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EDITORIAL

IPCC's 4th Assessment Report did not only boost public concern about climate –change, but also triggered a tremendously growing interest in water issues. From a global water system perspective this is all very obvious, as water is the key medium through which climate change unfolds its impacts on humans and nature. Adapting to climate change is closely related to water and a new thinking is needed that goes beyond simplistic adaptation to strengthen the adaptive capabilities of societies to cope with increasing dynamics of the global water system. We therefore invited Petra Döll to summarise the water messages of the IPCC report for this issue's lead article. Right now, the 'Biggest Water Festival on Earth', the Expo 2008 is being held in Zaragoza, Spain, drawing the world's attention to water and sustainable development. In this issue we report on one out of the countless events that is dealing with climate change and extreme events. As a timely response to this growing interest in global water issues, GWSP reached a mileston: In February 2008 the IPO launched the GWSP Digital Water Atlas providing a comprehensive set of currently more than 50 datasets and maps describing the global water system. Up to now we counted more than 35.000 visitors. Other articles and reports document the diverse range of activities going on in GWSP. We hope that these will motivate you all to get involved in our exciting field of research!

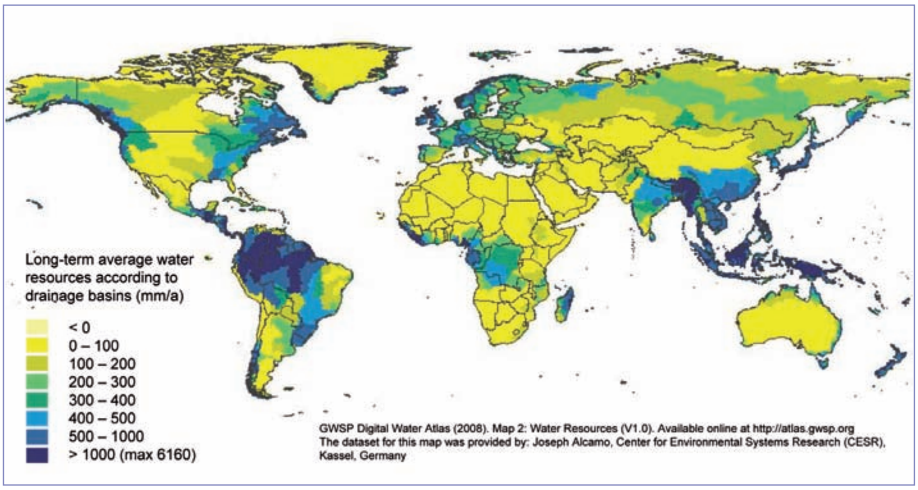
Daniel Petry
Science Officer,
International Project Office (IPO)

A GLOBAL AND INTERDISCIPLINARY VIEW ON THE EARTH'S WATER SYSTEM: GWSP DIGITAL WATER ATLAS GOES ONLINE

In February 2008 the GWSP IPO launched the Digital Water Atlas which provides at http://atlas.gwsp.org online access to over 50 annotated maps and datasets describing the Global Water System. This major activity was lead by Marcel Endejan, GWSP's former Deputy Executive Officer, who developed the atlas with contributions from many different research groups within the GWSP network.

Driven by the key overarching question of how human actions change the Global Water System and what the environmental and socio-economic feedbacks are that arise from these changes in the Global Water System, the Digital Water Atlas was developed as a first step to answering it. Unlike water-related atlases that are already available, the GWSP Atlas' focus is on clarifying the inter-linkages of the elements and changes in the state of the Global Water System by creating a consistent set of annotated maps. It also takes into account the effects of global change and looks at different time

Figure 1. *Water resources available in the world's river basins. One example for the range of topics covered by the GWSP Digital Water Atlas.*



scales including future scenarios of the Global Water System. A multi- and inter-disciplinary approach is taken by using indicators from various scientific disciplines, including hydrology, biology, biogeochemistry, ecology, and sociology.

The Atlas focuses on maps with global coverage. More detailed information may be provided for hot spot regions and for results of regional case studies in the next phase of the project. Comparing regional case studies results with global analysis is part of the quality control. The documentation of the maps also includes information about the datasets used to prepare the maps – the so-called metadata. The maps of the Atlas are not only based on simulation models but also on statistics and measurements such as remote sensing. Mapping the accuracies and uncertainties associated with maps will eventually improve the quality and applicability of the information provided by the Atlas. Besides, the process of building consensus on the mapped indicators and the interpretation of maps will stimulate further discussion among different scientific disciplines.

The IPO is coordinating the project, hosts the infrastructure and is responsible for the development and maintenance of the Digital Water Atlas. The datasets for preparing the maps and the map descriptions are provided by members of the GWSP community. The Digital Water Atlas is the first part of a more comprehensive Information System on global water issues. The development of the Atlas is linked with the 'Global Water System Lexicon', which is another GWSP activity led by the International Project Office, and the development of a conceptual framework of the Global Water System. Within the first 4 months of its existence the atlas attracted more than 30.000 visitors.

How to get involved

The content of the Digital Water Atlas is available online at http://atlas.gwsp.org with free and open access. Registered users can not only download maps, but also the individual datasets. The GWSP Digital Water Atlas is a community driven project. If you wish to comment on maps and datasets provided through the Atlas, see any other maps included, or wish to provide additional global maps and datasets please contact the GWSP: gwsp.ipo@uni-bonn.de

Marcel Endejan *was GWSP's Deputy Executive Officer until March 2008. His new affiliation is as a Consultant with Logica Germany, Team GEO IT & Management.*

CLIMATE CHANGE AND FRESHWATER RESOURCES: LESSONS FROM IPCC'S FOURTH ASSESSMENT REPORT (AR4)

In April 2008, the IPCC Technical Paper on Climate and Water (TP) was approved by the IPPC Bureau. The TP brings together all the knowledge about the relation of climate change and freshwater resources that is scattered among and within the three books which make up the AR4: on the physical science basis of climate change (Working Group I), on impacts, adaptation and vulnerability (WG II), and on mitigation (WGIII). From WGII, for example, information was not only drawn from the "freshwater chapter", but also from other sectoral chapters like the chapter on health impacts, and the regional chapters. While AR4 was developed between 2004 and early 2007 by reviewing and synthesising scientific literature that was published mainly after 2001, the TP was written in the following year based only on the literature already considered in the AR4. In my opinion, the TP has achieved to be a compendium of the relation between climate and water.

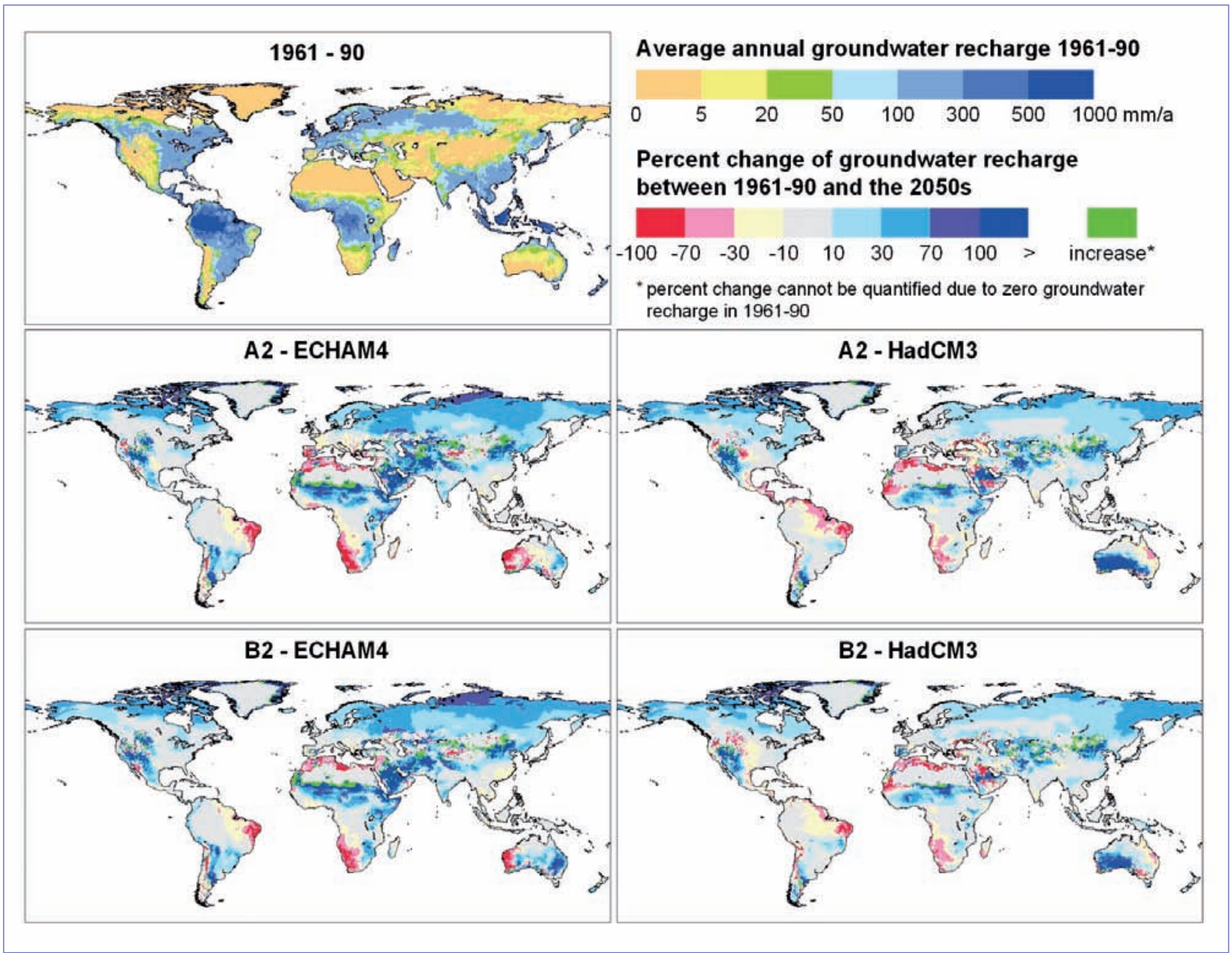
The most important conclusions of the IPCC with respect to climate and water can be found in the executive summaries of the TP and the freshwater chapter of the AR4 WGII report, which are both available at http://www.ipcc.ch, and in Kundzewicz *et al.* (2008). Many of those conclusions have been widely published in the media. Here, I will only present my personal selection of the most pertinent information that is now available.

Mean precipitation and renewable water resources

Considering the advances in knowledge about the impacts of climate change on freshwater since the Third Assessment Report of the IPCC in 2001, the improved characterisation of the uncertainty of projected precipitation changes stands out. It was made possible by ensemble predictions that are based on about 15 different climate models (or model runs). Even when looking at precipitation change over a period of 100 years, until the end of the 21st century, there are only very few land areas where the magnitude of the changes of the multi-model ensemble mean exceeds the inter-model standard deviation: The Arctic and Northern Asia with increasing precipitation, and the Mediterranean region with decreasing precipitation (figure 2.8 of TP). On most land areas, less than 80% of the climate models agree on the same direction of change (increase of decrease) in annual precipitation, soil moisture and runoff (figure 2.9 of TP).

The multi-model ensembles allow to conclude that increases of precipitation and renewable water resources throughout the 21st century are very likely in high latitudes and parts of the tropics, while decreases in some subtropical and lower mid-latitude regions are likely. Many semi-arid and arid areas (e.g. the Mediterranean basin, western USA and Mexico, southern Africa and north-eastern Bra-

Figure 1: *Impact of climate change on long-term average annual diffuse groundwater recharge. Percent changes of 30-year averages groundwater recharge between 1961–1990 and the 2050s (2041–2070), as computed by the WaterGAP Global Hydrology Model by applying four different climate change scenarios (climate scenarios computed by the climate models ECHAM4 and HadCM3, each interpreting the two IPCC greenhouse gas emissions scenarios A2 and B2) (Döll and Flörke, 2005).*



zil), which are particularly vulnerable to climate change, are projected to suffer from decreasing water resources due to climate change. While increased annual runoff, predicted for many regions of the globe, potentially leads to increased water availability, this will not always be beneficial. While annual runoff is increased, this may still be associated with decreased water availability during the dry season or lead to a water table rise that is problematic in urban and agricultural areas and can mobilise salt.

Variability of climate and terrestrial water flows

While even the sign of precipitation change is highly uncertain for most areas, the climate models do agree in predicting an increasing variability of temperature and precipitation. This is consistent with observed trends since the 1960s. Heavy precipitation events are very likely to occur more often almost everywhere, even in areas with lower mean precipitation. The higher the greenhouse gas emissions, the more variable precipitation becomes. The proportion of land surface under drought conditions at any one time is likely to increase, in addition to a tendency for drying in continental interiors during summers (outside high latitudes). More extreme events including heavy rainfalls, floods and droughts, together with higher water temperatures, are likely to exacerbate many forms of water pollution. As an example, pathogen transport will be accelerated by more heavy rainfalls, with negative effects in developing countries in particular.

Due to the temperature increases, less precipitation will be stored as snow (or ice in glaciers), which reduces water availability in surface waters by reductions in summer low flows. This has already been observed in the past. Glacier melting will lead to an increase in river discharge only for a restricted period of time (approximately a few decades, depending on glacier size and other factors).

Groundwater

The increased variability and thus decreased reliability of surface water flows that is caused by climate change will, in general, make the use of groundwater even more attractive than today. Groundwater is not only protected from pollution much better than surface water, the large natural storage capacity of aquifers allows constant water withdrawals even in the dry season and in dry years. It will, however, not be possible to increase reliance on groundwater in all regions of the globe. Only 30% of the continental areas are underlain by relatively homogeneous aquifers (www.whymap.org), and some aquifers are already pumped in an unsustainable manner. In coastal areas, in particular islands, groundwater resources will be diminished significantly by salt water intrusion that is caused by sea level rise if the land surface is less than 5 m, approximately, above sea level (Kundzewicz and Döll, submitted). Besides, where total water resources decline, renewable groundwater resources, which are only a fraction of the total renewable water resources which are equal to the long-term average of groundwater recharge, will decline, too. In those semi-arid regions where a strong reduction of total water resources is projected, groundwater recharge is projected to decline by more than 30% or even 70% (red colours in figure 1). Using the WaterGAP Global Hydrology Model (WGHM), which has been specifically tuned for groundwater recharge in semi-arid regions (Döll and Fiedler, 2008), Döll and Flörke (2005) computed that in semi-arid areas with decreasing groundwater recharge, the percentage decrease of groundwater recharge is higher than the percentage decrease of total runoff, which is due to the model assumption that recharge only occurs if daily precipitation exceeds a certain threshold.

These model-based projections, like all hydrological climate change impact studies, are highly uncertain. First, the climate input as computed by climate models is uncertain. Second, the projected increased variability of precipitation is not taken into account by impact models like WGHM. This is caused by the low skill of climate models in computing precipitation, so that precipitation calculated by climate models cannot be used as direct input to models which aim to represent (current) water resources and flows in a plausible manner. Up to now, changes in long-term average monthly precipitation as computed by climate models are generally used to scale observed monthly precipitation, and there is not yet an established method to represent increased variability of daily precipitation. More intense precipitation may lead to increased groundwater recharge in semi-arid areas where only high-intensity rainfalls are able to infiltrate fast enough before evapotranspirating, and where alluvial aquifers are mainly charged during floods. In humid areas, more intense precipitation may lead to decreased groundwater recharge as the infiltration capacity of the soil will be exceeded more often.

Freshwater-related costs of climate change, adaptation and mitigation

AR4 and TP conclude that the negative impacts of future climate change on freshwater systems are expected to outweigh the benefits. However, very little work has been done to support any monetarisation of the costs of climate change with respect to freshwater. The most important adaptation strategy to climate change, given the large uncertainties with respect to quantifying specific hydrological changes, is to lower the stress on freshwater systems by decreasing human water use, water pollution and structural modifications of surface waters, at least in my opinion. Mitigation of climate change reduces adaptation needs, but negative effects of certain mitigation measures (e.g. afforestation, hydropower and bio-energy crops) on freshwater systems need to be carefully considered.

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Petra Döll *is Professor of Hydrology at the University of Frankfurt am Main, Germany. She is lead author of both the freshwater chapter of IPCC AR4 Working Group II report and the IPCC Technical Paper on Climate and Water.*

OUR FRESHWATER UNDER THREAT – VULNERABILITY OF WATER RESOURCES TO ENVIRONMENTAL CHANGE IN AFRICA

Introduction

This article summarises the results of a rapid assessment of vulnerability of water resources to environmental change in major river and lake basins in Africa. The detailed assessment results will however be published in "Our Freshwater Under Threat – Vulnerability of Water Resources to Environmental Change" volume by UNEP-DEWA and START-Africa. This summary provides the status of water resources across all of Africa, touching on multiple dimensions of the complex issues (southern, eastern, central, western, and northern Africa) and the Western Indian Ocean Island States) and of major river, lake and groundwater basins (figure 2). The assessments were carried out by sub-regional groups of African researchers under the leadership of Prof. Eric O. Odada of START-Africa, using natural (physiographic), anthropogenic (socio-economic) and management criteria.

Key Messages

Water Availability

Africa's extreme variability of rainfall in time and space is reflected by an uneven distribution of surface and groundwater resources – from areas of severe aridity with limited freshwater resources like the northern and southern parts to the tropical belt of mid-Africa with abundant resources. The high temporal and spatial rainfall variability has repeatedly led to extreme climatic events (drought and floods) that pose a continuous risk to Africa's people and their livelihoods and itsj national economies. Global change scenarios predict an increasing frequency of drought and flooding, thus increasing the vulnerability of Africa's water resources.

Southern Africa: has experienced floods in the northern and southern parts and episodes of severe and prolonged droughts in other places. It is among the few regions in the world for which most global climate models agree upon increase in aridity in the future and hence a further lowering of the water availability for livelihoods. Countries have to prepare better for the increased magnitude, duration and impacts of floods and droughts.

Western Indian Ocean Islands: global warming, in the worst case scenario, is expected to cause a 1m sea-level rise by 2100 which would have dire consequences: loss of coastal land, agricultural opportunities, groundwater resources (due to salinisation), and loss of biodiversity critical to community support and livelihoods. The social impact of a sea-level rise will cause displacement of people, water-related diseases and water-supply problems.

Eastern Africa: general moisture circulation models predict an increase in rainfall of up to 20%, a change in seasonal distribution of rainfall and an increase in air temperature of up to 5 °C for this century and there are also indications of increasing frequency and intensity of droughts.

Central Africa: is characterised by an abundance of freshwater resources, except for the northern parts where in the past three decades there was a decline in rainfall (shrinkage of Lake Chad). The demand for water is rising, but it is unlikely that the region's freshwater availability will be affected much in the coming years. Pollution of the water resources is a major issue that needs special attention.

Western Africa: climate change is expected to bring about reduced rainfall and increased evaporation in the areas to the north, thus advancing the rate of desertification in the Sahel.

Northern Africa: is the most water-stressed subregion of Africa and freshwater availability will become an even more important issue in the coming decades. Climate change scenarios for western Maghreb predict a rise in temperature of up to 4 °C this century accompanied

Figure 2: *(a) Major river and lake basins (Transboundary Freshwater Dispute Database, 2000); (b) Major groundwater basins (WHYMAP, 2005 BGR/UNESCO).*

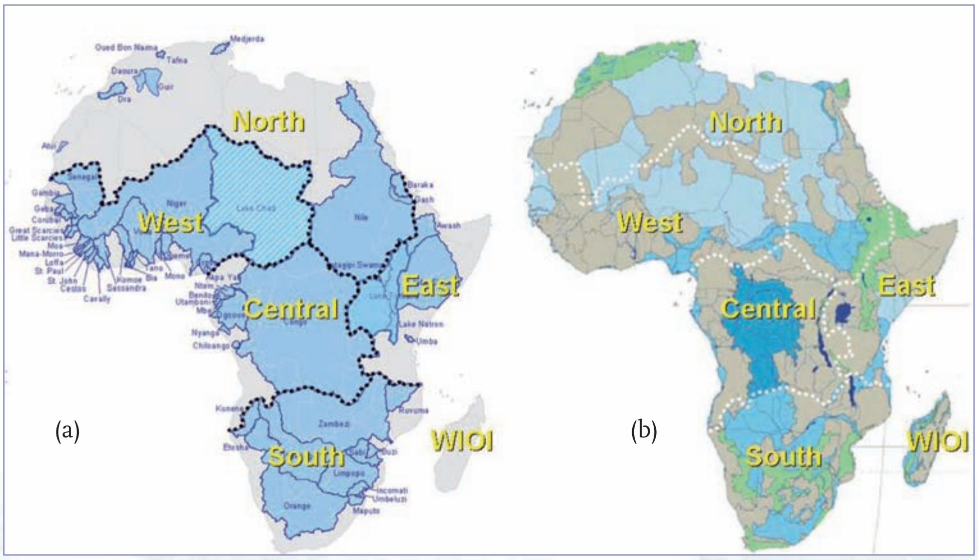
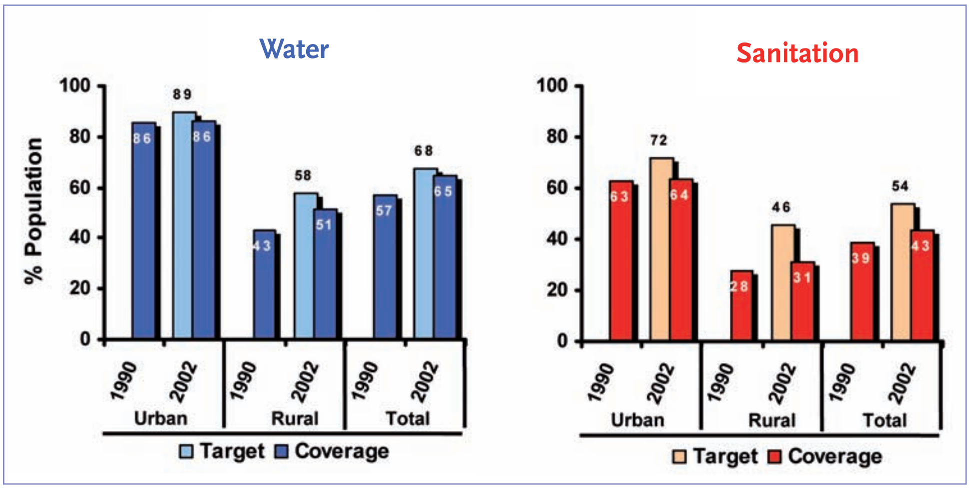


Figure 3: *Water-supply coverage in rural and urban settings between 1990 and 2002 for Africa. Source: WHO/UNICEF 2004.*



by a reduction in rainfall of up to 20%. This would result in decreased soil moisture and reduced surface and groundwater resources. Salinisation of soils, which threatens food production, is already a concern in irrigated areas, especially along the river Nile, and may worsen. Another concern is seawater intrusion resulting from over-exploitation of groundwater resources in coastal areas, where the main urban centres are located.

Development Pressures

Population growth, urbanisation and economic growth in general, all exert pressure on water resources through increased demand and pollution.

Safe drinking water and sanitation

Only 51% of the rural areas in Africa were covered by water supply in 2002 whereas the coverage for urban areas was 86% (figure 3). Analysis of water supply data of the region reveals that despite the progress in the coverage for drinking water between 1990 and 2002 (see figure 3 below) the improvement still falls short of the progress needed to achieve the MDG target of 75% coverage by 2015. Regarding the MDG sanitation target the situation is critical and progress should be accelerated. Northern Africa is almost on track in meeting both targets although it is the most water stressed sub-region.

Obstacles to accelerating the rate of progress towards the MDG targets in all sub-regions with the exception of northern Africa include political instability, high rates of population growth, poor governance, dwindling or diminishing budgetary allocations and subsequent increased demand from the agricultural and domestic sectors and low priority given to water and sanitation in terms of investment in infrastructure and maintenance.

Food security

Currently, huge crop failures, arising from droughts and flooding, are being experienced more frequently now than ever before in Africa, causing famines and economic hardships to families and communities. Insufficient national government investment and operational funds for irrigation infrastructure in many African countries is a major threat to the availability of water resources for irrigation. In all the sub-regions, there is a pressing need for food security, and thus meeting water needs for food security is of paramount importance.

Public health

Africa has relatively high morbidity and mortality rates as a result of waterborne and water-related diseases such as malaria, cholera and diarrhoea. It also has the highest incidence of HIV/Aids in the world. The implications of the above diseases are enormous particularly on the African economies as the young and productive age is most affected. Water availability to the infected and affected families is important to ensure that adequate hygienic conditions are maintained so as to curb spreading of diseases.

Vulnerability of water resources in Africa: drinking water supply in Boudtenga, Burkina Faso

Environmental degradation

Poor land use practices have resulted in sedimentation of river channels, lakes and reservoirs and changes in hydrological processes. Deterioration of the quality of water resources resulting from further increases in nutrient loads from irrigation and the domestic, industrial and mining sectors has also significantly depleted available fresh water resources and increased water scarcity. Increased human activities lead to the exposure of the water environment to a range of chemical, microbial and biological pollutants, as well as micro-pollutants. The mining and industrial sectors in particular produce high concentrations of waste and effluents that act as non-point sources of water quality degradation, including acid mine drainage which pollutes groundwater resources.

Large dams (over 60 metres high) have been built on many basins such as the Nile, Volta and Zambezi rivers for water supply and power generation, and new dams are currently under construction in the Niger, Orange and Oued Draa river basins. The construction of dams has caused significant changes in the flow regimes of rivers resulting in negative impacts on the environment and loss of ecosystems functioning. Hence there is need for a balance between water resources development and ecosystems degradation due to water resources development.

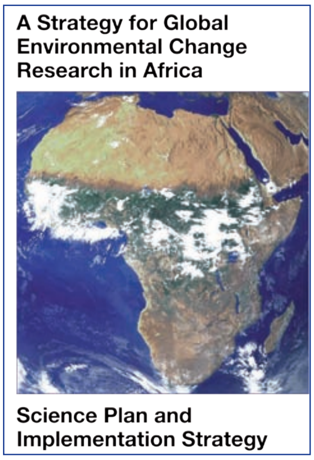
Concluding remarks and recommendations on the way forward

The results of these rapid assessments outlined in this article clearly show that Africa's water resources are already facing serious risks and the situation is expected to worsen in the future. The results of this study should thus be regarded as a vital starting point for comprehensive vulnerability assessments of Africa's river/lake/aquifer basins to inform the management of vulnerability risks at various levels. Still, more data remains to be collected, both in order to understand the changes that have already occurred in these ecosystems and to establish baseline data by which future changes can be assessed. If policy and management decisions are to have any hope of ensuring sustainable use of water resources, they will have to be informed by sound scientific assessments and this calls for a more comprehensive assessment that will focus on specific issues at the sub-regional level from which specific actions applicable at the local and sub-regional levels can be developed.

The full article, including further information on opportunities for action, is available from: http://www.gwsp.org/products.html.

Prof. Eric O. Odada
AfricanNESS Secretariat
University of Nairobi
Nairobi, Kenya

African Network for Earth System Science (AfricanNESS) – Science Plan and Implementation Strategy published



The African Network for Earth System Science (AfricanNESS) science plan and implementation strategy "A Strategy for Global Environmental Change Research in Africa" focuses on four top-level issues: food and nutritional security; water resources; health; and ecosystem integrity. Framed around these issues, the science plan describes a strategy for global environmental change research in Africa that concentrates on eight thematic clusters: rainfall, land cover, livelihoods, cities, diseases & pests, Africa and the Earth System, marine, and integrated development. Examples of possible research programs are provided for each of these areas. Finally, the plan outlines a way of implementing and organizing a network of earth system scientists in Africa, and connecting them to scientists around the world.

This science plan was developed over a period of three years through the collective efforts of many African scientists, as well as colleagues from outside the African continent. The editors gratefully acknowledge the support from the US National Science Foundation, the South African National Research Foundation, ESSP, START, and the ICSU Regional Office for Africa.

AfricanNESS co-ordination:
Department of Geology
University of Nairobi
P.O. Box 30197
Nairobi, Kenya
E-mail: africanness@uonbi.ac.ke

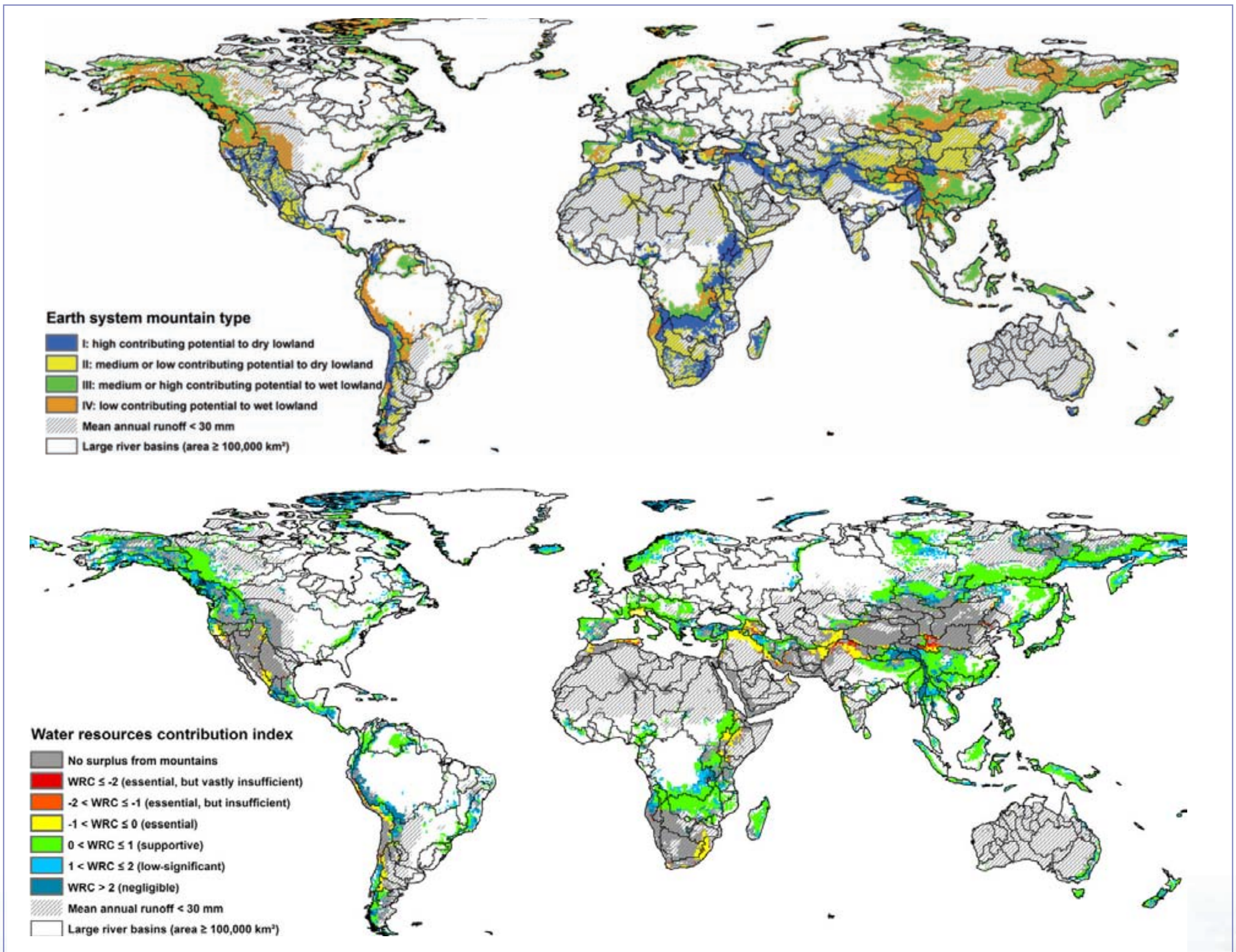
The Science Plan can be downloaded from
http://www.igbp.net/page.php?pid=412

MOUNTAINS OF THE WORLD – WATER TOWERS FOR HUMANITY: TYPOLOGY, MAPPING AND GLOBAL SIGNIFICANCE

Mountains and highlands provide essential freshwater for populations both upstream and downstream; therefore, they are often called the world's natural "water towers". Since freshwater resources are under increasing pressure, this contribution needs to be clarified. Extending concepts which were elaborated in earlier case-study-based assessments (Viviroli *et al.* 2003), a first spatially explicit, global typology of the so-called "water towers" is presented. Critical regions are identified where the disproportionality of mountain runoff as compared to the lowlands is extraordinarily high. Additionally, lowland climate conditions are used to assess the mountains' contribution in context of the ecosystem perspective, resulting in four different types of "water towers" (see figure 4, top). Finally, including the human dimension, the potential significance of water resources originating in mountains is assessed relative to the actual population in the adjacent lowlands and its water needs (figure 4, bottom). With the resulting global maps in 0.5° × 0.5° resolution, the significance of mountain runoff is identified on a cell-by-cell basis, and statements for individual basins, climate zones and relief types are summarized. Critically important mountain regions are found in the Middle East, South Africa, parts of the Rocky Mountains and the Andes. Particularly marked is the importance of mountain water resources in the western and eastern Himalayas which partly compensate the large lowland deficits.

An analysis of climate zones reveals that mountains in the arid zone clearly deliver most disproportional discharge as compared to their share in total area (share in total arid zone area 29.8%; respective share in discharge: 66.5%). This disproportionality is second highest for the temperate zone (share in area: 43.4%, share in discharge: 60.8%). The results show further that 23% of mountain areas worldwide are essential for downstream region hydrology in the earth system context, while another 30% have a supportive

Figure 4. *Global map of earth system mountain types (top) and of water resources contribution index WRC (bottom) in 0.5° × 0.5° resolution.*



role (cf. figure 1, top). When the actual lowland water use is considered (water resources contribution index WRC, cf. figure 1, bottom), 7% of global mountain area has an essential role in water resources, while another 37% provides important supportive supply (see figure 2). This is of special importance in arid and semiarid regions where vulnerability for seasonal and regional water shortage is high.

With the rather extensive definition chosen for the delineation of mountains (see Meybeck *et al.* 2001), it is also possible to identify those relief types which actually function as a "water tower": While low and mid altitude mountains produce the highest overall discharge sums, highest runoff values are found for hills, which is explained by the marked precipitation increase at the foot of mountain ranges. Elevated plateaux, on the other hand, produce significantly less runoff.

Our approach provides the basis for identification of critically important mountain regions on a global scale. This is especially of importance when considering effects of climate change and population growth which are expected to worsen water resources supply significantly, particularly through altered discharge patterns from mountains and increasing water demand for food production.

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Daniel Viviroli[1], Hans H. Dürr[2], Bruno Messerli[1], Michel Meybeck[3], and Rolf Weingartner[1]

[1] *Hydrology Group, Department of Geography, University of Berne, Berne, Switzerland*
[2] *Department of Physical Geography, Faculty of Geosciences, Utrecht University, The Netherlands*
[3] *UMR 7619 Sisyphe, Université de Pierre et Marie Curie (Paris VI), Paris, France*

ENVIRONMENTAL FLOW RESEARCH IN CHINA

Along with the rapid development of economics and dramatic increase in water demand by industry, agriculture and domestic use since the 20th century all over China, the rational water use has been in sharp contradiction to the environmental protection of the rivers. Examples are the seasonal dry-up of the lower reach of Yellow River, the bad appearance of the Wei River, one of the main tributaries of the Yellow River, which now looks like a pollutant-drain, the shrinkage of wetland in the Hai River, the blue algae blossoming in the Han River and Tai Lake in the middle and lower reach of the Yangtze River, and the burst of the Songhua River water pollution event, among others.

In order to help solving these problems, much documented research on environmental flows (EF) has been carried out in China over the past decade. The definition of ecological water demand has been discussed widely (e.g. Liu 1999, Cui 2001, Wang *et al.* 2002, Su and Kang 2003, Song *et al.* 2003, Shao *et al.* 2004, Xu *et al.* 2004). More and more people in China recognise that EF do not relate to minimum flows only but to the flow regime as a whole, which includes floods, average flows and droughts, to maintain desired ecological conditions and societal functions. As in other countries, several synonyms are being used in parallel, such as Ecological Flow (Liu *et al.* 2007a), Ecological Instream Flow Requirements (EIFR, Liu *et al.* 2007b), Ecological and Environmental Water Requirements (EEWR, Jiang *et al.* 2006). In this article, except when citing some papers, we always use Environmental Flow (EF).

Methods with low input data needs such as Tennant method and Wetted perimeter method, are widely applied in China. However, the more complex habitat techniques, such as in-stream flow incremental methodology, building block methodology and holistic method, which need detailed ecological data, have very limited applications in China at present. Therefore, Prof. Changming Liu (Liu *et al.* 2007a) defined the concepts of ecological flow velocity as well as ecological hydraulic radius (EHR) and proposed an ecological hydraulic radius approach (EHRA). This new method considers both the watercourse information (including hydraulic radius, roughness coefficient and hydraulic gradient) and the stream velocity required for maintaining certain ecological functions. The key parameter of EHRA is to fix the watercourse cross-sectional flow area corresponding to EHR, by which the relation between parabola shaped cross-sectional flow area and hydraulic radius is deduced. The EHRA not only meets the requirement of flow velocity for adequate fish spawning migration, but also for other ecological issues such as in-stream flow requirements for sediment transport and self-purification. From the same working group, Dr. Suxia Liu (Liu *et al.* 2007b) proposed a new approach for estimating ecological instream flow requirements (EIFR) based on the relationship between the life habit and flow variation, simply called LiHaFloVa method. After identifying the key ecological protection goals and their key stage months corresponding to the relative minimum of the seasonal variation of the coefficient variation (CV) of the discharge, EIFR is calculated in two parts. One is for the non-key stage months, which is the product of 90% exceedence flow and the minimum value of CV over the year. Another is for the key stage months, which is the product of 50% exceedence flow and the CV in the corresponding month. She (Liu *et al.* 2006) also proposed an analytical solution of the minimum ecological in-stream flow requirement (MEIFR) under the assumptions of triangular cross section channel and uniform stable flow. It is clearly shown that the results of MEIFR based on curvature technique (corresponding to the maximum curvature) and slope technique (slope being 1) are significantly different. Shang (2008) designed a multiple criteria decision-making approach to estimate EF based on wetted perimeter. Three of the above new methods are applied to the donating rivers in the Western Route South-to-North Water Transfer Project in China and have made useful suggestions for the decision-making of the project.

Chinese researchers collect hydrological data for the EF study in a poorly gauged area.

Chinese EF research is also focusing on large-scale catchments for which many existing methods, designed for small-scale studies, can not be applied. Therefore Chinese scientists have designed a framework of water budget considering the water requirements of rivers, lakes, wetlands, vegetation and groundwater. This framework has been applied already in Hai Luan River, lower reach of Yellow river and its delta, and Liao River (see Li *et al.* 2000, Cui and Yang 2002, Shi and Wang 2002, Yan *et al.* 2002, Liu *et al.* 2004).

Another focus is the integrated evaluation of EF including both water quality and quantity. Xia *et al.* (2005) addressed the concept of the available usable water resources related to both water quality and quantity and developed an integrated assessment model. This model has been applied to single and multiple sections as well as at the basin level of Luan River. Wang *et al.* (2007) discussed the meaning of the quantity and quality of environmental flows of rivers in dualistic water cycle in comparison with the meaning of unitary water cycle. The authors develop an integrated evaluation method for environmental flow requirements considering the relationship between environmental flow requirements, the efficiency of water resource usage, the consumption coefficient, and the concentration of waste water elimination. By applying this method in the Dong Liao River, it is seen that the water quality is the main factor that determines whether the environmental flows can meet the river ecosystem demands.

Reviewing the whole of EF research in China, it is concluded that EF research has been carried out in almost all large catchments, the Songhua and Liaohe River Catchment, Haihe and Luanhe River catchment, Yellow River catchment, Huaihe River Catchment, Southeast Catchment, Pearl River Catchment, Yangtze River Catchment, Southwest catchment and Continental catchment. Chinese scientists have made considerable progress on EF. However, not so many overseas EF experts so far recognise it. There is a strong appeal for further and wide cooperation. One of the very important international projects is the Chinese-Australian co-operation project headed by Profs. Changming Liu and Jun Xia on the Chinese side (2007-2009). Another cooperation, between Dr. Suxia Liu and Dr. Chris Gippel, Fluvial Consultancy Company, focuses on the relationship between amphibian habitat and river flow regime (funded by Chinese National Natural Science Foundation, 2007-2009). Within the Sino-Dutch cooperation programme on water management the Yellow River Delta Environmental study was conducted 2005 to 2007. EF have been the main topics in the national and international conferences held in China over the recent years, including the Western Pacific Geophysics Meeting (WPGM), Beijing, July 24–27 2006; the Earth System Science Partnership Open Science Conference, Beijing, 9-12, 2006; Eco Summit, Beijing, May 22-27, 2007; the GWSP workshop held in the 2007's International Yellow River

Forum, October 16–19, Dongying City, Shandong Province, China; and the EF Conference jointly sponsored by Yellow River Conservancy Committee and the World Wide Fund For Nature, in Zhengzhou, 15-16 June, 2008, a National EF Working Group has been established.

The research on EF is at preliminary stage in China. We welcome more and more international contributions via GWSP and all other channels.

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Suxia Liu, Changming Liu, Jun Xia, and Jingjie Yu

Corresponding author:
Dr. Suxia Liu
Contact: liusx@igsnrr.ac.cn
Key Lab. of Water Cycle & Related Land Surface Processes, Institute of Geographic Sciences & Natural Resources Research, Chinese Academy of Sciences (CAS), Beijing, China

GWSP GLOBAL INITIATIVES

Bringing the Global Perspective to River Basin Research and Management

First Expert group Meeting of the GWSP Global Catchment Initiative, 7–8 February 2008, Bonn Germany

For its 2007–2010 project phase the GWSP launched three "global initiatives". One of them is the Global Catchment Initiative (GCI) which has the overarching goal of expanding the viewpoint of river basin research and management to include the global perspective. (The term "global catchments" here refers to catchments with drainage areas about 100,000 km^2 or larger). Through the GCI, the GWSP will organize activities to encourage researchers to investigate questions having to do with the global water system and not normally addressed at the catchment-level (See Table 1 for examples of such questions). The GCI also aims to

- Advance the state of scientific understanding of the global water system through a worldwide comparative study of catchments
- Identify regional feedbacks between the hydrologic system, the terrestrial environment, the climate system, and governance regimes
- Develop new ideas for adapting to undesirable global changes on the river basin scale, and to communicate these ideas to policymakers and other stakeholders.

The first meeting of the Expert Group of GWSP's new Global Catchment Initiative was held February 7/8, 2008 in Bonn. Participants from UNESCO's HELP and FRIEND initiatives, the CGIAR Challenge Programme on Water and Food, the Water Footprint Initiative, the GLOWA Programme, and other scholars from natural and social science disciplines came together to discuss the scope of the Initiative, to identify research questions (see Table 1), and to select case study catchments. They also planned a dynamic agenda of activities for the next few years including a major conference, workshops and publications.

Writing teams of experts worldwide are now being formed in order to compile and synthesize expertise and knowledge on global change impacts on river basins and information on adaptation needs and strategies. Intermediate results will be presented in March 2009 at the World Water Forum in Istanbul, Turkey. The first major GCI conference is planned for November 2009.

The full report of the first GCI Expert group meeting is available for download from:
http://www.gwsp.org/cur_activities.html.

Joseph Alcamo and Daniel Petry

For further information please contact the GWSP IPO (gwsp.ipo@uni-bonn.de) or Joseph Alcamo, Chair of the GCI Expert Group (alcamo@usf.uni-kassel.de).

Table 1. *Research questions to be addressed by the Global Catchment Initiative as identified at the first Expert Group Meeting of the GCI (Abbreviated version. For full version see www.gwsp.org.)*

GWSP Core Themes	Research Questions for the Global Catchment Initiative
Theme 1 What are the magnitudes of anthropogenic and environmental changes in the global water system and what are the key mechanisms by which they are induced?	How is global change manifested in particular catchments (at the decadal to century time scales)? How do changes in climate, land cover/use, demography, institutions and consumption patterns, driven by external factors, affect the characteristics of particular catchments? Which other external factors are important? What are the expected impacts of these changes on society and ecosystems?
Theme 2 What are the main linkages and feedbacks within the earth system arising from changes in the global water system?	What meteorological, hydrological or biogeochemical connections from beyond the catchment are observed in specific catchments, why do they occur and which feedbacks do they induce? What are the determining factors and the consequences of virtual water trade? How do international power relations affect the use of water and other natural resources in catchments?
Theme 3 How resilient and adaptable is the global water system to change, and what are sustainable water management strategies?	What is an appropriate framework to address vulnerability, resilience and adaptive capacity of water systems in river basins from a global perspective. What is the best approach to identify and rank factors across different scales that influence sustainability? How do water governance regimes compare between catchments in their ability to achieve sustainable (environment, social, economic) management of water resources and successful adaptation to global change? What was and is the influence of international institutions (e.g. binding UN conventions, global norms) and global actors (e.g. World Bank, GWP, multi-national water companies, NGOs, scientific community) on the resilience of river basins?

GWSP INTEGRATION TOOLS

The GWSP - WATCH Water Balance Modelling Intercomparison

The 'First GWSP International Workshop on Computing the World Water Balance' was held in April 2007 as the first in a series of workshops engaging an international community of global modelling experts. The main goals of the model intercomparison project are:

1. Improved understanding of the uncertainties and the drivers of the global water balance
2. Improving the representation of the global hydrological cycle in Global Circulation Models through the improvement of land surface hydrological models (LSHM)
3. An improved estimation and understanding of the impacts of global change on the global hydrological cycle and water resources
4. Improved parameterization and routines of both LSHMs and global hydrological models (GHM)
5. Facilitation in the design of a modelling framework for an improved simulation of the global water balance

As the efforts progress, this community is now seeking the advice of a broader body of experts who can provide insight in past and future water availability and water use. To open the forum means to be able to include not only the

Table 2. *Models involved in the intercomparison.*

Modelling group	*Model name*
University of New Hampshire (UNH), USA	WBMplus
University of Reading, UK	MacPDM
University of Tokyo / National Institute for Environment Studies, Japan	H07
University of Kassel (CESR), Germany	WaterGAP
VIC community	VIC
Natural Environment Research Council, Centre for Ecology and Hydrology (NERC CEH), UK	GWAVA
Potsdam Institute for Climate Impact Research (PIK), Germany / Wageningen University and Research Centre (WUR), the Netherlands	LPJmL
Max Planck Institute for Meteorology (MPI-M), Germany	SL scheme/HD model (MPI-HM)
UK Meteorological Office / Hadley Centre (UKMO), UK	Jules
Laboratoire de Météorologie Dynamique, Paris (LMD), France	Orchidee
University of Utrecht (UU), the Netherlands	PCR-GLOBWB

Global Hydrological Models (GHMs), but also the Land Surface Hydrology Models (LSHMs) within the Global Climate Models for an enhanced analysis and improvement of modelling the global water balance.

Therefore the EU FP6 Project Water and Global Change (WATCH) was integrated in the next step of the model intercomparison and a joint workshop was held 22–24 April 2008 in Wageningen, the Netherlands. By bringing together hydrologists, water cycle experts and climate scientists, WATCH will develop new methods to analyse the impact of global change on the global water cycle and assess the vulnerability of water resources. The WATCH project will develop new consolidated climate and hydrological datasets for both the 20th and 21st century. In addition a consistent modelling framework for water resources, hydrology and climate studies will be developed which will make it possible to identify future hot spots of water scarcity.

This new comparison will also use forcing data for future scenarios and will look at a more integrated scale, *e.g.* looking at discharge of major river systems and eventually at the impacts of land use in terms of large scale irrigation. Besides this, we will also look at global consumptive water use in different sectors, not only for irrigation, but also for domestic, manufacturing and livestock farming purposes. In addition, focus will be on building interfaces between water resources, hydrological and climate models, attempting a maximum possible consistency in spatial and time scales involved, and in related process descriptions, which is one of the main innovative components of WATCH. At least 11 models will be involved in the model intercomparison (table 2).

Workplan

During the second workshop in April 2008 it was decided to have three more sets of model intercomparisons. The next round of intercomparison will focus on comparing the physics of the models and will be without human influences such as dams, reservoirs and irrigation. The second round will focus on the 20th century with human impacts. The last round will focus on the future, looking at the impacts of climate change on the global hydrological cycle and water resources.

After this second workshop model runs will be performed between mid-summer and September 2008. During the third workshop in November 2008, first results and problems emerging will be discussed. From previous experience we assume that we need some re-runs due to unforeseen circumstances. During this workshop also the next round of simulations should be discussed. In 2009 a next round of comparison is planned, in which model improvements will be included.

More information and progress on this model intercomparison can be found at our website: http://www.eu-watch.org/modelintercomparison

Joseph Alcamo[1], Frank Voss[1], Ingjerd Haddeland[2], and Fulco Ludwig[3]

[1] *Center for Environmental Systems Research, University of Kassel, Germany*
[2] *Department of Hydrology, The Norwegian Water Resources and Energy Directorate (NVE), Oslo, Norway*
[3] *Earth System Science and Climate Change Group, Wageningen University and Research Centre, Wageningen, the Netherlands*

Contact at the GWSP IPO:
Lydia Dümenil Gates (lydia.dumenilgates@uni-bonn.de)

RELATED CONFERENCES AND WORKSHOPS

3rd International Symposium on Riverine Landscapes. Global Change and River-Floodplain Ecosystems

August 27 – September 1, 2007, South Stradbroke Island, Queensland, Australia

Seventy-three international scientists and research students attended the 3rd International Symposium on Riverine Landscapes (TISORL) to discuss the implications of global-scale changes for river-floodplain ecosystems and to identify future research directions. Invited presentations addressed the effects of urbanisation and land-use change, water resource development, and climate change on river-floodplain ecosystems. Cross-cutting workshops focussed on key science needs relating to protection of aquatic biodiversity, connectivity and river-floodplain-coastal subsidies, flow-ecology relationships, and indicators and assessment. Poster sessions also provided an opportunity for environmental practitioners and students to present research relating to the science themes and workshop topics.

The symposium website (http://www.griffith.edu.au/conference/tisorl2007/) provides details of the symposium objectives, science themes and workshop topics. PDF downloads are also available of the symposium handbook, all invited speaker abstracts and presentations, workshop summaries and presentations, and poster abstracts.

The symposium, held at Couran Cove Island Resort in Queensland, Australia, was hosted by the Australian Rivers Institute, Griffith University. The event was generously sponsored by Griffith University, the Global Water System Project, CSIRO Land & Water, eWater Cooperative Research Centre, Queensland Government Department of Natural Resources and Water, SEQ Water and the International Water Centre.

Significant highlights and outcomes

Plenary session presentations

The symposium Plenary Sessions featured the science presentations by three eminent Keynote Speakers and invited presentations from 18 leading International and Australian researchers.

In his keynote presentation "*Envisioning the future of urban rivers*" (Science Theme 1: Urbanisation and land use impacts), J David Allan from the University of Michigan, USA, described the continuing degradation of the ecological health of rivers due to past and current land use practices and the ongoing threats due to future population growth and global climate changes. Prof Allan argued that integrated catchment management research and practice should develop realistic expectations for future landscapes. Furthermore, societal choices should be guided by achievable scenarios that incorporate planning, ordinances, and

Delegates at the 3rd International Symposium on Riverine Landscapes

best management practices into alternative futures. In Science Theme 2: Water use and flow regime changes, keynote speaker Charles Vörösmarty (University of New Hampshire, USA) outlined the diverse ways in which humans have transformed the global water cycle and how this poses a major challenge to earth system science and technology to ensure the sustainability of inland aquatic ecosystems. To tackle these challenges, Prof. Vörösmarty described some exciting science initiatives currently underway through the Global Water System Project, as part of the Earth System Science Partnership (ESSP). Keynote speaker Christer Nilsson (Umeå University, Sweden) addressed the major issue of climate change and consequences for aquatic ecosystems (Science Theme 3). He argued that proactive management intervention will minimize risks to ecosystems and human populations and may be less costly than reactive efforts taken once problems arise. In his presentation, Joseph Alcamo (University of Kassel, Germany) introduced scenario results for global change impacts on water stress. While climate change has a large impact on water stress in many "hot spot" areas, he points out that a more important cause of increasing water stress under the scenarios is the increase in water withdrawls.

Crosscutting workshop discussions

The major aim of the four cross-cutting workshops was to synthesise the key future science needs relating to the workshop topics. Major outcomes include the preparation of a number of scientific publications for submission to top international journals.

In workshop theme 1 (*Protection of aquatic biodiversity*), David Dudgeon (Hong Kong University, Hong Kong) and Jane Hughes (Australian Rivers Institute, Griffith University) chaired a discussion focussed on four general themes: structure, diversity, variability, and people. The first three reflected special attributes of riverine ecosystems, while the fourth concerned human use of rivers, management practices, and consequent impacts on biodiversity. The workshop group concluded that scientists have much of the basic understanding needed to begin to protect riverine biodiversity but lamented the fact that biodiversity is frequently not considered in the water resource planning process. Scientists must become more effective at communicating and applying what we know about river ecosystems, and better convey the value of biodiversity (and the ecosystem goods and services it provides) to planners, decision-makers, social scientists and other researchers, and to society at large. A scientific paper synthesising these ideas has been submitted to the journal *BioScience*.

The concept of *Connectivity and river-floodplain-coastal subsidies* formed the basis of discussions in Workshop theme 2. Bob Naiman (University of Washington, USA) and Michael Douglas (Charles Darwin University, Australia) led the group in developing conceptual models to describe the "natural flux regime" (movements of water, nutrients, organisms) in riverine landscapes. Discussion focused on the tropical floodplain rivers of northern Australia, which are the topic of a major new research program known as TRaCK, the Tropical Rivers and Coastal Knowledge initiative. The models revealed important knowledge gaps and served to generate testable hypotheses regarding spatial and temporal patterns in the flux regime and the impacts of human activities. This foundational science is urgently needed to support sustainable management of tropical rivers. A scientific paper synthesising these ideas is currently in preparation.

Angela Arthington (Australian Rivers Institute, Griffith University) and LeRoy Poff (Colorado State University, USA) chaired the workshop theme 3 discussion on *Flow-ecology relationships*. Two main themes were developed – a "Landscape Perspective on Environmental Flows"; and "Principles for Developing Flow-ecology Relationships in the Context of Multiple Environmental Drivers". Several scientific papers arising from this workshop have been submitted to a special issue on environmental flows for the journal *Freshwater Biology*.

Workshop theme 4 – *Indicators and assessment*, chaired by Charlie Vörösmarty (University of New Hampshire, USA) and Caroline Sullivan (Oxford University Centre for the Environment, UK) convened around developing strategies to construct and apply environmental flow metrics to detect patterns of biodiversity threat, with the particular aim of forwarding a fully global-scale perspective. Building on earlier work initiated by the Global Water System Project in 2005, a major product of the workshop was identification of key issues and steps toward a global assessment of environmental flows, their distortion under contemporary and future conditions, and the impacts on aquatic ecosystems. The workshop ended with a commitment to continue the effort through preparation of a series of papers to be published in the 2007–09 time frame.

Stuart Bunn and Mark Kennard
Contact: s.bunn@griffith.edu.au
Australian Rivers Institute, Griffith University, Brisbane, Australia

Global Climate Change and Sustainable Development Symposium

18–21 January 2008, Taipei and Kaoshiung, Taiwan

Under the auspices of the Taiwanese National Science Council and Academia Sinica, more than 100 scholars, stakeholders and policy-makers met at this two-legged symposium with its first half being held in Taiwan's capital Taipei and the second half in the southern coast metropolis of Kaoshiung. The event was organised by the China-Taipei IGBP National Committee to discuss the state of the art knowledge about global change implications for sustainable development in Taiwan. ESSP was represented by Kevin Noone, IGBP Executive Officer, and Daniel Petry, GWSP Science Officer, whose keynote speeches addressed the scientific evidence of global change and global change impacts on freshwater resources and resulting adaptation needs, respectively.

The Love River in Downtown Kaoshiung

High quality plenary sessions with senior researchers from the major Taiwanese universities and research centres discussed latest climate change projections for Taiwan, the role of agriculture in producing greenhouse gas emissions as well as adaptation needs and strategies for Taiwan's water management and policy. The symposium was also attended by government officials and stakeholders and created a platform for a lively and meaningful science-policy exchange.

For further information contact Prof. **Chen-Tung Arthur Chen**, *National Sun Yat-Sen University Kaohsiung, Taiwan: ctchen@mail.nsysu.edu.tw.*

Water Down Under 2008

14–17 April 2008, Adelaide, Australia

Water Down Under 2008 is a conference incorporating the 31st Hydrology and Water Resources Symposium and the 4th International Conference on Water Resources and Environment Research. The conference was convened by Engineers Australia and the International Centre of Excellence in Water Resources Management (ICE WaRM).

The conference consisted of a three-day scientific programme, pre-conference workshops and field trips. The conference themes include:

- Climate, Rainfall and Surface Water Variability
- Hydrological Modeling, Data and Forecasting
- Water Management and Sustainability
- National and International Water Issues and Case Studies
- Groundwater Systems

The scientific programme was organised in parallel sessions in accordance to the five conference themes. In addition to the parallel sessions, five eminent speakers from academia and industry presented keynote addresses on the following topics:

1. Approaches and tools for sustainable water management;
2. Educational issues and challenges in water resources management;
3. Water management in a drying climate;
4. Water, climate change, food and population challenges; and
5. Philosophical thoughts on hydrology and water resources.

One of the distinctive features of the conference was its extensive discussions on social-economic and institutional aspects of water resources management with empirical cases studies mostly from Australia. The situation partly reflects the fact that Australia has been at the forefront of the reform of water governance in response to the severe and prolonged droughts in recent years. Issues relating to water rights and water markets are at the centre of the reform. In Australia, water markets have increasingly been relied on to facilitate a reallocation of scarce water resources to new, more efficient and higher value water users. Such a reallocation has taken place also with the aim of providing more water for the ecosystems.

About 460 delegates participated in the conference. Of which, over 100 delegates were from outside of Australia. The conference was highly successful both in terms of scientific quantity of the presentations and the efficiency of the organisation of all the activities. At least 90% of the delegates remained at the closing session, indicating the broad interests and high enthusiasm of the participants in the conference and issues discussed.

Hong Yang
Contact: hong.yang@eawag.ch
EAWAG Swiss Federal Institute for Aquatic Science and Technology, Duebendorf, Switzerland

La Tribuna del Agua y Cambio Climatico

– impressions from a symposium at the world exhibition in Zaragoza, Spain, on climate change and extreme events

A recent symposium held 21–24 July at the Water Tribune of the World Exhibition in Zaragoza was devoted to the theme "climate change and extreme events". The conference topic is particularly relevant for the Iberian Peninsula where water scarcity and extreme droughts are issues of major concern. The symposium organised by José Moreno, University of Castilla-La Mancha, Toledo, Spain, addressed latest insights on expected climate change, potential impacts and adaptation strategies at different scales and in different world regions. It attracted an international audience of about 150 participants from science, policy and water management.

GWSP was represented by Joseph Alcamo who gave an inspiring talk on "Climate change and transformation of the Global Water System" and Claudia Pahl-Wostl who highlighted the importance of multi-level and adaptive governance in her presentation on "Climate change – a global challenge for water governance". The importance of adopting a global perspective and the need for global responses and innovative approaches to governance was also addressed in other presentations and was a key topic in the discussions. This is a clear indication of change in the water community's awareness of the importance of the global scale compared to the situation a few years ago. The discussions also highlighted the urgent need to lay the scientific foundations for addressing the global water challenges and the importance of bridging regional and global scales of analysis and levels of governance.

Further information on the EXPO 2008 and the symposium is available from: http://www.expozaragoza2008.es/

Claudia Pahl-Wostl
Contact: pahl@usf.uni-osnabrueck.de
Institute for Environmental Systems Research, University of Osnabrück, Germany

GWSP TRAINING AND CAPACITY BUILDING

How did European Colonisation Change Hydro-Systems of the USA?

First Summer Synthesis Institute convened in the Boston Area

The Northeast Consortium for Hydrologic Synthesis represents a broad cross-section of faculty, postdoctoral fellows and students in the hydro-sciences and affiliated water policy and management sectors. The effort is one of two projects funded by the U.S. National Science Foundation to explore modes of synthetic thinking in hydrology, and supports directly the objectives of the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI). This synthesis work is dedicated to addressing "The 500-Year Challenge" to understand the role of humans in shaping the character of hydrologic systems across the Northeast Corridor of the United States from year 1600 to 2100. A group of 11 Summer Synthesis Scholars participated in the 2008 Summer Synthesis Institute held from June 9 to July 18. Representation was from a broad range of disciplinary expertise, from hydrology and geomorphology to geography, environmental history, and human-water interactions. The central challenge for this year's Institute was posed as a question: What was the nature of hydro-systems across the Northeastern U.S. from pre-European settlement through the colonial period (1600–1776), and what were the relative roles of humans and the natural environment in defining those systems?

The summer scholars participated in a suite of fast-paced synthesis and integration activities, guided by mentors, but largely self-directed by the scholars themselves, working in small teams. Their chief findings indicated that in terms of the drivers of hydrologic trends over the Colonial Period, land cover and use was the most important determinant, followed by water engineering (the exchange of beaver dams for mill ponds), and climate. With respect to year-to-year and seasonal dynamics, the drivers shifted in prominence, ranked as climate first, followed by land cover and use, and then water engineering. These rankings will be confirmed (or refuted) through followup studies during the course of the year and for some of the scholars as part of their PhD research. Findings will be presented at the Fall Meetings of the American Geophysical Union in San Francisco.

Charles J. Vörösmarty[1] and Mark B. Green

[1] *Contact: charles.vorosmarty@unh.edu*
University of New Hampshire, Durham, USA
From 1st September 2008:
Director, CUNY Global Environmental Sensing and Water Sciences Initiative, Civil Engineering Department, City College of the City University of New York, USA

Managing Change: Methods and Tools for Adaptive River Basin Management

NeWater-GWSP Summer School in Königswinter, Germany, 9–19 July 2008

The third and final event of this joint NeWater-GWSP summer school series was held in Königswinter, Germany, within a stone's throw of the river Rhine. Through interactive teaching and group assignments the instructors from various physical and social science disciplines introduced innovative methods and tools for adaptive water management. After a general introduction and reflection of adaptive management principles, topics included system dynamics modelling, facilitation of participatory processes, and scenario analysis. The final part of the summer school was dedicated to hands-on experiences with case studies in the Amur Darya river in Uzbekistan, the Orange river in southern Africa, the Volta river in West Africa, and the Murray-Darling river in Australia. Case study work was rounded up by an excursion to the secretariat of the International Commission for the Protection of the Rhine (ICPR). The ICPR coordinates transboundary river basin management of Europe's most intensively used river.

Summer school participants and instructors who made it to the top of 'Drachenfels' – a steep rocky hill overlooking the Rhine valley at Königswinter

This year's group was the disciplinarily as well as culturally most diverse group in the summer school series. The 25 participants came from 22 different countries spread over 5 continents. This diversity is one of the reasons for the inspiring atmosphere and huge team-work spirit that participants, organisers and instructors found to make the summer school a grand success. The GWSP is proud of being able to contribute to this success through the funding provided for 8 participants from Africa, Asia, and Latin America and through the active involvement of GWSP SSC members Claudia Pahl-Wostl (as NeWater co-ordinator and instructor on adaptive management principles), Joseph Alcamo and Jay O'Keeffe (as instructors on scenario analysis and freshwater ecology respectively). A major thank you also goes to Caroline van Bers, the main organiser of the summer schools in 2006, 2007 and 2008. Without her engagement, oversight and enthusiasm the summer schools would not have taken place.

Further information on the summer school programme is available from http://www.newater.info/everyone/3112

Daniel Petry
Contact: daniel.petry@uni-bonn.de

Training Course: Teaching Adaptive Water Management

11–16 October 2008, New Delhi, India

The NeWater Project and UNW-DPC, the newly formed UN-Water Decade Programme on Capacity Development (hosted by the United Nations University) have formed a new partnership in Capacity Building by convening a train-the-trainer course to disseminate the NeWater-GWSP curriculum on Adaptive Water Management in New Delhi, India in October 2008. The training course is co-organised and co-sponsored by GWSP and forms one of six workshops of the International Human Dimensions Workshop (IHDW) of the International Human Dimensions Programme on Global Environmental Change (IHDP).

The course is aimed at instructors of environmental/natural resources management, hydrology and related disciplines: 17 individuals primarily from South Asia, Africa and South America have been selected to participate. The aim of the course is to familiarise (potential) university instructors with the teaching material provided in the NeWater-GWSP online curriculum, beginning with an introduction to the theoretical foundations of adaptive water management. Participants will work directly with the online curriculum during this training session, and will be able to use the material available in their own course design. The teaching curriculum will be available soon in the form of teaching modules on the Internet which may be used online or downloaded. The first set of downloadable modules introduces water management in the context of global change and concepts and methods of adaptive management and integrated water resources management. Topics include resilience and adaptive capacity, water policy mechanisms, uncertainty analysis, vulnerability assessment, participatory processes, performance indicators, governance, monitoring and more. Each module includes presentations with explanatory notes, exercises, discussion questions and background readings. The modules also provide recommended number of teaching credits. Users will also find relevant links and case study profiles for teaching purposes. Interested educators may use teaching materials online or download and adapt materials as needed, with the proviso that materials used are cited appropriately.

More information is also available from www.gwsp.org and www.newater.info/2654.

Caroline van Bers
Contact: cvbers@usf.uos.de
Institute of Environmental Systems Research, University of Osnabrück, Germany

Catharien Terwisscha van Scheltinga
Contact: Catharien.Terwisscha@wur.nl.
Alterra/Wageningen University, the Netherlands

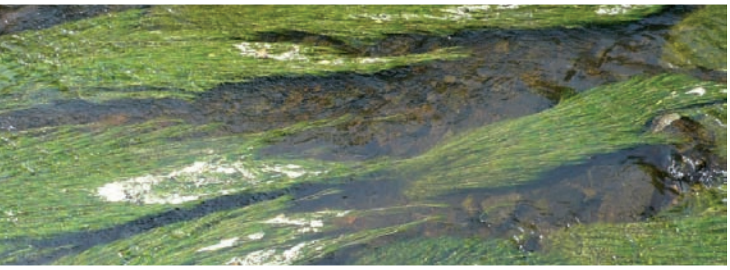
ANNOUNCEMENTS

News from the GWSP SSC and the IPO

At the end of his first term on the GWSP SSC, **Robert J. Naiman**, Professor for Aquatic and Fisheries Sciences at the University of Washington, Seattle, recently stepped down from the committee. Bob is one of the world-leading experts in freshwater ecology, dedicated to an integrative perspective on water resources and the balancing of human and nature water needs. He committed himself strongly to the development and implementation of GWSP's integrative approach. We thank Bob very much for his enthusiasm and commitment over the last four years. As he remains closely involved with GWSP and DIVERSITAS activities, e.g. through his role as the chair of the UNESCO IHP Ecohydrology programme, we look forward to further successful collaboration in the future.

Marcel Endejan left the IPO at the end of March after more than three and half years of being the project's Deputy EO. He took over the responsibility for the development of the

GWSP Information System and delivered his 'master piece' in February 2008 with the launch of the GWSP Digital Atlas (see p. 1). He helped jump start and facilitated many other GWSP activities such as the development of the Global Dams and Reservoirs Database (GRanD), the Deltas at Risk Initiative, and the implementation of the NeWater-GWSP Online Curriculum. Marcel was also instrumental in writing the AfricanNESS science plan (see p. 8). Marcel took up a new position as a consultant in information technology. We wish him all the best and hope to stay in touch!



CALENDAR

Important Change: IHDP Open Meeting will be held in Bonn, Germany, April 2009

IHDP announces that the 7th International Science Conference on the Human Dimensions of Global Environmental Change (Open Meeting), "Social Challenges of Global Change" originally scheduled for 15-19 October 2008, will take place from April 26-30 2009 in Bonn, Germany. For further information see: http://ihdp.org/

World Water Week 2008

17–23 August 2008, Stockholm, Sweden:

GWSP is co-convening the seminar 'Environmental Flows and Human Well-being', chaired by Michael McClain, Global Water for Sustainability Program, on Tuesday, 19th August, 13:30 – 17:00, room K21
http://worldwaterweek.org/

Global Change and Water Resources in West Africa

25–28 August 2008, Ouagadougou, Burkina Faso

International conference of the German-African GLOWA projects: http://www.glowa.org/eng/conference_eng/conference_eng.php

13th IWRA World Water Congress: Global Changes and Water Resources

1–4 September 2008, Montpellier, France

Please visit the GWSP booth!
http://wwc2008.msem.univ-montp2.fr/

IWA World Water Congress and Exhibition

7–12 September 2008, Vienna, Austria

http://www.iwa2008vienna.org/i8/

Adapting to the impacts of global changes on river basins and aquifer system

8–9 September 2008, Paris, France

UNESCO-IHP Workshop and Roundtable Discussion bringing together scientists form different networks such as HELP, GWSP, G-WADI, GRAPHIC, ISARM, FRIEND, IFI, ISI, IRI, IWMI, and WMO, Universities, research organizations and centres. http://www.unesco.org/water/news/newsletter/202.shtml#news_1

6th Meeting of the GWSP Scientific Steering Committee

23–25 September 2008, Sao Jose dos Campos, Brazil

By invitation only

Science and management of estuaries and coasts: A tale of two hemispheres

29 September to 3 October 2008, Bahía Blanca, Argentina

The symposium focuses on the Science and Management of Estuaries and Coasts, with emphasis on the interactions between physical and biological processes.
http://ecsa44.criba.edu.ar

HydroChange 2008 – Hydrological Changes and Managements from Headwater to the Ocean

1–3 October 2008, Kyoto, Japan

Further information is available from http://www.chikyu.ac.jp/HC_2008/index.htm. The international symposium is organised by the Research Institute for Humanity and Nature, Kyoto, Japan, and is co-organised by GWSP

Final NeWater Conference: Adaptive Integrated Water Resources Management under Uncertainty

17–19 November 2008, Seville, Spain

The central aim of the final NeWater conference is to present the experiences gained over the last four years of the NeWater project in the development, enhancement and/or use of various methods and tools for AIWM, and to discuss these experiences with water managers, policy makers and researchers.
http://www.newater.info/everyone/3319

5th World Water Forum: Bridging Divides for Water

16–22 March 2009, Istanbul, Turkey

For further information on how to get involved visit: http://www.worldwaterforum5.org/

IMPRINT

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The Global Water System Project (GWSP) is a Joint Project of the Earth System Science Partnership (ESSP) consisting of four Global Environmental Change Programmes: the International Geosphere-Biosphere Programme (IGBP), the International Human Dimensions Programme on Global Environmental Change (IHDP), the World Climate Research Programme (WCRP) and DIVERSITAS, an international programme of biodiversity science. The *overarching question* of the GWSP is how human actions are changing the global water system and what are the environmental and socio-economic feedbacks arising from the anthropogenic changes in the global water system.

Contact:
GWSP International Project Office (IPO)
Walter-Flex-Str. 3
53113 Bonn
Germany
Phone: + 49 - 228 - 73 61 88
Fax: + 49 - 228 - 736 08 34
Email: gwsp.ipo@uni-bonn.de
www.gwsp.org

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CONTENTS

Earth System Science Partnership

DIVERSITAS – an international programme of biodiversity science

GLOBAL IGBP CHANGE

WCRP – World Climate Research Programme

IHDP – International Human Dimensions Programme on Global Environmental Change