Conclusions and Recommendations

This volume presents a wide range of topics related to watershed hydrology, ranging from aspects of scientific research to practical applications for integrated watershed management. The authors comprehensively describe the nature of major achievements in various regions across the globe, and some of their main conclusions and recommendations should be emphasized. Thus, the final section of this book proposes a number of issues for consideration in conjunction with the forthcoming, 2008, Session of the Intergovernmental Council of the International Hydrological Programme of UNESCO.

STATE OF THE ART AND ACHIEVEMENTS

- Contemporary hydrology is essentially based on mathematical modelling; "models of everywhere" are becoming available.
- Hydrological research and practices are mainly conducted at the watershed scale – a definable unit. We have to keep in mind the existing mismatches between theories developed from small-scale measurements and the scale at which that theory is applied, and between the scale of measurement techniques and the scale at which we need to apply models for management purposes.

SCIENTIFIC ACHIEVEMENTS

- The development of comprehensive detailed GIS, radar and satellite data allows the heterogeneity of watersheds to be taken into account and the use of new technologies in data analysis, so strengthening research. Models integrating these tools are better adapted to evaluate development scenarios and improve the effectiveness of the achievements in the context of integrated watershed management.
- Hydrological understanding and data strengthens governmental capability to manage water resource planning in a sustainable way.
- Watershed hydrology is the science that underpins water resource development and as such it is a necessary, although not the only, requirement for the development and implementation of fully sustainable integrated management strategies.
- Knowledge Management in water resources consists of the gathering of information about the elements of the hydrological cycle and affects on them due to human activity, but also includes activities to ensure that this information will be used by decision makers and users to improve sustainability.
- The water resources system analysis must provide analytical decision-making tools for optimum utilization of available resources and to facilitate development planning to satisfy the increase in water demand.
- Watershed hydrology develops better understanding of biophysical linkages within freshwater ecosystems and provides water resource planners and managers with information on the costs, benefits and trade-offs of activities.
- In many watershed areas it has became difficult to maintain the hydrological balance in the biosphere that provides the stable replenishment of water resources in river basins.
- The Flood Risk Management Plan is a key-component of the River Basin Development Plan, and should integrate all measures for flood risk management, and be based on regional development strategy, including the options and the interest of communities.

- There is still a gap between the high level of environmental knowledge and policy action. Policy action is often not caused by model results. It is mainly forced by natural hazards and the visibility of global changes at the local scale. There is a lack of cooperation between scientific institutions, operational structures and policy administration.
- Confidence between the policy administration and scientists is the most important key for implementation and launching results. Confidence building between scientists and politicians is a long bilateral process.
- An interface between numerical hydrological models and policy implementation in river watersheds can be formed by land use and land-use changes, since they are the only factors that can be influenced in a short and medium time horizon.
- Watershed hydrology must fit within a holistic framework with other sciences to work together to develop new management approaches. Socio-economic analyses are indispensable integral parts of sustainable water resources management, including the analysis of their impact on the environment.

RECOMMENDATIONS

- Since representation of hydrological processes and the predictions of hydrological models will remain uncertain, two important issues that must be addressed in the future hydrological science are:
  - how to estimate that uncertainty (in both gauged and ungauged catchments) and constrain it using the most informative measurements;
  - how to present and use the uncertainty in management decisions.
- Solution of these issues will require a framework for spanning scales, for assessing the real information content of observations when testing models as hypotheses about system response, and for robust decision making under uncertainty.
- Greater coordination should be made in the establishment, maintenance and expansion of data networks, and in the installation of technological survey tools to allow development of the most up-to-date information and knowledge.
- Sustainable water resource planning requires a qualitative improvement of data sharing amongst governments, development agencies, and research and academic institutions.
- More detailed investigation of climate variation and the effects of global climate change is necessary, being an important factor in water resources management along with changes in land use, economic development and population growth. In this context, the methods of time series analysis must be improved, making best use of GIS technology, supported by extensive regional analyses.
- We need to pay more attention to groundwater due to its increasing importance as a resource for freshwater supply and irrigation. For watersheds where groundwater is a major part of water resources, effective algorithms need to be developed to evaluate and quantify the local resources, incorporating the heterogeneities of the rainfall, flow patterns and hydrogeological conditions.
- The implementation of the EU Water Framework Directive requires important efforts to improve and standardize the methods of monitoring and analysis of water quality parameters. This requires the introduction of improved indicators of water quality and ecosystem status in water bodies. Efficient mathematical models are indispensable for water quality analysis, particularly for the mitigation of the consequences of water pollution accidents.
- Water quantity and quality are often evaluated by economic necessity and financial gain allocated to water resources. More studies should be devoted to estimation of the quantity and quality of water by evaluating the natural environment conditions in river basins and the condition of the aquatic ecosystem.

- Sustainable water resources management and application of the EU Water Framework Directive cannot be achieved without improved understanding of the water balance under natural conditions and when exposed to change due to human activity.
- Mechanisms for improving renewable water resources in watershed should be strengthened. Priority must be accorded to undertake eco-restoration works.
- Flood risk maps needs to be provided to increase public awareness of the areas at risk of flooding and to supply information by defining flood risk zones to give input to spatial planning. A clear flood risk map supports the processes of prioritizing, justifying and targeting investments in order to manage and reduce the risk to people, property and the environment.
- It is important to strengthen the cooperation between regions and countries that share watersheds. Mechanisms must evolve for sharing the river waters during deficit rainfall years, normal rainfall years and extreme rainfall years.
- Innovation sociologists and political scientists should make proposals together to combine knowledge building and democratic decision-making processes, which were separated until the rise of the Nation-State and its involvement in the economy.
- The time required for confidence building is longer than the average project duration, thus new project and cooperation structures must be developed. New organization schemes are needed in addition to the re-launching of top-down structured research programmes.
- To encourage the creation, the structuring and the exchange of information, specific mediation projects and the implementation of mediation structures are recommended.
- Continuing education is recommended within the respective technical services, in order to improve the use of efficient hydrological models. Long-term learning by water professionals at all levels, not forgetting the training of decision makers, stakeholders and the general public, must be recognized as an important precondition of the successful application of advanced techniques of sustainable water resources management methods.
- Redistribution and decentralization of financial research resources from the EU to lower administrative levels are recommended to enable the countries and regions to structure applied research directly with respect to their needs.