be undertaken. Multiple objectives, multiple purposes, multiple means, multiple actors, and multiple decision-makers are characteristics of this complex management setting.

The integrated approach should explicitly include and emphasize the environmental and social consequences over short and long-term periods. The possibilities of non-structural controls for solving water problems in different climate zones should be investigated. Methods for supporting negotiations for water allocation should be developed and tested for international, national and regional scales.

2.4 Education, training, and transfer of knowledge

Access to knowledge and education is a human right. It applies equally to both general knowledge and to more specialized or technical education in the field of hydrology and water resources management.

With the worldwide recognition of the paramount importance of the human resource capital for sustainable and long-term development, IHP-V will continue its work on the transfer of knowledge, skills, information and technology.

The general objectives are:

- To improve knowledge of the hydrological and all other water-related sciences at all levels and to increase public awareness of the importance of a sustainable environment;
- To speed up the transfer of results from research and technological development for use in integrated water resources development and management;
- To foster co-operation among nations and regional or international programmes for education and training, for appropriate learning technologies and for the exchange of experts;
- To assist nations to develop water resources research and education policies;
- To increase the participation of women in all the related activities.

The results of water resources management research, including information on improved management strategies and techniques, need to be incorporated promptly into established education and training programmes. These programmes are extremely diverse. They range from water resources and water-related curricula in technical schools and at universities in developed and developing countries, to specific water resources training programmes and short courses.

3. PROGRAMME FOR IHP-V

The programme constitutes a framework for applied research and education in the field of hydrology and water management. It should be regarded as a dynamic concept whose aim is to improve the links between research, application and education and to promote scientific and educational activities within the framework outlined in Section 2.

It is suggested that there should be three main clusters containing problems related to:

Resource process and management studies

Regional studies

Transfer of knowledge, information and technology

The clusters are obviously not independent of one another. There must be overlaps and interactions. For example, the first cluster has elements which also belong to the second cluster. The third cluster is an umbrella that covers the former two it being understood that **the transfer of KIT** (Knowledge, Information and Technology) **is the very essence and primary objective of the Programme.**

Within the set of clusters eight themes given below have been identified as a support structure for the whole Programme. They cut across different hydrological scales and different climatic regions, but have **integrated water management in a vulnerable environment** as a common issue. The proposed themes are seen as cornerstones within which projects could be flexibly implemented. Due to the special importance of water problems in the humid tropics and in the arid/semi-arid zones as well as in urban areas these regions should gain increased attention.

The eight proposed themes are:

1. **Global hydrological and biogeochemical processes**
2. **Ecohydrological processes in the surficial zone**
3. **Groundwater resources at risk**
4. **Strategies for water resources management in emergency and conflicting situations**

5. **Integrated water resources management in arid and semi-arid zones**
6. **Humid tropics hydrology and water management**
7. **Integrated urban water management**

8. **Transfer of Knowledge, Information and Technology (KIT)**

To avoid a purely hierarchical structure of the IHP-V programme any theme will emphasize both methodological aspects (referring to improved understanding of both biotic and abiotic processes), and applied aspects (considering vulnerability of the environment in one of the proposed regions) as well as a process for knowledge transfer. All will include interactions in the biotic and abiotic environments as well as in decision-making.

GIS, as a tool to deal with spatial processes, will cut across all the IHP-V projects, where appropriate, whether they belong to process or regional studies or the transfer of knowledge. In order to set the stage and enhance the use of GIS technology throughout the fifth phase of IHP,

an international conference will be organised by IAHS, in Vienna, on "Application of Geographical Information Systems in Hydrology and the Water Resources Management".

4. PLANNING AND EXECUTING IHP-V PROJECTS

The eight main themes are sub-divided into projects. In the following section, each theme is described by some background information followed by the overall aims of a particular theme. Then the projects under the theme are presented at some length. Apart from the project of Theme 8 (KIT) all project descriptions are structured in the same manner, ie.

- **Objectives**
- **Activities**
- **Method of Implementation**
- **Co-operating Partners**
- **Products**

The products should be considered as the outcome of the **world-wide effort of the Member States, regional and international governmental and non-governmental organizations.** UNESCO, while conducting a large number of activities itself, will co-ordinate **all** IHP-related activities through the Intergovernmental Council for IHP regardless of the method of implementation.

IHP-V, being a science and education programme at global level, covers a wide spectrum of planned activities. The execution of this ambitious programme requires strong co-operation both intellectually and financially. As the range of activities envisaged for IHP-V is far too large for execution by UNESCO alone there is a strong need for **Co-operating Partners** who will take part in the programme execution both intellectually **and** financially. It is envisaged that national and international funds earmarked for funding national research and education programmes in hydrology will also be mobilized to achieve the goals of IHP. A number of large-scale activities can only be conducted if external funding from national and interantional donor agencies contribute to the execution. As IHP, being an intergovernmental programme, is the common denominator of the national governmental hydrology and water resources research and education programmes it is expected that the national efforts will be channelled into the international effort by earmarking, to the extent possible, national activities and funds into the international ones. IHP should be a two-way street on a give-and- take basis. Unless it is given the recognition it deserves by adequate funding the IHP programme will soon become a one-way street, if not a dead end. Given the magnitude of the world's water problems, particularly in the developing countries, this would be a fatal mistake with global consequences especially if one considers the alarming scenarios outlined for the not too distant future.

The paragraph **Methods of Implementation** in each project description therefore lists all the methods foreseen regardless of details of execution and funding.

Annex 1 summarizes the projects planned for IHP-V. In order to assist the identification of various interfaces between the freshwater programmes of UNESCO and WMO, Annex 2 summarizes the projects of the Hydrology and Water Resources Programme of WMO for the period of 1996-2005.

5. THEMES AND PROJECTS

Theme 1: Global hydrological and geochemical processes

Background

The accurate prediction of global change in response to increasing greenhouse gas concentrations or major changes in land use, and the elucidation of soil degradation at regional to local scales is dependent on a better understanding of the hydrological cycle and associated biogeochemical cycles in coupled hydroecological/atmosphere models. Particular effort is required to improve the capability of predictions and the interpretation of their regional consequences in northern latitudes, where the projected change is greatest and where snow and ice cover is common and poorly described. In tropical latitudes, especially in the humid tropics where atmospheric recycling of water is known to be substantial, variable and vulnerable to human interaction, and in arid and semi-arid regions where water resources are marginal and sensitive to alterations in precipitation, it must also be better understood.

Further, the indigenous ecosystems of the continents are also prone to modification, either directly in response to management practice, or indirectly in response to altered climate. Such changes in vegetation, and similar changes in the areal extent and timing of snow and ice cover, compound the problems of prediction, since they in turn modify the global cycles of water, energy and biogeochemicals.

During the course of IHP-IV a monograph on the "World Water Resources at the Beginning of the XXI Century" is being prepared (IHP-IV Project M-1.3) under the leadership and direction of the Russian IHP National Committee and the State Hydrological Institute (SHI) at St. Petersburg. Since that document requires the collection and generalization of a considerable amount of data on water resources and water use worldwide, it is expected that this project will not be fully completed during the IHP-IV. It should be continued in IHP-V, with some refocussing around recognition of possible global climate change. It is in turn expected that the monograph will contain valuable data concerning water resources assessment as well as base line data for impact prediction, and would also serve as a starting point for strategy formulation. As part of this process an agreement has been reached between the SHI and the University of Texas, Austin, USA (in co-operation with the USGS) for the development of a GIS database to accompany the monograph.

The strategy adopted in addressing the global hydrological issues is to stimulate and co-ordinate basic scientific research to improve the accuracy of global and regional scale predictions, by acting in co-operation with, and contributing to, other international programmes, such as WCRP, IGBP and IAHS/ICASVR, to provide an interface between these predictions and their interpretation in hydrological application. This is foreseen in the form of predicted space/time fields of hydrologically relevant variables and within the framework for scaling-up across micro-, meso-, and macro-scales, and training in their generation and use; and to development management strategies to give optimum response to the inferred changes in water resources. The emphasis of this strategy is to transfer understanding and the application of methods from middle latitudes, where their development will be most advanced to low and high latitudes where their use is most urgently needed.

It is urgent to incorporate more detailed studies on surface water hydrology in coupled surface/atmospheric models in future field experiments of WCRP-GEWEX and IGBP/BAHC. Also articulate and improve the methodologies of these large scales, but short duration

experiments (limited in duration for economic reasons) through the use of Experimental and Research Basins (ERBs) as benchmarks for comparison. The long term objective is for the ERBs to bolster the large-scale, short duration experiments. The preceding strategy is aimed to be coupled with the implementation of regional models arising from "upstream" modelling activities. It is also intended to initiate such surface studies within the theme including assistance in field validation of these coupled models in both humid tropical and middle latitude regions. To understand the impact of regional and global climate change, there is an urgent need to continue detailed studies of the cryosphere in terms of glacier mass balances, assemblage of computerized data on snow and ice changes, snow ecology and changes in snow and ice state under various climatic scenarios.

Aims

- To stimulate the creation and application of coupled hydroecological/atmospheric models at a range of temporal and spatial scales, from individual catchments through the mesoscale to the continental scale; and to provide calibration and validation of such models, through co-operation with WCRP-GEWEX, IGBP-BAHC in large scale field experiments and continental scale studies;

- To develop methods to interpret global change prediction along with the analysis of associated uncertainties; to focus on evaluating their hydrological and agrohydrological consequences; and to emphasize the application of such methods in the humid tropics, in arid and semi-arid regions, and in cold-climate high latitudes;

- To formulate a strategy for management response to cope with the inferred impact of anthropogenic induced global change on water resources.

Four projects are proposed under Theme 1.

PROJECT 1.1: Application of methods of hydrological analysis using regional data sets (Flow Regimes from International Experimental and Network Data Sets/FRIEND)

Objectives:

- To develop the understanding of the spatial and temporal variability of hydrological regimes using regional data sets for the support of global scale hydrological research and the development of risk procedure analysis;
- To develop the upstreaming of regional models, so as to compare them with process models, generally built from local scales, and so contribute to a more relevant disaggregation of regional knowledge;
- To sustain observations networks by a contribution to the development of relevant data bases having improved "easy-to-use/ /high-technology" ratios in collaboration with WMO.

Activities:

- Development of studies based on existing and proposed data bases (France (BRECHE Project), Germany, Ghana, Nordic countries (NOPEX), Russia);
- Organization of international workshops and conferences (the 1997 FRIEND conference will be organized by the AMHY group; Nordic expert meeting in Sjokulla gard, Finland "Spatial and Temporal Variability and Interdependencies among Hydrological Processes" as an input to the launching of the project);
- Israel proposes to establish a FRIEND network in the Middle East;

- Russia proposes the setting up of a regional FRIEND archive located at SHI, St. Petersburg;
- Flow formation studies at the Valdai Experimental Hydrological Station of SHI;
- International IHP/IAHS Symposium on the Development of Studies of Hydrological Processes and Phenomena within the Changing Environment at Local and Regional Scales, St. Petersburg, 2000;
- WMO Expert meeting on hydrological data for climate studies (1996);
- Netherlands-German proposal for a Conference on 'Data Quality and Management' in joint collaboration with WMO, planned for 1998;
- Germany proposes to hold the Second Symposium on Regionalisation of Data, Braunschweig, 1997;
- FRIEND 97 Conference, Postojna, Slovenia, 1997, jointly organized by AMHY and IAHS.

Method of Implementation:

- Strengthening of co-operation within the existing FRIEND groups;
- Extension of existing FRIEND projects into Eastern Europe and establishment of new FRIEND groups in the *Hindu-Kush-Himalaya* region, Africa, South America, North America, the Middle East and in large international river basins;
- Co-ordination of the activities by an international steering committee and annual technical meetings;
- Co-operation of WMO in the implementation of FRIEND;
- Co-operation with WMO in supporting the work of GRDC.

Co-operating partners :

- **IHP National Committees of :**

  Algeria, Argentina, Australia, Belgium, Canada, Chile, China, Costa Rica, Cuba, Czech Republic, Egypt, Finland, France, Germany, Ghana, Greece, Hungary, Indonesia, Israel, Japan, Malaysia, Morocco, Nepal, The Netherlands, Nordic countries, Oman, Panama, Peru, Poland, Romania, Russia, Slovenia, Spain, Sudan, UK, Ukraine, Vietnam.

- **Intergovernmental Programmes/Organizations :**

  ACSAD, Blue Plan/MEDO, WMO (project 52.2), EU.

- **Non-governmental Organizations :**

  CATHALAC, IAHS, IGBP/BAHC, ICSU/SCOWAR, various FRIEND groups, NOPEX.

Products:

- Data sets for global scale hydrological modelling;
- Reports on regional flow regimes;
- Proceedings of international workshops and conferences.

PROJECT 1.2: Development and calibration of coupled hydroecological/atmospheric models

Objectives:

- To foster development of coupled hydroecological/atmospheric models, with emphasis on their application in the humid and arid and semi-arid tropics, and cold-climate regions;
- To synthetize hydrological data relevant to the calibration of hydroecological/atmospheric models on a worldwide basis;
- To develop methodologies for identifying the effects of enhanced carbon-dioxide atmosphere, through changes in the vegetation growth, on the hydrological cycle.

Activities:

- International symposia and workshops;
- Establishment of post-graduate courses through regional centres;
- Preparation of multimedia digital data sets;
- Bulgaria, Canada, The Netherlands, Russia and *USA* will contribute various national projects.
- Russia proposes a study on "Modelling the Hydrological Cycle for Regions with a Cold Climate" based on measurement/distributed modelling of processes in experimental basins;
- Nordic/international project (NOPEX) -- follow up to IHP-IV contribution of NOPEX on regional energy, water and carbon budgets;
- IAHR Ice Symposia (1996 in China, 1998 in USA) will include sessions related to the project;
- Participation in the Large Scale Biosphere and Atmosphere Experiment in Amazonia (LBA) in collaboration with the IGBP-BAHC and WRCP;
- Development of a project at different scales (local, regional) by Switzerland in collaboration with Slovakia;
- The provision of data by Chile connected with an experimental station on a Southern glacier;
- Contributions from Germany under the GEWEX-GCIP/BALTEX experiments.

Method of Implementation:

- Group of national and international organizations;
- Working group operating in co-operation with regional centres and through the formal collaborative agreement with IGBP/BAHC.

Co-operating partners :

- **IHP National Committees of :**

  Argentina, Belgium, Bulgaria, China, France, Germany, The Netherlands, Nordic countries, Panama, Russia, Ukraine, USA, Vietnam.

- **Intergovernmental Programmes/Organizations :**

  WCP/GEWEX, WMO (project 52.2).

- **Non-governmental Organizations :**

  IAHR, IAHS/ICASVR, IGBP/BAHC, NOPEX, ICSU/SCOWAR.

Products:

- Proceedings of international symposia and workshops on models;
- Postgraduate courses on modelling methods;
- 4 dimensional digital data maps of calibration data;
- Technical reports of research and methodology development results.

PROJECT 1.3: Hydrological interpretation of global change predictions

Objectives:

- To develop methods to express global scale predictions from regional data sets in terms of regional fields of hydrologically-relevant variables (hydrometeorological variables, land cover);
- To co-ordinate these methods and distribute the ensuing predicted temporal as well as spatial (4D) data.

Activities:

- International symposia and workshops in co-operation with Germany, The Netherlands, IGBP/BAHC, IAHS/ICSI/ICT;
- International Conference on Climate and Water, jointly organized with WMO;
- Preparation of regional data sets and associated literature (Northern Research Basins (Canada); The Finnish Research Programme on Climate Change (SILMU); Nordic project - Nordic Hydrology and Greenhouse Effect; Commission internationale de l'hydrologie du bassin du Rhin (The Netherlands); various projects implemented by institutions of The Netherlands and USA;
- WMO technical conference on new developments in data collection and transmission systems (1998);
- Co-ordination of activity of national committees.

Method of Implementation:

- Group of international organizations;
- Working group and regional centres.

Co-operating partners :

- **IHP National Committees of :**

  Australia, Austria, Belgium, Canada, Ecuador, Germany, Ghana, Iraq, The Netherlands, Nordic countries, Oman, Panama, Peru, Poland, Russia, Spain, USA.

- **Intergovernmental Programmes/Organizations :**

  CHR/KRH, WMO (Project 52.2).

- **Non-governmental Organizations :**

  CATHALAC, IAHS/ICSI/ICT/ICASVR, IGBP/BAHC.

Products:

- 4 dimensional regional predictions of hydrometeorological and land cover as digital data;
- Proceedings of international symposia and workshops on scaling down global predictions. in co-operation with IGBP/BAHC/GCTE;
- Preparation of bulletins on glacier mass balance (ICSI);
- Publication of the "World Atlas of Snow and Ice Resources" (ICSI/Russian IHP/NC);
- Technical reports of research and methodology development results;
- Preparation of documents on snow ecology, and snow and ice changes in volume and in space.

PROJECT 1.4: Strategies for water resource assessment and management under conditions of anthropogenic global climate change

Objectives:

- To develop methodologies for water resource assessment and management for river basins and systems in non-stationary climatic conditions for a range of physio-geographic and water-use situations;
- To prepare a catalogue of case studies.

Activities:

- International symposia and workshops;
- International Conference on Scientific Bases for the Management of Water Resource Systems under Non-Stationary Climatic Conditions to be held in Russia;
- Preparation of research reports based on separate national activities carried out by national projects being undertaken in the Aral and Caspian sea regions;
- Preparation of research reports based on the comparative study of impacts of climate and anthropogenic changes on runoff to world oceans from USA and Russia;
- Preparation of Catalogue of Case Studies;
- IWRA conference focusing on the North Sea Area, Norway, 1997.

Method of Implementation:

- Group of National and International Organizations;
- Working Group(s) for Report/Catalogue;
- Co-sponsorship with WMO of WCP-Water activities.

Co-operating partners :

- **IHP National Committees of :**

  Belgium, Canada, China, Czech Republic, Egypt, Finland, Ghana, Germany, Iraq, Oman, Poland, Romania, Russia, The Netherlands, Switzerland, UK, USA, Vietnam.

- **Intergovernmental Programmes/Organizations :**

  WMO (projects 51.2, 52.2, 52.3).

- **Non-governmental Organizations :**

  IAHR, ICID.

Products:

- Symposium Proceedings;
- Research Report describing methodologies;
- Catalogue of Case Studies;
- Ghana will make available a report on the impact of land use changes on water resources in the Volta region.

Theme 2: Ecohydrological processes in the surficial environment

Background

Soil, water and sunlight are the fundamental resources driving the productivity of the land surface. Soils, interacting with the plant cover, serve as the interface for minerals, water and gases between the land, the atmosphere and the oceans. However, as a result of rapid population growth more and more land is being taken for agriculture, urbanization and infrastructural development. Large scale deforestation often followed by improper land use practices lead to increasing stresses on the environment often exceeding its absorptive capacity. As a result, highly productive land, especially in the humid tropics is endangered by erosion. At the same time, surface water quality is changed and dowstream users suffer under increased suspended load and sedimentation. Erosion and sedimentation processes are interfaced via the river system and the adjacent water bodies in the flood plain.

The modified land use also affects the pathways, *the residence times* and partitioning into which precipitation is transformed into surface runoff, soil moisture, evaporation and ground water. The artificial drainage of wetlands, channelization of river networks, reduction of flood plain areas also cause modifications in the flows of water, nutrients, sediments and pollutants. Some of the most important roles which flood plains and wetlands perform, as ecotones, are those of low cost water purification systems, highly productive ecosystems, buffers against floods and low flow periods, storage of nutrients, recreation areas and regions with high biological diversity.

Aims

The main aim is the conservation of the natural resources, especially land and water, to assist in sustainable development. To achieve this objective two major areas in need of exploration have been defined which would lead to a better understanding of the vulnerability of the land-water system to human activities:

- Land use, erosion and sedimentation: its consequences and control;
- Preservation and restoration of rivers and wetlands.

Four projects are proposed under Theme 2.

PROJECT 2.1: Vegetation, land-water use and erosion processes

Objectives:

- To assess the effect of land-water use on erosion processes and water partitioning into surface runoff, infiltration and natural groundwater recharge;
- To trace and identify possible impacts of the flow paths of nutrients and pollutants affected by erosion processes.

Activities:

- International workshops;
- Compilation of scientific report;
- Argentina will contribute a case study on Rio Grande watershed management and will organize a regional workshop on sediment transport in steep mountains in co-operation with IAHS/ICCE;
- Cuba will provide a case study on the agricultural crop influences on soil erosion and soil loss in representative basins;
- Romania will provide case study in the Buzau subcarpatian area;
- Russia will contribute results of studies on erosion processes conducted by *SHI;*
- Finland's Nature Conservation Research Unit of National Boards of Water and the Environment will provide data and results of his programmes;
- Ecuador will provide a case study on the Basin of the Rio Paute;
- IRTCES will provide case study and organize an international symposium;
- ICCORES will promote the establishment of a documentation and information centre;
- Fluvial morphodynamics session at the 27th IAHR Biennial Congress, San Francisco, 11-15 August 1997;
- IAHR will organize the Second Habitat Hydraulics Conference (Quebec, Canada, June 1996);
- FAO will develop, in co-operation with UNESCO, a GIS applicable to dynamic assessment of water resources.

Method of implementation:

- Co-operation of IHP/NCs, NGOs and IGOs;
- Co-operation between UNESCO and FAO.

Co-operating partners :

- **IHP National Committees of :**

  Arab States, Argentina, Australia, Austria, Belgium, Burkina Faso, Canada, Chile, China, Costa Rica, Cuba, Czech Republic, Ecuador, Finland, Germany, Ghana, Hungary, Morocco, The Netherlands, Panama, Romania, Russia, Slovenia, Spain, Sudan, Sweden, Tunisia, Ukraine, UK, Venezuela.

- **Intergovernmental Programmes/Organizations :**

  FAO, IAEA, CHR (Commission internationale d'hydrologie du Bassin du Rhin).

- **Non-governmental Organizations :**

  IAHR, IAHS/ICCE/ICRSDT/ICT, IRTCES, IGBP/BAHC.

Products:

- The development of hydrological information and models integrating abiotic and biotic parameters to estimate the erosive capacity and the partitioning of flow paths in relation to different land use, vegetation and climatic conditions;
- Improvement of methodologies combining remote sensing techniques, GIS, tracer techniques and hydrologic models to assess the vulnerability of soils (in co-operation with FAO);
- Soil vulnerability maps in digital form (in co-operation with FAO);
- Soil vulnerability map of Cuba.

PROJECT 2.2: Sedimentation processes in reservoirs and deltas

Objectives:

- To extend the knowledge on sedimentation dynamics including both quantitative and qualitative aspects of the sedimentation process in reservoirs/lakes and coastal areas;
- To identify the impacts of sedimentation on other water uses and the environment;
- To determine river channel and sedimentation patterns above and below reservoir structures.

Activities:

- International Symposium on Erosion and Sediment Yield: Global and Regional Perspectives, Exeter, UK, 1996;
- International Conference on Reservoir Sedimentation, Fort Collins, USA, 1996;
- International workshops and symposia;

- Training courses on:
  * Advanced monitoring techniques for sediment transport and river channel changes;
  * *Modelling sediment and transport and river channel changes.*
- Romania will provide research reports on mathematical models for sediment transport and silting;
- Russia will contribute case study related to processes of transport and sedimentation in Siberian reservoirs and will organize in Novosibirsk an international symposium in collaboration with IAHR;
- Russia will carry out a study on "Assessment and forecasting of dangerous hydrological phenomena related to floods and mudflows";
- Italy will prepare a monograph on catastrophic floods and mudflows;
- ICCORES, in collaboration with its components and in particular with IRTCES, will prepare a monograph on reservoir sedimentation and promote the establishment of an information and documentation centre;
- Ecuador will provide a case study on the Reservoir of Amaluza Hydroelectric Project PAUTE.
- First International Conference on River Tech: New/Emerging Concepts for Rivers, IWRA, Chicago, USA, September 1996.

Method of implementation:

- International working group in co-operation with ICCORES;
- Co-operative arrangements through networking amongst national research facilities dealing with sedimentation.
- Establishment of an international training center in Italy.

Co-operating partners :

- **IHP National Committees of** :

  Algeria, Argentina, Canada, Chile, China, Colombia, Cuba, Ecuador, Egypt, Ghana, Hungary, India, Iraq, Iran, Italy, Morocco, The Netherlands, Romania, Russia, Slovakia, Slovenia, Sudan, Sweden, Togo, Tunisia, Ukraine, USA, Venezuela, Vietnam.

- **Intergovernmental Programmes/Organizations** :

  Blue Plan/MEDO, CHR.

- **Non-governmental Organizations** :

  IAHS/ICCE/ICWQ, ICCORES, ICSU/SCOWAR, IRTCES, IWRA.

Products:

- Case studies;
- Research reports;
- Proceedings of international symposia;
- Guidelines for coping with reservoir sedimentation;
- Case histories from different climatic regions of the world;
- Monograph on the "Hydrology of deltas";

- Monograph on "Catastrophic floods and mudflows".

PROJECT 2.3: Interactions between river systems, flood plains and wetlands

Objectives:

- To contribute to the understanding of the role of the hydrological cycle in different ecosystems;
- To identify links between abiotic and biotic indicators in order to maintain the filtering capacities of flood plains and wetlands, with respect to sediment nutrients and pollutants and the buffering capacity against extreme hydrological events.

Activities:

- International workshops and symposium on ecotone functioning;
- Establishing teaching material and training courses on flood plain and wetland management for water engineers;
- Australia will prepare a publication presenting case studies on semi-arid zones;
- Argentina will contribute with data on several projects: Flatlands, Biosphere Reserves, Projecto Provincio de Buenos Ayres Plan Maestro;
- China will develop case studies on some large rivers: Yangtze, Yellow River, Fonghua River;
- Cuba will contribute a case study;
- France will provide results obtained by the Experimental and Representative Basins Network (ERB) and the Research Basins, and will publish information on the methodological approach used by the INONDABILITE programme;
- Germany will prepare a cast study and organize a workshop;
- Nordic countries will give guidelines on future IHP/MAB co-operation;
- Poland will contribute with the continuation of project M-3.4 of IHP-IV;
- Russia will conduct the national study "Migration of pollutants in wetlands of Russia" and will prepare a reference book, "Pollutants in Wetlands of Russia";
- Slovakia will contribute with data on the Danube River;
- USA will provide results of various national studies;
- IAHR will organize the 2nd Habitat Hydraulics Conference, Quebec, Canada, June 1996.

Method of implementation:

- International working group with links to IHP and MAB National Committees.

Co-operating partners :

- **IHP National Committees of :**

  Argentina, Australia, Belgium, Canada, China, Cuba, Czech Republic, Ecuador, Finland, France,, Germany, Ghana, Hungary, India, Iraq, The Netherlands, Peru, Poland, Romania, Russia, Slovakia, Sweden, Ukraine, USA.

- **Intergovernmental Programmes/Organizations :**

  CHR, Interamerican Research Agency.

- **Non-governmental Organizations :**

  IAH, IAHR, IAHS/ICSW/ICT, IRTCES.

Products:

- Comparison of related studies at different spatial and temporal scales and under different climatic studies;
- Improved understanding of the abiotic-biotic interlinks as a basis for the long-term, improved management of these systems;
- Raising the awareness of the importance of flood plain systems and wetlands;
- Casebook for river systems/flood plain/wetland management.

PROJECT 2.4: Comprehensive assessment of the surficial eco-hydrological processes

Objectives:

- To develop a methodological framework, through experimental research to describe and quantify the flow paths of water, sediments, nutrients and pollutants through the surficial eco-hydrological system of different temporal and spatial scales under different climatic and geographic conditions;
- To develop an integrated approach for managing the surficial eco-hydrological environment including the consideration of non-structural measures;
- To improve the methodology for water ecosystem vulnerability assessment.

Activities:

- Canada will organize an international workshop on Global Atmospheric Deposition of Pollutants to Lake Sediments;
- International conference on ecohydrology of high mountain areas, Kathmandu, Nepal, 1996;
- Establishing teaching material and training courses on ecohydrology for water engineers;
- Cuba will provide results of research programmes carried out in Cuba, presented in the publication, "Improved methodology for the assessment of the vulnerability of superficial environment; support of the decision-making process at local, regional and basin level";
- Development of learning materials on surficial eco-hydrological processes for post-graduate studies;

- Germany will prepare case study in co-operation with the German MAB National Committee;
- Hungary will prepare methodological guidelines;
- Israel offers to include a typical example of warm and salt lakes and provide data and research results concerning the Kinneret Lake and the Dead Sea;
- Nordic countries will provide research programmes results;
- Russia will contribute results of pilot projects on "Integrated use and conservation of water resources" carried out within the framework of co-operation with the World Bank.
- Sweden will prepare a monograph on "Ecohydrology - Linkages between terrestrial ecosystems and the circulating freshwater" to elucidate land/water linkages on mesoscale;
- Israel will provide relevant research results concerning the Sea of Galilea;
- SCOWAR will contribute data from its project on "Understanding of freshwater eco-systems at the scale of eco-regions".

Method of implementation:

- IHP and MAB/NCs will be requested to provide case studies;
- International working group to elaborate the learning materials;

Co-operating partners :

- **IHP National Committees of :**

  Argentina, Austria, Belgium, Bulgaria, Canada, Cuba, Czech Republic, Ecuador, Finland, France, Germany, Ghana, Hungary, Israel, Nepal, Peru, Russia, Sweden, Ukraine.

- **Intergovernmental Programmes/Organizations :**

  WMO (project 52.3).

- **Non-governmental Organizations :**

  IAH, IAHS/ICT, ICSU/SCOWAR, IGBP/BAHC.

Products:

- Conference proceedings;
- Learning materials;
- Specialized short courses;
- Improved methodology for the assessment of the vulnerability of the surficial environment;
- Support of the decision-making process at local, regional and the basin scale;
- Technical reports.

Theme 3: Groundwater resources at risk

Background

Among the most serious problems in water resources is the degradation of ground water. Ground water is vulnerable because of its strong linkage with surface water where pollution is often occurring. It can also be depleted, due to over extraction or reduction of the natural recharge. Throughout many areas of the world, the extent of groundwater contamination is not known. In the industrialized countries the problem is widespread and severe. Although contamination may originate at the land surface, its migration is greatly affected by processes occurring in surface water and in the unsaturated zone. Ground water is particularly vulnerable in coastal regions because of its high linkage with surface water where pollution is often highly concentrated populations and local extreme exploitation. As urbanization and industrialization expand, modern chemical compounds have made their way to ground water. Agricultural practices generate non-point contaminants which threaten ground water. They include inorganic constituents such as nitrate, sulfate and selenium as well as organic compounds from pesticides.

Aims

- To document the extent, spatial distribution, propagation and types of contamination including point-source and non-point source problems;
- To develop methodologies for optimal monitoring well layouts to serve as early warning and trend detection systems for possible water supply contamination;
- To analyze the processes of the interrelationship between surface water and ground water, and in particular the interaction of physical, chemical and biological processes in the unsaturated zone as controlling agents in the fate of groundwater contaminants;
- To identify common features in coastal regions where problems of over-use and salt water intrusion threaten the sustained viability of coastal ground water.

Five projects are proposed under Theme 3. An International Conference on Calibration and Reliability in Groundwater Modelling (ModelCARE '96) will be held in the USA, 1996, organized by IGWMC, IAHS/ICGW and IAH, which will embrace all projects under this Theme. It is also foreseen that in 1997 IAHS will organize an International Conference on Water Resources and Environmental Aspects in Headwater Areas: Impacts, Processes, Protection and Regeneration. A session on "Groundwater, an endangered resource" will be held at the 27th IAHR Biennial Congress in San Francisco in 1997. The Theme will be included in the third and fourth Regional Biennial Congresses of the IAHR African Division in 1998 and 2000. An International Conference on Analitics Based Modelling of Groundwater Flow will be held in Nunspeet, The Netherlands, in 1997. The projects of this Theme will also be taken up by the International Conference on Future Groundwater at Risk to be held in August 1998 in Changchun, China.

PROJECT 3.1: Groundwater contamination inventory

Objective:

- To document, with existing data, the extent, spatial distribution, and types of contamination including point-source and non-point-source problems, as well as natural contamination due to saline-water intrusion at regional scales.

Activities:

- IHP National Committees to gather available information and to assess the national situation;
- Regional Offices of Science and Technology (ROSTs) as focal points, to organize data collection and analysis;
- Regional workshops to harmonize methodologies, interpretation and boundary conditions as well as to prepare regional maps;
- Development of a standardized methodological guideline.

Method of implementation:

- International working group to establish methodological guidelines and synthesis report in co-operation with non-governmental organizations;
- Regional working group activities in co-operation with the ROSTs (each region would develop an independent contribution to this project);

Co-operating partners :

- **IHP National Committees of :**

  Algeria, Argentina, Cuba, Czech Republic, Denmark, Ecuador, Egypt, Finland, France, Germany, Ghana, Iran, Israel, Italy, Jordan, Kuwait, Mongolia, Morocco, The Netherlands, Oman, Qatar, Romania, Russia, Senegal, Spain, Sudan, Tunisia, Ukraine, Vietnam.

- **Intergovernmental Programmes/Organizations :**

  ACSAD, Blue Plan/MEDO.

- **Non-governmental Organizations :**

  IAH, IAHS/ICGW.

Products:

- A series of maps and descriptive text which discusses the nature and extent of the problems region by region;
- Standardized methodological guidelines.

PROJECT 3.2: Monitoring strategies for detecting groundwater quality problems

Objective:

- To develop methodologies for optimal monitoring well layouts to serve as early warning and trend detection systems for potential contamination of vulnerable water supplies. The scale of interest ranges from local to small regional.

Activities:

- International literature survey;
- Elaboration of practical guidance material;
- Israel will organize an international workshop;
- WMO meeting of experts on groundwater monitoring (1996).

Method of implementation:

- International working group in co-operation with non-governmental organizations and intergovernmental organizations;
- Inputs from IHP National Committees.

Co-operating partners :

- **IHP National Committees of :**

  Algeria, Argentina, China, Cuba, Czech Republic, Denmark, Ecuador, Egypt, Germany, Ghana, Hungary, Israel, Italy, Jordan, Kuwait, Mongolia, Morocco, The Netherlands, Oman, Qatar, Romania, Russia, Senegal, Spain, Sudan, Switzerland, Tunisia, USA.

- **Intergovernmental Programmes/Organizations :**

  ACSAD, WHO, WMO (project 51.2).

- **Non-governmental Organizations :**

  IAH, IAHS/ICGW.

Product:

- Preparation of a guidebook.

PROJECT 3.3: Role of unsaturated zone processes in groundwater supply quality

Objective:

- To study the processes occurring in the relationship surface water/ ground water and in particular the interaction of physical, chemical and biological processes in the unsaturated zone as controlling agents in the fate of groundwater contamination.

Activities:

- International workshops and symposia;
- Networking of IHP National Committees;
- Preparation of technical report(s);
- Israel will hold an international workshop on assessing long-term salinity effects caused by the vadose-cone.

Method of implementation:

- National Committees interested would create a network for co-operation;
- Co-operative arrangements with non-governmental organizations;
- Working group to prepare technical report(s).

Co-operating partners :

- **IHP National Committees of :**

  Algeria, Argentina, Cuba, Denmark, Egypt, Germany, Ghana, Ghana, Hungary, Israel, Jordan, Mongolia, The Netherlands, Romania, Russia; Senegal, Slovakia, Spain, Sudan, Sweden, USA.

- **Intergovernmental Programmes/Organizations :**

  ACSAD.

- **Non-governmental Organizations :**

  IAH, IAHS/ICT.

Products:

- Technical reports;
- Proceedings of international symposia.

PROJECT 3.4: Groundwater contamination due to urban development

Objective:

- To document the likely susceptibility of groundwater resources to present and future urbanization at local and regional scales.

Activities:

- IHP/NCs to provide case studies;
- Discussion in regional seminars;
- Working group to prepare state-of-the-art report for selected regions in developing and industrial countries;

- Israel will provide case studies.

Method of implementation:

- Working group;
- Network of IHP/NCs;
- ROSTs to co-ordinate regional activities.

Co-operating partners :

- **IHP National Committees of :**

  Burkina Faso, Canada, Denmark, Egypt, Ghana, Hungary, Indonesia, Israel, Italy, Jordan, Mongolia, Morocco, The Netherlands, Romania, Spain, Sweden, Sudan, Tunisia, USA.

- **Intergovernmental Programmes/Organizations :**

  ACSAD, Blue Plan/MEDO, WHO.

- **Non-governmental Organizations :**

  IAH, IAHS/ICGW.

Product:

- Report published in the IHP book series.

PROJECT 3.5: Agricultural threats to groundwater resources

Objective:

- To identify the vulnerability of ground water to agricultural practices concerning regional scale groundwater resources.

Activities:

- Regional case studies to be provided by IHP/NCs (Israel, Spain);
- Series of regional workshops on agricultural threats to ground water;
- International symposium on the common aspects of problems based on agricultural practices, environment and climatic considerations.

Method of implementation:

- Network of IHP/NCs;
- Editorial Board to edit the results of the symposium.

Co-operating partners :

- **IHP National Committees of :**

  Argentina, Egypt, Finland, Ghana, Germany, Hungary, Iraq, Israel, Italy, Jordan, Mongolia, Morocco, The Netherlands, Qatar, Spain, Sweden, Sudan, Tunisia, USA.

- **Intergovernmental Programmes/Organizations :**

  ACSAD, Blue Plan/MEDO.

- **Non-governmental Organizations :**

  IAH, IAHS, ICID.

Products:

- Workshop reports;
- Technical report to synthetise the state-of-the-art.

Theme 4: Strategies for water resources management in emergency and conflicting situations

Background

Water as a scarce and commonly shared resource may become the subject of conflicts. These may range from conflicts between different use and users of water at the local level up to conflicting situation around international water systems. Such conflicting situations referring to transboundary water systems (rivers, lakes, aquifers) have already occurred in the past and are likely to intensify in the future accompanying the increasing water stress. In the majority of cases the conflicts have a strong cultural component stemming from the different perceptions of the value of water under different socio-cultural environments.

The vulnerability of the environment also involves that it is possible to disrupt it from the welcome dynamic equilibrium towards non-sustainability, to exceed the natural adaptation range, to exhaust the buffering capacity for accommodating a shock (surprise) or trend.

The ultimate evidence of vulnerability of environmental and water systems becomes apparent in emergency situations of natural disasters and failures of man-made systems.

The analyses of consequences of water resources projects are typically made based on a simplistic representation of real, complex and interconnected processes. A need for holistic analysis arises, including more criteria than just means and variance of operational variables and net benefits. Comprehensive impact assessment should embrace environmental consequences (quality of environment, ecosystems, human health), social, political and cultural effects of different planning strategies which aim at achieving the same goals. Comprehensive assessment of effects of new legal acts is also needed. In particular the need for assessment of

different aspects of non-satisfactory system performance, related to water, comes about (risk, reliability, vulnerability, resilience and robustness considerations). Impact and risk assessment of rare, but possible, events (natural disasters and those related to man-made systems) need to be developed and implemented.

The development of water resources schemes sometimes becomes prohibitively costly, creates illusion of safety ("fail safe", rather than "safe fail" philosophy) and, as experience shows, may involve undesirable side effects. Therefore one is increasingly forced to look for non-structural means of alleviating water problems: improving the use of the existing schemes and identifying reserves that have not been exploited yet.

Aims

- To propose methodologies for emergency management and conflict resolution strategies and to disseminate up-to-date guidance materials;

- To develop methods for water-related disaster management support as a contribution to IDNDR (International Decade for Natural Disaster Reduction);

- To develop a methodological framework for comprehensive environmental risk and impact assessment including the consideration of the frequency and extent of impacts in order to quantify the vulnerability of the environment.

Three projects are proposed under Theme 4.

PROJECT 4.1: International water systems
(a) Conflict analysis and resolution
(b) Development of integrated hydrological information and decision systems for international river basins
(c) Large-scale diversions; Systems control, emergency procedures and extreme hydrological conditions

Objectives:

- To improve understanding of water-related conflicts at the transboundary scale;
- To adopt methodology of conflict analysis (identification of sources of conflict, players, options and stability study) and resolution including social impact analysis;
- To improve methodology for negotiation support;
- To apply negotiation support systems for selected case studies involving water resources conflicts.

Activities:

- Interdisciplinary project, jointly with UNESCO's Decade for Cultural Development, concerning water and civilization;
- Regional interdisciplinary symposia on water and civilization;
- Technical monographs on various aspects of water and civilization;
- Popularized documents on water-civilization-conflicts issues;
- Public education programmes on water in various socio-cultural settings;
- Series of workshops related to conflict management of international river basins;
- Symposium on water resources negotiation support systems;
- International conference on water conflicts of the past considering the socio-cultural aspects;

- Preparation of a monograph on water resources conflict resolution;
- IAHS/ASCE Symposium on Destructive Water: Their Abatement and Control, Anaheim, California, USA, 24-28 June 1996
- International Conference on Aspects of Conflicts in Reservoir Development and Management, City University, London, UK, 3-5 September 1996;
- 4th AIDA World Congress on Water Law: an asset for Sustainable Development, 30 September to 1 October 1996, UNESCO, Paris;
- Advanced courses on multicriteria decision making methodologies as applied to water-related conflict analysis and resolution;
- Nordic countries develop operative models used as an aid in decision-making in co-operation with Estonia;
- Germany will organize an international workshop on "Basic hydrological investigations for conflict management in international river basins";
- Biennial international conferences of the Danubean countries on the hydrology of the Danube River Basin;
- Hungary will provide results of HYDANUBE;
- The Netherlands will provide data and results on the programme on international waters carried out by IHE;
- Ghana will host a sub-regional workshop on the water resources of the Volta basin;
- Israel supports the proposal of the Arab States to establish a data base on water science institutions and scientists in the region and proposes to take an active part in its establishment;
- IAHS will implement the project on vulnerability mapping and protection zones;
- WMO Workshop on operational hydrology in international river basins (1996, 1998);
- IWRA will organize The Ninth World Water Congress entitled, "Water Resources Outlook for the 21st Century: Conflicts and Opportunities".

Method of implementation:

- Steering Committee to co-ordinate the interdisciplinary project on water and civilization;
- Interbasin co-operation of IHP/NCs of transboundary rivers;
- Interbasin networking of IHP/NCs;
- Regional working groups;
- Steering group to co-ordinate regional activities with support from the ROSTs;
- Editorial Board to prepare monograph on water resources conflict resolution;
- Courses attached to IHP post-graduate courses.

Co-operating partners :

- **IHP National Committees of :**

  Algeria, Bahrain, Bulgaria, Canada, Colombia, Danube countries, Ecuador, Egypt, Finland, Ghana, Iraq, Israel, Jordan, Libya, Morocco, Mozambique, The Netherlands, Oman, Palestine, Peru, Saudi Arabia, Sudan, Syria, Tunis, United Arab Emirates, Venezuela, Vietnam, Yemen.

- **Intergovernmental Programmes/Organizations :**

  ACSAD, CHR, ECLAC, LCBC, WMO (project 51.3), The World Bank.

- **Non-governmental Organizations :**

  IAH, IAHR, IAHS, IIASA, IWRA.

Products:

- Computerized negotiation support system for water-related conflict analysis and resolution;
- Guidelines to develop integrated hydrological information systems for international river basins;
- Monograph on water resources conflict analysis and resolution;
- Advanced courses and teaching material on water resources conflict management;
- Popularized publications for decision-makers.

PROJECT 4.2: Comprehensive environmental risk and impact assessment

Objectives:

- To develop methodologies for comprehensive risk and impact assessment of planned and existing structures and institutions (such as a new legal act) on the environment, alongside with political, social and cultural impacts;
- To develop and improve risk and impact assessment methodologies for rare but possible events and emergency situations (such as e.g. radionuclide contamination, release of toxic materials on the catchment, accidental oil spills, catastrophic droughts).

Activities:

- Collection of case studies illustrating comprehensive EIA;
- Ghana will provide EIA guidelines for the development of water resources in Ghana and will organize series of training workshops;
- Ghana will provide information and reports of case studies;
- France will provide data on the large scale case studies conducted in France;
- Hungary will contribute case studies;
- Romania will provide case studies;
- Russia will contribute to the implementation of the bibliographic data bank on the theme "The role of hydrological cycle in radionuclides transfer";

- Russia will organize a conference on "Radionuclides transport in surface and groundwaters" in 1996;
- Series of regional workshops;
- International symposium on comprehensive assessment;
- Elaboration of teaching material;
- Advanced short courses;
- 3rd IHP/IAHS Kovacs Colloquium on Risk, Reliability, Uncertainty and Robustness of Water Resources System, September, 1996, Paris.(A contribution to IDNDR)

Method of implementation:

- IHP/NCs requested to provide case studies;
- ROSTs to co-operate with National Committees;
- Steering Group to co-ordinate activities;
- Working group to elaborate teaching material;
- Courses attached to the IHP post-graduate network.
- Co-operation of WMO in identifying the role of national hydrological services in EIA activities.

Co-operating partners :

- **IHP National Committees of :**

  Algeria, Bahrain, Bulgaria, Canada, Ecuador, Egypt, Finland, France, Ghana, Hungary, Iraq, Israel, Jordan, Libya, Morocco, Oman, Palestine, Romania, Russia, Saudi Arabia, Sudan, Sweden, Sudan, Syria, Tunisia, Ukraine, United Arab Emirates, Venezuela, Vietnam, Yemen.

- **Intergovernmental Programmes/Organizations :**

  ACSAD, ECLAC, WMO (projects 52.1 and 52.3).

- **Non-governmental Organizations :**

  IAHR, IAHS/ICWRS, ICID, IIASA.

Products:

- Proceedings of international symposia;
- Improved risk and impact assessment methodologies;
- Teaching material for comprehensive environmental and risk assessment;

PROJECT 4.3: Non-structural measures for water management problems

Objectives:

- To identify the possibilities of non-structural controls that could remediate particular water problems in different zones and in different systems;
- To identify existing reserves and possibilities of improvement;
- To assess impacts of these controls, including:

* Laws, regulations, standards, priorities and water pricing (to enhance water saving in agricultural, industrial and domestic sectors);
* Enhancing public involvement and changing public attitude;
* Landscape structure management and land use control (zoning, insurance);
* Re-thinking reservoir operating rules.

Activities:

- Collection of case studies;
- Workshop(s);
- Elaboration of popularized documents;
- Preparation of guidelines on non-structural measures in water management;
- Russia will provide results of study carried out by national institutions;
- Hungary will provide results of related projects and the proposed "Water Act";
- The Netherlands will provide data and results from the programme carried out by IHE;
- Ghana will provide information on case studies;
- Romania will provide technical report;
- International Symposium on Water Resources Management in Emergency Situations, Russia;
- Israel is willing to share its experience in non-structural water quality management.

Method of implementation:

- IHP/NCs requested to provide case studies;
- Working group to prepare the guidelines.

Co-operating partners :

- **IHP National Committees of :**

  Algeria, Bahrain, Bulgaria, Canada, Czech Republic, Ecuador, Egypt, France, Ghana, Hungary, Iraq, Israel, Jordan, Libya, Morocco, The Netherlands, Oman, Palestine, Peru, Romania, Russia, Saudi Arabia, Sudan, Syria, Tunisia, United Arab Emirates, Venezuela, Yemen.

- **Intergovernmental Programmes/Organizations :**

  ACSAD, ECLAC.

- **Non-governmental Organizations :**

  IAH, IAHS, IIASA.

Products:

- Guidelines on non-structural measures for water management;
- Popularized document for decision-makers.

Theme 5: Integrated water resources management in arid and semi-arid zones

Background

The development in the arid and semi-arid regions is limited by the scarcity of water resources. With the high population growth rates of almost all the countries in those regions, this situation could lead to a serious water crisis in the forthcoming years and to possible conflicts in the case of shared water resources.

There is therefore a need for the development of a special programme on the hydrology of arid and semi-arid zones in order to help the countries concerned to solve their water problems.

In the arid and semi-arid zones, the understanding of hydrological processes, in particular recharge conditions, evaporation and evapotranspiration needs to be improved. The assessment of the available water resources in large basin aquifers, shared by several countries, is difficult to establish and changes from one region to another. In the case of surface water the average annual flow figures do not necessarily reflect the real situation, due to the occurrence of floods, particularly flash floods.

Water being scarce in the arid and semi-arid zones, its management has to be carefully conducted, taking account of the close relationship between surface water and groundwater, periods of drought, the possibility of recharging aquifers from runoff excess during the rainy season, and the possible re-use of waste-water after treatment; efficient water use and conservation is a must under semi-arid conditions.

Aims

- To improve the knowledge on the hydrological processes in arid and semi-arid conditions and water resources assessment methodologies;
- To develop the integrated management of the scarce water resources and their conservation for an efficient water use;

Four projects are proposed under Theme 5.

PROJECT 5.1: Hydrological processes in arid and semi-arid zones

Objective:

- To develop a better understanding of hydrological processes, in particular surface runoff, infiltration, groundwater recharge and evaporation.

Activities:

- Preparation of a guidebook;
- Preparation and support to an international conference on droughts (as a contribution to IDNDR);
- Regional workshops on arid zone hydrology and methodological approaches;
- Elaboration of teaching material;
- Research activities;

- USA will provide results of a large-scale semi-arid land-surface-atmospheric mountain-environment experiment;
- IAHS/ICT will organize workshops/courses on applicatons of tracer techniques in arid and semi-arid zones;
- Research activities on Wadi hydrology;
- Israel offers to organize a workshop on desert hydrology with other Middle-East countries;
- IAHS 5th Scientific Assembly, Rabat, Morocco, 1997.

Method of implementation:

- Working groups in co-operation with non-governmental organizations;
- Regional working groups;
- Co-operation between IHP/NCs of different regions under the co-ordination of ROSTs.

Co-operating partners :

- **IHP National Committees of** :

  Algeria, Argentina, Australia, Bahrain, Burkina Faso, Canada, Egypt, Germany, Ghana, Hungary, India, Indonesia, Iran, Israel, Italy, Jordan, Libya, Mongolia, Morocco, The Netherlands, Oman, Palestine, Panama, Qatar, Russia, Saudi Arabia, Spain, Sudan, Sweden, Syria, Tunisia, UK, United Arab Emirates, USA, Yemen.

- **Intergovernmental Programmes/Organizations** :

  IAEA, ACSAD, Blue Plan/MEDO, LCBC.

- **Non-governmental Organizations** :

  IAH, IAHS/ICT, ICSU/SCOWAR, IWRA.

Products:

- Guidebook on the hydrology of arid and semi-arid zones;
- Proceedings of the international conference and workshops;
- Technical reports;
- Teaching material on the specific hydrological problems or arid and semi-arid zones.

PROJECT 5.2: Water resources assessment in arid and semi-arid zones

Objective:

- To review the state-of-the-art of water resources assessment methodologies and to develop the capabilities in the region for their use at national and regional levels.

Activities:

- Preparation of a manual;

- Regional assessment exercises.

Method of implementation:

- Working group in co-operation with non-governmental and intergovernmental organizations;
- Organization of regional workshops under the co-ordination of the ROSTs for assessment exercises related to shared water bodies.

Co-operating partners :

- **IHP National Committees of :**

  Algeria, Argentina, Australia, Bahrain, Burkina Faso, Egypt, Germany, Ghana, India, Indonesia, Iran, Israel, Italy, Jordan, Kuwait, Libya, Mongolia, Morocco, The Netherlands, Oman, Panama, Palestine Qatar, Russia, Saudi Arabia, Senegal, Spain, Sudan, Sweden, Syria, Tunisia, UK, United Arab Emirates, Yemen.

- **Intergovernmental Programmes/Organizations :**

  IAEA, ACSAD, LCBC, WMO (project 51.2).

- **Non-governmental Organizations :**

  IAH, IAHS/ICWRS, ICSU/SCOWAR, IWRA.

Products:

- Manual on water resources assessment in arid and semi-arid zones;
- Monographs on some shared water bodies (lakes and aquifers);
- Technical reports.

PROJECT 5.3: Water resources management for sustainable development in arid and semi-arid zones

Objective:

- To develop strategies for the integrated management of water resources and their conservation and to establish a mechanism for technology transfer.

Activities:

- Setting up regional co-operative arrangements;
- Establishment of networks;
- Preparation of specialized documents;
- Training activities;
- Sweden to organize, jointly with India, a regional workshop;
- International Symposium on Groundwater Over-exploitation.

Method of implementation:

- Working groups at regional and international levels;
- Regional workshops under the co-ordination of the ROSTs and in co-operation with WMO's regonal bodies;
- International symposia.

Co-operating partners :

- **IHP National Committees of :**

  Algeria, Argentina, Australia, Bahrain, Burkina Faso, Canada, Egypt, Germany, Ghana, Hungary, Indonesia, Iran, Israel, Italy, Jordan, Kuwait, Libya, Mongolia, Morocco, The Netherlands, Oman, Palestine, Panama, Peru, Qatar, Russia, Saudi Arabia, Senegal, Spain, Sudan, Sweden, Syria, Tunisia, UK, United Arab Emirates, Yemen.

- **Intergovernmental Programmes/Organizations :**

  IAEA, ACSAD, ALECSO, ECLAC, LCBC, WMO (project 52.3).

- **Non-governmental Organizations :**

  IAH, IAHR, ICID, ICSU/SCOWAR, IWRA.

Products:

- Proceedings of international and regional symposia and seminars;
- International networks of experts and co-operating institutions;
- Regional meeting of participating countries;
- Development of projects;
- Technical and popularized publications.

PROJECT 5.4: Coping with water scarcity

Objective:

- To develop methodologies to cope with the scarcity of water resources and negative effects on the hydrological cycle and to develop public awareness.

Activities:

- Preparation of technical reports and popularized documents;
- Regional workshops and international symposia;
- Campaign for public awareness.

Method of implementation:

- Working groups in co-operation with non-governmental and intergovernmental organizations;
- Organization of regional workshops under the co-ordination of the ROSTs;
- Organization of international symposia and publication of the proceedings.

Co-operating partners :

- **IHP National Committees of :**

  Algeria, Argentina, Australia, Bahrain, Bulgaria, Burkina Faso, Egypt, Ghana, India, Indonesia, Israel, Italy, Jordan, Libya, Mongolia, Morocco, The Netherlands, Oman, Palestine, Panama, Qatar, Russia, Saudi Arabia Senegal, Spain, Sudan, Sweden, Syria, Tunisia, UK, United Arab Emirates, Yemen.

- **Intergovernmental Programmes/Organizations :**

  IAEA, ACSAD, Blue Plan/MEDO.

- **Non-governmental Organizations :**

  IAH, IAHS/ICWRS, ICID, ICSU/SCOWAR, IWRA.

Products:

- Technical reports on:

  * Water harvesting techniques;
  * Artificial recharge;
  * Hydrological aspect of drought and evaporation control;
  * Re-use of waste-water after treatment;

- Proceedings of international symposia;
- Popularized documents on water conservation techniques.

Theme 6: Humid tropics hydrology and water management

Background

It has been estimated the total world population will increase from 4.5 billion in 1980 to about 6.5 billion by the year 2000, with the most rapid growth in the developing countries. By that time, the countries within the humid tropics and the other warm humid regions will represent almost one-third of the total world population. This proportion will continue to rise in the twenty-first century. The humid tropics thus quite clearly is the region facing potentially serious social and economic problems.

The growing population in the humid tropics obviously requires that future actions must be carried out in terms of sustainable development. Several reasons have encouraged some clearly

unsustainable development policies and practices concerning water management in developing nations of the humid tropics. Environmentally unsound development of the water and related sources has been further aggravated by the rapid economic, social and political changes resulting from the rapidly growing tropical urban populations. This complex social structure, combined with a lack of knowledge on hydro-ecological relationships of the natural systems clearly show that the humid tropics is an extremely vulnerable environment with a declining potable water base.

It is urgent to question as to whether the fields of hydrology and water resources management have the appropriate methods in place to meet the rising demands that will be made on the water resources of the humid tropics and other warm humid regions. The analysis of humid tropical hydrological phenomena at different scales is of utmost importance and as a matter of urgency, particularly in light of the critical role the humid tropics play in the global atmospheric and hydrological processes. With the present level of data availability in the humid tropics there is no hope of reducing uncertainties in any global consideration. For example, recent results on climate modelling have suggested the importance of the Amazon region on regulating global climate. However, only a few studies have been conducted especially at the watershed scale. These studies are fundamental to validate results of larger scale modelling.

Some of the most urgent hydrological and water resource management problems that need to be addressed from an integrated environmental and socio-cultural perspective include: (1) population, food and agriculture, (2) population, deforestation and reforestation, (3) rural/urban water pollution, urban drainage, water treatment, water supply and health, (4) river systems, natural and man-made lakes, (5) interaction between ocean-atmosphere-water-man's activities, and (6) the special problems associated with tropical islands.

In order to accomplish the various activities foreseen as being needed, networks of water and water-related experts and research organizations involved in warm humid regions hydrology and related water management studies have been, and are being, established in Latin America and the Caribbean, Asia, Africa and the Pacific region.

Aims

- To assess the vulnerability of the humid tropical environment with respect to different water and land use techniques to assure sustainable development at short-term and long-term scales;
- To develop networks of water and water-related experts and research organizations involved in warm humid regions hydrology and water management studies;
- To evaluate, understand and define the spatial and temporal variability of key hydrological measures are strongly needed along with the modelling of hydrologic processes in the tropics at different scales;
- To evaluate the impact of human activities on the hydrologic cycle of the tropical forests to better understand the global climate system.

Four projects are proposed under Theme 6.

PROJECT 6.1: Hydrological processes and water management in the humid tropics environment and other warm humid regions

Objectives:

- To improve the understanding of hydrological process mechanisms in the humid tropics;
- To evaluate, understand and define the spatial and temporal variability of key hydrological variables including tropical rainfall;
- To develop models of hydrologic processes in the tropics at different scales;
- To evaluate the impact of anthropogenic actions in the hydrologic cycle of the tropical forests;
- To improve methodology and technology of tropical island hydrology and water management.

Activities:

- Co-operative research project amongst the concerned IHP/NCs to assess the hydrological impact of deforestation in the Amazon Basin;
- A joint IHP/MAB activity evaluating the impact of various tropical reforestation strategies (including both indigeneous as well as exotic tree species) on the ecohydrological processes and the related water balance;
- Establishment of a joint IHP/IGBP network to couple hydrologic models of different scales with AGCMs in close co-operation with activities in Project 1.2;
- Cuba proposed a project linking intense rainfalls with the hydrological impacts in the Caribbean;
- Establishment of further humid tropics hydrology centres;
- International Conference on Tropical Climatology, Meteorology and Hydrology, Brussels, Belgium, 22-26 May 1996;
- Regional humid tropics hydrology seminars;
- Colloquium on Humid Tropics Hydrology and Water Management;
- Joint IHP/MAB Institutes for Advanced Studies on Hydrological Processes in Tropical Forest Ecosystems;
- Development of training and teaching material;
- Continuation of the popularized documents series;
- Preparation of river catalogue in selected areas;
- Establishment of the pilot data dissemination and process system for monitoring tropical rainfall through space data;
- Co-operative research project amongst *several* IHP/NCs to assess the hydrological impact of cloud forests and intensive rains in the Caribbean basin.

Method of implementation:

- Regional co-operation of National Committees of the IHP with the support of the ROSTs;
- Regional working groups organizing workshops in co-operation with WMO's regional bodies;
- Short-term advanced courses;
- International colloquium at global level;
- Field projects forming integral parts of the theme but financed from extra-budgetary sources;
- Courses attached to the IHP post-graduate network;
- Regional working group for the mission of measurement and data dissemination and process of tropical rainfall;

- Regional co-operation project for understanding the characteristics of humid tropics through the exchange of river catalogues.

Co-operating partners :

- **IHP National Committees of** :

  Australia, Canada, Colombia, Costa Rica, Cote d'Ivoire, Cuba, Ecuador, Germany, Ghana, India, Indonesia,, Japan, Malaysia, The Netherlands, Panama, UK, Vietnam.

- **Intergovernmental Programmes/Organizations** :

  WMO (project 52.3).

- **Non-governmental Organizations** :

  CATHALAC, IAHS/ICT, IGBP/BAHC, IWRA.

Products:

- Networks of co-operating institutions dealing with humid tropics hydrology and ecohydrology;
- Regional Humid Tropics Hydrology Centres;
- Popularized documents for decision-makers;
- Advanced courses on humid tropics hydrology;
- Report on the role of the humid tropical region in the global change processes;
- Report on the hydrological impact of deforestation in the Amazon Basin;
- Report on the hydrological impact of intensive rains in the Caribbean basin.

PROJECT 6.2: Land use, deforestation, erosion and sedimentation in the humid tropics

Objectives:

- To understand the mechanisms of sediment yield and transport in a tropical environment as a function of the land use through the identification and measurement of sediment sources and storages;
- To identify cost-effective and ecologically appropriate interventions to manage sediment yield and timing, water quality and pollutants transported with sediments;
- To collate and systematize existing small catchment data on erosion and sedimentation into a predictive modelling framework.

Activities:

- Comparative studies of IHP/NCs on the impact of different land use patterns throughout the humid tropics;
- Regional seminars on the ecohydrological consequences of land use/deforestation;
- Establishment of experimental basins for hydrological and sediment yield studies;
- Regional workshops on the subject channelled into the Global Colloquium on Humid Tropics Hydrology;

- Guidelines for sediment control in tropical environment.

Method of implementation:

- Close co-ordination with the activities of Project 2.1;
- Regional Working Groups with strong links to the International Steering Committee;
- Sub-regional meetings of participating Member States.

Co-operating partners :

- **IHP National Committees of :**

  Australia, Colombia, Costa Rica, Cote d'Ivoire, Cuba, Cuba, Ecuador, Ghana, India, Indonesia, Japan, Malaysia, The Netherlands, Panama, Vietnam.

- **Non-governmental Organizations :**

  IAHS/ICCE, CATHALAC, IAHR, ICCORES, IGBP/BAHC, IRTCES, IWRA.

Products:

- Development of case studies for measurement of sediment yield of small tropical basins;
- Guidelines for sedimentation control in tropical environment.

PROJECT 6.3: Integrated water management for sustainable development in the humid tropics

Objectives:

- To establish a methodological framework for multi-objective consideration in water resources development and management in the humid tropics;
- To incorporate the hydroecological concept in the analysis of water resources projects through the integration of both quantitative and qualitative aspects. This includes the interrelation of hydrology with limnology, ecology and biological productivity of great tropical lake ecosystems;
- To encourage the use of demand management as a means to cope with scarce capital resources in the provision of the necessary supply.

Activities:

- Regional seminars on integrated water resources management in the humid tropics;
- Training courses on multicriteria decision-making methods;
- Development of guidelines on multiobjective water resources planning in the context of the humid tropics;
- Regional workshops on sustainable water management in the humid tropics, the recommendations of which will be channeled into the Global Colloquium on Humid Tropics Hydrology;
- Development of popularized documents on the subject for decision-makers.

Method of implementation:

- Co-operation of IHP/NCs;
- Rapporteur to develop guidelines based upon inputs for NCs.

Co-operating partners :

- **IHP National Committees of :**

  Australia, Canada, Costa Rica, Cote d'Ivoire, Cuba, Ghana, Indonesia, Japan, Malaysia, The Netherlands, Panama, Peru, UK, Vietnam.

- **Non-governmental Organizations :**

  CATHALAC, IAHR, IWRA.

Products:

- Guidelines on multiobjective water resources planning for humid tropical regions;
- Popularized documents on sustainable water resources development in the humid tropics.

PROJECT 6.4: Information exchange on regional hydrological processes research and experiences in water resources management

Objectives:

- To create a media for mutual understanding of the hydro-climatologically, geographically and/or hydro-sociologically similar neighbouring countries;
- To create scientific bases to undertake the relevant exchange and transfer of technology and experiences in water resource management.

Activities:

- Publication of river catalogues in the region;
- Establishment of a regional hydrological data bank.
- Asian Regional Working Group for the mission of measurement and data dissemination and processes of tropical rainfall, and preparation of river catalogues led by Japan IHP/NC.

Method of implementation:

- International Steering Committee to co-ordinate global efforts;
- Regional Steering Committees composed of representatives of each country of various tropical regions;
- Workshops and working groups;
- Training courses for data bank and data handling;
- Conferences.

Co-operating partners :

- **IHP National Committees of :**

  Australia, Costa Rica, Cote d'Ivoire, Indonesia, Japan, Malaysia, Panama, Vietnam.

- **Intergovernmental Programmes/Organizations :**

  WMO (project 51.3).

- **Non-governmental Organizations :**

  CATHALAC, IAHR, IWRA.

Products:

- Publication of river catalogues (with the co-operation of the Japanese IHP/NC)

Theme 7: Integrated urban water management

Background

It is also estimated that by the year 2000, half of the world population will be living in urban areas. As a result of this large human concentration there are changes that will occur in the urban environment, both in its physical and socio-economic aspects.

Urban drainage, water supply, solid waste and sewage disposal are components of urban water management that must be adequately integrated in order to cope with these increasing demands for municipal and industrial water uses. Integration must involve other levels of planning, including the transportation and urbanization sectors. Most urban centres in the developing world still lack the facilities that are adequate for the proper collection and disposal of domestic and industrial wastes. Urban run-off is typically highly polluted with pathogenic and organic substances that are public health threats during flood events.

Only about half of the urban population in these countries has access to sewage disposal systems. Most of the existing collecting systems discharge directly to the receiving waters without any treatment. Garbage, domestic and otherwise, is often either dumped directly into water bodies or disposed on roadsides or other equally unsuitable areas where they can often later be washed into streams and lakes. This vulnerable environment requires special attention and the solution of such complex and interdisciplinary problems call for an integrated water resources management approach.

Hydrology of urban areas has been a subject of research since many years. A significant number of methods have been developed for designing urban drainage systems. During IHP-IV, a greater emphasis was given to the qualitative aspects of urban waters which, in turn, made it possible to introduce the hydro-ecological approach to urban water management. IRTCUD has been established within the framework of IHP-IV. Taking into account that the

trend of urban population concentration increase will continue in the future, mainly in less developed countries, a programme for encompassing all hydrological, ecological and socio-economic aspects of urban planning and management should be in place.

Aims

- To improve the management of existing urban drainage systems through an integrated approach;
- To disseminate knowledge on integrated urban water management;
- To analyze the effectiveness of non-structural flood control measures such as: flood warning systems, flood plain zoning, flood plain insurance and relocation in reducing damages as an alternative to structural measures (contribution to IDNDR through pilot projects);
- To identify the impact of urbanization on surface and groundwater quality through point and non-point pollution;
- To establish experimental urban catchments and to create a worldwide data base for comparative urban hydrology studies concerning megacities as an extension of the FRIEND approach;
- To create access to available technology for developing countries through the establishment of regional centers of excellence in different climatic zones;
- To study impacts of storm water (wastewater discharges) on ecosystem health of receiving water courses in all parts of the world;
- To assess feasibility of drainage source controls designed to replicate the natural hydrology of area as closely as possible;
- To consider the need of urban inhabitants for reasonable land use.

Three projects are proposed under Theme 7. Sweden organized in 1995 an International Symposium on Integrated Water Management in Urban Areas: Searching for new realistic approaches with respect to the developing world. The outcome of the meeting will be an input to the launching of Theme 7.

PROJECT 7.1: Non-structural flood control measures to balance risk-cost-benefit in flood control management in urban areas

Objectives:

- To identify the effectiveness of non-structural flood control measures such as: flood warning systems, flood plain zoning, flood plain insurance and relocation in reducing damages as an alternative to structural measures in less developed countries;
- To develop methodologies for social communication in urban flood warning systems for fast and effective dissemination of information;
- To broaden the procedures for demand management, e.g. water use, efficiency, conservation.

Activities:

- Establishment of a network of co-operating IHP/NCs and ROSTs;
- Working groups to hold regional seminars;
- Elaboration of case studies for cities (Italy, Argentina, Greece, Switzerland, China, Brazil);
- Training courses;
- WMO technical conference on hydrological models and flood forecasting

Method of implementation:

- Regional co-operation of IHP/NCs;
- Regional training courses;
- Collaboration with IRTCUD and its regional sub-centres;
- Workshop on non-structural flood control measures in urban areas;
- Rapporteur to elaborate guidelines on coping with urban flooding;
- Co-operation of WMO in respect to flood warning systems. urban flooding.

Co-operating partners :

- **IHP National Committees of** :

  Argentina, Australia, Belgium, Canada, Chile, Ecuador, Egypt, France, Germany, Greece, Hungary, Iran, Italy, Morocco, The Netherlands, Peru, Poland, Russia, Spain, Sudan, Sweden, Switzerland, Tunisia, Ukraine.

- **Intergovernmental Programmes/Organizations** :

  ACSAD, WMO (project 52.1), ECLAC.

- **Non-governmental Organizations** :

  IAHR, ICID.

Products:

- State-of-the-art report on urban flood warning dissemination;
- Report on the feasibility of non-structural flood control measures for urban environments in developing countries;
- Guidelines on urban flood management.
- Pilot real-time flood management Decision Support System

PROJECT 7.2: Surface and ground water management in urban environment

Objectives:

- To provide a comprehensive analysis of the needs for integrated water management in the urban and surrounding areas encompassing technological developments, environmental constraints, socio-economic aspects and institutional arrangements;

- To analyze the impact of urbanization on surface and groundwater quality through point and non-point pollution;
- To examine pollution loads in receiving water courses.

Activities:

- Co-operation of IHP/NCs to produce case studies;
- International Symposium on Surface and Groundwater Management in Urban Environment;
- Development of a popularized document on urban groundwater quality problems;
- Training courses on urban hydrology and ecology;
- To establish a regional centre of UNESCO on water resources management studies in urbanized areas, and of a bibliographic data base;
- USA will provide results of an evaluation of hydrological and non-point source pollution transport models;
- Israel will provide case studies.
- Support to ECOPOLS project in Russia

Method of implementation:

- Regional co-operation of IHP/NCs through ROSTs;
- International symposium;
- Training material development at IRTCUD;
- Rapporteur to elaborate popularized document;
- Working group to co-ordinate execution.

Co-operating partners :

- **IHP National Committees of :**

  Argentina, Burkina Faso, Canada, Chile, Czech Republic, Ecuador, Egypt, Germany, Hungary, India, Indonesia, Israel, Kuwait, Morocco, Panama, Russia, Spain, Sudan, Sweden, Tunisia, Ukraine, USA, Venezuela, Vietnam.

- **Intergovernmental Programmes/Organizations :**

  ACSAD, WHO, ECLAC.

- **Non-governmental Organizations :**

  IAH, IAHR, IAHS/ICSW.

Products:

- Series of regional state-of-the-art reports;
- Proceedings of an international symposium;
- Popularized document for decision-makers;
- Technical reports.

PROJECT 7.3: Integrated urban drainage modelling in different climates: tropical, arid and semi-arid, and cold

Objectives:

- To enhance research on ecological and hydrodynamic processes involved in urban runoff with the development of appropriate technology for different climates;
- To establish experimental catchments and acquisition of relevant data to help create a worldwide database in hydrologic data for integrated urban drainage studies;
- To establish regional centers for water resources research, development and technology dissemination of methodologies for integrated urban development in developing countries.

Activities:

- Workshops in specific climatic zones;
- International symposium to synthetise the status of knowledge on different climatic zones;
- Establishment of experimental urban catchment areas;
- Development of training material;
- Training courses on tropical urban drainage at the IRTCUD Sao Paolo sub-center;
- Establishment of an IRTCUD sub-center in a semi-arid region;
- Elaboration of a monograph on urban drainage modelling in specific climatic zones.

Method of implementation:

- International working group co-operating with IRTCUD and the ROSTs;
- International symposium;

Co-operating partners :

- **IHP National Committees of :**

  Argentina, Chile, Egypt, Germany, Indonesia, Mongolia, Morocco, The Netherlands, Romania, Sudan, Sweden, Tunisia.

- **Intergovernmental Programmes/Organizations :**

  ACSAD.

- **Non-governmental Organizations :**

  IAHR, IAHS/ICSW.

Products:

- Workshop proceedings;
- Symposium proceedings;
- Multimedia training tools;
- Monograph on urban drainage modelling in specific climatic zones;

- Regional centers on urban drainage.

Theme 8: Transfer of Knowledge, Information and Technology (KIT)

Background

Following the worldwide recognition of the paramount importance of the human resources capital for sustainable and long term development IHP-V will encompass a theme on transfer of knowledge, skills, information and technology (KIT).

New lines of thought about human resources development and capacity building and more specifically about hydrological education (e.g. the UNESCO-IAHS panel report), life-long education and professional training at all levels have recently emerged. IHP-V should build upon these findings, encourage the internationalization of education and training, and co-operate as much as possible with international, regional or national on-going human resources development programmes.

Information technology in all its multiple applications (e.g. GIS, CAL, CD-I) is still expanding and is increasingly evident in education and training activities as well as in research and management fields. IHP-V should follow-up this development and introduce or help build up the tools for improving the performance of hydrologists and water resources managers. Partnership arrangements between universities, research institutions, administration, public and private companies should help to mobilize the resources needed for achieving these goals.

The transfer of hydrological and water resources KIT is foreseen to be an all-encompassing activity of IHP-V. It should not be a separate entity but rather an umbrella over all IHP-V activities to cover resource process and management studies as well as regional studies on integrated water resources management in different climatic zones. The generation of KIT is to be considered as an indispensable and strong component of all the other seven main themes. As indicated earlier all themes will lead to some transfer of KIT, be it a monograph, an advance course or popularized documents. On the other hand the transfer of KIT is certainly more than just an annex to the seven themes. It has its own self-propelled needs concerning different forms of education for different levels of different audiences.

Aims

- To improve at all levels the transfer of knowledge of the hydrological basic and engineering sciences and the findings of all other water-related sciences. Hence, multidisciplinarity, public awareness and education for a sustainable environment are an integral part of the objectives;

- To speed up the adequate transfer of research and technological development for integrated water resources development and management;

- To further the professional and managerial skills at all levels to apply the techniques for solving multidisciplinary water resources problems;

- To foster co-operation among nations and the regional or international programmes for education and training facilities, for appropriate learning technologies, for the exchange of information and experts in the field of hydrology and water resources;

- To increase the participation of women in all the above activities;

- To compile curricula and programmes on major subjects to teach specialists of various levels in hydrology and water resources and to prepare international textbooks in the above fields.

Four projects are foreseen under the transfer of KIT. Activity details as well as methods of implementation will be determined at a later stage based upon contributions and proposals made by IHP/NCs, NGOs and intergovernmental organizations.

PROJECT 8.1: Formal education at all levels

Objectives:

- To introduce the teaching of hydrology into regular school curricula;
- To enhance and improve the water-related components of the education of the technicians and university students and to reinforce the teaching of the basic hydrological sciences at university level;
- To enhance postgraduate education;
- To develop an academically recognized IHP degree programme through the establishment of an accreditation system;
- To assist in making co-operative arrangements for improvement of the UNESCO-sponsored postgraduate hydrology courses through the establishment of IHP Chairs and Lectureships (IRTCES). Continuation of the IAHR/IHP Lectureship programme.
- To increase the multidisciplinary aspects of the contents of the courses;
- To enhance the research-component of selected postgraduate programmes leading to the Ph.D level;
- Based upon the lecture notes of the IHP courses to develop a dynamically evolving system of lecture notes that is demand driven for various levels of university teaching;
- To compile, in co-operation with WMO, curricula for hydrological subjects for teaching at all levels, to prepare a manual on the contents of major textbooks on hydrology and water resources, used in various countries for teaching in advanced undergraduate university courses.

Co-operating partners :

- **IHP National Committees of :**

  Argentina, Australia, Belgium, China, Cuba, Czech Republic, Ecuador, Egypt, Germany, Greece, India, Italy, Mongolia, The Netherlands, Panama, Peru, Qatar, Russia, Spain, Turkey, USA.

- **Intergovernmental Programmes/Organizations :**

  ALECSO, WMO (project 51.4).

- **Non-governmental Organizations :**

  IAHR, IAHS/ICT, IAHS (Task Force on Developing Countries;. Training Assistance Programme), ICCORES, IRTCES..

PROJECT 8.2: Continuing education and professional training at all levels

Objectives:

- To encourage and assist in developing Computer-Aided-Learning (CAL) products such as multi-media packages by helping in quality control and in dissemination of these products;
- To promote training off-the-job arrangements for technicians and professionals at all levels to upgrade their skills. Training should be provided on a short-, medium- or long-term basis at regional or interregional scale;
- To promote short courses on national, regional or interregional scale for specific themes and at all levels;
- To enable technicians and professionals to regularly upgrade their skills and to follow-up their formal education;
- To gain experience with distance learning techniques and to encourage their use for greater efficiency;
- To launch a series of advanced study seminars, along the themes of IHP-V for policy and decision-makers, for postdoctoral researchers, for hydrology professors;
- To hold, in co-operation with WMO, training courses, workshops, tutorials at all levels (technicians, undergraduate, postgraduate) at different geographical coverages (national, regional continental, global);
- To establish model curricula and syllabi in hydraulics and water resources engineering.

Co-operating partners :

- **IHP National Committees of :**

  Argentina, Australia, China, Cuba, Czech Republic, Egypt, Germany, Greece, India, Italy, Jordan, Mongolia, Panama, Peru, Qatar, Romania, Russia, Turkey, USA, Vietnam.

- **Intergovernmental Programmes/Organizations :**

  ACSAD, ALECSO, ECLAC, WMO (project 51.4).

- **Non-governmental Organizations :**

  IAH, IAHR, IAHS/ICGW/ICT, ICCORES, ITRCES.

PROJECT 8.3: Transfer of information and technology

Objectives:

- To make potential users more aware of the value and costs of information;
- To increase access to new technologies (GIS) and application of data, information, knowledge;
- To increase information-related activities in developing countries, and to improve North/South co-operation;
- To update and extend the International Glosssary of Hydrological Terms; and make it available on electronic media, in co-operation with WMO.

Co-operating partners :

- **IHP National Committees of :**

  Cuba, Egypt, France, Finland, Ghana, Greece, Hungary, India, Iran, Jordan, Mongolia, The Netherlands, Peru, Qatar, Romania, Turkey, Ukraine, USA, Vietnam.

- **Intergovernmental Programmes/Organizations :**

  ACSAD, ALECSO, WMO (projects 51.3 and 53.1).

- **Non-governmental Organizations :**

  IAHS/ICT, ICID, IRTCES.

PROJECT 8.4: Public awareness issues related to hydrology

Objectives:

- To increase awareness in the minds of the general public and of young people of the key issues of water and environment in the 21st Century;
- To foster the human mobility for greater awareness of the world water environment problems;
- To follow-up the results of given research activities, geared towards their practical applications for selected audiences (decision-makers, politicians);
- To stimulate partnership between enterprises and educational institutions;
- To improve the management and communication aspects between research and public education programmes;
- To apply public awareness issues to different cultural and socio-economic settings.

Co-operating partners :

- **IHP National Committees of** :

  Canada, Cuba, India, Mongolia, The Netherlands, Oman, Turkey, USA, Vietnam.

- **Intergovernmental Programmes/Organizations** :

  ACSAD, ALECSO.

- **Non-governmental Organizations** :

  IAH.

PROJECT 8.5: Special project on "Women and water resources supply and use"

Objectives:

- To improve the quality of life of women by facilitating their access to water resources;
- To develop and extend appropriate techniques;
- To elaborate policies to facilitate women's involvement in water resources development programmes, recognizing their central role in the provision, management and safeguarding of the resources;
- To improve the participation of women in training programmes;
- To improve women's indigenous knowledge.

Activities:

- Development of Pilot Projects in arid and semi-arid rural areas;
- Organization of training courses for trainers;
- Discussion in regional seminars;
- Elaboration of policies;
- Development of popularized documents.

Method of implementation:

- Mobilization of financial support from national and international co-operation agencies;
- Co-operation of IHP National Committees;
- Multidisciplinary working group to elaborate policies;
- Training courses;
- Co-operation with NGO's;
- Pilot projects in arid and semi-arid rural areas of Africa;
- Regional seminars;
- Co-operation with UNIFEM, UNICEF, UNIDO, ILO.

Products:

- Report on the experience gained within the pilot projects;
- Policies at national level;
- Publication of public awareness documents;
- Learning material.

6. SUMMARY AND RECOMMENDATIONS

The present document is the Plan of the fifth phase of the International Hydrological Programme. It is based upon the deliberations of UNCED and on the work of several international meetings, notably ASCEND 21 and ICWE, which came up with a set of recommendations concerning freshwater issues. This document also reflects the recommendations of the UNESCO/WMO/ICSU International Conference on Hydrology towards the 21st Century: Research and Operational Needs, held in Paris in March 1993. The document is built upon the Concept for IHP-V which was adopted by the Intergovernmental Council for IHP at its 10th session held in 1992. The Council adopted the following:

- The fifth phase of the International Hydrological Programme should intensify the links between scientific research, technological development, management and education.
- The emphasis should be on application-oriented research and technology transfer.
- The hierarchical structure of IHP-IV should be at least partially replaced by a matrix-type structure to stimulate interdisciplinary and horizontal collaboration among the projects of different themes.
- The scope of research and activities should focus on fewer topics with more detailed research and better defined projects.

To follow these conclusions, a general leitmotiv emphasizing the vulnerability of the environment was proposed. In particular, the various sources of uncertainties in the biotic-abiotic water-related processes need to be identified, assessed at different scales and considered in integrated water resources management. Due to their specific characteristics and their importance for the world population, emphasis should be given, and applications geared, to the vulnerability of the environment in arid/semi-arid zones, in the humid tropics and in urbanized areas.

Eight themes were proposed which address both the process aspect and the resources management aspect as well as regional considerations. The themes refer to:

- Global hydrological and biogeochemical processes
- Ecohydrological processes in the surficial environment
- Groundwater resources at risk

- Strategies for water resources management in emergency and conflicting situations
- Integrated water resources management in the arid and semi-arid zones
- Humid tropics hydrology and water management
- Integrated urban water management
- Transfer of Knowledge, Information and Technology (KIT).

It is foreseen that a mid term scientific overview of the progress achieved will be undertaken. The UK IHP National Committee, together with the British Hydrological Society, will convene the **IHP-V International Mid Term Conference on Hydrology and Water Resources in a Vulnerable Environment** structured around the themes of the fifth phase (Exeter, 6-10 July 1998). This conference will also serve the identification of future research needs which will further be discussed at the **Fifth Joint UNESCO/WMO International Conference on Hydrology** to be held in 1999.

A map to the planned IHP-V is attached to this paper as Annex 1. Altogether there are some 31 Projects foreseen under 8 themes grouped into 3 overlapping clusters. As opposed to the 44 projects of the current, fourth phase of IHP, the number of IHP-V projects is less in order to be in line with the call for programme concentration. With a given funding level the concentration in principle makes more in-depth enquiry possible. In practice this can be done only through a more active participation of all players involved. The IHP National Committees and international governmental and non-governmental organizations are invited to participate in the execution of different activities.

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Annex 1

LIST OF IHP-V PROJECTS

THEME 1:	**Global hydrological and geochemical processes**
Project 1.1:	Application of methods of hydrological analysis using regional data sets (Flow Regimes from International Experimental and Network Data Sets/FRIENDS)
Project 1.2:	Development and calibration of coupled hydroecological/atmospheric models
Project 1.3:	Hydrological interpretation of global change predictions
Project 1.4:	Strategies for water resource assessment and management under conditions of anthropogenic global climate change
THEME 2:	**Ecohydrological processes in the surficial environment**
Project 2.1:	Vegetation, land use and erosion processes
Project 2.2:	Sedimentation processes in reservoirs and deltas
Project 2.3:	Interactions between river systems, flood plains and wetlands
Project 2.4:	Comprehensive assessment of the surficial eco-hydrological processes
THEME 3:	**Groundwater resources at risk**
Project 3.1:	Groundwater contamination inventory
Project 3.2:	Monitoring strategies for detecting groundwater quality problems
Project 3.3:	Role of unsaturated zone processes in groundwater supply quality
Project 3.4:	Groundwater contamination due to urban development
Project 3.5:	Agricultural threats to groundwater resources
THEME 4:	**Strategies for water resources management in emergency and conflicting situations**
Project 4.1:	International water systems - (a) Conflict analysis and resolution; (b) Development of integrated hydrological information and decision systems for international river basins; (c) Large-scale diversions; systems control, emergency procedures and extreme hydrological conditions.
Project 4.2:	Comprehensive environmental risk and impact assessment
Project 4.3:	Non-structural measures for water management problems
THEME 5:	**Integrated water resources management in arid and semi-arid zones**
Project 5.1:	Hydrological processes in arid and semi-arid zones
Project 5.2:	Water resources assessment in arid and semi-arid zones
Project 5.3:	Water resources management for sustainable development in arid and semi-arid zones
Project 5.4:	Coping with water scarcity

THEME 6: Humid tropics hydrology and water management

Project 6.1: Hydrological processes in the humid tropics environment and other warm humid regions
Project 6.2: Land use, deforestation, erosion and sedimentation in the humid tropics
Project 6.3: Integrated water management for sustainable development in the humid tropics
Project 6.4: Information exchange on regional hydrological processes research and experiences in water resources management

THEME 7: Integrated urban water management

Project 7.1: Non-structural flood control measures to balance risk-cost-benefit in flood control management in urban areas
Project 7.2: Surface and groundwater management in urban environment
Project 7.3: Integrated urban drainage modelling in different climates: tropical, arid and semi-arid, and cold

THEME 8: Transfer of Knowledge, Information and Technology (KIT)

Project 8.1: Formal education at all levels
Project 8.2: Continuing education and professional training at all levels
Project 8.3: Transfer of information and technology
Project 8.4: Public awareness issues related to hydrology

Annex 2

HYDROLOGY AND WATER RESOURCES PROGRAMME OF WMO *

5.1: Operational Hydrology Programme - Basic System

Project 51.1: Hydrological Services
Project 51.2: Water resources assessment
Project 51.3: Technology in operational hydrology
Project 51.4: Capacity building in hydrology and water resources

5.2: Operation Hydrology Programme - Applications and Environment

Project 52.1: Hydrological aspects of naturalisation
Project 52.2: Hydrology in the context of global environmental issues
Project 52.3: Hydrology and sustainable development

5.3: Programme on Water-related Issues

Project 53.1: Water-related activities within the United Nations system
Project 53.2: Inter-governmental and non-governmental organizations concerned with hydrology and water resources

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* **Programme 5 within the 4th WMO Long-term Plan (1996-2005) as adopted by Twelfth WMO Congress.**