# Climate Change Adaptation and Integrated Water Resource Management – An Initial Overview

**As the recent Intergovernmental Panel on Climate Change (IPCC) Report[1] makes clear, water is in the eye of the climate management storm. Global warming and related climate changes are predicted to present significant challenges over the next century. These challenges are increasingly better understood and there is growing consensus on their likely scale.**

**To date, much attention has been focused on the dimensions of temperature and sea level rise. Substantial work has also been done on some of the consequences, such as changes in rainfall and the risk of more, and more intense, floods and droughts. However, not nearly enough work has been done to understand how to cope with the potential impact of climate change on the water environment at a regional, national and local level.**

As the same IPCC report has also made clear, "irrespective of the scale of mitigation measures, adaptation measures are necessary."[2] This implies an integrated approach to climate change that embraces both ***mitigation***, which addresses the drivers of climate change, and ***adaptation***, which considers the measures necessary to accommodate such changes. In this context, the challenges of water management will become increasingly important because there is general agreement that the supply of and demand for water resources will be substantially affected by climate change.

**The first key message is that, if our global energy habits are the focus for mitigation, the way we use and manage our water must become the focus for adaptation.** One reason for this is that it is widely predicted that relatively small temperature changes of a few degrees Centigrade will see average river flows and water availability increase by 10 – 40% in some regions while, in others, they will decrease by 10 – 30%. **A further message is thus that changes in climate will be amplified in the water environment.**

If the challenges of climate change for the world's water are not understood and addressed, we run the risk that the water supplies we provide to the communities of a growing, urbanizing world, the infrastructure we build to serve them and the industries and agriculture that supply and feed them, will prove to be unsustainable.

There are also broader dangers. If we fail to understand the interaction between climate change and water, other climate change strategies may actually aggravate the problems and increase the vulnerability of communities to both natural and man-made calamities (see Box "Kenya's water-wise roses").

[1] IPCC, 2007. Climate change 2007: Climate Change Impacts, Adaptation and Vulnerability. Contribution of Working group II to the Fourth Assessment Report of the IPCC.

[2] IPCC, 2007. Climate change 2007: Mitigation. Contribution of Working group III to the Fourth Assessment Report of the IPCC.

Global Water Partnership

Adaptation efforts must begin immediately because both the institutions that we establish and the infrastructure that we build today lock us into patterns of behaviour for many years to come. Unless we act now, we will miss opportunities to make it easier to ensure a more sustainable long term future.

It is thus important for water managers and water users alike to get to grips with the future that is unfolding. An approach to water resource management that can identify and address the challenges – and uncertainties – is needed. But as important as promoting better, more intelligent, water management, we need to ensure that in all sectors of society, the water challenges are addressed in broader climate change and development strategies.

Although it will be some time before the full extent of the impacts of climate change on water resources become evident and are fully understood, it is important that they should be addressed sooner rather than later to adapt to a future that many believe has already begun to occur. Moreover, the best way for countries to build the capacity to adapt to climate change will be to improve their ability to cope with today's climate variability. Adaptation on seasonal to inter-annual time scales will be critical in adapting to the impacts of longer term climate change as well. **So another overarching message is that improving the way we use and manage our water today will make it easier to address the challenges of tomorrow.**

While this brief focuses on the emerging challenge of adaptation, it is important to recognize that aspects of water use contribute to climate change and that different approaches to water management can help to reduce these impacts. Indeed, mitigating global climate change will require addressing a range of thorny water and development problems, such as tapping more of the world's hydroelectric energy potential in ways that are socially and environmentally responsible, balancing the allocation of scarce land and water resources for biofuel production against other key uses, and finding ways to reduce the energy-intensity of desalination and groundwater-based approaches to increasing freshwater supply.

## The impact of climate change on water resources

### The challenges of climate change …

To address the challenges that climate change poses in the water sector, it is first necessary to consider its potential impacts on different dimensions of water resources and their management.

***Quantity - less rainfall, and more***

Rainfall will increase in some areas and decrease in others. In some larger regions, there is already substantial consensus, based on the results of many modeling studies, about what changes are likely. In other areas, there is still disagreement. Changes – both increases and decreases - in average rainfall of up to 20% are predicted in many cases.

***Extremes - floods and droughts***

A related issue is the size of extreme water events such as floods and droughts. There are sound reasons to expect that there will be more powerful, intense, storms and floods and longer, more intense droughts.

***Frequency – intensified challenges***

As important as the size of extreme events is how often they occur. It is predicted that extreme events will occur more often; floods and droughts that previously occurred once in a lifetime, every 50 years, may now occur every 5 or 10 years.

### … **for water resources**

City dwellers – and irrigation farmers, and hydropower companies – are worried less about how much it rains and more about whether there will be enough water in the rivers and dams to meet their needs and whether storms and floods will damage their homes, equipment and transport infrastructure.

So to understand the full impact of climate change on communities, it is necessary to be able to predict average rainfall, stream flows and groundwater yields (to determine water availability and storage requirements) as well as extreme flows and storms (to plan settlements and design infrastructure to withstand them).

While the general shape of the future is increasingly clear, there is still substantial uncertainty about the climates that will be experienced in different parts of the world. The broad picture of global warming is reasonably well understood and there is growing agreement about its regional dynamics and scale. However, moving from temperature predictions to reliable predictions of local rainfall, its distribution and the resultant river flow is a huge step forward.

***Rainfall***

At present, even rainfall predictions are still relatively general and are indicative rather than definitive *(see diagram taken from the recent IPCC Report summary[3])*. Currently, these predictions can only be used to describe the kind of challenges that may arise rather than to predict them more exactly. Similar caveats apply to the other key dimension of climate variability, for example the predictions that there will be more extreme events.

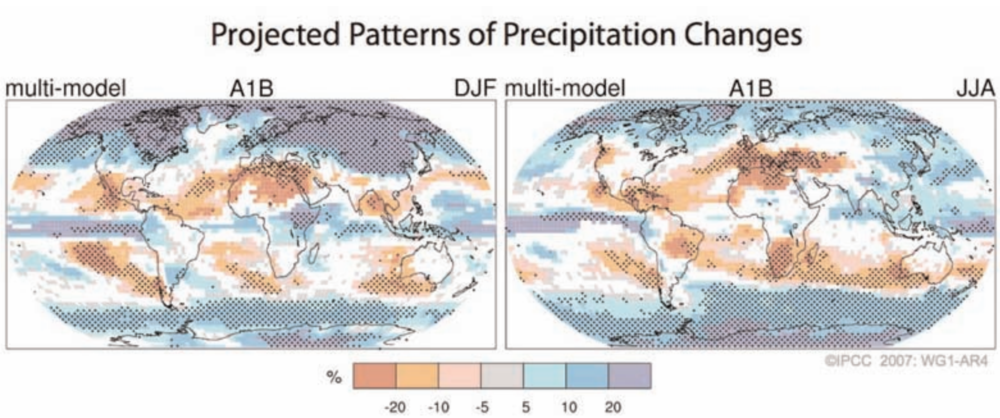



**FIGURE SPM-7.** Relative changes in precipitation (in percent) for the period 2090–2099, relative to 1980–1999. Values are multi-model averages based on the SRES A1B scenario for December to February (left) and June to August (right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change. {Figure 10.9}

If it is difficult to make good predictions about the future of rainfall and storms, it is more difficult to predict the impact of changing temperatures and rainfall on water availability.

[3] IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC, pg. 16.

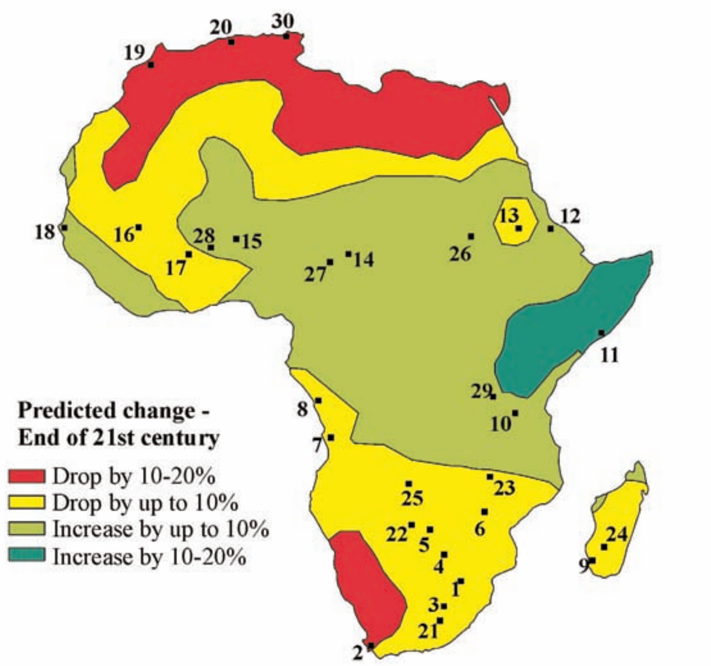
***Temperature and aridity***

One effect of temperature increases that is often forgotten is the increase in aridity – the ratio between rainfall and evaporation. Since evaporation increases with temperature, aridity will increase in many areas.

***Runoff and streamflow***

Rivers rise when rainfall "runs off" the land or percolates into aquifers underground to emerge later as springs. With the drier ground of a more arid climate, less water will run off to the rivers or percolate into the deeper aquifers. This is why climate change is "amplified" in the water cycle. The reduction in runoff will be perhaps the most serious impact of global warming on the water environment. In some drier areas, notably in sub-Saharan Africa and the Mediterranean region but also in South Asia and Australia, reductions in stream flow of more than 50% are confidently predicted. There will also be changes in the proportion of water courses with year round riverflow (as shown in the Changes in Surface Water Supply diagram). This change could have devastating impacts on human activities as well as bringing about permanent changes in the natural environment, including the extinction of many species.

At the other extreme, more intense rainfall will saturate the ground faster than usual. If it continues to rain, more water will run off into streams and rivers and floods will be larger and more damaging.




**Changes in Surface Water Supply Across Africa with Predicted Climate Change**
Maartin de Wit and Jacek Stankiewicz
Sciencexpress: www.sciencexpress.org/2March2006/Page1/10.1126/science1119929
Work done at AEON-Africa Earth Observatory Networks

*Floods and loss of storage as glaciers and snowfields melt*

A further direct consequence of temperature increase is the shrinking of glaciers and snowfields. These areas currently act as "natural reservoirs," storing water in winter and releasing it gradually as melt-water in summer. So the melting of snow and glaciers will first increase and then reduce river flows, causing first floods, then droughts. There is also likely to be substantial erosion of newly exposed surfaces.

## The impact of climate change on human activities and communities – and thus on the management and use of water

These changes will have some very obvious and direct impacts on the way people use and manage water:

- where water availability is reduced, communities will either have to change their water habits to use less water, bring water from further afield, at greater cost, or both;

- hydroelectricity, an important source of non-polluting[4] renewable source of energy, depends on reliable water sources. Lower river flows will reduce electricity supplies and power failures will affect the economic and social life of many communities unless new investments are made.

- more intense rainfall will increase the cost of flood protection works as well as that of associated infrastructure such as roads and stormwater drains.

There are also many less direct effects:

- where urban and industrial wastes are discharged into rivers, acceptable water quality is achieved by diluting the pollutants. If streamflows are reduced, either pollution discharges will have to be reduced as well or treatment intensified simply to maintain the same environmental standards;

- bringing water from further afield will not only increase its cost but also intensify competition between users for the reduced amounts of water that are available. Social and economic impacts will include higher prices as well as the aggravation of rural unemployment as farmers lose their supplies to other users;

- increased flood risks will reduce the land available for settlement, aggravating the impact of sea-level rise in coastal cities;

- rising sea levels will infiltrate unusable saline water into coastal aquifers, reducing the water supplies of coastal communities, particularly in small island communities.

While attention understandably focuses on the negative effects, it should not be forgotten that some areas will benefit from the higher temperatures and changed rainfall regimes that are predicted. These will create new economic and social opportunities that countries and communities should seek to understand and exploit.

[4] The IPCC does not consider methane generated in reservoirs to be a significant source of greenhouse gases (GHG), noting that "while some GHG emissions from new hydroelectric schemes are expected in the future, especially in tropical settings,... in the absence of more comprehensive field data, such schemes are regarded as a lower source of $CH_4$ emissions compared to those of other energy sector or agricultural activities". Hydroelectric power is therefore not treated as a separate emission category in the Special Report on Emissions Scenarios. (see IPCC Special Report on Emissions Scenarios, UNEP/WMO 2006).

## Integrated Water Resources Management – an intelligent strategy for adaptation

Better water management will be essential if communities are to adapt successfully to climate induced changes in their water resources. The strategies adopted will have to use a combination of "hard," infrastructural, and "soft," institutional, measures and to go well beyond what is normally considered as "water business". Critically, they will require major changes in the way agriculture, industry and human settlements in general are managed. The future resilience (or vulnerability) of human communities to climate change related impacts will depend, in large measure, on their success. This brief suggests that the IWRM approach provides a framework for action, indeed that **the best approach to manage the impact of climate change on water is that guided by the philosophy and methodology of Integrated Water Resources Management (IWRM).**

IWRM promotes a holistic approach to water management and recognises that there are multiple pathways to building resilience. The methodology seeks to identify, and then to achieve tradeoffs between, different water management objectives including environmental sustainability, economic efficiency and social equity. It encourages the structured engagement of communities and sectors impacted upon by water into its management both to seek and promote "win-win" solutions but also to ensure that a better understanding of water constraints and challenges is developed and diffused into the society.

IWRM involves both "hard" infrastructural and "soft" institutional strategies. Indeed, it is the judicious mix of both hard and soft strategies that offers countries the best chance of coping successfully with climate variability and change, through the use of soft tools that complement infrastructure and help ensure that infrastructural investments work effectively[5].

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### Hard Strategies - infrastructure

Building resilience to manage the impact of variable climates on human activity is not new and has been the day to day business of society's water managers for generations.

Traditional water infrastructure, the household rain water cistern, the "tank" in the Indian town, enables households and communities to manage the variability of the water resources on which they depend, which in turn, reflects their local climate. The same is true for the simple river "training" and flood wall structures and flood diversion canals that protect many of the world's towns and cities.

Since the useful life of large water infrastructure is often measured in hundreds of years, investments that are made today will still be operating under the new climates of the 22nd century and need to be designed for the future as well as for the present.

One way to manage the impact of climate's variability on water resources is to capture and control river flows. Dams can retain and store flows in excess of user requirements and release them when low flows are not sufficient; this can also help to maintain aquatic ecosystems. Peak flood flows can be stored and released later, avoiding flood damage by reducing maximum flows. Both functions are important to sustain human settlements and to avert disasters caused by floods and droughts.

Dams also store water as a form of potential energy to generate electricity without which healthy human life is difficult to sustain, particularly as settlements increase in size. 19% of the world's electricity is currently generated from hydropower and this could be substantially expanded, particularly in developing countries, supporting economic and social development without aggravating global warming.

[5] See forthcoming GWP Technical Brief on "Infrastructure and IWRM Plans", in preparation.

Other important water infrastructure includes canals, tunnels and pipelines that serve not just to supply human demands directly but also, by creating linked systems with multiple sources, suffer less variability and offer enhanced supply security. Wastewater disposal and stormwater drainage systems enable communities to maintain their activities and to protect public health during extreme weather events.

Other technological strategies, including the recycling of wastewater and desalination of brackish water can also help, although cost is often a barrier.

**However, another message is that there are no simple technical fixes.** Thus engineered flood protection may protect communities from "normal" floods but can make them more vulnerable and aggravate flooding disasters in more extreme events, as was vividly demonstrated in the New Orleans disaster. And energy intensive solutions such as desalination may in turn aggravate climate change if applied on a large scale.

## Soft Strategies - institutions and management systems

The armory of the water manager to address variability and extreme events is not restricted to infrastructural means. As important are the institutional mechanisms that, again more or less formally, help to deal with climate variability and to achieve goals such as water supply for people, industries and farms, to protect communities from flooding while sustaining ecosystems.

Integrated water resource management also offers a set of soft tools that are often cheaper, and may be more effective, than its infrastructural tools and can certainly complement infrastructure to ensure that it works effectively.

Thus, in addressing potential water shortages, **as much attention should be given to managing demand as to increasing supply, by introducing more efficient technologies as well as simply promoting a culture of conservation.** This is going to be particularly important in areas where overall water availability declines.

In many countries, this is already done in a rudimentary way. Organized drought restrictions in agriculture and "hosepipe bans" for domestic users should not be seen as supply failures but rather as institutional mechanisms used to manage variability by prioritizing different water uses at times of supply stress.

An important element of demand management is to encourage water users to use what they have more efficiently. It has been widely demonstrated that, with help and encouragement, well-off households can substantially reduce their consumption. Farmers can usually get far more "crop per drop"; industrialists often achieve more production per unit water when put under regulatory pressure and can also locate water intensive processes in areas where water is plentiful. Incentives for water users to exchange their current water allocations, either through administrative systems or "trading," can help to achieve more efficient water use, although the social impacts need to be carefully managed.

At a larger scale, the global trade system has a substantial impact – positive and negative - on water use, which needs to be understood and engaged (see Box "Kenya's water-wise roses"). In this context, the current promotion of biofuels as a source of energy could greatly aggravate the challenges of water scarcity if not carefully planned and regulated.

Beyond direct water management, institutional instruments such as land use planning can substantially reduce the vulnerability of communities to water based natural disasters if they are informed by reliable flood data. This demonstrates that there is often a choice from a suite of hard and soft instruments that can be applied to enhance resilience. Thus resilience against floods can be achieved by building protective infrastructure or through planning which restricts settlement in vulnerable areas.

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“ ...the global trade system has a substantial impact – positive and negative - on water use, which needs to be understood and engaged.

In all this, it is important to recognise that many of these challenges are not new and are certainly not the product of climate change alone. Thus the changing lifestyles and dietary patterns associated with growing affluence in countries like China and India will, arguably, have an even greater and more immediate impact on the water environment.

### Balancing adaptation and mitigation – the case of Kenya's high-flying water-wise roses

Every night at Kenya's Nairobi airport, air freighters are loaded with freshly picked flowers and vegetables which the next day will be sold in markets across Europe.

With less than 1000 kl of water per person per year, Kenya is one of the most water stressed countries in Africa. With that situation aggravated by population growth and now climate change, Kenyans have to worry about making the most of their limited water resources.

There is already too little water to irrigate all the 500 000 plus hectares of suitable land. And, without irrigation, it is hard and risky work to scratch a living from the land, one reason why many rural Kenyans have flocked to the towns and cities.

In this context, the growth of the horticulture and floriculture industry has been a real boon. Intensive production of vegetables and flowers uses water relatively efficiently. Certainly, the value of the crop produced, per unit of water, is far higher than for traditional food crops as is the number of paying jobs that are created both on farm and in processing and packaging.

Growing high-value cash crops thus enables the country to afford the more water-intensive foods that it needs to import to feed its people.

But there is now a cloud on the horizon; more specifically, the trails of the jet freighters have been blamed for aggravating climate change. And indeed, taken by itself, it makes sense from a climate change perspective to restrict air freight and there have been proposals made to that effect.

A ban or tax on air-freighted fresh produce would be devastating for Kenya's economy. Paradoxically, it might do little to reduce the impact on climate change. The alternative to importing fresh produce from Kenya might be to grow it in European greenhouses. That has huge energy implications which also impact on climate.

This is a good example where a water efficient approach, good for adaptation, may conflict with a narrowly conceived approach to mitigation. An integrated approach that evaluates potential measures in terms of both adaptation and mitigation effects will be needed if mitigation efforts are not to make poor people poorer and more vulnerable and preventing them from adapting effectively to climate change.

## Future challenges (and IWRM responses)

There are multiple challenges confronting communities and countries that seek to "climate-proof" themselves, in the sense of increasing their resilience to the effects of climate change, by managing their water resources more intelligently. As always, poorer countries will face the greatest challenges. Addressing them will require strong, and well informed, leadership as well as effective strategies.

### Intelligent institutions to coordinate responses and support difficult decisions

A key challenge is begin to orient water managers, as well as their partners in key water use sectors, to the potential impact of the emerging new climates. Intelligent institutions are needed that can go beyond managing water on a day to day basis to identify water use trends, areas vulnerable to climate change and opportunities to respond as best possible to the emerging challenges.

This cannot be addressed as a "once-off" project. It is about building dynamic organisations that are able to respond strategically and effectively to changing circumstances. To achieve this, key water use sectors must be engaged and common understandings of the challenges developed so that appropriate responses can be identified and supported, and trade-offs made.

## Designing the technical responses will require enhanced water knowledge

The design of expensive water infrastructure and complex management arrangements needs more than technical capacities. It must be guided by sound information about the water resource.

Paradoxically, one consequence of the wide uncertainty about the future impact of climate change is that water managers are still using historic climate data to design water infrastructure and guide their management decisions. This has been aggravated by a worldwide decline in the availability of hard water data over the past few decades. In many poorer countries, hydrological information systems have been allowed to decay under pressure to allocate scarce resources to more immediate needs. As a result, they have limited information to support the planning, development and management of their water resources, a situation which cannot be reversed overnight. However, unless a start is made to rebuild the basic systems to provide information about water resources, the danger is that new dams will not achieve their predicted yields; that revised water allocations will turn out to be "dry."

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## Funding the actions required

To support enhanced management that climate change will need tomorrow – and climate variability requires today - a more strategic and better prioritized approach to funding is required.

The current global focus is on the short-term - immediate poverty priorities such as basic water supply and sanitation and "bankable" activities such as hydropower and industrial water supply. Yet there is a real likelihood that, without effective long term water management, these current activities will prove to be unsustainable. Hydropower plants are already failing to produce the amount of electricity expected; basic water supplies are failing for lack of adequate water sources. This is a clear case of penny-wise, pound foolish.

Many poorer countries cannot even manage their current climate variability, not because the strategies needed are unclear but because the means to implement them are lacking. They may reasonably ask why they should address tomorrow's climate change if they cannot afford to manage today's drought?

The challenge of "climate-proofing" the future requires that adequate funds are allocated today for water resource management. One way to raise funds and support better water management is to put a price on commercial water use – including "luxury" levels of domestic consumption. Higher water prices have been shown to promote increased efficiency, particularly in agriculture. At a global level, poorer countries should benefit from the "polluter must pay" principle, since they are incurring costs imposed on them by the action of richer countries. So the funding of adaptation in the water sector needs to be taken up in the broader development finance discussions.

## The way forward

### Global

There is a clear need for a coherent approach to water resource management to address the challenges of climate change and obvious potential for an IWRM approach to help meet this need as well as to contribute to the broader goal of sustainable development. The foundation has already been provided by the decision, at the 2002 World Summit on Sustainable Development, that all countries should establish integrated water resource management plans by 2005.

Since many countries are already promoting and implementing IWRM, this framework should be used to address the challenges of climate change. This will obviate the need for new institutions and activities and should be undertaken in a manner that helps to mainstream adaptation or "climate-proofing" into national development plans.

### Regional and national

An important early step will be to work at regional and national level to ensure that all stakeholders are helped to understand the specific local challenges of climate change for their water management.

The ongoing IWRM planning process should provide a foundation for this engagement. It will however be important to ensure that climate change is addressed in a structured way. For this to occur, complementary assistance will be needed not just to support climate change adaptation but to ensure that water resource managers, particularly in poorer developing countries, are equipped and helped to use the new tools and approaches that will have to be developed.

### Final word

Many of the impacts threatened by climate change are just extreme examples of challenges that are already addressed on a daily basis across the world. Countries which have established effective institutions and infrastructure to deal with today's climate are better placed to deal with the more extreme variability which we expect tomorrow.

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Being rich certainly helps, but being wise is as important. For poor countries, it is arguably more important to develop and apply water wisdom to the challenges of climate change, to compensate for the lack of resources that might tempt them to rely on more traditional, hardware, solutions.

The systematic approach offered by IWRM has already proved to be a useful first step. But if it is to make a difference, much more work is needed.

[10] Fourth World Water Forum, "Integrated Water Resources Management: Strengthening Local Action", Thematic Document, Framework Theme 2, Mexico City, March 2006

## Key messages

- If our global energy habits are the focus for mitigation, the way we use and manage our water must become the focus for adaptation.
- Changes in climate will be amplified in the water environment.
- Improving the way we use and manage our water today will make it easier to address the challenges of tomorrow.
- The best approach to manage the impact of climate change on water is that guided by the philosophy and methodology of Integrated Water Resources Management.
- There are no simple technical fixes.
- In addressing water shortages, as much attention should be given to managing demand as to increasing supply, by introducing more efficient technologies as well as simply promoting a culture of conservation.
- The challenge of "climate-proofing" the future requires that adequate funds are allocated today for water resource management.

Graphic design: Svensk Information. Production: Red Shift. Printers: Elanders 2007

## Resources and further reading

*Climate changes the water rules - How water managers can cope with today's climate variability and tomorrow's climate change*. Synthesis report of the Dialogue on Water and Climate. March 2003.

Cooperative Programme on Water and Climate: www.waterandclimate.org

Kabat, Pavel, R.E. Schulze, M.E. Hellmuth, J.A. Veraart and Roberto Lenton. *Climate Variability and Change-Freshwater Management*, International Review for Environmental Strategies, Volume 3, No. 2, Winter 2002.

Lenton, R., *Water and Climate Variability: Development Impacts and Coping Strategies*, Conference Proceedings, Stockholm Water Symposium, 2003.

NeWater Project on adaptive water management: www.newater.info

This brief was prepared under the direction of the Global Water Partnership Technical Committee (TEC), with TEC member Mike Muller as lead author. The brief is intended as an initial contribution of a new GWP programme of work to review different aspects of water use and management relating to climate change, in an effort to better understand and address the challenges that have been identified. Through its partnership network GWP hopes also to identify the regional specific dimensions of the challenge and the particular interventions that are required at each level.

The brief complements a series of policy and technical briefs designed to help countries accelerate their efforts to achieve the action target for the preparation of IWRM and water efficiency strategies and plans set by the 2002 World Summit on Sustainable Development (WSSD). The briefs, as well as related publications such as "Catalyzing Change: A Handbook for Developing Integrated Water Resources Management (IWRM) and Water Efficiency Strategies", can be downloaded from www.gwpforum.org or hard copies can be requested from gwp@gwpforum.org.