WORLD CLIMATE PROGRAMME

WORLD CLIMATE APPLICATIONS AND SERVICES PROGRAMME

WORLD CLIMATE PROGRAMME - WATER

EXPERT MEETING ON WATER MANAGER NEEDS FOR CLIMATE INFORMATION IN WATER RESOURCES PLANNING

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FINAL REPORT

EXECUTIVE SUMMARY

Recognizing that climate information is presently not widely used by water managers, the expert meeting aimed to identify the current state of climate information that potentially could be used by water managers and looked into the perception of water managers with regard to the use of climate information that would suit their requirements. The meeting also served as a scoping platform to identify current uses of climate information in water management and to provide an overview at which scales climate information has the greatest potential for use now and the near future. Likewise, gaps and deficiencies in present knowledge and research were identified. The meeting showed that climate predictions and seasonal climate outlooks at present have the highest potential to be more readily used while predictions of climate variability and change, while inherently useful, are not yet ready to be applied from an engineering point of view and other techniques, such as using multi-model ensembles and downscaling techniques are required to improve prediction skills to reduce large uncertainties. The expert meeting concluded that all possible information should be processed in such a way that it would allow the development of adaptation processes and activities even though there are large uncertainties still prevailing. Major outcomes of the expert meeting were:

- Participants encouraged the development of demonstration projects based on a project proposal developed by WMO “Bringing Climate Information to Water Managers” and
- Participants developed an agenda and work plan for a WMO initiative on “Improvement in Water Resources Planning through the Use of Climate Information”.

1. INTRODUCTION

1.1 Under the auspices of the World Climate Programme – Water (WCP-water), an expert meeting on the climate information needs of the water planning and management community was held at the World Meteorological Organization (WMO) in Geneva, Switzerland from December 18-20, 2006. The meeting had two primary objectives. The first objective was to facilitate a substantive dialog between those who conduct water resources planning and those who provide climate information and services, particularly in terms of climate information content and uncertainty, and water planning information requirements. The second objective was to consider a project concept developed by WMO to facilitate and expand the use of climate information in water resources management, and to promote research and development related to climate predictions and their use in water resources planning and operations.

1.2 Outcomes were sought that would support several specific issues, including establishing a platform for the exchange of climate information appropriate for use in the planning of water resources infrastructure; determining climate information needs of water managers, while assessing the availability and suitability of climate information that could be used for management purposes; determining mechanisms and activities to standardize the use of appropriate climate information in water management activities; and developing an outreach process to improve the quality of water management/planning through the use of climate information.

1.3 To accomplish the workshop’s objectives, a diverse group of experts in disciplines associated with climatology, hydrology, water resources management, impacts assessment, and capacity building were invited. The list of participants is attached as **Annex 1**, and the agenda appears as **Annex 2**. The project concept is attached as **Annex 3.**

2. ORGANIZATION OF THE MEETING

2.1 The meeting was opened by the Deputy Secretary-General of WMO, Mr. Hong Yan, who welcomed the participants and provided an overview of the growing importance that WMO is placing on water as a core organizational theme. He emphasized that this meeting presented a significant opportunity for WMO to demonstrate its commitment to improving the use of climate information in water resources management, and that the Secretariat would be closely following the outcomes. Ms. Yan closed by offering his best wishes for a successful meeting. The meeting chair, Mr. Harry Lins, then reviewed the objectives, activities, and products of the World Climate Programme - Water (WCP-Water), the activity under which this expert meeting had been organized. Finally, Mr. Wolfgang Grabs of the WMO Hydrology and Water Resources Department presented the objectives and expected outcomes of the meeting, along with its structure and flow. He noted that activities had been organized around eight topical themes that are reflected in the meeting agenda, aimed at enhancing participants understanding of climate information (types, availability, and accuracy) and the water management process and its information needs.

2.2 Participants felt that this is the first meeting of its kind to get the water and climate communities together. It was noted that this was a single-best opportunity to understand needs and requirements of the water sector and match these with the present capabilities of the climate research and applications community to provide useful information to water resources planning and management at different levels of complexity. It was further noted that this expert meeting would foster cooperation between meteorological and hydrological services and climate research and application programmes to better serve water managers on the levels of policy making, adaptation, and operation of water schemes.

2.3 The sections that follow summarize the substance of the presentations, discussions, and conclusions that were made during the sessions and that resulted from the three-day expert meeting.

3. THEME I: CURRENT PRACTICES IN WATER RESOURCES PLANNING

3.1 The term “water resources planning” is used here to distinguish planning from the (day-to-day) operation of water resources infrastructure. This includes the design of new structures as well as the rehabilitation of existing structures to meet future (adaptation) requirements and the review of current operating procedures when adaptive management procedures are necessary. Equally important are policies in the decision-making process to finance water infrastructure and management in a time horizon covered by present-day climate scenarios. Time horizon is on a seasonal to interannual scale when making use of climate outlooks/prediction and up to 50 years when making use of scenario-based climate information.

3.2 It was felt that it is necessary to be clear in the discussions at which level of water management (I.e. day-to-day, seasonal, strategic decisions) climate information becomes useful. Participants were clear that the topic covers a wide range of time scales and attributed temporal and spatial information contained in climate information, including uncertainties. The discussions therefore did not focus on climate change issues alone but moreover covered the full range from long-range weather prediction to climate outlooks to reaching out to climate variability and climate change.

3.3 Experts noted that the thrust in using climate information is presently on the boundary between long-range weather forecasting (where water mangers are well–versed in the use of such information) and seasonal climate prediction. Experts remarked that there is usually only one seasonal forecast issued per year which lacks the opportunity of a flexible adaptation of the forecast in a progressing year. The difficulties in verification of such forecasts were also mentioned.

3.4 At present information on climate variability (other than historic climate variability which is embedded in present design procedures of water resources infrastructure and associated management rules) is at best used as additional source of information. But information on (future) climate variability and climate change is only rarely used by water managers in decision-making processes. There was a general observation that the state of the art of climate prediction is not yet at a level where it can be used directly.

3.5 Some participants noted that water managers in this situation use risk management practices that are undertaken using appropriate safety contingencies and redundancies especially in the water supply industry. These practices however are undertaken without taking climate information into consideration although the potential usefulness of climate information for risk analysis was clearly highlighted.

3.6 Under the agenda item, presentations from various backgrounds were provided to inform participants on current planning practices and procedures for water resources planning.

3.7 Eugene Stakhiv: *What Water Managers Need to Know about Climate Change and Variability for Water Resources Planning: Adapting to Uncertainty*

Water managers deal with different types of water uses, from hydroelectric power generation to recreation and ecological needs. They typically deal with large uncertainties in the information and data bases, but necessarily deal with this information in a deterministic manner by converting probability distributions into <u>discrete design criteria</u>; e.g., the “probable maximum flood.” In this context, much of the available climate change information (such as the long-term scenarios presented by the IPCC) is relatively uninformative. To be of direct use, scenarios of long-term change in climatic conditions need to be converted to reasonably reliable predictions of shifts in flood and drought frequencies, as well as changes in specific types of events (hurricanes, extratropical storms, precipitation rates and durations, etc.). The tools of risk and uncertainty analysis provide managers with adequate comparative information which, when coupled with stochastic simulation techniques, provide the necessary information to “bound” the problem without having to utilize climate change scenarios. The choice of a specific design criterion (100-year flood return period, 50-year drought, etc.) is a policy issue that can be informed by an analysis of climate variability and change, but it primarily represents society’s decision as to the acceptable level of protection/reliability it is willing to pay for. Accordingly, the climatic information most needed by the water management community is not long-term scenarios (to support design criteria for structures), but shorter term seasonal forecasts which allow water managers to improve the effectiveness of water management decisions for irrigation, water supply, reservoir management, and flood and drought contingency management.

3.8 Gertjan Zwolsman: *Influence of Climate Change on Water Quality and Drinking Water Function of the Rhine River*

Surface water is an important source of drinking water in the Netherlands, accounting for about 35% of total drinking water supply. The rivers Rhine and Meuse are the major sources for drinking water production. It is of vital importance to assess future changes in hydrology and water quality of these rivers due to climate change and other drivers (e.g. implementation of the EU Water Framework Directive). Many studies have shown that climate change will affect the hydrology of the Rhine, with a tendency towards higher winter discharges and lower summer discharges. Moreover, an increase in the frequency and intensity of extreme hydrological events (floods and droughts) is foreseen, posing an increasing threat to drinking water production from river water. In this perspective, Kiwa Water Research has conducted a comprehensive study on river water quality during hydrological extremes, from which it was concluded that water quality is under pressure indeed during floods, rainstorms, and droughts. The summer drought of 2003 is used here as an example to assess the impact of future droughts on water quality. An obvious decline of the water quality of the Rhine was observed during the hot summer of 2003 (with respect to ordinary summers), which could be attributed to limited dilution of point sources due to low river flows. For example, high concentrations of heavy metals and non-reactive substances, such as chloride and bromide (both highly relevant to drinking water production), were observed in the Rhine during the drought period. In addition, the water temperature was frequently above the 25 °C standard and the algae concentration increased. Adaptive strategies are suggested to deal with future periods of poor surface water quality, based on increasing the flexibility of the water intake strategy. This can be accomplished by exploring alternative water resources (e.g. brackish groundwater), creating new reservoirs or enlarging existing ones, and by new water storage concepts (e.g. aquifer storage and recovery).

3.9 Mark Svendsen: *Allocating Dry Water – The Case of the Colorado River*

- One hundred years of interactions among allocation, storage development, and water use on the Colorado River have characterized a complicated and highly non-linear process of basin development. The resulting "law of the river" has been established without a centralized basin authority, but has depended on legal respect for the many contracts and agreements that have been reached among riparian owners.

- The impacts of changes in basin runoff hydrology become more problematic and serious as basin water resources become more fully committed.

- Storage is a key basin parameter and a critically important tool for managers to use in responding to changes in basin hydrology. Managers of a basin like the Colorado with 4X+ storage have many more options than the operators of the Indus system in Pakistan with ~10% storage. But while storage can help with seasonal flow variability, it is of little help in dealing with long-term secular changes in basin water availability.

4. THEME II: PRESENT DAY PROVISION OF CLIMATE INFORMATION IN THE AREAS OF CLIMATE OUTLOOKS, VARIABILITY AND CHANGE

4.1 Under this agenda item, presentations were made informing the meeting on currently available climate information on a variety of time and space scales and using model-based predictions as well as scenario-based information and the possible use of these predictions and scenarios by water managers. As a general observation, participants observed that although there is a widespread great awareness of climate change issues and potential impacts on water resources management, such information is little used at present. It was mentioned in various interventions by participants that the focus is of discussions on climate change whereas there are large-scale processes atmospheric-oceanic that also influence water resources availability and hydrometeorological extremes and that these phenomena are usually treated more in the background whereas more directly suitable information derived from these large scale processes is needed. A good example mentioned in this context is the Interdecadal Pacific Oscillation (IPO) which major effects on mean and peak flows, changes in the flood frequency and occurrence as well as persistence of drought.

4.2 Jean-Pierre Ceron: *Climate Information for Water Resource Management*

The components of the hydrological system are the atmosphere, the soil/vegetation layer and the hydrological component. All information on one part of the system can be useful and notably from the atmosphere which give the forcing terms to the hydrological system. From now, quite a lot of products allowing the monitoring of the climate system are available and notably among them the rainfall analyses (e.g. GPCP), satellite products (e.g. SAF land, SAF Climat) or rainfall estimations (e.g. EPSAT).

The Regional Climate Outlooks, which deal with forecasts at the seasonal time scale, provide information on the quality of the next rainy season. It's a probabilistic forecast which brings information on the occurrence of predefined scenarios (tercile categories) and the associated probability. More extreme scenarios are also issued notably by the main numerical centres issuing seasonal forecasts. Some regions provide also the hydrological feature of the next hydrological season (Tercile categories and associated probabilities). Forecasting information on the low level water is also useful but not presently prepared.

Tailored Seasonal Forecasts improve the information brought to the water manager; the first step being to get high quality dataset from the hydrological domain. As the flow appears to be more predictable vs rainfall, these specific products prepared using downscaling methods (both space and time), bring additional information to the management system and a high additional value can be brought to the decision making process.

Coupled models are available notably in the frame of the impact IPCC studies on water resources. One challenge is to convey the information from the GCM (which has generally a low resolution – e.g. 200 km) to the hydrological model (which needs a higher resolution – e.g. less than 10 km). The gap in term of space sale is very large and in this point of view, GCM information which is the main input for the regional and subregional scales must be improved prior to the downscaling problem. Quite a lot of potential applications can be expected from these Atmosphere/Soil-vegetation/Hydrological simulations. Among them one can highlight information on the soil wetness, follow-up of the hydrological situation, slow flood warning, information on the snow cover and even use in prediction mode.

4.3 José Luis Camacho Ruiz: *Present-day Provision of Climate Information in the Areas of Climate Outlooks, Variability and Change*

Western Coast of South America (COF) elaborated a monthly seasonal forecast on rainfall, maxima and minima temperatures for Venezuela, Colombia, Ecuador, Peru, Bolivia and Chile through a virtual and cooperative process made by the six NMS and CIIFEN. This is the basis for several projects that are going to develop sectoral applications in agriculture (project funded by the Inter-American Development Bank to be started on January 2007), water management, climate and health and climate change scenarios. The bulletin and seasonal forecast are received by more than 7,000 users. CIIFEN is an international organization participated by World Meteorological Organization, International Strategy on Disaster Reduction, the Government from Ecuador and Spain and the CPPS. Web page: www.ciifen-int.org

4.4 Alfred Opere: *The IGAD Climate Prediction and Applications Centre*

The IGAD Climate Prediction and Applications Centre (ICPAC) is an institution for 10 countries in the Greater Horn of Africa (GHA): Kenya, Tanzania, Uganda, Ethiopia, Eritrea, Somalia, Sudan, Burundi, Rwanda, and Djibouti. ICPAC's mandate is capacity building in the region in the generation of climate products mainly at seasonal time scales (seasonal outlooks). However, they also provide shorter time scales (decadal), tailored to specific user needs. The application of these climate products in different sectors (water, hydro-power, disaster reduction, agriculture, etc.) has lately been the emphasis of the Centre. The climate products are largely based on statistical approaches relating rainfall to other parameters (global mean sea surface temperature, outgoing long-wave radiation, Madden-Julian Oscillation, Southern Oscillation Index, etc.). The statistical models are used to generate the predictions based on probabilities. There has been limited attempt to introduce dynamical methods (the limitation being data, appropriate data and hardware, human capacity, etc.). The greatest challenge facing ICPAC now is not only to improve the accuracy of the climate products, but also to downscale this information for the various users.

5. THEME III: RELIABILITY AND UNCERTAINTIES INHERENT IN CLIMATE INFORMATION PRODUCTS

5.1 Based on the presentations summarized below, participants were provided a reference base to discuss the agenda item under the aspect of suitability of climate information for use in water resources planning and requirements to reduce uncertainties in climate information products. A key issue for water managers is the reliability of any climate outlook or forecast. Participants argued that with a prediction skill that is often below 50% the usefulness of such information is questionable. Likewise, at present there are no openly available tools to track prediction performance on a comparative level.

5.2 The meeting observed that presently seasonal climate outlooks seem to be more used than information on climate variability: The latter is in many cases taken into account of in the design of water resources infrastructure and the flexibility in operating such infrastructure under the (questionable) assumption of static climate in the past that is being used as reference for setting design criteria. In this regard it was observed that using the last 20 years of climate records as a reference period may not always be a good guide to the next 20 years. Climate change signals seem to be more consistent over the globe in terms of trends but these trends are not yet quantifiable with sufficient accuracy.

5.3 It was pointed out that, derived from selected information climate variability will have large effects on seasonal and interannual precipitation while climate change will result in smaller changes of mean temperature and amounts of precipitation but in a marked change in frequency and intensity distributions and in changes in the seasonality with regard to water availability but also water demand and the distribution of extremes with a disaster potential.

5.4 In order to statistically improve on climate prediction uncertainties, the use of multi-model ensembles has shown to be useful. However, with regard to information on the variability in the ensemble distribution, the there is little evidence that there is any information in the ensemble beyond the shift in the ensemble mean. For application purposes, most information is contained in the ensemble mean. It was also observed that model forecast can be improved by correcting spatial errors that are inherent in GCM outputs. For applications, the forecast skill can be improved by methods using spatial aggregation methods where, for example, by statistical procedures the model grid is adjusted to reflect true geographical locations. For large spatial areas, for example the skill for precipitation prediction could improve by 10% to 20%.

5.5 It was also pointed out that in general, mesoscale weather forecasting is improving because the boundary conditions at the mesoscale level are better understood than in the regional scale models. Some participants pointed to the fact that the use of regional models is not so much better as they are forced by global models and therefore an other viable approach could be to use global models and then combine its outputs with a statistical model e.g. for spatial corrections.

5.6 Simon Mason: *Reliability and Uncertainties Inherent in Climate Information Products – A Seasonal Forecast Perspective*

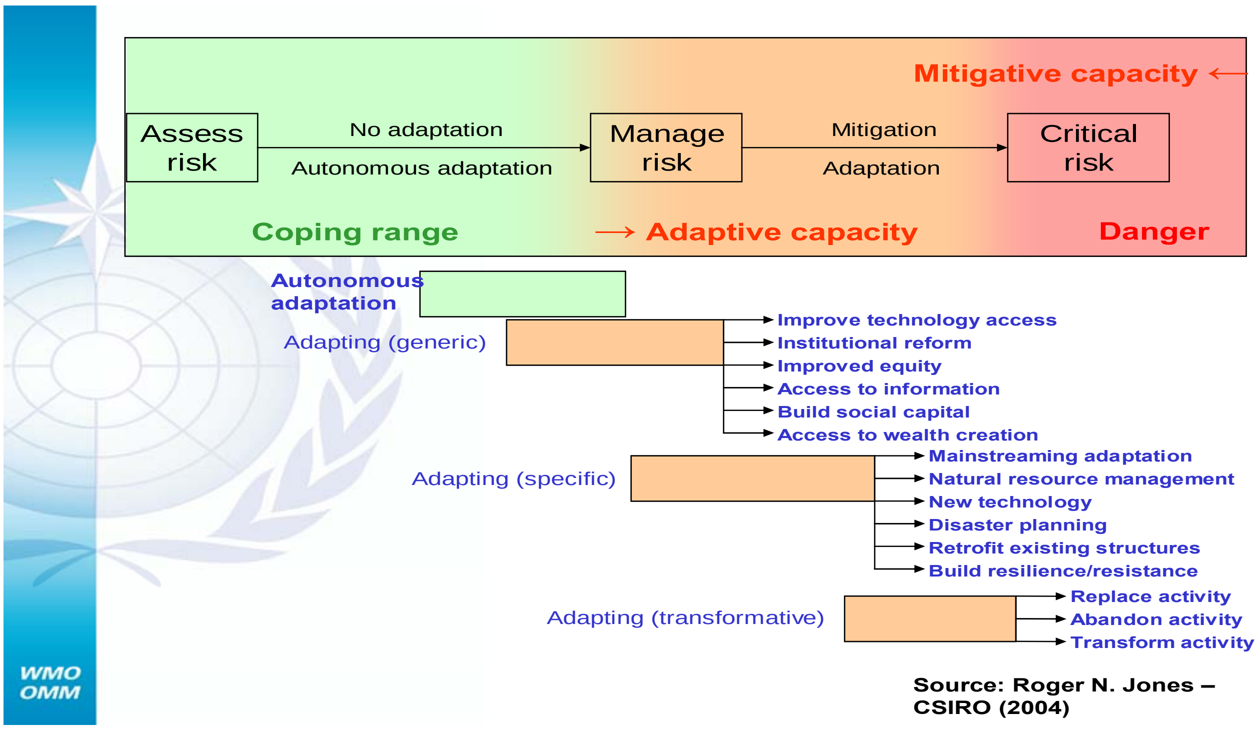
Precipitation is a notoriously difficult meteorological variable to forecast. The dynamical models used in seasonal climate prediction reproduce observed precipitation very poorly: errors in reproducing the observed climatology can be large, and there are only a few regions and seasons in which the year-to-year variability is reproduced with any meaningful skill. Even in areas with high skill, the ensemble-median does not provide a reliable indication of changes in rainfall: the probability of rainfall exceeding the ensemble median decreases (increases) when wet (dry) conditions are forecast. However, the precipitation forecasts can be improved by statistical correction, including correcting for spatial errors in the model predictions, by spatial aggregation, and by combining forecasts from different models. Notable improvements in reliability (the correspondence between the forecast probability and the observed relative frequency of an event) can be achieved. At the current state of the science the useful information in the forecast ensemble is almost entirely summarized by the ensemble mean; there is only occasional marginal additional information in year-to-year changes in the ensemble spread. As a result, the best way to generate an ensemble for input to other models is to sample from a distribution fitted to the ensemble. Part of the difficulty in forecasting precipitation is the highly localized nature of intense rainfall. Rainfall occurrence is much more spatially coherent than rainfall intensity, and so at all timescales it is easier to predict occurrence than total rainfall. Recent results indicate that for many parts of the globe seasonal forecasts are more skilful when expressed in terms of frequencies of rain-days over a season rather than seasonal totals.

5.7 Yuping Yan: *Climate information applied in water resource management in China*

In terms of applying climate information to water resources management, a reliable monitoring system is one of the most important things. And the data reliability has much direct effects on more precise prediction of the numerical models, not only climate prediction/projection models but also hydrological models. So an integrated national wide (or world wide) observation system is necessary. Based on the reliable datasets, climate impact assessment models are used in estimation of water resources in different river basins in China. Climate changes projected by various numerical models and their impacts on runoff under different scenarios showed considerable difference on monthly runoff, especially in the rainy season. The precipitation change is the main factor that brings about the change of runoff and the differences in the runoff, although temperature change also needs to be taken into account. The feedback of runoffs in different river basins to climate change scenarios is also different.

6. THEME IV: RESILIENCE AND ADAPTATION CAPACITY OF CURRENT WATER MANAGEMENT PRACTICES IN THE LIGHT OF CLIMATE VARIABILITY AND CHANGE

6.1 Based on a presentation highlighting on the robustness but also vulnerability of current planning practices and management of water resources schemes, the experts discussed the issue with a view to find a common perspective on how climate information could be used to ensure service reliability of water resources infrastructure and management practices. In the discussion of this subject, some participants argued that water resources management is inherently a self-adaptive autonomous process where large events trigger innovations or adaptations in the design and operation of water resources infrastructure and management practices. A refinement of this process would be to use other adaptive approaches including those mentioned in the figure below.



6.2 Mr Monirul Mirza: *Climate Change and Variability: Resilience and Adaptation Capacity of Current Water Management Practices*

- In the global system, everything is connected to everything else. The climate and freshwater systems are interwoven in a complex way so that any change in one of these systems induces a change in the other.
- Water related extremes are on the rise; so the damage around the world.
- There is an 'adaptation deficit'. The adaptation measures are inadequate to reduce increasing damage. Climate information is very vital to design adaptation measures.
- In order to meet future challenges we must evaluate '**adaptation baseline**' which includes measures and policies to reduce the risk of climate and water related hazards as well as damages.

- There are many determinants of adaptive capacity which may include: Economic Resources; Human Resources; Technology; Institutions; and Regional & International Cooperation. No system is termed to be sufficient to adaptive. There are always scopes of improvement because we really don't know what will the distribution of extreme climate/weather and hydrological events over space and time.

6.3 Charles Pearson: ***Resilience and adaptation capacity of current water management practices in the light of climate variability and change - a hydrologist's view***

Current water resources management practices use standard design techniques to ensure that systems are resilient to climate variability and change. When systems become vulnerable through short or long term changes (including land-use change), adaptation measures can be identified and implemented, subject to the adaptation capacity (cost-related). An example of a resilience project is the WMO World Hydrological Cycle Observing System (WHYCOS) Pacific HYCOS project of the Pacific Islands. This project will develop surface and ground water monitoring, for the beginnings of sustainable water resources management in the vulnerable Pacific Island region. Climate variability will continue to dominate over climate change for the next couple of decades. Climate change will increase in importance especially for large investments with long lifetime. Greater understanding of water resource systems is required, with continued data collection and model development, and multidisciplinary science. Greater communication is required amongst climatologists, hydrologists and water managers, for better planning. Water is an increasingly scarce resource, and water hazards likely are likely to become more frequent. Climate information should be proven and then used for better water management – even modest climate forecasting ability can be used to help make best use of every drop of water!

7. THEME V: DEFINING THE NEEDS OF WATER MANAGERS FOR CLIMATE INFORMATION IN WATER RESOURCES PLANNING

7.1 Against the background of current practices in water resources planning and knowledge of available climate information products, participants exchanged experiences, identifying the need for a "requirements document" of water managers for climate information needed in the planning process. On the communication of climate information to water managers, participants observed that there is not much systematic information on the actual use of such information. Also, such information is brought forward in a format and language that is not useful for water managers. A proper needs-based requirement assessment for climate information developed by water managers would by a starting point for the development of tailor-made climate information products that actually could be used then.

7.2 In order to improve the knowledge base on the use of climate information for water managers it was recommended that past documented cases on the use of climate information for water management should be mapped and documented across dimensions such temporal, sectoral and geographical dimensions. There should be also objective criteria to measure the usefulness of climate information, notably climate forecasts in water management. It was felt that benchmarking of case studies would be important in comparison with different climate models used and procedures applied to adapt and use such information for water management.

7.3 The meeting generally observed however that water managers do not focus on issues of climate variability and change but pragmatically on the way in which this translates into changes in water availability, regulatory flexibility and repercussions on demand management as well as changes in the frequency and intensity of hydrometeorological extremes.

7.4 Henk van Schaik: *Towards Defining the Needs of Water Managers for Climate Information in Water Resources and Water Services Planning*

Building on substantive number of case studies that illustrate the current use of climate information in water management, Mr Schaik outlined current practices, attitudes and policies in the water planning and management sector and summarized that:

- Climate is an externality for water managers. Designs and operations use historic data (temperatures, precipitation, run off, groundwater availability).
- Relation between temperature and precipitation with hydrology and run off is scientifically complicated and not well established
- The impact of climate change on hydrology is expected to be minor (10 %).
- Millenium Development Goals (MDGs) do not include risks including climate change
- Most plans for Integrated Water Resources Management (IWRM) do not consider climate change.

Most of the present use of climate information relates to seasonal forecasts and predictions at the borderline between climate predictions and long-range weather forecasting. On a strategic horizon of years and decades, climate information is hardly used for planning and management purposes at present.

He therefore concluded that the water sector at present pays scant attention to climate information. On the other side, planning for adaptation to climate change is still in its infancy. For a meaningful adaptation planning the water sector needs site specific information for e.g. (flood) defense, water allocation, utilities etc. Dialogue on the specification of the information in with user groups is required. Parallel to the provision of climate information other activities are also essential such as advance in science and process understanding, awareness raising, innovation towards “climate proofing”.

He concluded in providing information on climate proofing activities in the Netherlands and pointed out that specific use of climate scenarios in water management requires “tailoring” He outlined as example that the Dutch Programme **Climate Changes Spatial Planning** co-funded a “tailoring project” that centres amongst others on high resolution time series of precipitation, ground water tables in the Netherlands, Rhine discharge and closure of Maasland barrier.

7.5 Esko Kuusisto: *Needs of Water Managers for Climate Information - Experiences in Finland*

In his presentation, Mr Kuusisto pointed out that Climate data is essential for adaptation in the water sector, namely:

Short-term data needs with regard to precipitation forecasts and temperature forecasts;
Long-term data/information relate mainly to the availability of suitable climate scenarios.
Main users of scenarios in the water sector have been identified:

- Flood management
  - Dam safety
  - Land use planning
- Hydropower
  - Changes in seasonal flow distribution
- Water supply
  - Summer droughts
  - Groundwater formation

He stressed that a number of changes of hydrological regime parameters have already changed in the recent past including annual maximum snow storage, runoff from the territory of Finland, general warming trend, and - according to climate scenarios changes are to be expected for the hydrological regime and in particular a shift in seasonal runoff that also will effect hydropower production. Especially in the planning and/or adaptation of water infrastructure including dams, a major concern is the necessity to re-evaluate or change design-values in the future due to climate change.

As one of only few countries at present, Finland has adopted a “National Strategy for the Adaptation to Climate Change”. Key elements in this strategy are:

- Adaptation will be included as ***part of the environmental and other management systems*** of institutions and branches of administration
- Adaptation will be a ***part of environmental impact assessments*** at the level of plans and programmes.
- Adaptation can be included in ***the risk assessments*** applied by different sectors, organisations and companies.

8. THEME VI: CHALLENGES AND OPPORTUNITIES TO MEET PRESENT AND FUTURE CLIMATE INFORMATION NEEDS OF WATER MANAGERS

8.1 Based on requirements for climate information on different spatial and temporal scales as well as accuracy and reliability requirements, participants exchanged information on research and development programmes and activities aiming to improve knowledge and making available applications-oriented tools to enable water managers to better use advanced climate information. Participants also discussed linkages with climate research programmes/projects that could provide valuable assistance in this regard.

8.2 Marta Moren Abat: *Challenges and Opportunities to Meet Present and Future Climate Information Needs of Water Managers – Setting the Research Agenda*

FP7 is the 7th Research Framework Programme for Research and Technological Development. This the European Union’s main instrument for funding research in Europe and it will run from 2007 to 2013. The European Commission budget for the next seven years is €50.5 billion. This represents a 41 percent increase from FP6, the previous research programme. FP7 is composed of five specific programmes (Cooperation, Ideas, People, Capacities, and Nuclear research). The Cooperation Programme is the core of FP7, and includes a number of key themes. One such theme addresses environment (including climate change), and has a budget of €1.8 billion for the period 2007-2013. One area within this theme focuses on climate change, pollution and risks, and encompasses research on environment and climate, environment and health, and natural hazards.

9. EXAMPLES FOR THE USE OF CLIMATE INFORMATION TO IMPROVE THE QUALITY OF WATER RESOURCES PLANNING

9.1 As a result of the previous presentations and discussions, two presentations highlighted on the issue of actual use of climate information from different perspectives.

9.2 R Kolli: *World Climate Applications and Services Programme (WCASP) and the CLIPS Project: Perspectives on Water Sector*

In his presentation, Mr Kolli explained that the World Climate Applications and Services Programme (WCASP), a constituent of the World Climate Programme (WCP), has the long-term objective of developing climate services within the National Meteorological and Hydrological Services (NMHSs) and contribute to national sustainable development. The Climate Information and Prediction Services (CLIPS) project was established in 1995 as an implementing project of WCASP. The principal objective of CLIPS is to develop the capacity of the NMHSs to take advantage of the rapid advances in the science of climate and in the processing and dissemination of climate information, and to pass along the benefits of the improved climate services to the user community. CLIPS provides an essential link between climate prediction/information and their applications – bridging the gap between the science and the applications to promote development activities in a manner beneficial to both producers and users of climate information and prediction products. Mr Kolli stressed that CLIPS pioneered the concept of regional climate outlook forums (RCOFs), which are actively pursuing consensus-based climate outlook preparation and end-user liaison in different parts of the world notably in Africa, South America and Asia, with support from WMO and other partners. Employing climate information in leveraging the decision-making process at different levels in the society, both in exploiting the opportunities and managing the risks, is increasingly being recognized as a crucial factor in sustainable development. Concepts like climate-related risk management are rapidly developing, in which the NMHSs have a critical role to play. The Espoo Statement of 2006, resulting out of a WMO Conference focusing on climate applications, called for an approach driven by the needs and requirements of the users, for which effective partnerships with the decision sectors and development of local capacities are crucial. In the context of the water sector, while climate variability and change play a significant role in water decision making across decadal, seasonal and inter-annual, and day-to-day scales, it is important to note that the water managers focus not on climate variability and change per se, but on the way in which they translate into changes in water availability, quality, regulatory capacity, and demand. It is therefore important to ensure that incorporation of climate information into water resource decisions and improvement of decision making is driven and led by water institutions and agencies, and to promote the use of decision support tools to translate climate variability and change into water aspects. WCASP/CLIPS provide an excellent global framework to build partnerships between the NHMSs and the water sector, and pursue the relevant climate risk management approaches in a complementary manner.

9.3 Arthur Meuleman: *When Climate Change is a Fact: Adaptive Strategies from a Drinking Water Perspective*

In his presentation, Mr Meuleman highlighted on areas where climate change affects sources for dinking water supply:

With more frequent and persistent low flows, there is no dilution of the pollution. The Rhine river discharge in the dry summer 2003 showed a marked increase of heavy metal concentrations that had been a problem for drinking water supply facilities, drawing on direct and bank filtration schemes. Salt water intrusion in coastal areas has already become a stringent problem in the Netherlands:

- Already more than 15 production stations closed because of salt water intrusion & upcoming of brackish groundwater
- 15% of total Dutch drinking water production capacity is endangered
- Economic damage (treatment costs, agriculture)

Increase of treatment performance is already needed for peak loading rates such as for:

- Algae
- Ammonium
- Heavy metals
- Organic contaminants
- Pathogens

The distribution network will also be affected through an increased microbiological stability in distribution network as a result of higher temperatures, chemical corrosion of the distribution network including problems with taste (consumer complaints) and physical damage of the distribution network due to (for example) soil inclination (peat & clay soils) and extreme storm events.

Climate change affects water demands and for the Netherlands an increase in total average water demand in the order of 4-7% is expected, based on Dutch meteorological Institute (KNMI) climate change scenarios. It is also expected that there will be an increase of the number of peak events/demands and a lower water pressure at tap.

In summary, Mr. Meuleman pointed to the following problems in drinking water supply as a result of climate change:

- Increasing water quality problems
- Physical damage due to extreme events and soil inclination
- Temperature increase in sources & distribution network
- Increase in average water demand and extreme water demand events

As the environment is changing, stress is laid on the need to adapt water supply in the future. Adaptive strategies could be based on:

- Balanced permit system, focusing on water quality
- Reducing peak demand: increasing the customer awareness
- Adopting a “Multi Source Strategy”, together with a combination of treatment strategies depending on available sources
- Adaptation of customer perception with regard to the feasibility of a constant water quality at all times and the
- Adoption of a “FlexWater” concept that will allow flexible resources management and treatment, i.e. the use of seasonal available resources & temporary storage to match peak demands and extreme events

10. THEME VII: BRINGING CLIMATE ISSUES IN WATER RESOURCES PLANNING INTO NATIONAL DEVELOPMENT AGENDAS

10.1 Recognizing different development stages of countries including their institutional and technical capabilities but also their vulnerability to impacts of climate variability and change on their water management systems, participants outlined mechanisms and approaches to mainstream water and climate related issues in a national context. In discussing the issue, participants largely agreed to the following views:

10.2 While progress continues to be made in seasonal climate forecasting, the net benefits of using seasonal climate forecasts in water management still have to be better demonstrated. A number of factors are responsible for this situation:

- The inaccessibility of climate information and forecasts, and insufficient advocacy by climate scientists at local to international levels.
- Poor communication between water managers and climate scientists about their perceptions of research priorities and views on knowledge gaps.
- The complexity of the problems faced by water managers and the effects of political and institutional constraints on their decisions.

- Conservatism in the water sector towards funding development of new technologies and applying emerging technologies in practice, and skepticism about the accuracy and value of climate forecasts.
- Water managers have limited training in or experience with climate science.

10.3 These factors re-emphasize the need for regional water managers to share their experiences and commit to long-term dialogue with climate forecasters. Such a dialogue is necessary if climate forecasters are to build a comprehensive and accurate picture of the water managers' information needs, and for water managers to appreciate the scope and depth of recent advances in climate prediction science and the knowledge gaps that remain.

10.4 Some specific reasons why climate information is not yet widely used in water management had been mentioned:

- Lack of suitable information about forecasting uncertainties and error bandwidth;
- Mismatch of forecasting information with regard to requirements for the temporal and spatial resolution of climate information products;
- From the perspective of water managers, there is insufficient documented and demonstrated value of the added benefit of the value of forecasts within the operational framework conditions of water managers rather than from the perspective of climate researchers;

10.5 Eric Sprokkereef: ***Bringing Climate Change Issues in Water Resources Planning into National Development Agendas***

The overall objective is the "climate proofing" of the Netherlands based on evidence of changes, the consideration of the implications of new climate scenarios including their perceived influence on water management. The result of these factors and conclusions has been the development of the ARK program (Adaptation to climate change in spatial planning). Mr. Sprokkereef highlighted that the evidence of climate change as observed in the Netherlands are:

- Strong evidence that most of the global warming observed over the last 50 years is attributable to human activities
- Clear increase of winter precipitation
- Increase of number of extreme wet days in winter
- Moderate increase of dry days in summer
- Increase of min. temperature in winter => reduction of snow cover
- Increased stream flow, mainly in winter, mainly for low and mean flows

The conclusions from the above are that in a changing climate, risks would increase. It is also evident that mitigation measures may not be sufficient to prevent climate change. Therefore, to make a country "climate proof", many adjustments are necessary. Adaptation is important for many sectors but has large consequences for spatial planning, transport and energy supply. It is also clear that not all consequences for society can be avoided and the remaining risks should be minimized and made clear to all parties concerned. To address these issues, the ARK (Adaptation to Climate Change in Spatial Planning) Programme has been launched by the government of The Netherlands. Its main objective is to arrive at a climate proof spatial development of The Netherlands, where water management is an important part of the program. Linked to ARK are complementary activities dedicated to continue with mitigation measures, enhancing the cooperation between Ministries, provinces, water boards, communities, and ensuring input from universities/institutes. Mr Sprokkereef outlined major fields of activities within ARK such as

- Awareness: increase of support among all parties concerned. Working together on a national adaptation strategy.
- Knowledge development: what are the effects of climate change for The Netherlands?
- Measures: What measures should be taken in the short-term and what projects and policy are needed for the long-term?

ARC will be implemented in a phased approach. Phase 1 will include activities related to communication, increase of commitment of local governments, business community and Non Governmental Organizations (NGO's); zero measurement of the climate resistance; quick scan of knowledge gaps; investigation of adaptation options and a cost benefit analysis of long-term problems. Phase 2 comprises of the translation of the strategy into concrete activities and the development of an implementation program. Building on the strategic approach and the implementation plan, phase 3 will then deal with "hot spots" and the development of innovative methods to expand the adaptive abilities of the Netherlands. Despite all knowledge that has been inverted in ARK, there are open questions that need to be addressed to ensure achievement of the objectives of ARK including:

- How to deal with uncertainties? How far do we look into the future?
- 90% of the NL is already constructed and there is the question to renovate/adapt or to move infrastructure;
- Another societal issue is the problem-solving mechanism in the context of governmental action and responsibilities and the abilities/responsibilities of private entities;
- Finally, the costs for climate-proofing carry are immense with an estimate in the order of 20 billion EURO.

11. THEME VIII: PERSPECTIVES ON AN INITIATIVE ON "IMPROVEMENT IN WATER RESOURCES PLANNING AND MANAGEMENT THROUGH THE USE OF CLIMATE INFORMATION

11.1 At this point of the meeting and based on the results of discussions and presentations, experts developed a perspective of an outreach strategy to improve the quality of water management/planning through the use of climate information. Amongst others, key components would be the development of guidance materials to use climate information in water management, the formulation of requirement documents of water managers and for the direction of research and development including the improvement of the scientific basis of climate information for water management, and determining ways to mainstream the use of climate information in water management in the development agenda of countries.

11.2 Avinash Tyagi: *Proposed Outline of a Water and Climate Initiative*

A proposed WMO project designed specifically to create national enabling environments to facilitate the use of climate information in water management activities was prepared prior to the expert meeting. In particular, the proposed project aims to promote research and development as an interface between issues related to climate predictions, variability, and change and the water management sector, including the planning and operation of water resources infrastructure and disaster management. The discussion associated with this proposal appears in section 12 below, and the proposal itself is attached in **Annex 3**.

11.2 Fred Hattermann: *Challenges and Opportunities to Meet Present and Future Climate Information Needs of Water Managers - Setting the Research and Development Agenda*

Mr Hattermann stressed that there are major uncertainties in quantitative projections of changes in hydrological characteristics for a drainage basin, the basic unit of water management.

Precipitation, a principal input signal to water systems is not reliably simulated in present climate models. Uncertainty has two implications. First, adaptation procedures need to be developed, which do not rely on precise projections of changes in river discharge, groundwater, etc. Second, based on the studies done so far, it is difficult to assess, in a reliable way, water-related consequences of climate policies and emission pathways. Research on methods of adaptation in the face of these uncertainties is needed.

Research efforts into water-climate interface are required aiming to improve understanding and estimation, in quantitative terms, of climate change impacts on freshwater resources and their management, and to satisfy information requirements of water managers who are responsible for adaptation.

Among the research issues related to the climate-water interface, where developments are needed are the following:

It is necessary to improve understanding of sources of uncertainty in order to improve credibility of projections, which are strongly scenario and model dependent. Scenarios, which represent unpredictable details of socio-economic futures, have themselves strong inherent uncertainty.

There is a scale mismatch between the large-scale climatic models and the catchment scale, which needs further resolution. Water is managed at the catchment scale and adaptation is local, while global climate models work on large spatial grids.

Improvements in coupling of climate models with the land-use change including vegetation change and anthropogenic activity such as irrigation are necessary.

- Climate change impacts on water quality are poorly understood.
- Relatively few results are available on economic aspects of climate change impacts and adaptation options related to water resources, which is of great practical importance.

Research into human-dimension indicators of climate change impacts on freshwater is in its infancy and a vigorous expansion is necessary especially with regard to

- Impacts of climate change on aquatic ecosystems.
- Detection and attribution of observed changes in freshwater resources, with particular reference to characteristics of extremes is a challenging research priority.

There are challenges and opportunities posed by the advent of probabilistic climate change scenarios for water resource management. Despite its significance, groundwater, soil water and water availability to plants has received little attention for climate change impact assessment.

Water resources management clearly impacts on many other policy areas (e.g. energy projections, nature conservation). Hence there is an opportunity to align adaptation measures across different sectors.

11.3 Peter Letitre: *How can the use of climate information improve water resources planning? A groundwater perspective*

Mr Letitre presented an overview of the objectives and activities of the International Groundwater Resources Assessment centre (IGRAC). The perspectives of groundwater in the light of climate variability and change are: Groundwater as a resource vulnerable to climate change and Groundwater as a buffer resource facilitating coping with climate change. He pointed out that most obvious impact of climate change is on groundwater recharge and on coastal aquifers, where groundwater recharge is strongly influenced by rainfall quantity, intensity and patterns well as temperature–induced changes in snowfall and snowmelt patterns. Raising sea levels cause spatial reduction and deterioration of the water quality of coastal aquifers. He observed that

- Issues of climate variability and change focus largely on surface water, that the same is true for
- Adaptation strategies (disregard of groundwater issues);
- Risks from droughts not well understood;
- Largest vulnerabilities to climate change are in least developed regions especially in arid and semi-arid regions;
- Use of groundwater models is frequently hampered by lack of data
- Sustainability issues of groundwater is overlooked even in most recent programmes

Amongst the identified challenges are:

- Better understanding needed of effects climate variability and change on groundwater and its availability in long term planning;
- More attention to most vulnerable areas;
- Develop strategies to cope with data scarcity (i.e. combination groundwater models with remote sensing);
- Develop and promote adaptation strategies for groundwater (artificial recharge, control of water abstraction);
- Include sustainability assessments in all water related projects;
- Develop new technologies for global monitoring of groundwater.

12. DISCUSSION: DEVELOPMENT OF DEMONSTRATION PROJECTS: REVIEW OF A DRAFT PROPOSAL ON "BRINGING CLIMATE INFORMATION TO WATER MANAGERS"

12.1 On the basis of a project concept document (Annex 3), participants discussed avenues and practical methods to create national enabling environments to facilitate the use of climate information for water managers. The experts specifically recognized the need to promote research and development as an interface between issues related to climate predictions, variability and change and the water management sector. Participants noted the importance to include the planning and operation of water resources infrastructure and disaster management in this process.

12.2 In particular, participants agreed to the objective of the project to:

Create a national enabling environments to facilitate the use of climate information for water managers and to promote research and development as an interface between issues related to climate predictions, variability and change and the water management sector, including the planning and operation of water resources infrastructure and disaster management.

12.3 Participants further agreed on the deliverables and the outreach strategy proposed in the concept document. It was agreed that the project concept should be further refined and would serve as a substantial component of the planned WMO initiative on "Improvement of Water Resources Planning through the Use of Climate Information".

13. DISCUSSION: DEVELOPMENT OF AN AGENDA AND WORKPLAN FOR A WMO INITIATIVE ON "IMPROVEMENT IN WATER RESOURCES PLANNING THROUGH THE USE OF CLIMATE INFORMATION"

13.1 In addition to the project concept referred to above, main components of a work plan were developed by the meeting with the aim to indicate key proposed activities within an appropriate time frame. It was felt that individual institutions and experts need to be identified to take lead of selected activities.

13.2 Based on a training package "Managing Climate Variability and Change in Water Resources" for the then "Dialogue on Water and Climate" project undertaken by the Netherlands, Mr van Schaik provided an entry for the discussion:

13.3 There are many decisions based on climate and weather conditions that need to be made and at various scales. They may be classed into three types of decisions

Strategic decisions would be those linked more to long term climate change over a number of years.

Tactical decisions would be linked more towards medium term forecasts, i.e. the seasonal forecasts of rainfall over a number of months.

Operational decisions are concerned with short term weather forecasts and their implications on day-to-day water resources operations.

Type of Decision	Climate		Weather
	Long Term	Medium Term	Short Term
	Climate Change	Seasonal Forecast	1-7 Day Forecast
Strategic			
Tactical			
Operational			

Figure 4.1 Types of decisions based on climate and weather (Schmidt, 2003)

Translated to the context of the meeting, participants developed an outline of a matrix with exemplary activities under the decision-making scales from strategic to tactical to operational decision-making.

Decision Type	**Climate (10-50 years) Long-term change**	**Climate (6-12 months) Seasonal-decadal**	**Weather (1-7 days) Weekly**
Strategic	Revisit design criteria & standards based on historic information, design flow estimation under non-stationary conditions; development of adaptation strategies, Changes of the hydrological response in basins oriented towards decision support, regulation of water withdrawals and abstractions, water quality issues, transboundary water sharing agreements, Spatial planning, groundwater recharge scenarios,	Drought contingency planning, flood warning & evacuation planning (triggering, tactical and operational activities below),	
Tactical	Review of operating rules towards more robust systems, water allocation schemes (including basin and reservoir storage, defense structures, utilities et al..),	Seasonal climate forecasts (extreme precipitation, temperature..), risk mapping (floods, droughts..), water quality aspects, transboundary water sharing agreements, aspects of irrigated agriculture,	
Operational		Use of products derived from oscillations in seasons & regions where there is high predictive skill,	Storage management (irrigation, hydropower, peak municipal water demands..)
	Supply demand Reservoir safety Reservoir sizing Land management	Operating rules Water orders Water allocations Demand management	Irrigation scheduling Flood warning Demand management

Assumption: Climate and water data bases are available

13.4 Needs derived from the activity matrix:

- Improved observation networks, ensuring that observations are being utilized;
- Identify a specific list of variables including amongst others their accuracy;
- Develop and apply multi-model approaches and downscaling techniques including regionalization;
- Research the role of periodic oscillations such as El Nino and NAO;
- Investigate possible increase in frequency and intensity of extreme events;
- Assess sea level rise and water resources management issues in coastal zones.

14. CONCLUSIONS, FINDINGS, AND RECOMMENDATIONS

14.1 Meeting participants concluded that a communications gap existed between the water management and climate information communities. This gap is not simply associated with a lack of awareness within the two communities of the needs and products of the other. Rather, a significant problem stems from not knowing how to translate the information produced by one community into a form that the other community knows how to utilize. For example, water managers often plan projects using traditional techniques of flood frequency estimation; techniques that depend upon instantaneous peak discharge data as observed at individual stream gauges. Climate models do not produce this type of information and, currently, no procedures exist for translating the relatively coarse spatial and temporal precipitation and runoff data that the models do produce into a form that water managers are accustomed to working with. The need exists, therefore, for expanded dialogue, particularly on technical issues, between both sides.

14.2 The meeting also enumerated a set of concepts, findings, and recommendations that should guide future interactions between the water management and climate information communities. These include:

1. Recognition that both water managers and climate information providers and the water managers benefit from working side-by-side in addressing common issues; in other words, improved planning for and management of water resources can be achieved in the context of Integrated Water Resources Management.

2. General consensus that climate information has high potential value, but that there are still large predictive uncertainties with regard to the kinds of quantitative information that water managers traditionally use. Further work is needed to improve the reliability of climate model predictions at all time scales.

3. Despite these uncertainties, information on climate variability as well as from climate change scenarios is sufficient for developing adaptation strategies and measures.

4. Most immediate opportunities exist at the scale of seasonal climate outlooks, as this type of information is easier for water managers to assimilate at present.

5. Opportunities should be based on temporal synergies, that is, using climate information on different time scales (long-range weather forecasts, seasonal climate outlooks, inter-annual climate variability, and climate change) in conjunction with corresponding operational, tactical, and strategic management functions.

6. There is general agreement that measures and activities should be communicated and planned predominantly at the national level, using the modified conceptual framework provided during the meeting.

7. Operational, tactical and strategic water management issues, as listed in a matrix discussed at the meeting should serve as the entry point for detailed planning of future programme activities.

8. The meeting identified priority areas of necessary investment in climate research that focused on water management information needs.

9. The meeting covered questions of the scientific basis for validating predictive skills of climate models and their utility for water management. This should be one focus of the proposed conceptual framework for follow-up activities.

10. Specific cases from around the globe were shown that demonstrate the usefulness of climate information in different environments related to water management.

11. Water managers do not make routine use of climate predictions. There is no generally agreed upon conceptual framework for the use of climate predictions/scenarios.

12. There is an urgent need for the climate community to quantify uncertainties in climate predictions and for water managers to explore how probabilistic climate products can be utilized more routinely.

13. A project concept and plan for facilitating the use of appropriate climate information by water managers, particularly within developing countries, was developed and is presented in **Annex 3**.

15. OUTREACH ACTION

15.1 The Expert meeting agreed that an initiative on “Water Management and Climate Information” should be launched based on the outcomes of the meeting. This initiative should be lead by WMO in collaboration with appropriate partners including international organizations, NGO’s and – where necessary – private organizations especially in the water management sector. Participants encouraged WMO to prepare plans and activities towards the formulation and eventual implementation of such an initiative.

16. CLOSURE

16.1 The Chair, Mr Lins, noted the importance of the meeting – one of the first tasks of the newly redesigned WCP-Water. Successful completion of this effort will represent a significant WCP-Water contribution to research in general, and to the IPCC in particular. The Chair thanked the hosts at CEH Wallingford and the staff for the excellent facilities and support before and during the meeting.

16.2 Mr Grabs, noted that this effort will put science a step closer to a quantitative assessment of the sensitivity of hydrologic elements to climate and will do much to evolve our understanding of climate and water for the benefit of water management with a climate perspective. He tanked the participants for their contributions to a productive session.

16.3 Mr Tyagi, on behalf of the WMO Secretariat thanked the participants and requested their participation when the WMO “Initiative on Water Management and Climate Information” would enter its detailed planning and implementation stage.

16.4 The meeting closed on 20 December 2003 at 16:30.

ANNEX 1

LIST OF PARTICIPANTS

CANADA

Dr Monirul Mirza
Adaptation and Impacts Research Division (AIRD)
Environment Canada
C/o Centre for Environment
University of Toronto
33 Willcocks Street
TORONTO, ON M5S 3E8

Tel : + (1 416) 978 6201
Fax: + (1 416) 978 3884
e-mail: monirul.mirza@utoronto.ca

CHINA

Dr (Ms) Yuping Yan
Beijing Climate Centre
China Meteorological Administration
46 Zhongguancun Nandajie
100081 BEIJING

Tel : +86 10 68400091
Fax : +86 10 68400097
e-mail: yanyp@cma.gov.cn

ECUADOR

Mr José Luis Camacho Ruiz
International Director
CIIFEN
Fundacion El Universo
Escobedo 1204 y 9 de Octubre
GUAYAQUIL

Tel : (593) 4 251 4770
Fax: (593) 4 251 4771
e-mail : j.camacho@ciifen-int.org

FINLAND

Mr Esko Kuusisto
Hydrologist
Finnish Environment Institute
P.O.Box 140
00251 HELSINKI

Tel: +(358 9) 40300566
Fax: +(358 9) 40300590
Mobile: +(358 40) 8319165
E-mail: esko.kuusisto@ymparisto.fi

FRANCE

Mr Jean-Pierre Ceron
DClim/DAE, Meteo-France
42, av. G. Coriolis
31057 TOULOUSE cedex1

Tel : + (33) 561 078310
Fax: + (33) 561 07 83 09
e-mail: Jean-Pierre.Ceron@meteo.fr

GERMANY

Dr Fred F. Hattermann
Potsdam Institute for Climate Impact Research
(PIK) Telegrafenberg A51
PO box: 60 12 03
D-14412 POTSDAM

Tel.: +49 (0)331 288 2649
Fax : 0049 (0)331 288 2695
e-mail: hattermann@PIK-Potsdam.de

KENYA

Dr Alfred Opere
IGAD Climate Prediction and Applications Centre
P.O. Box 10304-00100
NAIROBI

Tel: + (254) 20 387 83 40
Fax: + (254) 20 387 83 43
e-mail: aopere@uonbi.ac.ke

NETHERLANDS

Mr Peter C. Letitre
IGRAC
Princetonlaan 6
P.O. Box 80015
3508 TA UTRECHT

Tel : + (31) 30 256 48 13
Fax: + (31) 30 256 47 55
e-mail: peter.letitre@tno.nl

Mr Arthur Meuleman
Manager Department of Water Systems
Kiwa Water Research
P.O. Box 1072
3430 BB NIEUWEGEIN

Tel: +(31) 6 51602241
e-mail: Arthur.Meuleman@kiwa.nl

Mr Eric Sprokkereef
Rijkswaterstaat – RIZA
Postbus 9072
6800 ED ARNHEM

Tel: + (31 26) 3688367
Fax: + (31 26) 3688678
e-mail: e.sprokkereef@riza.rws.minvenw.nl

Mr H. Van Schaik
Director
Cooperative Programme on Water and Climate
PO Box 3015
2601 DA DELFT

Tel: + (31) 15 215 1882
Fax: + (31) 15 212 1676
e-mail: hvs@ihe.nl

Mr Gertjan Zwolsman
Kiwa Water Resources
Postbus 1072
3430 BB NIEUWEGEIN

Tel: + (31 30) 60 69 542
e-mail: gertjan.zwolsman@kiwa.nl

NEW ZEALAND

Mr Charles Pearson
Regional Manager
National Institute of Water &
Atmospheric Research Ltd (NIWA)
PO Box 8602,
CHRISTCHURCH

Tel +64 3 343 7871
Fax +64 3 348 5548
Email c.pearson@niwa.co.nz

SWEDEN

Mr Michael Moore
Project Officer
Stockholm International Water Institute, SIWI
Drottninggatan 33
SE-111 51 STOCKHOLM

Phone: +46 8 522 139 83
Fax: +46 8 522 139 61
Mobile: +46 73 914 3983
Email: michael.moore@siwi.org
http://www.siwi.org

UNITED STATES OF AMERICA

Mr Harry Lins
US Geological Survey
415 National Center
Reston, Virginia

Tel: (1 703) 648 5712
Fax: (1 703) 648 5722
e-mail: hlins@usgs.gov

Mr Simon Mason
IRI, The Earth Institute of Columbia University
61 Route 9W
Palisades
New York 10964-8000

Tel: + (1) 845 680 4514
Fax: + (1) 845 680 4865
e-mail: simon@iri.columbia.edu

Mr Eugene Z. Stakhiv
US Co-Director
IJC Upper Lakes Study
Institute for Water Resources
7701 Telegraph Road
Alexandria, VA 22315-3868

Tel: (1 703) 428 8077
Fax: (1 703) 428 6686
e-mail: Eugene.Z.Stakhiv@iwr01.usace.army.mil

Mr Mark Svendsen
P.O. Box 1389
PHILOMATH, OR 97370

Tel: + (1 541) 929 4855
Fax: + (1 541) 929 4855
e-mail: msvendsen@peak.org
e-mail: marksvendsen@aol.com

EUROPEAN COMMISSION

Ms Marta Moren Abat
Environment and Climate System Unit
Directorate Environment, DG Research
European Commission
CDMA, 3/130
1049 BRUSSELS

Tel: (32 2) 29 66227
Fax: (32 2) 299 5755
e-mail: marta.moren-abat@ec.europa.eu

EUROPEAN ENVIRONMENT AGENCY

Mr Niels Thyssen
Project Manager Water and Biodiversity
European Environment Agency
Kongens Nytorv 6
1050 COPENHAGEN K
Denmark

Tel: + (45) 33367156
Fax: + (45) 333672725
e-mail: niels.thyssen@eea.europa.eu

UNESCO

Mr Siegfried Demuth
Division of Water Sciences
UNESCO
1, rue Miollis
75732 PARIS CEDEX 15
France

Tel: + (33) 1 45 68 39 94
Fax: + (33) 1 45 68 58 11
e-mail: s.demuth@unesco.org

WMO

Mr Avinash Tyagi
Director, Hydrology & Water Resources
Department
World Meteorological Organization (WMO)
Case postale No. 2300
7 bis avenue de la Paix
CH - 1211 Genève 2
Switzerland

Tel: + (41) 22 730 83 55
Fax: + (41) 22 730 8043
e-mail: atyagi@wmo.int

Mr Wolfgang Grabs
Chief, Water Resources Division
Hydrology & Water Resources Department
World Meteorological Organization (WMO)

Tel: + (41) 22 730 8358
Fax: + (41) 22 730 8043
e-mail: wgrabs@wmo.int

Mrs A. Henderson-Sellers
Director, World Climate Research Programme
World Climate Research Programme Department
World Meteorological Organization (WMO)

Tel: + (41) 22 730 8246
Fax: + (41) 22 730 8036
e-mail: ahenderson-sellers@wmo.int

Mr Rupar Kumar Kolli
World Climate Programme Department
World Meteorological Organization (WMO)

Tel: + (41) 22 730 8377
Fax: + (41) 22 730 8042
e-mail: rkolli@wmo.int

ANNEX 2

Agenda

Monday 18 December

09:00 – 09:30 Registration

09:30 Opening session - *The Expert Meeting will be opened by a representative of Senior Management of WMO*

09:45 Adoption of the Agenda and introduction of participants

10:00 Background to the meeting and expected outcomes
H. Lins, Objectives and deliverables of the World Climate Programme – Water (WCP-Water)
W. Grabs, Objectives and expected outcomes of the Expert Meeting

10:30 Coffee Break

10:50 <u>Theme</u> 1: Current practices in water resources planning
Expected presentations from: E. Stakhiv, K. Addo, G. Zwolsman , M. Svendson

12:30 Lunch

13:45 <u>Theme</u> 2: Present-day provision of climate information in the areas of climate outlooks, variability and change
Expected presentations from: J. Cerron, J. Camacho, A. Opere

14:45 <u>Theme</u> 3: Reliability and uncertainties inherent in climate information products
Expected presentations from: S. Mason, Y. Yan

15:30 Coffee Break

16:00 <u>Theme</u> 4: Resilience and adaptation capacity of current water management practices in the light of climate variability and change
Expected presentations from: M. Mirza, C. Pearson

16:45 Chairperson's summary of the day and conclusions

17:15 Meeting adjourns

17:30 Cocktail Reception

Tuesday 19 December

09:00 <u>Theme</u> 5: Defining the needs of water managers for climate information in water resources planning
Expected presentations from: H. Schaik, E. Kuusisto

10:00 Coffee Break

10:30 Theme 6: Challenges and opportunities to meet present and future climate information needs of water managers - Setting the research and development agenda
Expected presentation from: M. Abat.

12:00 Lunch

13:30 Round-table discussions: How can the use of climate information improve the quality of water resources planning?
Expected presentations from: R. Kolli, C. Letitre

14:30 Coffee Break

15:00 Theme 7: Bringing climate issues in water resources planning into national development agendas
Expected presentation from: E. Sprokkereef

16:00 Chairperson's summary of the day and conclusions

16:30 Meeting adjourns

Wednesday 20 December

09:00 Theme 8: Perspectives of an initiative on "Improvement in Water Resources Planning and Management through the Use of Climate Information"
Expected presentations from: F. Hattermann, A. Tyagi,

10:15 Coffee Break

10:45 Discussion on the development of demonstration projects; review of a draft proposal on "Bringing Climate Information to Water Managers"

11:30 Development of an agenda and workplan for a WMO Initiative on "Improvement in water resources planning through the use of climate information"

12:15 Lunch

14:00 Conclusions and recommendations

14:30 Writing teams convene to prepare a first concept of the Initiative based on the discussions and conclusions

16:30 Closure of the meeting

ANNEX 3

Bringing Climate Information to Water Managers
- Project Concept -

1. Introduction

Prevailing and anticipated changes in climate conditions as a result of interannual and seasonal change as well as projected changes of the climate system are a major factor influencing planning, operation and management of water resources. For the sustainable management of water resources, it is therefore important to develop a framework for managing hydrometeorological risks by facilitating the use of key climate and meteorological information to support water management activities and provide an insight to the profound understanding of climatological issues on hydrological processes.

Bringing climate information to water managers is essential for the sustainable development of water resources within the development agenda of countries. The scientific evidence about impacts of increasing climate variability on the water sector needs to be clearly demonstrated through multi-disciplinary research supported by the study of impacts of and vulnerabilities to climate change on various sectors related to water such as drinking water, irrigation, hydropower, agriculture, food, health, ecosystems and disasters.

2. Climate variability and change

According to the IPCC Third Assessment a warming climate and therefore higher atmospheric moisture content with a resulting high latent energy in the atmosphere, could increase the flood frequency and magnitude in many parts of the world. At the same time higher temperatures would also mean change in the demand patterns thereby influencing the water management decisions.

The effect of climate change on stream flow and groundwater recharge though complex to predict, will largely follow projected regional changes in precipitation. Further, the changes in temperature will affect the temporal distribution of stream flows due to accelerated snowmelt and shrinking of glaciers. Many of the largest rivers of the world originate in high mountain areas that have been termed the water towers of the world due to their seasonal or perennial cover with vast snowfields and glaciers. Snow and glaciers are highly sensitive even to small changes in climate and worldwide there is an alarming trend in the reduction of glaciers in virtually all-high mountain environments. Snow and glacier melt augment to a large part the lean flow of rivers. It will also impact the water consumption trends as well as redistribution of surface and groundwater both temporally as well as spatially.

A better understanding of climate change impacts on water resources and their availability is crucial to its long-term planning. In consideration of climate change and its potential effects on societies, it is critical that water governance decisions strive to reduce this vulnerability particularly in developing countries so that they can achieve sustainable development. At the same time the variability of climate both in time and space is on the rise. The past trends are no more an indicator of the future realities.

3. Climate change and water management

Recognizing that climate change is happening now, and that adaptation action will be required to priority has to be given to identifying where careful and targeted action and investment across governments, industry and communities is needed as an insurance against the future water related risks. National Hydrological Services' roles in adaptation include:

- generating information about likely climate change as a basis for planning by all stakeholders;
- reviewing codes, standards and planning schemes to ensure that these facilitate adaptation.

Inherently, current engineering design practices rely on historical time series of observations assuming them to be representative of the future trends with unchanged overall statistical parameters. Design practices overlook the likely possibility that under a changing climate these trends, which are not necessarily linear, are difficult to account for. However, the accuracy of information required by water managers, i.e. operator of irrigation schemes or reservoirs can at present not be provided, one reason being the still insufficient reliability of downscaling results from global circulation models to a scale that matters to local water managers.

Many water managers prefer not to use climate change information since the water management decision process is complex enough – climate information is an important but only one of many factors to be considered in a decision process. Further, the uncertainty associated with climate change predictions puts the question mark on the desirability of factoring it in decision-making. Sometimes these reasons may include non-availability or accessibility of the data, lack of confidence in the new products that are either too difficult to interpret and use or are too uncertain.

4. Justification for project intervention

The largest vulnerabilities arising from climate variability and change are likely to occur in unmanaged water systems and systems under stress such as most water resources systems in the arid and especially semi-arid zones. Poorly managed water resources systems are also amongst those that are likely to be adversely affected by climate variability and change. Developing countries with insufficient coping mechanisms and resources are highly vulnerable to climate change impacts on water resources. Limited efforts to address this situation are to a significant part associated with a knowledge and communication gap between climatologists and water managers that in effect prevents an exchange of know-how and application of available knowledge to improve water resources management under changing conditions. Under this condition and based on information requirements by water managers, it is a challenge to transfer the state of the art knowledge in the field of climatology to water managers in a format that is practical and usable.

Additional constraints in this respect are the generally insufficient resources for research and development in competition with other pressing needs that makes it difficult especially for developing countries to set up multi-disciplinary teams to collaborate in issues related to water and climate. This would require effective coordination mechanisms between various institutions including ministries and line departments. Such efforts do not take off for want of a clear understanding of the role of various disciplines such as hydrology, meteorology, climatology, development policy and economics in the processes involved in the assessments. The initial inertia in identifying a National Team of Experts (NTE) from various disciplines is most of the time responsible for the half hearted attempt at the subject and makes the water manager take a defensive stance with respect to use of climate information and climate change issues. More often than not the water managers are not fully aware of the likely magnitude of the impacts and the availability of outputs from the climate models and likewise, the climate community is insufficiently aware of the information requirements of water managers. In this situation, a project concept is presented to address this issue.

5. Objective of the project

In a 3-year project, WMO aims at bringing down these barriers by facilitating the transfer of know-how and technology and promoting research and development through partnerships and capacity building, particularly in developing countries. The project objective is therefore

to create national enabling environments to facilitate the use of climate information for water managers and to promote research and development as an interface between issues related to climate predictions, variability and change and the water management sector, including the planning and operation of water resources infrastructure and disaster management.

Developing countries will be supported in their efforts in carrying out scientific studies to assess the climate impacts on water resources by establishing multi-disciplinary research projects and facilitate financial support by developing partnership. The initiative in the long run will help countries in the use of climate predictions and the developing capacity to provide best effort projections of the potential impact of climate variability and change in on water resources in the context of national development agendas. These assessments will help water managers in incorporating the results in improved water resources planning, management and operations and to develop adaptive measures and policy options in the light of climate variability and change.

6. Expected Outputs

The principal expected output of the project is the institutionalized establishment of a national platform to integrate best available science and technologies in water and climate related fields to improve water management in its various aspects. In particular, the following results will be achieved:

- Establishment of national platforms (national teams of experts) to initiate and actually conduct cross-sectoral exchange of know-how and technologies,
- Utilization of climate information for the operation and management of water infrastructure more efficiently,
- National assessment of climate change impacts on water resources, and
- Development of various adaptation strategies.

7. Project approach

It is proposed to implement the project on the scale of pilot or demonstration projects in five developing countries of various environmental and socio-economic settings. The approach, although country-specific, would be developed in a generic manner that will enable the replication of the generic approach to other countries after a post-project assessment of the results achieved in the proposed project.

The pilot projects would help in:

- Raising awareness and stimulate discussions in the water community on climate issues,
- Determination of climate information requirements of water managers,
- Assessment of climate information capabilities to improve water resources planning and management,

- Setting up a multi-disciplinary National Team of Experts (NTE) as national platform to coordinate and initiate research, development and applications aspects of climate predictions, variability and change and to take up studies on the impact of climate on water management,
- Facilitating development of appropriate linkages with the international research community,
- Developing a medium and long-term program for such activities in the country,
- Developing decision-support systems and
- Putting in place response strategies to adapt to long-term climate change on water resources planning.

8. Outreach strategy

Based on the outcomes of the pilot projects, further guidance would be developed for other countries to take up such activities to replicate the achievements gained in the pilot projects. A platform for the exchange of information would be created to continue such activities in future under different administrative and funding arrangements. It is proposed to develop guidance material for using climate information for Water Management. The guidance material should include the following:

1. Use of seasonal climate outlooks in hydrological forecasting
2. Suitability of available hydrological models required for assessing different impacts.
3. Types of impacts of likely climate variability and change on water resources availability both temporally as well as spatially.
4. Technical approach and methodology adopted to quantify these impacts.
5. Establishment of data and information requirements to effectively utilize climate information in water management including scientific analysis of data to detect climate change signals relevant for water management.
6. Needs and processes for downscaling the regional climate models (possible areas of research which a team may have to take up within the country: with or without the international help).
7. Coupling of climate models and hydrologic models.
8. Review of best practices adopted through out the world for management of climate variability and change in water management
9. Assessment of climate change implications in design, planning and operation of water resources management systems

9. Project implementation and management

National Team of Experts, consisting of experts from various related disciplines and institutions would be set up. One developed country as a Partner Country would be requested to contribute through a national centre of excellence or an otherwise acknowledged institution with experience in carrying out such activities in the country. The contributing institution or a nominated expert would provide guidance to the NTE. The inaugural national workshop with participation from NTEs and other users and planners would kick-start the project in the countries selected for the project. The workshop would lay down the framework of activities to be undertaken by the NTE members under the supervision of identified experts from the Partner Country. Yearly workshops would be organized in the country to review the progress of the studies and exchange experiences. Some of the NTEs would be invited to visit the Partner Country to get first hand experience and would also be supported to attend international conference/ meetings on the subject for better and wider exposure. Provision would be made for some of the hardware and software needs of the NTE.

WMO with its unique position of working with both the climate scientific community as well as water managers through the expertise developed in its World Climate Programme (WCP), the Hydrology and Water Resources Programme (HWRP) and through its WCP-Water Steering Committee would provide multi-stakeholder oversight to the project. Overall guidance would be provided by the WMO Commission for Hydrology with support from the WMO Commission on Climatology. Both Commissions are in a prominent position to contribute with expert advice including with experts from its member countries. Through the establishment of a Project Coordination Group, the WMO Secretariat would coordinate the activities undertaken the project. The Working Group of International Commission for Irrigation and Drainage (ICID) on Climate Change, through its National Committees would be collaborating in such a project from users perspective. A first progress report on the take off of the project could be presented at the 3rd Water and Climate Conference in August 2007.

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