

STATEMENT OF THE WORKSHOP ON WATER AND THE ENVIRONMENT

IGNACIO RODRÍGUEZ-ITURBE

A scientific workshop on 'Water and the Environment' was held at the Pontifical Academy of Sciences on 12-14 November 2005. Underlying the programme of the workshop was the basic premise that the survival of humanity and all species on earth depends upon the fate of water. Where water is absent, life is absent. The common symbol of life for mankind and all species, valued and respected in all religions and cultures, today water is symbolic of social equity.

There are two facets to the question of 'Water and the Environment'. The first belongs strictly to the natural sciences and centres on the understanding of the hydrologic cycle and its interactions with the living and non-living components of the earth and its atmosphere. The second facet pertains more to the social sciences and focuses on the fair distribution of water, considering both quality and quantity aspects, as well as the impact of these issues in the economical and spiritual growth of people around the world. These two facets are inextricably linked, with scientific knowledge providing a basis for well-informed decisions expected from the policymakers involved, decisions that will affect all humanity over many generations to come.

The main emphasis of the workshop was on the first of the above-mentioned facets. It dealt in particular with up-to-date scientific research bearing on the impact of hydrologic dynamics on issues concerning sustainable development, in which water resources are of paramount importance. Contamination, ill-planned industrial development, mega cities, are just a few of many threats to these vital resources. Some hope of success in countering these threats is provided by concepts such as the so-called Integrated Resources Management, a (management) process which promotes the coordinated development and management of water,

land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.¹

Such coordinated development and concomitant decision-making need firm scientific underpinning, in which the science of Hydrology – with its intimate links with Ecology and with its geophysical sister sciences, Geomorphology, Geology, Climatology and Meteorology – has a key role to play. In the words of Hedin *et al.*,²

this disciplinary convergence will over the next several decades transform our understanding of basic processes that control the stability and sustainability of natural environmental systems. The ensuing findings will have extraordinary implications for our abilities to predict and manage how humans impact the health of ecosystems across local, regional, and global scales. Such knowledge is a critical component of a safe, sustainable and prosperous future.

The workshop was organized around recent advances in research in five main areas – Biodiversity, Global Hydrology, Climate Change, Land-Atmosphere Interactions, and River Basins – with hydrologic dynamics providing the unifying theme to the discussions. Particular emphasis was placed on the investigation of feedbacks and interactions between the five areas, with the goal of identifying some of the main scientific challenges that need to be faced in the immediate future.

The presentations and discussions of the different topics took place in the Casina Pio IV in an environment which could be described by the eloquent words of Paul VI characterizing the attitude of a scientist:

On the one hand, he must honestly consider the question of the earthly future of mankind and, as a responsible person, help to prepare it, preserve it, and eliminate risks; we think that this solidarity with future generations is a form of charity to which a great many men are sensitive today, in the framework of ecology. But at the same time, the scientist must be animated by the confidence that nature has in store secret possibilities which it is up to intelligence to discover and make use of, in order to reach the development which is in the Creator's plan. This hope in the Author

¹ Global Water Partnership, TAC Background Paper, No. 4.

² Report to the U.S. National Science Foundation, 2002.

of nature and the human spirit, rightly understood, is capable of giving new and serene energy to the researcher who is a believer.³

In order to keep the overall perspective and deal with the range of implications of the scientific topics, the workshop was opened and closed with two presentations providing a link between the science aspects and the social impacts of the themes under study. These presentations were entitled 'The Fair Distribution of Water' and 'Heading Towards Basin-level Hydrosolidarity: Goal for Land/Water/Ecosystem Coordination'. Thus the workshop opened with a strong message that access to sufficient and healthy water is a human right which has to be taken into consideration by governments without discriminations of any kind. It is essential to consider the fair distribution of water when applying concepts like 'sustainable development', 'globalization' and 'food security'. All these need to be discussed considering the challenges and obstacles of geographical, social, cultural and political nature that impact any effort towards a world-wide fair distribution of water. The workshop then ended with the discussion of a road map towards hydrosolidarity framed on the scale of the multiple uses by different geographical regions of the water resources of a river basin. It involves a plea that it is an ethically demanding duty for the scientific community to prepare wisely for the water related challenges involved in the Millennium Development Goals over the next half century. Thus it will be crucial to develop a scientifically sound and ethic-based vision, that will stimulate new optimism and involve people in striving towards hydrosolidarity-based balances of interests and activities in river basins.

The five general themes of the workshop presented a challenging perspective of the scientific aspects of some of the most crucial areas related to water and the environment. Thus, in Biodiversity and Hydrologic Dynamics, the extremely important role of water was made clear in the preservation of biodiversity and in the temporal and spatial patterns that biodiversity exhibits. The main causes of accelerating extinction rates are habitat destruction and degradation, the introduction of exotic species, pollution, overexploitation and global climate change. In all key aspects of biodiversity, hydrologic dynamics play a crucial role and it was clearly shown that natural or human-caused fluctuations of the water cycle are fundamental drivers of the vegetation dynamics. The different characteristics

³ Paul VI, *Papal Addresses*, The Pontifical Academy of Sciences, Scripta Varia 100, Vatican City 2003, p. 208 f.

of the interaction between vegetation and climate were discussed in-depth for both savannah and river basin ecosystems. In the case of savannahs, the dynamic grass cover enhances the degree to which the savannah vegetation is optimal with respect to its use of the stochastic water input. In the case of river basins the deep coherence was made apparent between the geomorphological organization of the watershed and the vegetation patterns that exist around the river network.

In the session on Global Hydrology and Hydrologic Dynamics, special emphasis was placed on the fact that the impact of climate change will be felt most strongly through changes in surface hydrology (e.g., changes in the frequency of floods and droughts), which affect ecosystems and agriculture, as well as the water available for direct human use. The key drivers of contemporary changes in river flow (land use change, climate change, solar dimming and direct CO₂ effects) were assessed by comparing model simulations to continental-scale runoff records. These comparisons suggest that direct CO₂ effects can already be detected, with important consequences for water availability in the 21st century. Our ability to meet the water resources requirements of this century demands a coordinated scientific agenda at the international level and a review was provided of the progress towards addressing the above requirements for an integrated water resources management system.

The topic discussed above continued with the study of Climate Change and Hydrologic Dynamics where it was pointed out that anthropogenic climate change is expected to affect the hydrologic cycle in many ways and it is not unlikely that changes in precipitation will be more serious than those in temperature. Of particular concern are long-term changes in precipitation stretching over multiple years. Worldwide changes in evaporative demand are also of fundamental importance in this topic and received extensive discussion especially in what concerns the apparent paradox between global warming and decreased evaporative demand. Aerosols are another important factor impacting the hydrologic cycle since they change cloud characteristics in many ways. Human emissions of aerosols cause a reduction of solar radiation at the surface (e.g., solar dimming). This has important consequences for the surface energy budget and for the hydrologic cycle.

Land-Atmosphere Interactions are a key component of the intimate interdependence between water and the environment. A particularly important region for this mutual feedback is the Amazon River basin which contains the largest, contiguous extent of tropical forest on earth.

Over the past 30 years almost 600,000 km² have been deforested in Brazil alone due to the rapid development of Amazonia. There are observational evidences of regional changes in the surface energy budget, cloudiness and lower troposphere radiative transfer due to biomass burning aerosol loadings. Observational evidence of changes in the hydrologic cycle includes reductions of streamflow and modelling studies of large scale deforestation indicate a likely drier and warmer post-deforestation climate. Precipitation suppression by anthropogenic air pollution is likely to lead to a major loss of water resources where we need them most. The study of the physical mechanisms responsible for suppressing the precipitation forming processes provides the scientific basis for corrective actions that were discussed. The need to quantify the linkage between plant hydraulics and leaf biochemistry was also shown for understanding how the biosphere-atmosphere exchange of water and carbon occurs under current and projected climate conditions.

River Basins play a fundamental role in all aspects of water and the environment and they constitute complex adaptive systems where the action of water is central to the dynamic origin of their scaling characteristics. They also constitute fascinating laboratories for the study of how nature works across a wide range of scales. Of particular importance is the discussion of the dynamic origin of their scale-invariant forms which lies at the core of the organization and evolution of river networks and their associated ecosystems. How does biology affect landscape form and evolution? How do biotic processes influence weathering, erosion, and sediment transport mechanisms, and how could such influences be manifest in landscape-scale morphology? Is there a topographic signature of life? These questions are intimately linked to the basic premise of the workshop underlying all presentations: the survival of humanity and life depends on the fate of water. The preservation of earth as a planet that nurtures life crucially depends on the understanding of the hydrologic cycle and its interactions with the living and non-living components of the earth and its atmosphere.

All the above topics need measurements from space which have provided information on the water cycle with unprecedented accuracy. This new information provided by satellite shows that when comparing Mars, Venus and Earth, which are all of the same geological age, only Earth has liquid water whose dynamics is controlled by the hydrologic cycle. If we do not conserve the equilibrium of this cycle the singularity of Earth and the life it sustains are very much at risk and the Earth could

become like other planets. Furthermore, given the global nature of the processes involved any effective action will benefit immensely if it is planned within an international framework.

The workshop provided a truly unique opportunity for leading scientists of different disciplines to find a common ground in a problematic area that is of fundamental importance for mankind. The cross-fertilization and links that took place in a climate of free scientific discussion are bound to have a lasting impact.