SUMMARY OF RECOMMENDATIONS FOR POLICYMAKERS ON **ADAPTION TO CLIMATE CHANGE IN WATER ENGINEERING**

This report is a contribution of the IAHR Working Group on Climate Change to the scientific and technical debate on this global challenge in the water sector. Some experts in different fields, from our Association, reviewed and recommended structural and non-structural adaptation measures being taken or to be taken in the hydro-environment engineering community to mitigate the impact of climate change on humans, nature and infrastructures.

Trend analyses and changes detection in space-time data

Public bodies dealing with the policy and management of water resource systems, should investigate adaptation measures to face the following issues related to observed trends:

- Understand and quantify short- and long-term trends in hydroclimatic variables especially precipitation and streamflow and other essential climatic variables
- Evaluate the occurrences, variability and sudden changes of extremes (considering frequency and magnitude) in space and time and develop sustainable and climate-change sensitive hydrologic designs
- Assess the influences of climate variability on streamflow and precipitation changes at different spatial and temporal scales considering the extent of regional climatology influences
- Understand changes in trends and attribute or separate them based on natural variability or anthropogenic influences

Rainfall and Runoff

Climate change is expected to cause a shift to more intense individual storms and fewer weak storms as temperatures increase. Return periods are projected to be reduced by about 10-20% per degree Celsius (°C) over most of the mid-latitude land masses, with larger reduction over wet tropical regions. It is recommended that design flood estimation and planning for an asset or activity should consider: service life or planning horizon, design standard, purpose and nature of the asset or activity, screening analysis, climate change projections and their consequences of impact, and statutory requirement. It is also recommended to take into consideration also a class of worst case extreme events estimated to occur under climate change as survival critical or edge of survivability, partly because projected future changes in design value may have high uncertainty.

Downscaling and Adaptation to Urban Hydrology Scale

The main challenge in urban hydrology is to predict accurately the future variability of urban hydrologic processes (such as temperature, rainfall, and runoff) at the scale of the urban area in the context of climate change in order to build suitable scenarios for the operation and management of urban water systems. Various impact assessment procedures and adaptation measures should be developed and tested in order to find the most cost-effective method for management and control of the urban water environment. Examples of some existing adaptation measures are:

- Storage and infiltration devices together with re-naturalization of urban watercourses are more and more frequently considered and their use should be further enhanced. However, more research is necessary to optimize their application particularly if conditions are changing (drainage flow regime, sediment inputs, vegetation growth linked with temperature, etc.)

The competition between food, water and soil in drought-prone areas will become more severe in a warmer climate (photo: R. Ranzi in Southern Vietnam)

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Structural measures as reservoirs and irrigation channels can mitigate the effects of the projected enhanced variability of runoff. But also non-structural measures as improved tools for management, planning, and decision making in reservoirs operation can be effective for adapting to a changed water cycle

- Adaptation measures at individual scale (mainly storage or infiltration) should also be favoured but they are only efficient up to some given rainfall volume or intensity; so they should be included in the overall management plan at the municipality scale, which requires complementary tools to integrate water, social and economic issues

Adaptation in Groundwater Management and Drought Management

Groundwater will be increasingly critical in sustaining water supplies through periods of climate change as it will help balance the larger fluctuations in precipitation and increased water demands caused by high temperature and drought. Droughts are expected to have their patterns of occurrence and magnitude changed in the future. Policy leadership is required to support efforts toward identifying and funding adaptation measures and related research such as:

- ✓ Groundwater quantity and quality data collection
- ✓ Conjunctive use of surface and ground water resources
- ✓ Managed aquifer recharge
- ✓ Water reuse and brackish groundwater supplies
- ✓ Rainwater harvesting
- ✓ Protection of groundwater supplies
- ✓ Improved tools for management, planning, and decision making
- ✓ Water demand management
- ✓ Adaptation of policy, legal and institutional frameworks for water management

Impact on Hydropower Generation and Mountain Hydrology

The impact of projected rainfall and evapotranspiration losses changes at the global scale imply highly variable spatial patterns of runoff changes and resulting hydropower generation potential. More clear is the projected impact on mountain hydrology, with a projected shift of the snowmelt season to early spring months, a decrease of summer runoff and an increased variability of runoff regimes, thus enhancing the potential impact of droughts and floods on inflow to reservoirs. Public bodies dealing with the policy and management of water resource and energy should investigate and implement adaptation measures to face the following topics:

- increasing variation (distribution and quantity) on water incoming to hydropower reservoirs imply the need of an increase of storage volumes, in some cases.

- Increasing damages to the connectivity of water bodies and injures to the river ecosystems imply reservoir regulation paying more attention to environmental issues as an adaptation measure.
- Increasing demand and competition among different water uses imply more accurate planning and management optimization of the water resources and participation of stakeholders in decision making processes.

Climate Change, Sea Level Rise and its Impact on Land and Water

Sea level rise may also be ascerbated by storm surges and wave set up. In addition to causing loss of coastal land, these sea level variations will directly impact the surrounding ground water table. While construction of embankments, dikes, and dams etc., could be implemented in suitable areas to prevent land loss, the preferable approach would be to demarcate areas under threat and use them for recreational purposes, with very minor construction.

Trans-Boundary Watershed Management

The management of trans-boundary watersheds requires an integrated regional approach which should consider:

- the increase in future water variability.
- Changing social, economic and climate conditions which may alter current hydro-political balances, in terms of potential inability of states to meet their treaty commitments.
- Water scarcity as effect of climate change will have impact on international conflict and security.
- An effective international legal framework addressing future challenges of climate change is required.

Decision Making for Climate Change Adaptations and Water Resources Management

The decision making process under a changing climate should be based on principles that can handle effectively primary attributes of climate change such as deep uncertainty and non-stationarity. Good decisions under climate change can:

- perform reasonably well over the entire range of uncertainty,
- allow various options through the entire decision making process,
- be iteratively refined as new information including trial errors is available,
- take into consideration a class of worst case extreme events estimated to occur under climate change as survival critical or edge of survivability.

Key aspects to be considered in the decision making process include:

- ✓ Climate change impact on water resources management
- ✓ Technical adaptations to Climate Change
- ✓ Institutional adaptations to Climate Change
- ✓ Legislation adaptation to Climate Change
- ✓ Capacity building improvement
- ✓ Public involvement improvement