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Water Dependencies: The Environment under Stress and Societal Response: Whither to After Four Decades of Effort?

Shaminder Puri
UNESCO-IHP & ISARM
E-mail: ShammyPuri@aol.com

Alice Aureli
Division of Water Sciences IHP, UNESCO
Paris
E-mail: A.Aureli@unesco.org

"The factory of the future will have only two employees; a man and a dog.
The man will be there to feed the dog.
The dog will be there to keep the man from touching the equipment."

—Warren Bennis, Professor of Business Administration
University of Southern California.

ABSTRACT: An overview of the four decades of the development of the science of hydrology, spearheaded by the International Hydrological Programme (IHP), suggests that new insights into 'water dependencies' in ecosystems, are required in future hydrological endeavours. Given the progress of the multiple UN supported action, and the worldwide work towards the successful achievement of the Millennium Development Goals, the international community has committed itself to responding to the recognised risks to ecosystems from poor management of water. In the forthcoming decade the science of hydrology now needs to deepen its focus on inter disciplinarities, so that policy makers operate within an informed atmosphere with access to the essential notions, at a time of significant global changes such as the increasing global climatic variability and the relentless acceleration in globalisation of economies.

In considering the 'whither to' in the title of this paper, the start point is that water is at the centre of interactions between many of the Earth's systems. The science of hydrology has been able to corroborate the findings of related sciences that many of the planet's systems (hydrological as well as ecological) are strongly interdependent, and that a number of these systems are now under identifiable stress from population growth, urbanization, land conversion or the accumulation of many different pollutants. Global programmes such as World Water Assessment Programme, GIWA and the Millennium Assessment have made the same findings. Stress levels in some regions are so elevated that the global community is now prepared to respond to the concerns put forward by hydrologists over the past four decades.

INTRODUCTION

A Present View of the Future

The quotation at the top of this paper might seem to portray an apocalyptic view of a future in which groups of humans would be kept from doing what we think we know how to do best, i.e., invent and then operate equipment. For operate *'equipment, read instead operate systems',* including water systems and the related infrastructures. Will the water systems of the future indeed be run by automatons, and will all the present day groups of water sector operators be replaced by just the nominal one, who will be kept from 'optimising' the operational functions by his dog? This rhetorical question is worth raising at the WEES Conference which brings together a representative group of the worlds great experts in water, environment, energy and society. Bennis's (1977) analysis of the future arises from his study of group behaviour and group leadership. As he says... "None of us is as smart as all of us", noting that this is good, "because the problems we face are too complex to be solved by any one person or any one discipline", a situation that today applies to the water-energy-environment nexus more than it ever did in the past. In Bennis' analysis he goes on to say that it is Great Groups of people, made up of a variety of disciplines that have to work together to solve the great problems faced by humanity. To understand such Great Groups he studied the Manhattan Project, the paradigmatic Great Group that invented the atomic bomb; the computer revolutionaries at Xerox's Palo Alto Research Center and others.

Hydrologists as a 'Great Group'

In this paper, we have been tempted to ask if the experts that have been involved in the UN's hydrological sciences programmes from the mid 1960's through to today's Phase VII of the UNESCO IHP may not be considered to be a Great Group that has made substantial and significant contributions to understanding 'water' and 'environment' though not so much in energy?, and how should they now be considering the expansion of their linkages to seemingly unrelated disciplines, such as astronomical science, given that Martian aquifers are reputed to hold some water?. Given the nature of the issues, far from a comprehensive analysis, this paper will provide some outlines of theses for later testing in a more quantitative manner.

In order to assess the influence of the great group of hydrologists, and their impacts on society, we will firstly overview the four decades of the global development of the science of hydrology that has been spearheaded by the International Hydrological Decade (1964–1974) and the International Hydrological Programme (IHP) that commenced in 1975 and has now, in 2008 reached its VIIth Phase carried out in approximately six year cycles. We follow this overview by a detailed review of the VIIth Phase and its underlying rationale, aims and objectives. We then consider some of the major drivers in global hydrological endeavours, such as the Millennium Development Goals which galvanized the great group of water specialists into concentrated actions, and the recognition of the need for greater multi disciplinarity (expanding the great group?).

We consider how the translation of this need for expansion has taken place in some of the significant projects such as the World Water Development Reports, the bi annual World Water Forums, global assessment programmes, such as the GIWA and how the environmental stress levels in some regions of the world are still *expected reach break point*, by considering the findings of the Millennium Ecosystem Assessment. We then give some views on how the IHP VII, which we consider to be a central piece of the jigsaw puzzle of working towards global environmental sustainability, fits into a contribution towards global environmental gains, as promoted by the GEF, and finally we present a prognosis of the roll-out of IHP VII implementation, which ends in 2013.

THE EVOLUTION OF THE IHD AND THE IHP

From the Hydrological Decade to the Hydrological Programme

The International Hydrological Decade sponsored by UNESCO, began on the 1st January 1965 as "man's first concerted attempt to take stock of his diminishing available resources of fresh water and to co-ordinate world wide research on ways of making better use of them"—these were the momentous words of R.L. Nace (1969) presented at a midway point of the decade that raised the awareness of the world community to the importance and significance of fresh water on the planet. The purpose of the Decade was to accelerate the scientific study of *water resources* and *water regimes* in order to improve water conservation, management and use. As a result, the Decade was a time of significant effort which provided for the first time, new quantitative information about the volumes and distribution of fresh water on the planet, the amount that rivers discharge to the sea and approximations of the amount held in the polar ice caps, (see Table 1).

One of the problems in the course of the Decade was the scarcity of scientific professionals. UNESCO's study of the numbers of senior scientists of the world in the late 1960's showed that there were about 300,000 professionals, considered even at the time to be a pitifully small number, to be guiding the scientific revolution in the world's water affairs. Because of the shortage of scientists, many Member State representatives disliked the term 'scientific hydrology' in the scope of the IHD, as most of the practitioners then were hydraulicians or engineering hydrologists—practical and technologically orientated! As noted by Volker (1990), the Chair of the Netherlands National Committee of the later IHP, that his first reaction to the need for scientific hydrology in IHD was not enthusiastic, because he failed to see how scientists could promote a discipline, that in his view was orientated to hands-on practical application to daily problems. He thought that IHD's programme on scientific hydrology would only be of relevance to geographers and geophysicists.

Seemingly in 1963, when the work programme of the IHD was being developed by an expert working group (much like the Task Force set up to develop the IHP Phase VII in 2004) "Nobody had a clear concept

Table 1: Selected Major Outcomes of the UNESCO International Hydrological Debate

Product	*Data*
International Yearbook(s) on Hydrology	Data from 1000 stations worldwide, water levels, discharges, sediment transport
International Guide on Water Balance Budgeting	Assessment of changes in water resources due to various factors
World Water Balance and Water Resources of the World	Atlases, 65 maps, observations from 50000 meteorological and 18000 hydrological stations around the world; water balances of the major river basins and continental regions
Technical Series, on a range of subjects, prepared under national initiatives of the IHD	Planning and Design of Hydrological Networks (Canada, 1965)
	Representative and Experimental Basins (Hungary, 1965; New Zealand, 1972)
	Hydrology of Lakes and Reservoirs (Italy, 1965)
	Flood and their Computation (USSR, 1967)
	Hydrological Forecasts (Australia, 1967)
	Use of Analogue and Digital Computers in Hydrology (USA, 1966)
	World Water Balance (UK, 1970)
	Design of Water Resources Projects with Inadequate Data (Spain, 1972)
Multi lingual Hydrological Glossary	1974 giving terms in English, Russian, French, Spanish—Providing unification in hydrological terminology

of the modus operandi, either an internationally agreed programme of work with member countries who had committed to work according to an agreed programme, or a mere exchange, and perhaps, pooling of knowledge and experience obtained in national programmes" (Volker, 1990).

IHD's first attempts at formulating a feasible programme of work for the decade were understandably difficult. The programme was based on a theoretical classification of the components of the water cycle, and a set of research studies and projects were formulated, that justifiably had to be of a multi disciplinary character, and which eventually had to be judged by administrative and financial authorities. Despite these early stumbling blocks, the Mid Decade Conference in 1969 proved that the grouping of these scientists and many charismatic leaders of the great group, had produced valuable findings and programmes for the scientists as well as engineering hydrologists, (Table 2).

Achievements of the Hydrological Decade

Some of the high points of the Decade were the great and important projects that are to some extent still running now, albeit with new objectives and aims. It was within the IHD that the global significance of the great Pantanal of the Rio Paraguay Basin in Brazil, Bolivia and Paraguay was noted and brought to international attention. In parallel, Centres for Applied Hydrology were being established (e.g., at the Porto Allegre, Brazil). In Africa the Chad Basin, shared by Chad, Cameroon, Niger and Nigeria, became another major project that built upon the previous studies of the Arid Zone Research Project, which was the precursor of the IHD. The region of the Northern Sahara became another area of important focus, with investigations of the North Sahara Aquifer Systems and the Nubian Aquifers—each also shared among countries. Research and educational centres were set up in Argentina and in Iran. All these efforts brought the issue of sound management of water resources to the fore of the scientific and the practicing community, and through this also to the more informed decision makers in the governments of the Member States. Many of these achievements were presented at a global first, the UN Water Conference in Mar de Plata in 1977, while the Decade transpired into the Programme in 1974.

A Quarter Century of Hydrological Endeavour

Twenty five years after the start of the Decade, in 1990 during the initiation of the IHP Phase IV, there was an emerging change in perceptions about the domination in hydrology of pure science, to a recognition that hydrology was a component of "the environment" that it was the newly adopted concept of the environment that was at the centre of the world's concerns, rather fresh water by itself. The International Hydrological Decade and the Programme had achieved some of their central goals, those of making the science of hydrology a required ingredient within national policy making, with, at the same time, raising concerns among the authorities in many countries about the future availability of sufficient volumes of water of good quality, if they did not explicitly manage them well. As more international agencies became involved in the IHP's activities (such as WMO, ECE, OECD, Council of Europe, etc.) 'water' became only one of the issues, among many others—all encompassed under the newly emerging lexicon of "the environment". These pressures for changes of emphasis led the IHP's promoters become more aware of the need to take a look at its own performance and some of the points that were considered were: 'balance the science with practical components'; 'concentrate the programme, rather than making it too broad'; 'involve more developing country scientists'; 'publish more practical and usable texts'; 'address the needs of the developing countries' (Ayibotele, 1990).

The Mid Point review of the IHD/IHP also reveals some interesting stances among the 'great group' that have persevered throughout the history of of IHP, and still appear in some form in today's programmes. Ayibotele (1990) reports that those among the great group that favoured the pure science of hydrology, and those that sought some more practical application of the science, were rather divided. Apparently the initial title of the IHP Phase III was to be "Hydrology and the Scientific Basis for the Rational Management of Water Resources for Economic and Social Development" and the inclusion in the latter part of the title, that concerning the 'economic and social' caused considerable heated debate, so much so, that it had to be dropped! Those among the great group that favoured the mathematics, statistics and numerical modelling rather than those that wished to study the actual hydrological processes on-the-ground, had a rude awakening to the fact that the global community wanted answers to newly urgent questions on environmental sustainability, climate change as it was then anticipated, drought, land degradation and the fate of living organisms found in water bodies, rather than theorising for example, about the fate of evapotranspiration.

Challenges of Taking Science to Policy

Strong voices in the IHP were eventually able to prevail, and the title of Phase IV thus reflected the contemporary needs in "Hydrology and Water Resources for Sustainable Development in a Changing Environment", clearly aiming to fulfil the more urgent needs of society. Unfortunately, this relatively late awakening in the IHP put it somewhat out of the very rapidly developing "environmental" agenda of the time. The perception that IHP operated as a science club engaged in high level Working Groups of Experts, attending conferences on theoretical aspects of hydrology and frequently rather narrow specialist issues led by academicians from the Developed Countries, meant that the Developing Country experts and the Donor Agency staff found IHP difficult to engage with for the real world problems that needed solutions. Ayibotele (1990) recounts that the imbalance between Developed Country and Developing Country participation in such IHP actions was so glaring that special efforts were made to redress this balance and in IHP III (1984–1989), 48 out of the 159 members of Working Groups were from developing countries, an improvement from the 15 out of 98 in IHP I (1975–1980), though still highly skewed.

Table 2: Phases of the UNESCO International Hydrological Programme

Phases of the UNESCO International Hydrological Programme (IHP)	
1965–1974 IHD	Experimental Basins, World Water Balance and Water Resources of the Earth
1975–1980 IHP I	1981–1983 IHP II 1984–1989 IHP III
1990–1995 IHP IV	Hydrology and Water Resources for Sustainable Development
1996–2001 IHP V	Hydrology and Water Resources under Vulnerable Environments
2002–2007 IHP VI	Water Interactions: Systems at Risk and Social Challenges

THE REQUIREMENTS OF SOCIETY AND THE DELIVERY FROM HYDROLOGISTS

What are the requirements of society and what delivery is expected from hydrologists in 2010? These questions are not new: in 1990, at the quarter century of the IHD/IHP this type of self assessment was made by Vit Klemes, President of the IAHS, in his provocative essay "The Science of Hydrology: Where have we been? Where Should we be going? What do Hydrologists need to know?" (Klemes, 1990). Among the responses to the essay, Law (1990) turned the questions around by noting that in the 60's and 70's the value of the Hydrologist was high to society, but then it faded, having been overtaken by the economist and the sociologist; Law states, though that the economist has precious little to say to the public that may have been worrying about climate change. With this background the following is an assessment of the needs in the years ahead from 2008 to 2014.

In making an assessment of the needs in the coming decade therefore, several key drivers need to be considered. Today, in the midst of the decade in which Millennium Development Goals are to be achieved, water is linked to poverty through ensuring that it is supplied to all, through ensuring that basic sanitation is available and that basic health is assured. Water is also linked to the environment, through its increasing scarcity, through water related disasters, and through its pollution and transboundary sharing. Yet there are challenges: water and governance is linked through lack of adequate financing, through its poor valuation and through the need to adopt, often intricate, integrated resource management principles. Many of these concerns have to be placed in the context of the rapidly amplifying impacts of globalisation, a measurable warming up of the planet, a consideration of 'water' in its various manifestations in global ecosystems. Clearly, then, water related education for sustainable development is essential.

Rationale, Aims and Objectives of a Programme for the Future

As noted above the world faces new challenges related to unequal economic development, environmental degradation, and globalisation. It is an accepted view that the science of hydrology has been mobilised by its great groups to respond to such challenges. The results of IHP's work noted above, corroborates the findings of related sciences that many of the planet's systems (hydrological as well as social and ecological) are strongly interdependent, and that a number of these systems are now under identifiable stress from population growth, urbanization, land conversion or the accumulation of many different anthropogenic pollutants. Global programmes such as GIWA and the Millennium Ecosystems Assessment have made the same findings. Stress levels in some regions are so elevated that the global community is now prepared to respond. There is no silver bullet that provides a simple fix to the global water issue: as the conclusion of the 2nd UN World Water Development Report (WWDR, 2006) shows, only through creating the links and synergies can the issues be addressed appropriately. The 2nd WWDR noted that the linkages where synergies were to be built were, 'water and poverty', 'water and governance', 'water and environment'. Here, then is the baseline for looking ahead for the years 2008 to 2013, when International Hydrological Programme enters into the VIIth Phase.

It is now widely accepted that water in its many manifestations is of principal concern to most sections of the economies of all countries and fundamental to global sustainability, thanks in a large part to the effort of three decades of hydrologists scientific leadership.

The baseline for future efforts is the wide adoption of the *quantified* hydrological cycle, which is at the heart of Integrated Water Resource Management (IWRM). The quantitative definition of the various components of the hydrological cycle, frozen fresh-water, surface water and groundwater, provides a powerful engine that drives all the processes in IWRM, and a large number of other great groups from related sciences have joined forces, forming a wide constituency, continuously improving the assessments.

Dialogue in the Public Arena

In recent years the number of great groups, or partners, have expanded considerably. They constitute not only the hydrological scientists, but also increasingly a complex plethora of other engaged representatives of multifarious organizations, all striving to interlink the various components and sub-components of the hydrological cycle, IWRM and environmental sustain-ability. This is encapsulated in the World Water Assessment Programme (WWAP) with the contribution of twenty four UN Agencies, has issued two major World Water Development Reports (2003 and 2006).

A measure of the extent to which the issue has taken on the interest of many groups are the mega conferences devoted to the issue of water. The sheer number of submissions to any global forum devoted to water, such as the World Water Forum (WWF) or the Stockholm Water Week is the undisputed evidence of the increasing constituency of water as being central to all global ecosystems. These two events now attract the participation of upwards of 20000 people between them. From water related mega conference being the rarity in the mid 1970's to the present several, held in each year, that it may be worth asking, how and when have they evolved? In what form do knowledge trends they arise from, develop? Are there organizational interconnections that are positive? Have the mega conference succeeded or failed their objectives?

It may be argued that the water related mega conference is an indication of the success of the great group of hydrologists who have raised the issue to the awareness of the wider global community, and have taken the science into policy relevance and orientation for the interested actors.

MAJOR DRIVERS FOR THE FORTHCOMING YEARS POST 2008

In formulating the Concept for IHP Phase VII (Figure 1), the great group on the IHP Bureau and the IHP Inter

Governmental Council kept in broad view the targets and audiences that hydrology would need to address in the years from 2008 to 2013. In comparison to the previous decades, quite a few new subtleties need to be introduced, such as a new approach to the Polar Regions and the melting glaciers in high mountainous regions, as discussed below.

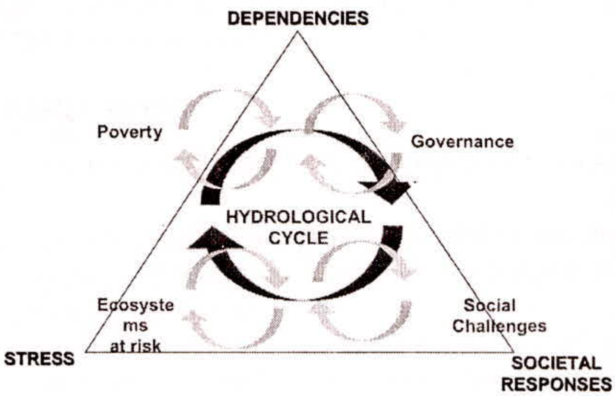

Fig. 1: Conceptualising the water dependencies

Social and Economic Issues in Water Management

There was an agreed need to mainstream social and economic issues in IHP's work on hydrology, for example by strengthening cooperation among hydrologists, practitioners, and socio-economists, especially in the debate on the 'right of access to water' and 'water as a common good'. These are issues that had been addressed in the 2nd World Water Development Report, where it was noted that water is a fundamental right and that the fast socio-economic and environmental change is making the water crisis more severe in some areas. IHP VI made a good start in this area by launching the HELP project, the Water Ethics project and PCCP. To address these types of issues, developing greater cooperation among disciplines is crucial for building bridges between hydrology, economics and the social sciences. Cooperation is also necessary for ensuring sound financing for natural resources management, which in turn can lead to socio-economic benefits at national level. Moreover, strengthening cooperation would make it easier to include the 'water sector' in national economic development plans, many of which are now formulated as Poverty Reduction Strategy Papers (PRSPs).

Economics of Hydrology?

It was observed that hydrologists should continue to contribute to the debate on the economical and financial issues linked to water. The implementation of Integrated Water Resources Management (IWRM) is often constrained by the inadequate and 'sectoral' flow of funds, mainly because investment policies fail to recognize the full spectrum of true environmental costs and benefits. For example, financing for flood alleviation projects is rarely linked to direct financing for integrated basin management (basin wide forest replanting, soil conservation, erosion reduction measures) and to the affordability levels of populations. Similarly investments in major road-rail projects, that create a new linear feature, often cutting across a river basin, and thus creating not just a barrier, but also pathway that can cross the natural hydraulics, does not often include investment components to integrate them into the hydrological regime. Furthermore, financing for the sustainable management of the hydrological unit, the basin, can be frustrated by the difficulty of finding concordance between administrative units (which provide the necessary socio-economic base, both at the national and the international scale) and the river basin, which forms the unit for natural resources management.

Water Governance for Sustainability

It is said, and it has been emphasized in the 2nd WWDR, that the water crisis is essentially a crisis of governance, as experienced through the fragmented nature of water management. Institutions lack the capacity to overcome conflicting approaches in the use and allocation of water from within one basin or aquifer system, both at the national and transboundary level. For example, the way certain economic instruments are being used for environmental management provides a case in point. While they can be very useful, there are significant shortcomings in the manner in which they have been applied. The free market economic system treats water, which is a common pool resource, as a good to be priced and traded (given the trend towards privatization and commercialisation), which, by its nature, ignores the value of aquatic environments as a habitat for biodiversity and other services noted earlier. The ultimate consequence is the degradation and the depreciation of Nature's capital. Experience has shown that practitioners and decision-makers often lack a common platform for addressing these kinds of issues. As a consequence, the water resource is not viewed in holistic terms. Rather, it is treated simply as a raw material for society's needs under conditions of high uncertainty and complexity, where all competing demands cannot possibly be met over the long term. The definition of good water governance remains elusive, but notions of ethical use, cultural diversity, transparency, equity, accountability, all come into play, to achieve sustainability. The science of hydrology and its practical applications have much to contribute to this developing area of concern. Thus governance for sustainability will be one of the themes for IHP VII.

Water for Life Support Systems

The planetary life support systems require a reliable supply of wholesome water. This subjective statement can be turned into objective requirements when it is related to human health. The relationship between water consumption and human health has been demonstrated in many studies. Less well defined is the impact of modification of catchment water quantity and quality on the health of populations. With the anticipated increased reuse of water within the basin, an understanding of the health consequences of water in the supply system that is found 'before the pump' is needed. Alteration in water dynamics at basin level can impact health of organisms, for example, the through passage of endocrine disrupters through the basin. The water logging of communal living areas may lead to health problems. Methodologies are needed for a common understanding of how integrated river basin water resource management can contribute to the good health of populations. A better understanding of the fate of contaminants and pathogens passing through the water cycle of basins would also benefit from integrated studies. The scientific knowledge gained would provide insights to help achieve UN Millennium Development Goals.

Ecohydrology for Sustainability

Earlier phases of IHP implicitly recognized ecology as an integral component of land habitat hydrology. IHP Phase V had adopted a theme to investigate 'eco-hydrological processes in the surficial environment'. Now there is need for an explicit ecohydrology platform in IHP VII, one that incorporates environmental sustainability at the landscape level.[1] Such an approach would broaden IHP's constituency and promote efforts to strengthen 'soft engineering' solutions to supplement hard engineering. As noted above, this calls for improved understanding of water-landscape level management of the environment, taking full account of interactions among ecosystems[2] and their dependent habitats. Agrobiodiversity and the related sustainable land use, is one example of the types of issues that need to be emphasized. When food production, and the environmental services that support it, are disconnected in terms of land management, the subtle changes that result from this can have far-reaching, long-term impacts, such as the reduction in the recharge potential for aquifers. These changes can be also be associated with nutrients (biogeochemistry) and water cycles that feed the systems. For example, modifications resulting from land use changes can be the source of such impacts. It is understood that human life-support activities might generate more or less unavoidable environmental problems due to the physical and chemical landscape manipulations they involve. In the worst case, these actions can affect ecosystems to the point where they are unable to deliver ecosystem services, such as fresh water, productive soils or maintenance of valuable biodiversity—with direct consequences for livelihoods, vulnerability and security.

Groundwater Resources Integrity

While 'integrated watershed and aquifer dynamics' has been one of IHP's themes during Phase VI, there is still insufficient attention being given to the long term management of groundwater resources and its scientific underpinnings. The large storage capacity of groundwater resources, many of which are transboundary, can play a crucial role in supporting adaptation measures for coping with impacts from climate variability, global changes, hydrological extremes and natural disasters. The accelerated use of groundwater resources in the absence of good long range management has already caused serious local problems in many locations. To a large extent, this reflects the existing lack of scientific knowledge about aquifers and lack of investment in developing appropriate groundwater resource management strategies. The need to examine groundwater more closely has now been recognized. For example, the Global Environmental Facility's (GEF) focal area of 'international waters'[3] and its Scientific and Technical Advisory Panel (STAP)[4] have decided to stress

[1]The Millennium Projects Task Force no. 6 on environmental sustainability identifies 'Environmental management at the landscape level' as one of the problems requiring urgent action (see www.unmillenniumproject.org).

[2]An ecosystem is defined as a dynamic complex of plant, animal and micro-organism communities and the abiotic environment interacting as a functional unit, with humans forming an integral part.

[3]The GEF IW focal area is devoted to the sound management of transboundary water, be they marine or terrestrial and has established a partnership with the UNESCO led ISARM Programme.

[4]UNESCO was requested by the STAP of GEF to provide expert consultations on the significance of groundwater in GEF operations. Groundwater will be explicitly emphasized in future GEF financing in all of its focal areas, with the exception of the

groundwater resources in their own future programmes, especially with regards to SIDS, in cooperation with UNESCO. In IHP VII, there should be a new emphasis on groundwater resources and their sound management at all scales, continental, through to small islands developing states. This would include formulating science-based policies and principles, preparing appropriate regulations to curb over-exploitation, developing technologies and policy instruments that would help to replenish overdrawn systems, and the sustainable management and use of groundwater resources. Closer attention should be paid to trans-boundary aquifers, non-renewable groundwater resources, enhancement of aquifer recharge, adaptation measures to climate variability, groundwater quality, groundwater protection, groundwater-dependent ecosystems and urban groundwater management.

Urban Water Management for Increasing Demands

Over half of the world's population will live in cities by the year 2010, a large part in an increasing number of mega cities. Urban water problems are growing more complex and acute all over the globe. The developing world is faced with uncontrolled expansion of large cities confronting extreme conditions: dense population concentrations further exacerbated by high rates of rural migration and large income disparities between the wealthier and poorer segments of the population, and the explosive growth of periurban areas. Widespread mismanagement of water resources, growing competition for the use of freshwater, degraded sources—sometimes by pollutants of unpredictable effects—only heighten the depth of these problems. Cities in the developed world also face critical challenges often including deteriorating infrastructure, a degrading environment and inability to face successfully extreme events. Improving freshwater management to provide improved access to safe drinking water and basic sanitation, as called for by the MDGs, particularly in the urban environment in developing countries, now commands a greater sense of urgency and is seen as a necessary pre-condition for health and success in the fight against poverty, hunger, infant mortality and gender inequality. These problems can only be addressed properly through a concerted effort which involves scientific, social and institutional approaches. New paradigms for improved urban water management are emerging—reflecting integrated management of all components, and emphasizing more efficient water use and reuse and solutions adapted to the particular physical and socio-economic settings. IHP has already made significant inroads into urban water management in IHP V and IHP VI; now, in the light of the growing and evident need of facing urban water problems the world over, particular emphasis shall be placed in this area in IHP VII through the UWMP.

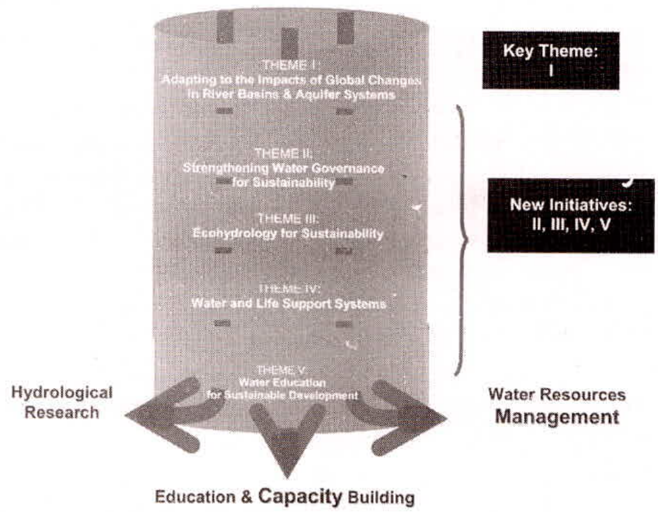

Fig. 2: A structure to bring together the facets of hydrology, responding to social needs

CRAFTING THE VIITH PHASE OF THE IHP: WATER INTERACTIONS TO WATER DEPENDENCIES

Given this background, IHP VII was crafted to make a seamless transition from Phase VI's 'water interactions' to 'water dependencies'. Research results of the previous three decades of scientific hydrology suggest that water-interactions in practically all terrestrial ecosystems are water-dependent. There is good scientific evidence that within natural, as well as the built systems, there are inter-dependencies connected by water. Further, there is a direct causal link between the quantity and quality of the water delivered to an ecosystem that may be undergoing stress. Experience shows that switching the water regime of an aquatic ecosystem by a small amount results in a changing balance of its components. Given time, the in-built resilience of the system will adapt to the switched regime and to the stress imposed. A more radical switch intuitively suggests that an ecosystem may not be able to mobilize its resilience to the stress and readapt, with the result that it will collapse. The quantitative transition point between 'small' to 'large' switches in stress levels remains elusive in large ecosystems, though in smaller ones such interactions can be quantified and demonstrated. Consequently, in addition to water-dependencies, the notion of stress and its management has become an important component of environmental management and is to be used in IHP Phase VII.

The Phase VI's 'systems at risk and social changes' has identified and characterized the types and scope of risks, and the consequent stresses being experienced, as exemplified in the Millennium Ecosystems Assessment. The social changes that take place when systems are at risk include the human migration from rural to urban habitats, the increases in urbanization and the associated decline in the productivity of land that may have been abandoned. Such social changes create new challenges faced by all stakeholders, especially for those to whom water acts as an essential life support system when linked to productive landscape ecosystems. Phase VII would thus seek to address the linkages between the systems under stress and the societal responses to these stresses. Evidence from communities that are the most affected indicates that local actions are being taken and that they are effective and many of these local measures consist of adaptation measures to the most serious impact of global changes, including that of climate. Communities in many arid zones have started to work together to operate rainwater harvesting, managed aquifer recharge and other measures to reduce erosion and replenish exhausted aquifers. At the global level there is similar evidence of response from society. Some globally relevant societal responses to which IHP has already made a substantial contribution in Phase VI are the shared water resources and related conflict resolution initiatives. In addition the UN system-wide triennial WWDR, provides a global measure of the state of the resource and to which the IHP VII will have a pivotal role.

From the foregoing the transition of Phase VI into Phase VII is based on the principle of *continuity with change*, with IHP building on lessons learned from results achieved in earlier phases of the programme.

Key Elements in the Phase VII

IHP's Phase VII is entitled: 'Water Dependencies: Systems under Stress and Societal Responses', and a series of sub themes were developed (Table 2). Just as for the IHP's IIIrd Phase discussions on a suitable title, for the VIIth Phase, the title was also vigorously discussed in the great group. Several rounds of consultations were carried out and comments received from individual and national groups. In the large majority of the comments from the Member States, the comments and suggestions made were incorporated into the scope of the various sub themes. As a result of this process the theme titles were adjusted to increase or re focus the scope.

Table 3: Major Themes and Sub Themes of the IHP VIIth Phase

Water Dependencies: Systems Under Stress and Societal Responses	
Theme 1: Adapting to the impacts of global changes on river basins and aquifer systems	
Focal area 1.1	Global changes and feedback mechanisms of hydrological processes in stressed systems
Focal area 1.2	Climate change impacts on the hydrological cycle and consequent impact on water resources
Focal area 1.3	Hydro-hazards, hydrological extremes and water-related disasters
Focal area 1.4	Managing groundwater systems' response to global changes
Focal area 1.5	Global change and climate variability in arid and semi-arid regions
Theme 2: Strengthening water governance for sustainability	
Focal area 2.1	Cultural, societal and scientific responses to the crisis in water governance
Focal area 2.2	Capacity development for improved governance; enhanced legislation for wise stewardship of water resources
Focal area 2.3	Governance strategies that enhance affordability and assure financing
Focal area 2.4	Managing water as a shared responsibility across geographical and social boundaries
Focal area 2.5	Addressing the water-energy nexus in basin-wide water resources
Theme 3: Ecohydrology for Sustainability	
Focal area 3.1	Ecological measures to protect and remediate catchments process
Focal area 3.2	Improving ecosystem quality and services by combining structural solutions with ecological biotechnologies
Focal area 3.3	Risk-based environmental management and accounting
Focal area 3.4	Groundwater-dependent ecosystems identification, inventory and assessment
Theme 4: Water and life support systems	
Focal area 4.1	Protecting water quality for sustainable livelihoods and poverty alleviation
Focal area 4.2	Augmenting scarce water resources especially in SIDS
Focal area 4.3	Achieving sustainable urban water management
Focal area 4.4	Achieving sustainable rural water management
Theme 5: Water education for sustainable development	
Focal area 5.1	Tertiary water education and professional development
Focal area 5.2	Education and training of water technicians
Focal area 5.3	Water education in schools
Focal area 5.4	Water education for communities, stakeholders and mass-media professionals

MULTI DISCIPLINARITY—THE WAY AHEAD THROUGH CROSS CUTTING PROGRAMMES

In the forthcoming decade the science of hydrology now needs to deepen its focus on inter disciplinarities, so that policy makers operate within an informed atmosphere with access to the essential notions, at a time of significant global changes such as the increasing global climatic variability and the relentless acceleration in globalisation of economies. This has been conducted through the process of cross cutting projects that have become the norm in the IHP and also in a range of other UN agency efforts.

Table 4: A Summary of the Key Cross Cutting Efforts in the IHP

Cross-cutting Programmes	*HELP, FRIEND*
Associated programmes	International Flood Initiative (IFI) International Sediment Initiative (ISI) Water for Peace: From Potential Conflicts to Cooperation Potential (PCCP) Joint International Isotope Hydrology Programme (JIIHP) Internationally Shared Aquifer Resources Management (ISARM) Global Network on Water and Development Information in Arid Lands (G-WADI) Urban Water Management Programme (UWMP) World Hydrogeological Map (WHYMAP)

Whither to (i): How have we been Doing?

From the foregoing it can be deduced that the science of hydrology has been able to corroborate the findings of related sciences that many of the planet's systems (hydrological as well as ecological) are strongly interdependent, and that a number of these systems are now under identifiable stress from population growth, urbanization, land conversion or the accumulation of many different pollutants. This overarching statement blurs much of the detail in the global hydrological outlook. There are a precious few regions of the world where the identifiable stress is being alleviated, mostly in the OECD Countries, while across much of the rest of the world actual stress reduction in terms of environmental stability is just absent (Figure 3). The latter assertions can be measured by placing measures of human security vis a vis species abundance; it would seem that at present this is a zero sum state. The Task Force that was set up in 2004 to develop the IHP VII, postulated that global environmental status would continue to decline for the next three decades (2030) and after that might improve, bringing about the change in the zero sum state. In summary, despite the immense efforts that have been expended by initiatives such as the IHD/IHP and the mega conference that have been held from 2000 onwards there has been little indication of change in the zero sum state of human security vs species abundance, the latter being used as proxy for 'good' water status.

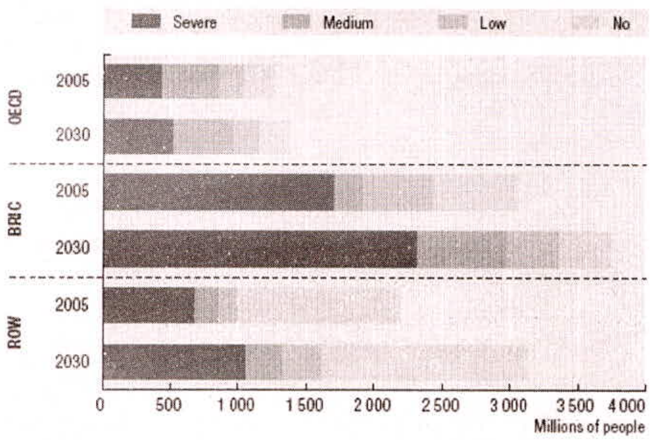

Fig. 3: People living in areas of water stress by level of stress 2005 and 2030 (*Source:* OECD 2008)

Whither to (ii): What do Major Water Programmes Tell Us?

Global programmes such as World Water Assessment Programme, GIWA and the Millennium Assessment have made similar findings. Stress levels in some regions are so elevated that the global community is now prepared to respond. This preparedness to respond can be measured in the Ministerial statements that have been made from time to time in conclusions to some of the mega conference that have become the forums for voicing public opinion. At the end of the 4th WWF held in Mexico in 2006, the Ministerial declaration reaffirmed the decision of the 13th Session of the Commission of Sustainable Development that a substantial increase of resources from all sources, including domestic resources, official development assistance and other resources will be required if developing countries are to achieve the internationally agreed development goals and targets, including those contained in the Millennium Declaration and the JPOI. The Ministers also reaffirmed that Governments have the primary role in promoting improved access to safe drinking water, basic sanitation, sustainable and secure tenure, and adequate shelter, through improved governance at all levels and appropriate enabling environments and regulatory frameworks, adopting a pro-poor approach and with the active involvement of all stakeholders. Therefore after the four decades of effort under such actions as the IHD/IHP the Governments of countries have recognised that finances are required from the treasuries for balancing human security and species abundance, though it would be safe to say that in 2008 there is not sufficient evidence to note a measurable improvement in global environmental status.

Whither to (iii): Where Does IHP VII 'Fit in' to the Great Group

The work of the IHP even after four decades is not yet over. The Phase VII (2008–2013) is a time for intensification of effort. However, the manner of this intensification and the thrust of its actions calls for multi scale innovations. The shape of IHP VII allows for innovation—IHP can no longer be the domain of the the pure hydrological scientist alone, multi disciplinarity has to be deepened and enhanced. Falkenmark in 1990 noted that "we need a new breed of interdisciplinary professions able to bridge the gap between ecohydrology and landscape hydrology". She missed out all the various specialists of social science and economics in developing the breed, though the omission may have been unintentional in 1990, but in 2008 such an omission would be a singular failure to appreciate the lessons from the five decades gone. Creating the breed suggested by Falkenmark could still be a challenge—the disparities, differences of perspective, diverging priorities of those attending the mega conferences and the immense number of events that are held in them is any indicator of the range of interests devoted to water. An essay by Varady (2008) attempted to assess the value of such hydrological mega conferences and made several suggestions about making them more effective in attempts at reducing the mismanagement of many river basins in the world. He remarks that even if mega conferences continue to elude easy evaluation, their aims are nonetheless important. The efforts of the IHP and the national networks of the IHP are an important element in this process, though its constituency could be expanded. For example, water sociologists and water economists could have a place in the national committees representing the national ministries of social welfare and economic development. Experience so far indicates that UNESCO IHP's mandate is focussed on the science, it could well now branch out especially since in IHP VII there is the element of 'societal response'.

CONCLUSION AND A PROGNOSIS: WILL MAN BE ABLE TO FEED THE DOG THAT KEEPS HIM FROM TOUCHING THE MACHINE?

Returning to Bennis' to consider the apocalyptical symbiosis of Man and his Dog, one would be justified in assessing whether the Man of the future may indeed be in a position to feed the dog, that keeps him from the 'machine' which in turn provides the food in a Catch-22 scenario. The perception is that as long as the dog keeps the man from touching the machine, the food will be produced and dog will be fed—if humans can be kept from interfering with the global planetary systems, the planets inherent processes will continue to function for a very long time. Unfortunately interference with the world planetary systems is now well advanced and there is little insight that suggests that the interference will reduce—if anything it is on the increase, thus the prognosis is rather pessimistic. For the great group of hydrologists, water as such, has now been submerged (!) into considerations of ecosystems and their sustainability in the context of globalisation of the economy of the planet. Nevertheless, water as a naturally occurring element, still requires vigilance and attention, as it is subjected to poor management as a consequence of it being a raw material for a bewildering number of processes, especially in the 'factory' of the future. Therefore, the hydrologists of the future will need to become significantly more multi dimensional in their perceptions, acquiring skills from the social sciences and economics, so that the water in global processes receives the due attention that is needed and thus be in a position to feed the dog.

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