**Change - Adaptation of water resources management to climate change**
Climate change is here and will be with us for the long-term. The challenge facing water professionals is how to make decisions in the face of this new uncertainty. This book outlines a new management approach that moves beyond technical quick fixes towards a more adaptive style that is inclusive and innovative. Only by thinking, working and learning together can we tackle the impacts on water resources and uncertainties induced by climate change.

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The World Conservation Union

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Adaptation of water resources management to climate change

*Ger Bergkamp, Brett Orlando and Ian Burton*

IUCN
The World Conservation Union

Water & Nature Initiative

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# Contents

# Key messages

## 1. Waking Up to Climate Change

*The water sector has paid little attention to and is often unaware of the expected impacts of climate change on future water resources.*

Water managers around the world are often unaware of the changes that are likely to occur in the world's hydrological cycle over the next few decades. Given their involvement in water resources developments that often take decades to materialise, they will need to pay more attention to incorporating climate change considerations into their work.

## 2. Mounting Evidence, Emerging Responses

*Climate change is here and will be with us for a long time to come. It will have a significant impact on water resources and their management.*

Over the last 100 years, the global climate has warmed by an average of 0.5 degrees Celsius, owing in part to greenhouse gas emissions from human activities. Unless concerted action is taken to dramatically reduce these emissions, climate models project that the Earth will warm by another 1.4 to 5.8 degrees Celsius over the next century. These changes will have a substantial destabilising effect on the hydrological cycle, resulting in greater variability in precipitation and stream flows, and increasing intensity of extreme hydrological events.

*Water professionals will need to adapt to climate change.*

Existing commitments to reduce greenhouse gas emissions are insufficient to halt present climate change, making adaptation a necessity. On their own, neither planned nor spontaneous adaptation would be able to mobilise the society-wide movement for adaptation that will be needed. A combination of approaches, ranging from engineering types to societal processes, will be required. This means a combined top-down / bottom-up approach should be adopted that brings together the public and private sectors, and civil society.

*Societies will need to live with the greater uncertainty arising from climate change.*

Existing climate data and models have been instrumental in pointing out some general changes in the hydrological cycle that are triggered by climate change. They will not be able, however, to substantially reduce current uncertainty and projected changes in climatic conditions at scales required for water management. Therefore existing risk and uncertainty management approaches need to incorporate climate scenario analysis and vulnerability assessments.

## 3. Living with Uncertainty

*To adapt to climate change, water professionals will need to reinforce the current changes in water management priorities.*

An increasing emphasis is now being placed on integrated approaches for water management to respond to changing social, environmental, economic and political realities. Current water resources planning and management is beginning to take a system's approach, emphasizing the role of ecosystem goods and services. Maintaining and strengthening the delivery of these goods and services can be an important aspect of adaptation to climate change.

*Adaptation to climate change will require water managers and users to deal more effectively with risks and uncertainties.*

Current approaches to risk management, such as expert-based operational rules, are generally inadequate when it comes to dealing with climate change impacts. Such approaches only incorporate known risks and are unable to address the impacts of unknown risks and uncertainties, including those stemming from climate change. Managing risk and dealing with uncertainty in river basins will become a key priority in the near future. This can be achieved using various measures, including monitoring known hazards and risks, reducing the unknown risks through system research, and determining the range and type of relevant uncertainties. Such actions can reduce existing uncertainty to a minimum.

*The first priority for adaptation should be to reduce the vulnerabilities of people and societies to shifts in hydro-meteorological trends, increased variability and extreme events.*

An increase in the occurrence of floods, droughts and other extreme weather events due to climate change poses a considerable threat to national economies and sustainable development. Current and future risks and uncertainties associated with such weather-related problems need to be addressed to safeguard people and societies from increased loss of life, property and assets. Particular attention needs to be paid to the most vulnerable countries and the most vulnerable groups within societies.

*A second adaptation priority will be to protect and restore ecosystems that provide critical land and water resources and services.*

Ongoing degradation of water and land resources threatens the continued production of goods and services from river basin ecosystems. Protection and restoration of such ecosystems is urgently needed to maintain and restore natural capacities that support the protection of people and assets against increased climate variability and extreme events.

*A third adaptation priority will be to close the gap between water supply and demand.*

In many regions, water demand now exceeds or threatens to outstrip sustainable levels of supply. Conventional strategies to increase water supply can no longer meet growing future needs, and

are unable to cope with the uncertainty arising from increased climate variability and climate change. Sustained efforts thus need to be made to reduce water demand and mobilise non-conventional water resources through appropriate policies, laws, incentives and technical measures. The responsibilities of various actors for this will need to be clearly set out.

## 4. Beyond Pipes, Pumps, and Ponds

*Adapting water management to climate change will require going beyond a "technical quick fix" by catalysing a broad societal process.*

Conventional practices alone are ill-equiped to deal with the projected changes to water regimes. The risks and uncertainties induced by climate change means water resources management cannot be handled by experts alone. Wider stakeholder involvement and transparency is therefore required to build political support for sharing the burden and benefits of the impacts of climate change.

*Adapting water management to climate change will require building the capacity of people and institutions.*

Adaptation of the water sector to climate change will require the training of engineers, hydrologists, planners and many other professionals on these issues. It will require investing in strengthening the ability of people to manage their water resources more efficiently and equitably. Making resources available for strengthening both institutional and individual capacities is a critical early step in adapting to climate change.

*Maintaining and increasing social capital will be needed to build the capacity to coordinate and participate in adaptation efforts.*

The capacity of societies to adapt depends on their ability to maintain and increase their social capital. Building trust, instilling norms and maintaining societal networks will facilitate cooperation in the face of the challenges raised by climate change. A deliberate effort is needed to enlarge social capital by raising awareness, organizing special events, and securing financial and other support from community-based groups.

*Water users and managers will need to adopt an adaptive management style and be prepared to engage in "social learning".*

Water resources are part of complex ecosystems that are not yet fully understood. As climate change adds further risks and uncertainties, a water resources management style is needed that is flexible enough to adjust to ongoing change. Monitoring and evaluating performance is an essential part of an adaptive management style that forms the corner stone of "social-learning" – that is, learning with stakeholders how best to manage the shared water resource.

*Adaptation to climate change will require improving water-conflict management and strengthening other relevant skills.*

Climate change will intensify water-stress and hazards and the conflicts associated in dealing with these. Adaptation to climate change will therefore need to pay explicit attention to managing water conflicts and assisting water users and managers to find agreeable solutions for sharing their common resource. Building these assets requires special attention as it is often overlooked when discussing adaptation to climate change.

## 5. Meeting the Challenge

*National Adaptation Coalitions will need to be set-up to bring together the relevant water-actors and develop a society-wide process of adaptation.*

Water professionals cannot define strategic priorities for adaptation to climate change alone. They will need to work with all interested groups and stakeholders brought together through National Adaptation Coalitions. These coalitions will need the capacity to innovate, adapt and manage conflicts.

*Coalitions will need to make adaptation work for people and involve them through national and local forums.*

Determining what people want through dialogues, consultations, and other forums is critical if a National Adaptation Coalition is to work. These Coalitions need to care for people by designing actions that promote short-term benefits for those involved. To have lasting impact, stakeholders will need to see benefits from investing in the adaptation process.

*Coalitions will need to catalyse innovation through a series of experiments that kick-start adaptation in the water sector.*

Encouraging innovative water users and water professionals to experiment with new ideas forms a critical element in getting adaptation started. By learning through experimentation, all water actors can contribute to delivering on progress and innovation in an incremental and sustainable way.

*Coalitions will need to engage political leaders to support the adaptation process and instil the underlying core values.*

A critical first step for National Adaptation Coalitions is to identify and agree on a set of core values that underlies the way they want to deal with climate change. Communicating these values and the actions required to a wider audience is the main task of leaders of government, business and civil society. Making adaptation a success requires generating political buy-in from key interest groups, and using political opportunities to move forward.

# Preface

This report will help water professionals to identify actions that can be taken to adapt to the changes in the world's water regimes expected to occur over the coming decades. It's origins can be traced back to the World Water Vision, a declaration on global water issues adopted in March 2000 during the Second World Water Forum. The Vision highlighted climate change as one of the major challenges facing water professionals over the next twenty-five years.

The World Water Vision coincided with a growing awareness within the United Nations Framework Convention on Climate Change (UNFCCC) on the need to adapt to climate change. Changes to the climate are already leading to more unstable and shifting water regimes around the world. The limited reductions in greenhouse gas emissions that are agreed upon in international negotiations will be inadequate to mitigate their effects. It is becoming apparent that if we cannot prevent the problem, we must adapt to it.

IUCN's work on the linkage between water and wetland resources and climate change stems from its engagement in the Ramsar Convention on Wetlands. As a long-standing partner of that Convention, IUCN provided technical advice to Parties when they adopted their first resolution on climate change at their seventh Conference of Contracting Parties in 1999. More recently, IUCN prepared the *Wetlands and Climate Change* report, which provided an analysis of the linkages between the Ramsar Convention and the UNFCCC.

Further work conducted by IUCN in partnership with others has unveiled more and more evidence of increasingly unstable and shifting water regimes around the world. Water professionals in most countries are confronted with greater variability in the amount and seasonality of rainfall and stream flows, as well as the increasing frequency and intensity of extreme hydrological events. Their concern is that this variability will increase with a warming world, and place ever increasing challenges on conventional water practices and policies.

This book encourages water professionals to continue with, and to strengthen, the changes they are already beginning to make. Climate change reinforces the new style of management that is emerging within the water sector in response to rising demands for water resources. Such a management style moves beyond technical quick fixes to engage with various societal groups in a process to deal with emerging risks and uncertainties. The new management style includes all stakeholders, relies on the capacities of people, encourages joint learning, and invests in managing conflicts.

IUCN looks forward to working with water professionals and other partners in catalysing a society-wide process for addressing one of the most pressing environmental issues of our time. Only by thinking, working and learning together can we tackle the impacts on water resources and the uncertainties induced by climate change.

Achim Steiner
Director General
IUCN-The World Conservation Union

# Acknowledgements

IUCN actively supported the creation of the Dialogue of Water and Climate, and has been a strong partner in implementing its work programme over the last year. With generous support from the Dialogue on Water and Climate, IUCN convened five regional dialogues on water, wetlands and climate in 2002. These regional dialogues – held in Central America, the Mediterranean, Southeast Asia, Southern Africa, and West Africa – were convened jointly with the regional nodes of the Global Water Partnership in Central America, West Africa, and the Mediterranean, as well as the Regional Committee for Water Resources (CRRH) in Central America and the Inter-States Committee for Drought Control in the Sahel (CILSS) in West Africa. We are thankful for our partnership with these institutions.

The dialogues attracted participants from different disciplines and institutions including representatives from ministries of environment and water, departments of meteorology, drought and flood management, as well as national climate change units. Scientific institutes, river basin authorities, hydropower operators, water sanitation companies, civil engineers, hydrologists, forecasting experts, representatives from community-based organizations, and national and international non-governmental organizations also participated. Rarely does such a diverse group come together, and we are grateful to these individuals for contributing their time and expertise, and for making the dialogues a success.

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Los Angeles London Moscow Shanghai
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Chapter 1

# Waking Up to Climate Change

"The evidence shows that climate change is occurring ...and we cannot wait any longer to take action," declared UN Secretary-General Kofi Annan in a speech to American college students back in May 2001. Almost every day, it seems that we hear further evidence that the Earth's climate is changing. The 1990s was the warmest decade in the last hundred years, and 1998 was the warmest year on record. During the past century, global temperatures climbed by about 0.5°C – the largest increase in at least one thousand years.[1] As a result, snow cover is decreasing, glaciers are retreating, lakes and rivers are warming, rainfall patterns are changing and El Niño episodes are occurring more often. Extreme weather, including thunderstorms, flash floods, and droughts, are becoming more frequent and severe in many areas of the world. The diminishing Arctic sea-ice and rising sea levels further contribute to global distress. These changes are causing biological systems to alter, affecting the range, distribution and population density of a multitude of plants and animals around the globe. Whether the topic is polar bears or poplar trees, there is now compelling evidence of a world that is starting to warm up.

For many water professionals, however, the onset of a warming world is not considered a real problem. Many of the public debates on climate change have left the impression that the science is unclear and that the causes and effects of climate change are still in doubt. In addition, there have been few serious attempts to inform water experts about the links between climate change and the water sector. Under such circumstances, it is hardly surprising that the water sector has so far paid little attention to climate change, preferring for the most part to focus on other issues that must seem far more pressing. Although quite understandable, continuing to ignore or underestimate climate change and its impact on the water sector would be a mistake.

In the first place, the science of climate change is now anything but unclear about what direction we are heading. While models might differ in projecting the rate and magnitude of warming, all of them project a warming of the Earth's climate, and all forecast significant changes in water quantity and quality and in the ecological character of ecosystems around the world. Though there are still some processes such as the role of clouds and water vapour that vex climate experts, the last fifteen years of research and modelling has revealed a great deal about how the climate system operates and the key factors that drive it to change. The original trickle of evidence has now become a flood. Further, though a small number of scientists contest the conclusions of climate change research, the vast majority agree that the Earth's climate is changing and that much of the change can be attributed to human activities[2,1].

*"THE ORIGINAL TRICKLE OF EVIDENCE HAS NOW BECOME A FLOOD."*

"So climate change is a problem, but it is probably not an urgent one" might be the reply of a sceptical water professional. He/she would point out, quite correctly, that the most dramatic

warming to the Earth's climate is expected to take place in 50 to 100 years time, so there is no real need to address this problem now. "With so many other more pressing and more localized water management issues to deal with today - connecting people to clean water and maintaining irrigation, for example - why should I divert attention to what is perceived as a long-term problem?" the cautious water professional could ask.

But, the recurring droughts in South Asia and throughout Africa, the recent floods in Europe, Mozambique, Bangladesh, Vietnam, and Hurricane Mitch in Central America and Hurricane Andrew in the United States are continuing reminders of societies' vulnerability to climatic events. These events shatter lives and cripple economies. In the worst cases, whole societies are set back developmentally for a decade or more. Though these individual events cannot be directly attributed to climate change, they foreshadow the changes that are on the horizon.

Many of the decisions water professionals make today can reinforce societies' vulnerability if climate change is not taken into account. Over-exploiting rivers and wells for irrigation can exacerbate sensitivities to drought, for instance. Our decisions today will greatly affect society's ability to adapt to increasing variability in tomorrow's climate. Climate change is, therefore, not an issue that can be left for 50 or even 20 years, but one that needs to be addressed now.

What should water professionals be doing to respond to the problem? The more sceptical water professional might give a conservative answer: "The existing technologies and approaches will be sufficient to cope with the problem, just as they have in the past. We can construct more dams to store water and build more irrigation canals to re-distribute water resources." According to this approach, dealing with climate change will require nothing more than a quick technological fix; indeed, it provides a further reason to continue with conventional sector-oriented water resources management.

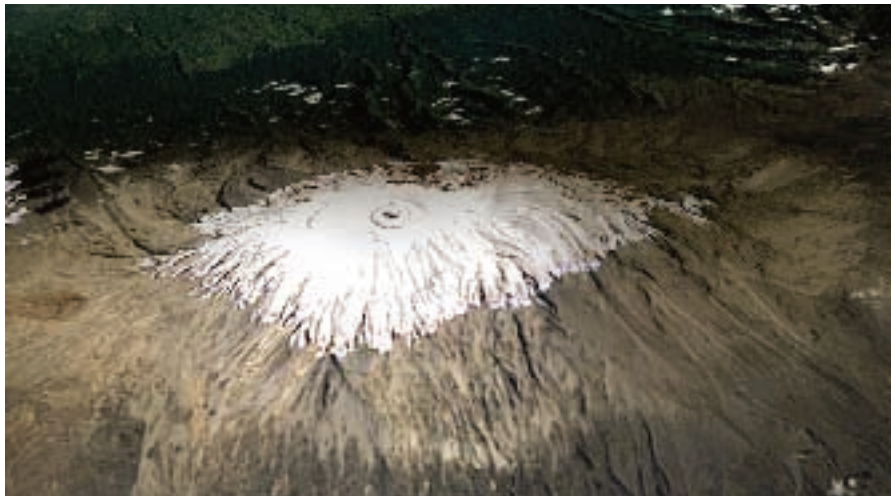
But, using traditional measures is unlikely to help. Indeed, those who rely on the "tried and true" approaches of the past could land themselves in hot water. That's because climate change challenges existing practices by adding a critical new element to the equation: uncertainty. The historic basis for designing and operating infrastructure no longer holds with climate change because the future hydrological regime cannot be assumed to be the same as that of the past. The key challenge, therefore, is incorporating uncertainty into water resources planning and management.

*"THOSE WHO RELY ON THE 'TRIED AND TRUE' APPROACHES OF THE PAST COULD LAND THEMSELVES IN HOT WATER."*

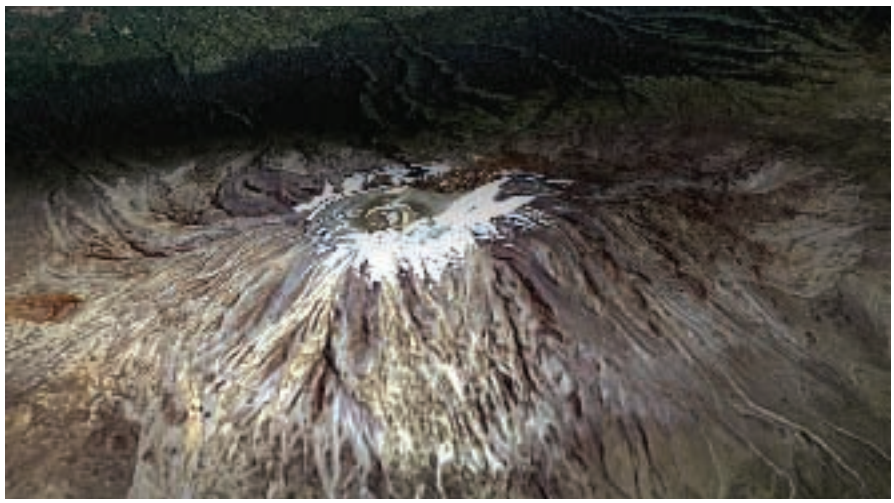
If there is no easy fix for climate change, then whose responsibility is it to deal with the problem? Some water professionals would prefer to believe that it is not theirs. After all, it is the energy-consuming sectors of the economy that have created this problem. Should it not also be their responsibility to fix it by reducing the amount of carbon dioxide and other greenhouse gas emissions generated by the use of coal, oil, and gas ?

Unfortunately, it isn't that easy. Although governments and some progressive businesses are starting to take responsibility for their emissions, we are now past the point where the current warming of the Earth can be avoided. Worse still, the emissions reductions that have been agreed so far are too modest to have any significant impact on the warming trend. Most experts regard the Kyoto Protocol as "a first step".

For better or worse, climate change is certain to become a growing pre-occupation of water professionals around the world. Increasingly, water resources management is about reconciling different and changing water uses and demands. Conventional water resources management has been shown to have its weaknesses by being too inflexible to address the current challenges facing the sector. In this respect, adaptation to climate change can be viewed as an opportunity to reinforce the trend towards greater flexibility in the way water use is managed and planned. It can be a positive force that strengthens existing and new efforts to innovate water management. As such, even the most sceptical water professional would be well advised to learn more about successfully adapting to climate change.



Snow and ice cover on Mount Kilimanjaro in 1993



Snow and ice cover on Mount Kilimanjaro in 2000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Chapter 2

# Mounting Evidence, Emerging Responses

## 2.1 Changing Climate, Changing Waters

### The evidence

Climate change is here, and will be with us for the long-term. For at least the next few decades the planet is set to experience an increase in temperature and change in rainfall patterns. There are no mitigation plans on the horizon that will have more than a slight delaying effect on the process of planetary transformation that has now begun. The empirical evidence for this is already mounting. To date, most attention has been given to the temperature dimension of climate change – which explains why the threat has become popularly known as global warming. While it is true that the direct effect of the heat-trapping gases is on global temperature, however, the consequences of a warmer world will be greatly amplified in the response of the world's water. We are faced with nothing less than a great destabilization and reshuffling of the world's hydrological systems.

Although we know that large changes are afoot, we do not know precisely how great they will be. The magnitude and pace of change will depend in large part upon what happens to the global emissions of greenhouse gases. If atmospheric concentrations of greenhouse gases can be stabilized at 550 parts per million (ppm), projections indicate a global mean temperature rise of 1.9 to 5.1 degrees Celsius above the 1990 average by 2100. Stabilization at 750 ppm, however, will lead to an increase of 2.8 to 7.0 degrees Celsius. As a comparison, global mean temperatures increased over the last 100 years by 0.5 degrees Celsius and the current level of $CO^2$ in the atmosphere is 350 ppm.[1]

*"WE ARE FACED WITH A GREAT DESTABILIZATION AND RESHUFFLING OF THE WORLD'S HYDROLOGICAL SYSTEMS."*

The projections further indicate that warming will vary by region, and will be accompanied by both increases and decreases in precipitation, depending on region and locality. There will also be changes in the variability of the climate, including rainfall and snowfall, and an increase in the frequency of some extreme climate phenomena, such as floods and droughts. The amount of warming will be greater towards the poles and in the continental interiors, and less over the oceans. More heat in the atmosphere will cause more evaporation from water surfaces and transpiration from vegetation, resulting in greater amounts of moisture in the air.

This destabilization of the world's hydrological systems will be manifested in many different ways. A number of global or large area generalizations have been made recently by the Inter-governmental Panel on Climate Change (IPCC) – the leading international source of expertise. In

### *CLIMATE CHANGE AND VULNERABILITY IN SOUTHERN AFRICA*

At the Regional Dialogue on Climate Change, Water and Wetlands in Southern Africa, held in November 2002, participants discussed the region's high sensitivity to current climate variability, particularly drought. Managing water scarcity is the predominant challenge. Long-term observations suggest that temperatures have increased 0.5°C over the past 100 years, that the seasonality of rainfall is changing, and that annual flows of some rivers such as the Zambezi are declining. Droughts appear to be increasing in frequency and severity.

At the same time, the region is starting to experience intense flooding, a phenomenon that is inconsistent with the long-term climate of the region. Between 1999 and 2002, the region was hit by a series of intense rainfall episodes including tropical cyclone Connie that produced the worst flood in 50 years. Two weeks later, tropical cyclone Elaine further inundated the region, causing extensive flooding in the Limpopo River Basin. Such an event is supposed to occur only once every thousand years. The overall conclusion is that Southern Africa is facing more and more climate variability.

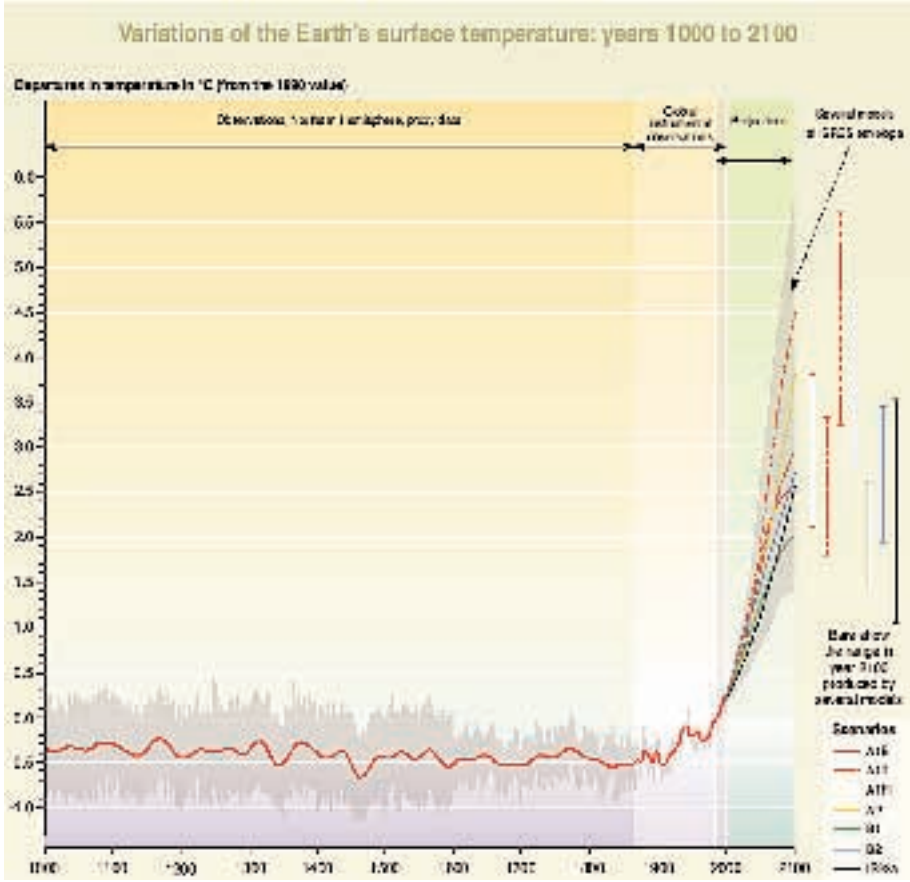
These changes are consistent with the climate change projections of the Intergovernmental Panel on Climate Change. With a projected warming of 1.7°C over the next one hundred years, rainfall in the region is expected to decrease by 5 to 20% in all the major river basins. Increases in evapo-transpiration are expected to result in losses of run-off in all the major river basins of the region. The most severe impact are expected in the Ruvuma River Basin in Tanzania and Mozambique and the Zambezi River Basin, whose resources are shared by eight countries - Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe.

With demand for water in the region expected to increase more than 90% by 2020, meeting these needs will require a major investment in resource development and management. When the current and projected trends of climate change are added to the equation, the situation appears daunting.

its Third Assessment Report published in 2001, the Panel concluded that annual precipitation would increase in high and mid-latitudes and most equatorial regions, but would generally decrease in the subtropics. The Panel also projected alterations to the seasonal distribution of precipitation, with the likelihood of more rain, less snow, and higher evaporation as temperatures increase. Rainfall intensity and variability is expected to increase in many areas.

## The impacts

These changes are already having an effect. In many places mountain glaciers are shrinking, and mountain snow cover is decreasing. This is likely to decrease the volume of spring and summer flow in rivers fed by snow and ice melt, and increase the winter flows. River basins where this is happening include the Rhine and the Rhone in Europe.[3] In tropical regions, such as the Andes and Mount Kilimanjaro, a dramatic melting of glaciers has already occurred over recent decades and is likely to affect downstream livelihoods sharply. Since water is more in demand during the growing




Forecast of the IPCC on global temperature rise

season, the shift in seasonal flows can be expected to have an adverse impact on downstream water users. Irrigators will probably face shortages at critical periods. Hydropower operators will be affected by the changes in the quantities of water available, especially during periods of drought and high power demand.

In Arctic regions the warmer temperatures have already resulted in the thawing of permafrost and the unseasonably early break-up of ice on rivers and lakes.[1] These changes impede road transportation that depends on a frozen surface, cause the destabilization of natural ecosystems and soils, and damage buildings and public infrastructure. Other consequences of climate change include the lengthening of high-latitude growing seasons and shifts in plant and animal ranges, including those of insects and disease vectors.[1] Such changes have serious implications for water quality and seasonal water availability.

## The uncertainty

The climate of the past can no longer be regarded as a reliable baseline from which to forecast climate variability and extremes in the future. Extrapolations from observed data are becoming increasingly unreliable. This suggests that the data and assumptions on which water use has been

Drought in India

Devastation from extreme river flows, Southeastern USA

planned and managed in the past can no longer be regarded as valid for the future. Unfortunately, the general indications of climate change and its impacts are as yet insufficiently precise to be a reliable basis for changing current day-to-day water management decisions.

With higher temperatures and greater humidity destabilizing the global atmosphere and the hydrological cycle, weather patterns are set to become increasingly difficult to predict. There is considerable uncertainty about the rate and even the direction of change at the regional and local level. Global warming does not mean that the same degree of warming will be experienced everywhere. Some places may become cooler. The same applies to snowfall and rainfall, with some areas becoming drier, in spite of the global trend towards more precipitation.[1]

*"THE DATA AND ASSUMPTIONS USED IN THE PAST CAN NO LONGER BE REGARDED AS VALID FOR THE FUTURE."*

It is unlikely that more precise information about changes in water availability will become more accessible in the near future. Information on the frequency and magnitude of floods and droughts or on variations in stream flow or groundwater recharge are not derived from or coupled with current climate models. Unfortunately, neither the extrapolation of recent trends nor the downscaling of global models can produce the precise information that water planners, managers and users would like to have access to.

The difficulty in applying global models at a regional level lies in the scale mismatch between global climate models and catchment hydrological models. Climate models use a monthly time step at a spatial resolution of several tens of thousands of square kilometres. Catchment and water management models, on the other hand, require data on at least daily scales and at a resolution of perhaps a few square kilometres. Although different hydrological models can give different values of stream flow for a given input, the greatest uncertainties in the effects of climate on stream flow arise from the uncertainties in the climate change scenarios themselves.

The more we find out about climate change and the impacts on water resources, the more unknowns we will recognise. What to expect is a kind of uncertainty that increases with the growth in knowledge. The challenge facing the water management community is therefore less about adaptation to specific climate changes, and more about adaptation to the added uncertainties being created by climate change.

## *2.2 Adaptation to Climate Change*

### The perspectives

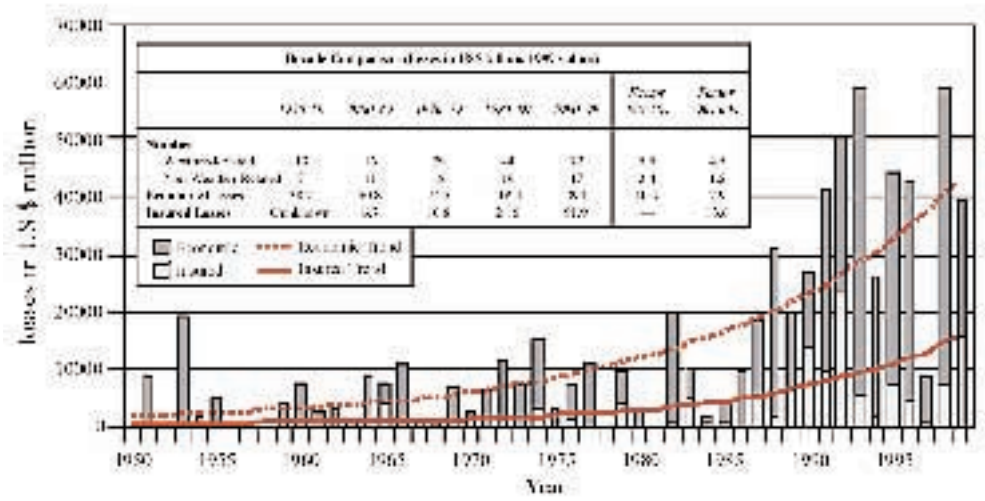
The United Nations Framework Convention on Climate Change (UNFCCC) has as its ultimate objective "the stabilization of greenhouse gas concentrations in the atmosphere at a level which is not dangerous to the climate system" – a goal often referred to as "mitigation."[4] Since the reduction of greenhouse gas emissions is proving to be a difficult process, it is becoming ever more clear that mitigation alone will not be sufficient to protect societies from the effects of climate change. It is now recognised that adaptation has a major role to play in reducing the impacts of climate change on people, businesses and society at large.

## *MEDITERRANEAN VULNERABILITY TO CLIMATE CHANGE*

The consensus of the Mediterranean Dialogue on Water, Wetlands and Climate Change, held in December 2002, was that climate variability will increase in the future. Current pressures on water regimes will intensify, leaving little room to manoeuvre, especially in drought situations.

Morocco and Tunisia are particularly susceptible to drought, and increasing climate variability is expected to exacerbate water scarcity, soil erosion and wetland degradation. In Cyprus, where rainfall has decreased 1 mm/year over the last century and mean temperatures have increased by 0.5°C, water availability has gone down by 40% from the estimates made in 1970. In the water scarce regions of Turkey, climate change threatens to accelerate desertification. In Tunisia, studies to develop water resources assume a stable climate. The key challenge, therefore, is to incorporate climate change assumptions into current water resources planning. In France, climate change models for the Rhone Basin project more severe floods in autumn and winter and more marked drought periods.

In the Mediterranean, the sector most likely to be affected by climate change is agriculture, since that sector utilizes a high proportion of the available water resources. At present there is a delicate balance between water supply and demand in relation to agriculture. Climate change threatens to destabilize this. Changes in water regimes are likely to go beyond the limits of recent experience in terms of quality, quantity, variability and extreme events. The changes that will occur are likely to vary greatly even over relatively short distances. A key challenge for the Mediterranean is to address this uncertainty in water resource planning and management.




Rising costs of loss in assets due climate related events

Adaptation in the context of climate change is defined by the Intergovernmental Panel on Climate Change as "the adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits opportunities."[1]

Adaptation may be categorized in a variety of ways, with a distinction often being made between planned and spontaneous adaptation. Planned adaptation is a process of public policy making and preparation that is based on an awareness of the existing conditions and vulnerabilities, the attributes that will change and the actions required to minimize loss or optimise benefits.[5] Spontaneous or autonomous adaptation is often referred to in the context of businesses adapting to change, usually triggered by markets or welfare changes and societal preferences.[5] Planned adaptation therefore refers primarily to governments working in a more pro-active manner, while spontaneous adaptation emphasises the role of the private sector, often taking a more reactive approach.

Those who favour deploying "concrete" adaptation measures, such as the creation of reservoirs or development of irrigation systems, have sometimes been reluctant to embrace "softer" adaptation methods such as education, extension services, regulations, penalties and other incentives. In fact, both approaches have their advantages. Given the pervasiveness of climate change, there is a role for adaptation at all levels of social organization, from national and local governments to the private sector, civil society and individuals and households.

Discussions on adaptation also differ from sector to sector. In the public health field, adaptation measures are generally referred to as "prevention". Prevention can be "primary", in which the disease vectors themselves are attacked or controlled, for example in the case of malaria eradication or vaccinations. It can also be "secondary" when referring to steps taken to reduce the risk of exposure to a particular illness or disease. Such "secondary" prevention might include the use of mosquito nets or measures to ensure safe sources of water supply.

In coastal zone management the three-fold approach to adaptation of "protect – accommodate – retreat" is widely used. Protection refers to the building of coastal defences such as sea-walls or dikes. Accommodation is focused on the harmonization of coastal land use with storm hazards and sea level risks, for example through land-use and building regulations or warning systems.

### *DISASTERS IN CENTRAL AMERICA: THE RISING TOLL OF IMPACTS*

One of the main findings from the recent Central American Dialogue on Water & Climate, held in November 2002, is that the impact of climate change on the region's water resources will threaten all sectors of society, especially the poorest and most vulnerable. The Central American region is particularly susceptible to natural disasters. Although it contains less than ten percent of the total population of Latin America, it has suffered more than half of the wider region's disaster-related casualties since 1960. From 1960 to 1999, the total number of people who died due to disasters in Central America totaled almost 60,000, with another 125,000 people injured, and over ten million made homeless or displaced. Nearly half of these people were the victims of climate-related disasters. During the same period, the accumulated economic cost of these events is estimated to have exceeded US$15billion. Water professionals need to initiate concerted efforts to reduce the vulnerability of the region to climate-related disaster and climate change.

### *MEKONG RIVER BASIN VULNERABILITY*

The Mekong River Basin is utilized for a variety of economic activities, from fishing and subsistence farming to intensive rice cultivation. At the Regional Dialogue on Water, Wetlands and Climate Change in the Mekong River Basin held in December 2002, participants concluded that climate change is likely to trigger significant alterations in the pattern and distribution of rainfall over the entire basin. Seasons will shift, with the dry season lasting longer and experiencing even less precipitation (except in the Mekong delta), and the rainy season starting earlier. The upper Mekong in southern China is expected to receive 20% less rainfall, while the Korat Plateau in the middle Mekong may see a 10% increase. The Eastern Highlands and Lowlands are expected to receive the same overall amount of rainfall, but with significant changes in month-by-month precipitation levels. Temperatures are expected to increase from 1 to 3°C over the next century.

Reduction of rainfall in the upper Mekong in southern China will affect subsistence and commercial farming. Changes in rainfall patterns could alter flooding regimes, which may in turn affect ecosystems such as the flooded forests in Vietnam and elsewhere. Mangroves and brackish water fisheries in the Mekong delta are likely to be affected by changes in ambient salinity. Severe floods are expected to threaten the heavily urbanized lowland areas of the Mekong.

Rice cultivation, the main source of food in the region, will be strongly affected by changes in the hydrological cycle triggered by climate change. Seasonal shifts in rainfall may have a strong impact on crop yield and crop cycles. The generally shorter and more intense rainy season could make varieties of rice and other crops currently cultivated unsuitable. Some of the low-lying land may have to be abandoned if the level and duration of flooding affects crop survival or productivity.

Retreat is conducted when people abandon land in the coastal areas and leave it to the sea, for example when creating a coastal zone nature reserve [6].

When discussing adaptation to water management, a distinction is often drawn between supply-side options, such as increasing storage capacity or extending water delivery services, and demand-side approaches, which might include reducing water use and fixing leakages. Seven categories often used in the natural hazards field could also be applied when considering climate change adaptation in the water sector. These categories offer a checklist of potential adaptation options. The categories are:

- *Share the losses*: distributing losses from climate events over a wider population than those directly affected. Means of sharing losses extend from family and community sharing of resources to public relief, rehabilitation and insurance.
- *Bear the losses*: accepting losses is an option where they are expected to be small in relation to total wealth, and can also be a necessity when poverty precludes any other action.
- *Modify the event*: engineering or structural measures can be used to modify stream flow through flood control works, irrigation systems and sea walls, and attempts have been made to produce rainfall by cloud seeding.

- *Prevent the effects*: reducing vulnerability without affecting the natural processes themselves, including through modifications in water and land-use planning, infrastructure design, and agricultural practices.
- *Change use*: adaptation measures can include changes in resource use or reallocation, such as restoring developed flood plains into public open space or for the rehabilitation of wetlands and other ecosystems; or allocating more water to higher-value urban and industrial purposes.
- *Change location*: people and property may be relocated over short distances, for instance when property is removed from affected areas or not reconstructed after a particular event. There can be also long distance relocation when people migrate from one region to another as change continues.
- *Share information and knowledge*: there is an important role in adaptation for supporting research, education, and capacity building. Improved knowledge and awareness can help catalyse further actions.

Recent discussions on adaptation to climate change have mostly emphasized specific adaptation measures. In agriculture, proposed measures include providing more irrigation water, changing crop varieties to drought resistant or heat tolerant ones, and modifying cultivation practices. Other measures discussed include drip irrigation and the installation of water-saving devices to reduce the quantity of water used for domestic purposes. Yet other means include limiting flood plain development to areas higher than the 50 or 100 year flood frequency line or increasing public expenditure for the detection of leaks in water supply systems. These and other specific measures are the means whereby specific policies can be implemented.

So far little attention has been given to developing policies and determining the strategic directions for adaptation in the water sector. Adjusting existing policies and planning approaches in the various sectors is crucial, however, if adaptation to climate change is to take place.

## A way forward

What are the advantages and deficiencies of the presented adaptation approaches when applied to water management? Much of the discussion on climate change mitigation and

### *POLICIES TO ADAPT TO CLIMATE VARIABILITY HAVE EXISTED FOR MORE THAN A CENTURY IN BRAZIL*

Since the drought of 1877, Brazil has developed policies to address the impacts of climate variability, especially for its semi-arid regions. Over time these policies have evolved from short-term relief efforts to more complex approaches. Short-term relief has focused on maintaining the income levels of the rural unemployed population through public construction works. In addition, water distribution through trucks and the importation of food supplies have helped people to overcome the immediate impacts of drought. Longer-term measures have focused on building hundreds of dams to increase water storage capacities by several billion cubic metres. The creation of storage is an example of a classic approach to dealing with variability of rainfall and perennial water courses. The limitations of the approach are becoming apparent in already over-allocated systems and where environmental and social concerns over dams are high.[7]

adaptation has focused on a top-down approach and relatively neglected local and regional perspectives and capacities. The planned adaptation approach will require a significant capacity for policy-making and management innovation. Unfortunately, many countries do not have the

### *CLIMATE CHANGE AND VULNERABILITY IN WEST AFRICA*

At the Regional Dialogue on Water, Wetlands and Climate Change in West Africa, held in November 2002, participants concurred that the 1970s marked a turning point for the region in terms of water resources availability. Since that time, rainfall has decreased across the entire region, with the largest declines in the north. Several large river and lake systems, including the Sokoto River system in northwestern Nigeria, have suffered significant reductions in river flow as a result of lower rainfall and higher rates of evapo-transpiration.

According to the Intergovernmental Panel on Climate Change, West Africa is projected to experience about a 1°C warming over the next 50 years. Climate change may substantially affect irrigation withdrawals because of higher temperatures and greater evapo-transpirative demand greater evapo-transpiration. The success of rain-fed agriculture in the region depends much on the onset and cessation of monsoon rain. There is great deal of uncertainty about how climate change will affect monsoon dynamics. In a majority of West African countries, river run-off is expected to decrease, as is the amount of water available for activities downstream of dams. Many vector-borne diseases that are prevalent in West Africa, such as dengue and malaria, are expected to increase their geographic range.

Floods contaminate downtown Franklin, VA with oil

required expertise and resources. Particularly in the least developed countries, such capacities are only weakly developed. A top-down approach is thus unlikely to gain wide support.

In recent decades, increasing awareness about the role of natural hazards, the risks they pose and their potential economic damage has led some countries to improve their planning. However, considerable time and resources are often needed to develop these plans. In France, a decade of risk zoning at the community level has resulted in 30% of at-risk communities now having an approved plan in place. Meanwhile, in Bangladesh, 15 years of flood and drought risk planning has not significantly reduced the actual risks to the most vulnerable. Even if an integrated planning process is established, it might take decades to develop such plans to a satisfactory level, and still longer to implement them. Technical and financial constraints often hinder more rapid progress and institutional and political obstacles can take years to overcome.

Progress with autonomous adaptation, driven largely by the private sector, has also been slow. As with public water managers, businesses have only started to look at climate change in a piecemeal way over the last five years. Thames Water in the UK has conducted some studies on the water availability in its concession areas, as many of its investments have a time horizon of several decades. Re-insurance companies like Swiss RE and Munich RE have also carried out extensive studies to better define future risks. However, the actions of these large companies contrast sharply with a lack of attention from other larger and smaller companies in the water sector. Though many options for adaptation exist, it is not yet apparent whether a widespread "autonomous adaptation" will simply emerge without some sort of external catalyst.

*"A NEW APPROACH IS NEEDED CHARACTERIZED BY FLEXIBILITY AND BUILDING ADAPTIVE CAPACITY IN THE FACE OF UNCERTAINTY."*

Experiences in other policy areas, such as health, education, and agriculture, demonstrate that success in adopting new ways of working does not lie exclusively with either the public or private sectors. Civil society also has an important role to play. While the private sector clearly forms a part of this group, the collective efforts of various stakeholders from civil society can often contribute significantly to establishing innovative practices. Recent extreme weather events illustrate some of the many ways in which civil society can contribute to adaptation. Participation in dike surveillance and protection squads, individual assistance to flood victims or the organization of food parcels during droughts demonstrate how civil society can play a critical role in adaptation to climate change. Strict top-down or bottom-up approaches are clearly not the answer.

What is needed is a new approach that would be characterized by flexibility and building adaptive capacity in the face of uncertainty. It would draw on existing approaches, techniques and expertise to create a new blend of strategies, styles and means to innovate and implement concrete adaptation measures. It would represent a middle way between planned and top-down technocratic management and the more laissez-faire reliance on spontaneous actions. Adaptation in this sense would be used to strengthen more progressive elements in the water sector. The new threat of climate change and its attendant uncertainties would thus help to propel innovation, and make the required changes more visible and salient. In this way it would support the changes that are occurring in the water sector at present and create opportunities for taking a more integrated and sustainable approach to water management.

Chapter 3

# Living with Uncertainty

## 3.1 Waters Running Uphill: Paradigm Shifts in Water Management

The call to start adapting to climate change comes at a time when a fundamental shift in water management is already underway. A wide range of economic and societal changes are currently taking place, influencing the demand, supply and use of water resources. Water management has to deal with these new risks and new uncertainties. In recent decades, a paradigm shift has occurred in the water sector. Increasingly, sub-sector based policies, planning and supervision is being replaced by more integrated approaches to water resources management. One of the main drivers behind this paradigm shift is the population growth and rising levels of water demand. The conventional "command and control" approach to water management has become less effective. Larger numbers of people are at risk from floods and drought, and do not have access to safe drinking water supplies or sanitation. This is increasingly considered unacceptable in many countries.

There is thus a growing awareness that water supply to households, industry, farmers, tourism, and the transport sector, as well as for the maintenance of river ecosystems, need to be dealt with in a more integrated manner. The more integrated approaches to water resources management utilize different institutions and people from a range of disciplines working together to solve complex allocation and acccess issues. They encourage different levels of government to become more connected and responsive to internal and societal demands, and support engaging water-users in decision-making.

*"A NEW STYLE OF MANAGEMENT IS EMERGING IN WHICH A WIDER VARIETY OF MANAGEMENT TOOLS AND OPTIONS IS ROUTINELY CONSIDERED."*

An ecosystem approach is emerging as a promising approach to dealing with integration and sustainabilty of water management. It considers the use of a wider variety of management tools and options. In its application it is promoting greater efficiency in water use and controlling the amount of withdrawals. It also deploys alternative non-structural measures to cope with floods and droughts. Increased control and regulation of emissions of pollutants into surface and ground waters are another characteristic of this management approach.

The need for an ecosystem approach to water management is now increasingly being recognised amongst water professionals. The approach takes into account the role of environmental goods and services, incorporates knowledge about the functioning of the entire catchment ecosystem into planning and management, and focuses on managing both water and land resources within catchments and river basins. It explicitly recognises the need to maintain river ecosystem

### *CORE VALUES OF MODERN WATER MANAGEMENT*

*Equity* - water management activities enhance equitable distribution of costs and benefits from water resources use and management and explicitly include activities to alleviate poverty and create a gender balance.

*Efficiency* - management of scarce water resources places an emphasis on the most efficient use and reflects the full value of the resource, including market values, ecosystem values and socio-cultural values.

*Sustainability* - the water management regime endures and supports self-sustaining changes in water management, including those to adapt to changing conditions.

*Legitimacy* - water management institutions are open, transparent, representative and have a sound legal basis while their decisions and actions are seen as legitimate and fair by all stakeholders.

*Accountability* - water policies, responsibilities and actions are decided and implemented in a transparent and accountable way and lead to clear, effective, fair and legitimate uses of water resources.

*Subsidiarity*- water management institutions devolve decision-making authority to the lowest appropriate level, ensuring that the power and resources to make such decisions meaningfully are similarly developed.

*Participatory* - all stakeholders are given the opportunity to participate in water resources planning and management decision making and to become involved in reducing water conflicts.[8,9]

health, for example through the protection of vegetation cover in upper-catchments, the maintenance of river flow for people downstream, or the reduction of pollution for good water quality.

The emphasis on maintaining freshwater ecosystem functionality is not based solely on intrinsic values of ecosytems. It stems also from the fact that people benefit directly from the goods and services these ecosystems provide. Healthy freshwater ecosystems can buffer against heavy rainfall events and thus help in managing flood risks. Managing upper-watershed forests wisely can reduce sediment loads or lower peakflows, which benefits people living downstream. Identifying and zoning high-risk areas is a measure deployed increasingly in some countries to prevent construction and reduce flood damage. In Switzerland, for example, the relicensing of dams is now being linked to the development of "green" hydropower. To cover the costs of the minimal upgrades required, dam owners invest beyond this minimum to qualify for green-power certification that would increase the unit price they can charge for the electricity generated.[10] Investing in the maintenance or restoration of ecosystem services is now recognized to yield significant benefits.

## *3.2 Decision Deadlines Facing Uncertain Futures*

Managing risk has long been a part of the development and management of water resources. Risks are inevitable given that water is a resource that varies in terms of its geographic range and temperal availability. Risks within the water sector include both resource risk and enterprise risks.[11] Resource risks include those natural or human-induced risks, such as of the effects of an unsecure supply, water quality, and extreme weather events, public on health and safety. Enterprise risks are those faced by water management entities in undertaking their work. These can include finance and market risks, political risk and labour risk. Such risks can be modelled using historical trends with measurable probabilities being attributed to them.

Responding to the risks from climate change poses a particular problem, however. Most societies will place short-term economic growth ahead of what many still perceive to be a more intangible long-term problem. It is only when people and societies are made aware of immediate economic threats from climate change and climate variability, and the important role water resources and their management can play in reducing these threats, that significant action to adapt can be expected.

### *VISION FOR WATER AND NATURE - A WORLD STRATEGY FOR CONSERVATION AND SUSTAINABLE MANAGEMENT OF WATER RESOURCES IN THE 21ST CENTURY*

The IUCN's strategy on water resources envisages a world in which the benefits of freshwater and related ecosystems to humans are optimised, while the intrinsic values of these systems are respected and preserved. In this world, the mutual dependence of people and ecosystems is accepted, and unavoidable loss of ecosystems' functions and biodiversity is more than compensated through restoration.

This is a world in which environmental security is guaranteed as people increasingly accept personal responsibility for the conservation and wise use of freshwater and related ecosystems. The maintenance of environmental security is based on integrated management of all land and water use through an ecosystem-based approach within river and drainage basins, including associated marine and coastal zones.

It is also a world in which social security is strengthened by providing everyone with equitable access to and responsibility for safe and sufficient water resources to meet their needs and rights, by means that maintain the integrity of freshwater and related ecosystems.

Finally, it is a world where ecosystems are managed and used in a fair and equitable manner to achieve economic security. Efforts are made to rectify and reverse existing trends in demographics, consumption patterns and human-nature relationships, in order to ensure that the current and future demands for water resources can realistically be achieved without compromising the ecological, biological and hydrological basis and integrity of freshwater and related ecosystems.[9]

Until recently, there has been little open discussion on these types of risks. Public involvement in the decision-making process on water issues has been minimal. Water professionals have usually made decisions about key security and safety issues along technical lines and using "professional norms". For example, dams and reservoirs were often designed to withstand a 50-year flood or drought. But, there was little economic or social justification for why such an event was included in the design criteria. Other decisions about risk were made as a result of a political bargaining process among different water management agencies or private entities.

*"FOR WATER PROFESSIONALS, CLIMATE CHANGE IS A NEW SOURCE OF UNCERTAINTY."*

Beyond risk lies uncertainty. While risk can be quantified, uncertainty cannot [12]. Uncertainty applies to situations in which the world is not well-charted; it relates to questions of how to deal with unprecedented events or situations. In such cases, past observations offer little guidance for uncertain futures. For water professionals, climate change is a new source of uncertainty. The current uncertainty about trends and changes in specific regions and basins requires management approaches that incorporate a higher degree of flexibility. This can be done, for example, through creating "buffers" based on (artificial) groundwater recharge, reforesting catchments to retard runoff, or restoring wetlands to store floodwaters.

While no approach can make the challenges of uncertainty go away, reducing the level of uncertainty and tailoring strategies to that uncertainty can help lead to more informed and confident decisions. It is often possible to identify clear trends, such as reduced rainfall, that can help to define the range of future climatic conditions. There are also usually a host of factors that are currently unknown but are in fact knowable, that is, those that could be known if the right analysis was carried out. Examples include runoff variations and seasonality of water abstractions and increased demand due to projected population growth. Maintaining and improving monitoring networks and forecast systems are essential if these aspects of uncertainty are to be adequately addressed.

### *BANGLADESH'S DILEMMA OF FLOODS AND DROUGHTS*

Floods frequently inundate large parts of Bangladesh. Since the 1980s a wide range of stakeholders in the country has been discussing the development and implementation of the Bangladesh Flood Action Plan. Two opposing flood management approaches have dominated the debate – a capital-intensive "high-tech" intervention and a "living-with-floods" approach. So far, however, little attention has been given to addressing the vulnerability of the people that are living in the flood-prone areas. The people's concern is not so much the floods per se, as they also benefit from these through the good harvests that follow the floods. But, their livelihoods are particularly vulnerable to droughts with low-rainfall monsoons in summer and normal dry winters that lead to low yields outside irrigated areas. In this sense there is more of a need to deal with water shortages and drought control than channelling large amounts of money into flood prevention. Addressing climate variability by directly linking it with people's vulnerability is likely to produce different approaches that may be less costly and more effective. [13]

*DEFINING FLOOD RISK IN FRANCE – A DECADE OF INSTITUTIONAL AND POLITICAL PROCESS*

France has a long record of land-use planning, including defining submersible areas prone to flooding and removing vegetation to allow the free flowing of water in river channels. In 1987, a new law was enacted that required risk exposure plans to be developed indicating non-building areas, building areas under constraints, and building areas that could expect flooding. In 1995, further legislation called for development of 10-year plans focused on river management and protection against floods. Special Plans for the Prevention of Risks (PPRs) had to be produced by high-risk communities within five years. Only 10% of the communities at risk had PPR documents approved by 1998. By 2002, these had increased to 30%.

Major obstacles in the production of PPRs include the cost of the studies, a lack of expertise, poor definition of the responsibility of the local authorities vis-à-vis the central government, and the consequences for property values and building rights of identifying risk zones. Recent floods in southern France have hastened work to produce the PPRs. France's experience shows that even a relatively simple measure to define risk zones at a local level can take at least a decade to be put in place nationwide. Capacities, financial resources, institutional and political constraints often hinder a faster process, even if there is the political will at the national level.[14]

For water professionals, incorporating uncertainty in their policy making work is no easy task. If handled incorrectly, it can lead to measures that neither defend against threats nor take advantage of the opportunities. At one extreme, assuming the world is entirely unpredictable can lead water managers to ignore the issue, and simply throw up their hands in defeat. At the other extreme, risk-averse water managers who think they are in very uncertain environments might avoid making choices, and fall into decision paralysis. Making systematically sound strategic decisions under conditions of uncertainty requires a different approach: an approach that avoids both defeatism and paralysis. In spite of the challenges that uncertainty brings, water managers should be able to identify a range of potential outcomes or even a set of scenarios, based on available climate modelling information. Narrowing the field of possibilities can be an extremely powerful tool in reducing the level of uncertainty.

Given the nature of uncertainty, expert judgements should be complemented with stakeholder inputs to arrive at political decisions about management interventions. With increasing uncertainty, stakeholder involvement will be essential to build a wide acceptance for sharing the potential burden and benefits of the impacts of climate change on water resources.

## *3.3 Strategic Priorities for Adaptation*

Improving the way societies deal with water-related risks and uncertainties will be critical for adapting the water sector to increased climatic variability and change. A key goal for adaptation in the water sector will be to reduce the vulnerability of societies and people to the effects of this increased variability and change. Below are three strategic priorities for achieving this.

## Strategic Priority 1. Reducing the vulnerabilities of people and societies to shifts in hydro-meteorological trends, increased variability and extreme events

Climate-related floods and droughts pose a serious threat to national economies and sustainable development. Managing risks and dealing with uncertainty from these events can bring immediate benefits to people's welfare and help minimize the loss of life and damage to properties and other assets. The most vulnerable groups within societies should receive particular attention.

### Rationale

Managing risks and dealing with uncertainty from increased climate variability and climate change can reduce the vulnerability of people and societies. It can bring direct and immediate benefits, including minimizing the likelihood of crop failure, floodplain degradation, flooding or drought. Both large-scale and small-scale interventions have their place in this and can boost local economies, making it more of an immediate political priority. In many cases, these investments will be essential to improve environmental conditions, increase the standard of living, create jobs and increase income. Healthy people and ecosystems, jobs and higher incomes are critical aspects of reducing vulnerability and increasing society's capacity to cope with extreme events and adapt to change.

Adapting to climate change can also involve the creation of buffers. This includes adjusting the margins to maintain safety and reliability, for instance by topping-up current water reserves, increasing the margins of operations, and changing design criteria. A high priority needs to be placed on meeting the needs of the most vulnerable. Flood and drought recovery and preparedness strategies need to be designed taking into account the need to reduce the risks to vulnerable segments of the population. The protection of major assets that generate wider public benefits should also be a priority. Only by addressing the most vulnerable countries and societal groups can the adaptation of water management to climate change contribute effectively to the wider objectives of poverty alleviation and sustainable development.

### Examples of actions:

I. Policy and planning:

- Improving land-use and water resources planning, including risk zoning and evaluation of the design, safety criteria and current status of infrastructure;
- Reinforcing and/or (re)introducing flood and drought preparedness programmes;
- Ensuring compliance with existing regulations, such as those relating to at-risk zones, building zones, upper watersheds and floodplain use;
- Developing insurance products to cover the impacts of climate-related disasters and risks.

II. Capacity building and awareness:

- Sharing information within and between governments, the business sector and civil society on potential and observed climate change impacts and extreme events;
- Developing disaster preparedness and recovery systems, including forecasting, early warning and rapid response.

III. Measures and direct interventions:

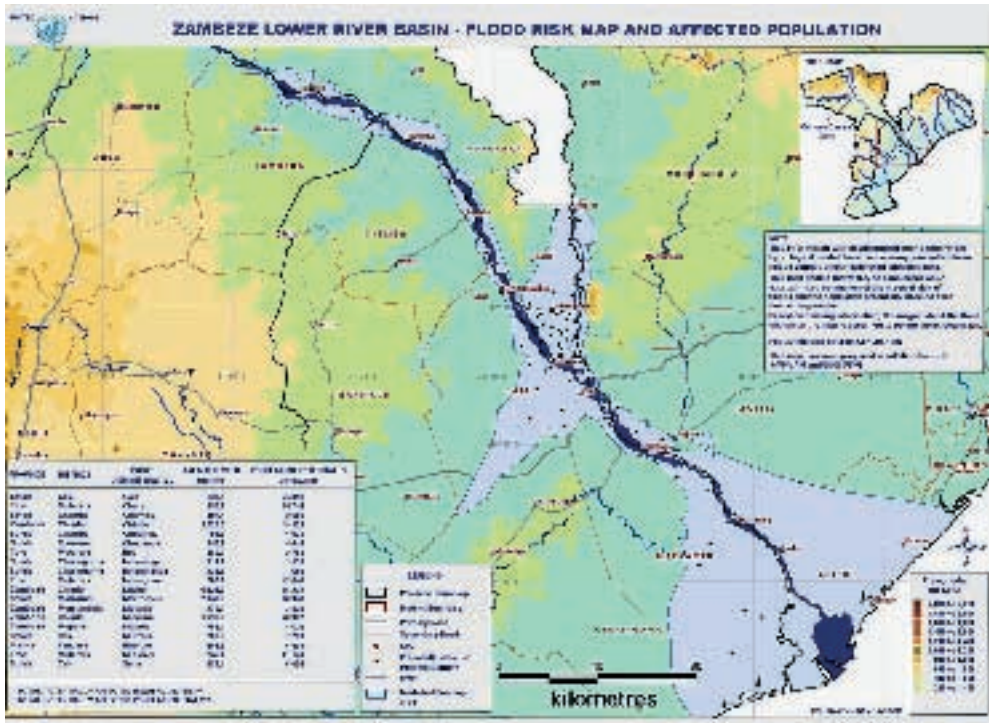
- Modifying existing infrastructure and operations to cope safely with and perform in more variable and extreme conditions;
- Reinforcing or (re)introducing watershed management measures to regulate extreme event runoff, erosion, and sedimentation originating from higher intensity rainfall;
- Constructing or improving urban storm water evacuation infrastructure.

## Strategic Priority 2. Protecting and restoring ecosystems that provide critical land and water resources and services

Ongoing degradation of water and land resources threatens the continued production of goods and services in river basin ecosystems. Protection and restoration of river basin ecosystems is urgently needed to maintain and restore natural capacities that support the protection against increased climate variability and extreme events.

### Rationale

Water forms an integral part of catchment ecosystems, which provide goods and services for downstream uses. Forested slopes can provide base flow water supply during the dry season, certain wetlands can store floodpeaks, and rivers can cater to the needs of those engaged in both professional and recreational fishing. The ongoing degradation of water resources and catchments threatens the continued provision of these services. Sediments from eroding deforested slopes can block rivers. Polluted and obstructed waterways contribute to disappearing fish stocks.




Map of flooding risks in the Zambezi river basin

*RESTORING FARM BIODIVERSITY TO COPE WITH CLIMATE VARIABILITY AND DROUGHTS IN MEDAK, INDIA*

A millet that grows on dew; sorghum that can survive on very little water. These are not genetically modified organisms (GMOs) but traditional crops used by farmers in Medak (Andra Pradesh). For many women these crops, which they have been growing on their small farms for centuries, have been the difference between starvation and survival. Over the last six years, poor women of lower castes have expanded their seedbanks of local crop varieties and now supply seeds to others in their villages. Many of these traditional crops are rare as they have been replaced by higher yielding varieties and irrigated sugarcane. During periods of severe drought, however, these crop varieties carry a much greater risk. Maintaining crop-biodiversity for local small-scale farmers is an important strategy for drought relief that targets the most vulnerable.[16]

Floodplains cut off from the river no longer ease the floodpeaks that threaten economic centres. If continued unabated, the declining size and quality of catchment ecosystems will reduce the benefits they provide and expose local populations to more severe and frequent water-related hazards.

Protecting catchment ecosystems and restoring those that are degraded can maintain or bring back their functions and benefits to people. Protecting upper-catchment forests can reduce local flood peaks. Restoring floodplain wetlands along rivers can allow flood waters to be stored. While they can reduce the impacts of climate change, these measures also provide additional benefits to local communities. Clean water, fish, timber and non-timber forest products are often essential for the livelihoods of the poorest and most vulnerable. Maintaining and restoring natural and semi-natural ecosystems can thus provide multiple benefits by alleviating poverty and reducing vulnerability to increased climate variability and climate change.[15]

To maintain and restore forests, rivers, lakes and wetlands, sufficient water needs to be allocated to these ecosystems. The needs of these ecosystems should therefore be integrated into the wider water management strategy. This will require a balancing of these water demands with other uses, in particular agricultural use. Where waters are already over-allocated, serious pressures will arise about how the re-allocation of water can be achieved.

## Examples of actions:

I. Policy and planning:

- Developing legislation and regulations to allow water allocation for restoring downstream wetlands as flood-water storage areas;
- Developing groundwater protection and restoration plans to maintain water storage for dry seasons and years.

II. Capacity building and awareness:

- Developing awareness campaigns to highlight the value of the services that rivers, upper watersheds and wetlands provide as buffers against increased climate variability;
- Raising public awareness and securing public acceptance for land and water resource protection measures to adapt to climate change.

III. Measures and direct interventions:

- Restoring or preserving mountain forests to reduce soil erosion and peak-flows;
- Carrying out environmental flow releases and reducing water off-takes to maintain or restore floodplains and coastal ecosystems as buffers against extreme events.

## Strategic Priority 3. Closing the gap between water supply and demand

Water demand now exceeds or threatens to outstrip sustainable levels of supply. Conventional strategies to further increase water supply can no longer meet growing future needs, and are unable to cope with the uncertainty arising from increased climate variability and climate change. Sustained efforts are needed to reduce water demand and mobilise non-conventional water sources through appropriate policies, laws, incentives and technical measures.

## Rationale

The need for water is growing around the world. The most common strategy to meet this increasing demand is to further develop water supplies. Building dams to increase water storage capacity, constructing new channels to augment water transport capacity and installing more pumps that produce water from deeper layers of the earth are the frequently-selected responses. In many areas, however, the limits for the sustainable development of water supplies for human use have been reached or are about to be reached. With the over-allocation of water resources, the ability of the water system to buffer extreme events and shocks, in particular droughts, has been seriously compromised. People and businesses depending on these water systems are now vulnerable to even limited climatic variability and change.

As increasing the conventional water supply is no longer feasible, a greater emphasis needs to be placed on reducing water demand. Water allocations need to be made to higher-value uses based on a greater flexibility to allocate between competing demands. The adjustment of policies and operational guidance will be critical to achieve this. Additional incentives such as tax breaks for drip irrigation or blocked water tariffs can assist in reducing demand. A wide range of technical measures and know-how are now available to reduce water demand from households, industry and agriculture.

Non-conventional water supplies also need to be mobilised to reduce the gap between demand and supply. The re-use of return flows and the use of wastewater can replace the conventional water supply for irrigation. In coastal areas, desalination of water can provide an important source of non-conventional fresh water supply. Increasingly, techniques and know-how are available to tap non-conventional water supply sources in a sustainable manner.

### *IN THE US, MARKET FORCES ARE AT WORK TO ADDRESS WATER SHORTAGES DURING A DROUGHT*

Drought stress often forces water managers to seek creative solutions for immediate water shortages. One of these solutions was the establishment of the Drought Emergency Water Bank in California in 1991. At the height of a six-year drought, more water was offered by water rights owners than buyers were willing to purchase, even though prices were reasonable at approximately US$1 per cubic metre (note: the typical range of US municipal water supply is $ 0.1 – 1.4 $m^{-3}$).[17]

*IN THE NETHERLANDS, SMALL GATES AND CULVERTS COULD ATTENUATE THE INCREASING FLOOD PEAKS IN LOW LYING AREAS*

The climate in the Netherlands is expected to become warmer and wetter during this century. Peak flows in water systems are expected to increase by 10-30% resulting in more frequent flooding. Model simulations were carried out to analyse measures to attenuate peak flows. Increasing the areas of open water, raising flow resistance and restricting water flow through small-scale infrastructure such as gates and culverts was modelled to have a variable effect in attenuating peak flows. Even if applied to only 50% of the command areas, gates and culverts would be able to reduce peak flows by 7 - 19%. The exercise indicated that measures need to be adjusted to the type of command area and that a combination of various small-scale interventions could be effective in off-setting the impacts of climate change and increased climate variability at a local level.[18]

### Examples of actions:

I. Policy and planning:
- Optimising existing water regulation so water can be allocated to the most efficient and highest value uses and to defined priorities;
- Introducing greater flexibility to allocate between competing demands and to match water quality with demand.

II. Capacity building and awareness:
- Creating awareness for the need to balance the supply for off-stream services with in-stream requirements;
- Training of farmers and other water users in the application of techniques to improve water use efficiency.

III. Measures and direct interventions:
- Implementing demand side measures such as end-use technology, recycling and conservation;
- Developing, where still appropriate, supply side measures, both of conventional and non-conventional sources.

## *3.4 Adaptation to climate change as an opportunity*

Many deficiencies in the current management of water resources need to be addressed. This does not mean that the concern about climate change can be delayed or put off. On the contrary, climate change should serve to reinforce calls for improved water management. The systemic approach needed to address climate change has many similarities with the approach needed to resolve current water resource problems. In this light, adaptation to climate change can be seen as an opportunity that gives the rationale for change in the water sector added impetus.

In the first place, climate change can reinforce the ongoing reform in the water sector. With increasing demands and risks, traditional sectoral solutions can no longer provide all the water benefits societies demand. Adapting to climate change adds a new global dimension to the need for improved water management. As climate change is a globally pervasive issue in which all

people and countries are involved, a sense of a wider responsibility is growing. Climate change can bring a global solidarity to water management. This could help to promote innovative solutions that offer more than those that have traditionally been applied.

*"CLIMATE CHANGE CAN BRING A GLOBAL SOLIDARITY AND INNOVATION TO WATER MANAGEMENT."*

A second dimension is the factoring of climate change into water management. Finding ways to deal with greater uncertainty in water management can act as a catalyst for innovation. New technical and social approaches will need to be developed and tested that will require a shift away from simple demand-and-control approaches. These new approaches will help improve adaptive capacities, maintain and strengthen social capital, develop social learning and support conflict management processes.

### *THE RESPONSE OF NORTH AMERICAN FARMERS TO CLIMATE VARIABILITY*

Between the 1920s and 1980s, the boundaries of winter wheat production shifted northwards to a location about 3.5 °C cooler and 15% dryer than its original area in the US Mid West. At the same time the southern boundary areas have experienced a 2 °C warming. These US farmers maintained and increased production by diversifying the wheat varieties use. In addition, better use of fertilizers, nitrogen and improved water management led to increased productivity. Other farmers in the southeastern US developed and maintained animal feed stores to keep their operations diversified to minimize loss from rainfall variability. In addition they diversified cropping to reduce weather-related production risk, for example in Illinois, where farmers cultivate maize, oat and clover rather than just maize alone. They also used technical measures to manipulate the timing of cropping or supplemental irrigation in arid and semi-arid regions. Adapting production to other climatic conditions is thus possible, in particular when using a variety of approaches and techniques.[19,20]

Sandbags along river dike in Senegal river delta, Mauritania

Chapter 4

# Beyond Pipes, Pumps, and Ponds

## 4.1 Developing the Capacity to Change

Pumping more water, restoring wetlands and building dams and dikes could be viable measures to adjust water management to changing conditions. However, adapting water management to climate change and increased variability is unlikely to be solved simply by a technical "quick fix" that transfers traditional approaches from one place to the next. Those methods that are applied successfully in one country could well fail to generate similar results under other socio-political and physical conditions. Adaptation will thus need to go well beyond technology transfers and become a broad societal process in each country and sector.

The wide involvement of stakeholders will be critical as risks and uncertainties induced by climate change can no longer be handled by experts alone. Water professionals' knowledge and expertise will need to be complemented with the views, opinions and knowledge of stakeholders. Without their political support for adaptation efforts, political and business leaders will prioritise other needs and refrain from taking decisions that help societies in general and the water sector in particular to adapt to climate change.

When considering the adaptive capacity at a national level one needs to distinguish between general and specific adaptive capacity. The former refers to societal characteristics that permit a response to new threats or challenges of almost any kind. The richer a society and the more wealth available, the greater the general capacity to change and adapt. The same is true for the level of skilled human resources, the effectiveness of organizations and institutions, and the prevailing levels of education and health, as well as for the presence and quality of infrastructure and the degree of equity and social cohesion in a society.[21]

*"THE WIDE INVOLVEMENT OF STAKEHOLDERS WILL BE CRITICAL."*

Specific adaptive capacity adds to this the dimensions arising from the specific skills, knowledge and systems available in different sectors. In relation to water management it means, for instance, the funds available for investment in water resources management, the effectiveness of companies and relevant agencies of government, and the availability of the required skilled personnel, such as water managers, hydrologists, engineers and economists.

Water managers often possess the experience and capacity to adapt to changing conditions. Droughts, floods, increasing water demands and changing water quality are just some of the aspects they have to deal with regularly. However, current institutional and technical capacities may preclude the type of adaptive strategies and measures needed to deal with climate change, particularly with increased variability and its associated risks and uncertainty. Strict sectoral planning,

for instance, is still a widespread phenomenon despite a decade or more of working towards more integrated approaches. It often inhibits a more holistic approach towards water management required to deal with the increasing pressures from increasing demands and uncertainty.

In developing adaptive capacities it is important to overcome the great inequities that exist amongst and within societies, and to recognise that adaptive capacity is very unequally distributed both globally and within countries. Countries with limited financial and human resources, poor infrastructure, unstable and weak institutions and inequitable access to resources are likely to have little capacity to adapt.[1] Countries and communities that find themselves in this situation will be vulnerable to climate change, just as they are to other stresses. Adaptive capacities are generally considered to be high in Australia, New Zealand, Europe and North America. In much of Asia, Africa, Latin America and the Small Island States these capacities are considered to be low.[1]

Large differences in adaptive capacity may also exist within countries. In many instances individuals, families, communities, and local governments lack the capacity to engage fully in adapting to new threats such as climate change. Adapting water management to climate change will thus require building the capacities of both institutions and people. In many countries they lack awareness, information, knowledge, know-how and a network that can support them in incorporating climate change in their decision-making and water management. It is for this reason that the building of adaptive capacity is a priority for many countries in preparing to respond to climate change.[1]


Hazard mitigation counseling at a disaster relief center, USA

*PARTICIPATION OF VULNERABLE GROUPS AND LOCAL ELITES IN FLOOD MITIGATION AND ADAPTATION IN GUYANA*

The vulnerability of communities to hazards is a product of their limited access to economic, environmental, social, political and personal assets. Opportunities for coping are influenced by livelihood, community structure, social groups, household structure, age, ethnicity, history and health. Those most vulnerable to floods rely primarily on individual mitigation strategies or adaptation during flood events. When dealing with flood mitigation and adaptation, an opportunity to build social capital can easily be lost if a top-down approach to community targeting is used. Failing to promote social capital will simply confirm and strengthen existing linkages of dependency and control, and will not reduce vulnerability. Securing participation of the most vulnerable sectors of the population will require strengthened political institutions and a commitment to participatory approaches.[23]

## 4.2 Pumping Alone: the Role of Social Capital in Adaptation

Social capital plays a highly significant role in organising and changing societies. Social capital is generally considered to consist of the combination of trust, norms and networks that facilitate coordination and cooperation for mutual benefit. In relation to flood hazard and vulnerability, social capital will, for instance, reflect the amount of co-operation amongst people and the quality of this cooperation.[23] Networked people assisting flood victims by pumping dry their basement, providing them with temporary shelter or giving them seeds for a new crop are a clear expression of social capital. People often do not recognise and respect social capital as a resource until the moment they realize they have very little of it.... the moment they are pumping alone.

Social capital is widely varied among societies and changes over time. Some consider that social capital is rapidly declining in the developed world. The declining level participation in civil society groups and volunteer associations in the U.S. can be regarded as an indicator of this phenomenon.[24] Changes in agricultural cooperatives in Europe could also be considered indicative of such a decline. With a higher emphasis on market orientation, efficiency and competitive strength, farmer cooperatives are losing some of their ability to sustain a sense of solidarity and reciprocity.[25]

*"PEOPLE DON'T RECOGNISE SOCIAL CAPITAL UNTIL THE MOMENT THEY ARE PUMPING ALONE."*

A decline in social capital can have serious consequences for the capacity of a society to adapt to climate-induced change and related shocks. For instance, when a Vietnamese community's social coherence is reduced and people are no longer willing to volunteer their time for necessary dike repair works, local authorities will need to hire paid labour to do the job. In northern Vietnam this has resulted in an increase in household taxation to cover the cost, while a decline in social coherence related to disaster preparedness has also developed.[2]

### *VIETNAM'S EXPERIENCE WITH INSTITUTIONAL ADAPTATION TO FLOODING*

Vietnam is currently undergoing rapid economic and political transition. Changes in the socio-political situation have significant implications for adaptations and coping strategies. Private property rights in coastal areas and the river delta at Xuan Thuy are changing perceptions about climate-related extreme events. "The 1986 storm seemed worse as it was our own property that was being lost. I was much more worried when the property was my own as I had to look after it myself", said a householder in Giao Hai. With privatisation, private credit can play an increasing role, as can the local community "Street Associations". Previously, both were abolished or co-opted as Communist Party affiliated organizations. Since 1992, however, community leaders have no longer allocated the traditional large work brigades to coastal and river defence. Instead, taxes are now raised to hire workers to carry out minimal maintenance and focus mainly on works to counter coastal land salinisation and maintain the country's shrimp ponds. Adaptation under these conditions implies adapting not only to a changed natural environment, but possibly more important still, of adapting to a changed socio-political and institutional setting.[22]

However, there are also many examples of how civil society has been able to organise itself effectively to deal with change. Cooperatives, associations, clubs, community-based groups, and traditional forms of organization have significant potential to contribute to adapting to increased climate variability and climate change.

Children carrying water in South Africa

The strengthening of social capital can be achieved through various methods. Improving health-care, schools, or communal water supplies will provide essential services and can be a meeting point for joint action. The establishment of production, manufacturing and trading cooperatives can also contribute to social capital by creating solidarity among stakeholders and enabling collaborative action in communities that may have little experience with such approaches. Community-managed village banks are another mechanism to strengthen social capital; they have proven to be very effective in providing people with access to credit and in building a sense of solidarity. So far, social capital has remained an aspect of adaptation that has received very little attention. However, maintaining and strengthening such capital is essential if adaptation is to succeed.

## *4.3 An Adaptive Management Style and Social Learning*

The adaptation process will need to be driven by a genuine willingness to change and innovate, particularly in terms of priority setting and decision making. It is likely that it will only develop in a significant way if changes are viewed not as a threat that paralyses, but as a stimulus for innovation. As such it is more likely to be an iterative process than a series of simple choices about technical interventions.

An adaptive style of management will need to be taken up by water users and managers if water management is to adapt to climate change. Adaptive management can be defined as a systematic process for continually improving management policies and practices by learning from the outcome of operational programmes.[26] When applied to water resources, adaptive management can build on the acknowledgement that water resources and benefits that accrue from them are derived from complex natural (or semi-natural) ecosystems. As ecosystems are complex systems, their functioning and role in providing water resources is partly unknown. Dealing with such uncertainty therefore needs to be incorporated into management.

### *WORLD BANK SUPPORTS SOCIAL LEARNING AND INNOVATION*

Innovation rarely works with "blueprint projects". In the 1990s, the World Bank established the Learning and Innovation Loan (LIL). These loans are a cost-effective instrument for testing and piloting innovative development ideas. With loans of up to US$5 million, the World Bank gives special emphasis to small, risky and/or time-sensitive projects. LIL focuses on experimentation, learning and piloting to identify possible development solutions, prior to potential large-scale operations. The loans also focus on promoting ownership and broad political commitment among stakeholders. The loan programme enables the World Bank to work in partnership with donors and NGOs in a more flexible manner. To qualify for the loans, project proposals need to clearly state a testable hypothesis and incorporate intensive monitoring and evaluation. They must also include indications of how the project results will aid the borrower in making decisions about replicating and scaling-up the project. More flexible financing will be essential to stimulate innovation for dealing with climate variability and change and reducing vulnerability.[33]

An adaptive management style to water resources applies a systems approach. It builds on trial and error, and establishes feedback loops to learn from experiences and adjust water management to fit people's and ecosystem's needs. It should be an inclusive style that builds new bridges between stakeholders and engages them actively in decision making.[27]

*"AN ADAPTIVE STYLE OF MANAGEMENT WILL NEED TO BE TAKEN UP BY WATER PROFESSIONALS."*

Being one of many styles that can be applied in managing water resources, adaptive management is relevant where change is driven by high impact human activity, especially when such activity causes resource scarcity and threatens to undermine ecological functions and capacities. Adaptive management challenges water managers who base activities on a standardized set of rules and procedures. Under an adaptive management style, rules are updated on a regular basis to fit new natural, social, economic, political and institutional realities and projections.

An adaptive management style can be extremely costly and time consuming. Often the outcomes remain incomplete, as management is likely to require an ongoing series of further experiments. This open-endedness has the danger of seldom presenting conclusively cut-and-dried answers that politicians and decision makers can use as a basis for policy formulation. [28] To overcome these challenges, those using an adaptive water management style will need to define and achieve time- and space-bound results that are also affordable.

Monitoring and evaluation of activities, outputs and outcomes is at the core of adaptive management. Without being fully aware of the progress made, it will be very difficult to learn from current successes and failures and adapt to changing conditions. A range of techniques are now widely available for monitoring and evaluation, and are increasingly known and used by managers of water resources projects and programmes. Regular measurements of indicators, including river discharge, rainfall and lake water levels, are at the heart of any monitoring programme. With the decline of meteo-hydrological networks, however, accurate information on even the most basic indicators is generally becoming more and more scarce, especially in many developing countries. If this trend continues it will contribute to a further reduction in some countries' capacity to implement an adaptive management style.

Social learning is a critical aspect of an adaptive management style. As a form of ongoing dialogue among all stakeholders to explore problems and propose innovative solutions, social learning helps achieve a shared understanding of the situation.[29] Where conventional learning focuses on individuals acquiring knowledge and skills, social learning ensures that stakeholders' collective efforts are at the heart of the learning process.[27, 30,31,32]

When applied to climate change adaptation, social learning fosters a strong interaction between scientists, water managers and other social actors to find innovative solutions. Today's management of water resources involves a broad range of interdependent actors with different perspectives and interests that can often conflict. In this context, adaptation cannot be confined to the application of a single, unvarying recipe but will need to be a process of incremental and experimental steps. To be able to adapt, all actors, including scientists and water managers, will

have to recognise that they have much to learn and that they should remain open and responsive to change.

Adapting to climate change will require strengthening people's ability to learn together. This will involve training and may often require the use of new tools. For instance, to inform a multi-stakeholder process on water management options, different scenarios can be presented using a decision support system. Given the uncertainty of future climates in specific basins, actors will want to use a range of scenarios to test the sensitivity and vulnerabilities of specific sectors or of the entire system. This will enable stakeholders to go through a process of "self-discovery". Experiences across cultures have shown that using new tools is often the only way for people to change their basic attitudes. Using innovative and appropriate tools will be essential to have people step out of their current mindset and behaviour patterns and begin engaging in adaptation to climate change.

## *4.4 Managing Conflicts Over Uncertain and Troubled Waters*

Water resource disputes occur throughout the world. In the future, increased climate variability and change are likely to lead to an augmentation in the occurrence, intensity, public profile and complexity of such disputes. Public and private water policies and planning have, however, paid relatively little attention to the management of water conflicts, even though the existence of conflicting claims over water resources and related land resources is a clear obstacle to sustainable water management. Further increases in water demand and threats derived from climate variability and change will make it increasingly important to find new mechanisms and institutions and develop the required skills to manage conflicts over water resources.

*"SPECIAL ATTENTION NEEDS TO BE GIVEN TO MANAGING BOTH EXISTING AND EMERGING WATER CONFLICTS."*

Policies and measures related to climate change, including those dealing with adaptation, can themselves lead to increased conflict. Defining and demarcating high flood-risk zones along rivers can, for example, lead to tensions between administrators and land and property owners. Likewise, the allocation of water to maintain downstream river areas and wetlands can generate tensions among water users. In over-allocated river basin systems in particular, the conflicts arising from new policies and plans to adapt to climate change might give rise to new tensions or intensify existing conflicts. In such circumstances, the adaptation process can even bring conflicts out into the open that have been hidden for decades if not centuries.

Special attention needs to be given to managing both existing and emerging water conflicts. Natural resources conflict management, including water and land dispute management, is a process rather than a specific package of standard procedures and solutions. In all cases it has to deal with resource scarcity and the contested allocation of resources. In some settings, resources are used by people in ways that are defined symbolically.[35] Waterways and fish are not simply resources people compete over; they are part of a particular way of life. These symbols and identities are highly significant in an ideological, historic, social, economic and political sense. Managing conflicts over water and land requires acknowledging and building on this reality to find solutions acceptable to all stakeholders.

### *GIS ASSISTED JOINT LEARNING OF WATERSHED MANAGEMENT IN THE PHILIPPINES*

Government-installed water districts (barangays) in the Ifugao catchment of the Philippines followed arbitrary administrative boundaries that did not match the natural boundaries of watersheds and traditional divisions of barangays. In 1999, local communities and government used a geographic information system (GIS) to carry out an assessment of the Ifugao catchment to restore terraces to combat soil erosion and land degradation. The GIS system helped to bring together the experience of a range of farmers and to generate new knowledge about the watershed. It inspired new ideas and solutions and facilitated the re-establishment of the traditional barangays' boundaries as official boundaries. In combination with the use of traditional institutions and the accompanying rituals, songs and chants helped to institutionalise the results of the joint learning exercise.[34]

An important element of this is the need to build the capacity of stakeholders to constructively engage in dispute management. Public agency staff, private sector operators, landowners, farmers, and tourism operators, for instance, could all benefit from training at the start of a dispute management process [34,36,37]. Such training could be focused on creating skills in conflict mapping,

Sales of goods as local strategy to reduce vulnerability in Cameroon

priority setting, defining stakeholder needs, anxieties, and underlying motivations, and developing a provisional conflict-management plan. Dialogue in this sense is not simply a series of talking shops, but rather a well-designed and facilitated process of collective learning.

Managing water and land conflicts, including those related to climate change, is thus not just a matter of providing technical keys to unlock the right decision or allow consensus to be reached. It is rather a way to facilitate and coordinate a shared and managed decision-making process. In many instances it will require the acceptance of certain levels of decentralised decision-making and pluralism; the recognition of a range of views and knowledge about the resource base and its management. Thus, rather than trying to reach some "ultimate consensus", it respects the skills and limitations of each party and creates opportunities for step-by-step progress towards reconciliation and long-term engagement in joint action.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Chapter 5

# Meeting the Challenge

## 5.1 Establishing National Adaptation Coalitions

Water professionals have a long record of dealing with variations in water resources by using traditional risk management approaches. The uncertainty arising from climate change, however, requires a new adaptive management style – a style that focuses on transparency and involves stakeholders in decision making and implementation. This means adaptation to climate change will benefit from the establishment of a broad-based, inclusive coalition of a range of actors: National Adaptation Coalitions.

Establishing National Adaptation Coalitions can provide a platform to bring together the various actors. They can act as a catalyst for getting adaptation started by supporting immediate actions, plans for the medium-term, and the establishment of key priorities for the long-term sustainability of adaptation. The coalitions will need to include actors from a variety of government agencies, private companies, societal groups and research institutions. Representatives will have to define their set of shared policy principles. They also will need to agree on the ways they want to influence decision making in both government and non-government institutions.

*"NATIONAL ADAPTATION COALITIONS CAN ACT AS A CATALYST FOR GETTING ADAPTATION STARTED."*

A National Adaptation Coalition could combine a top-down planning approach with an "autonomous" adaptation process. It would bring together the strengths of public policy and planning with the energy and creativity arising from the involvement of a wide range of actors. Creating coalitions is likely to be one of the best possible responses to the complexities of water management in an era of climate change.

National Adaptation Coalitions can be set-up when individual groups and organizations come to understand that it is in their own separate as well as collective interest to engage. While the profit motivation of the private sector is clear enough, the reasons why a broader section of civil society should be involved in adaptation will not always be so apparent. The most obvious cases involve situations where there are specific interest groups, such as farmers wishing to ensure an adequate supply of irrigation water, or downstream flood-plain dwellers aiming to protect their lives and property. These groups need to be informed about climate change so that they understand its implications and can engage in coalition building.

Obviously, all coalitions will not look the same; they are likely to vary in different countries, provinces, companies, and communities as they configure themselves according to local conditions

## *PRIORITIES FOR ADAPTATION TO CLIMATE CHANGE IN CENTRAL AMERICA*

During the Central American Dialogue on Water & Climate, local experts on agriculture and water resources management discussed key adaptation options to reduce vulnerability. Useful options that were identified included:

- adapting engineering practice to the impacts of floods and any other hydro-meteorological events;
- strengthening Early Warning Systems;
- establishing an efficient organization for disaster response;
- reforming insurance systems and policies, in order to start considering and accounting for the frequency of floods;
- reforming water laws; and
- saving water in "aljibes" in the rainy season to be used during the driest months.

In the agricultural sector, participants supported the development and distribution of drought-resistant plant varieties, flexibility in sowing times, agro-climate zoning, crop rotation during adverse weather conditions, and an effective incentives system to encourage the improvement of water-efficiency for irrigation practices.

Participants also supported the development of a GIS (geographic information system) tailored to local needs. This would allow the mapping of flooding areas in order to avoid occupying and investing in hazard-prone lands. Implementation of river basin management policies and practices was also supported. Besides reforestation of slopes with native species, participants noted that fruit trees can be used, that soil conservation can be promoted with permanent shrub vegetation, and that fast growing species of trees and bushes can furnish peasants with wood.

## *SCOTLAND IS MANAGING CONFLICTING INTERESTS AND ADDRESSING CLIMATE CHANGE*

In Scotland, new ways of water management are being pioneered that build strongly on a multi-stakeholder process. A number of river basins in the Scottish Cairngorms mountains face growing pressure on water resources due to an increase in conflicting water demands and the potential pressures of climate change. Whisky distilleries, anglers and fishermen, tourists, nature protection advocates, and farmers all demand certain water regimes. Following the introduction of the EU Water Framework Directive, consultations with stakeholders were conducted to define a response to increasing pressures in surrounding catchments. Bringing together the various stakeholders has helped generate a wide interest in the improved management of the catchments. The experience revealed that climate change issues need to be embedded in water management policies if they are to be fully addressed by stakeholders.[39]

and capacities. What should be common to every coalition and every country, however, is the goal of bringing about a fundamental change in how climate-related risk and uncertainty in the water sector is addressed.

## *5.2 Making Adaptation Work for People*

It will be important for efforts to focus on servicing people's needs so they are better-off once adaptation measures are implemented. Such adaptation should build on the real needs and

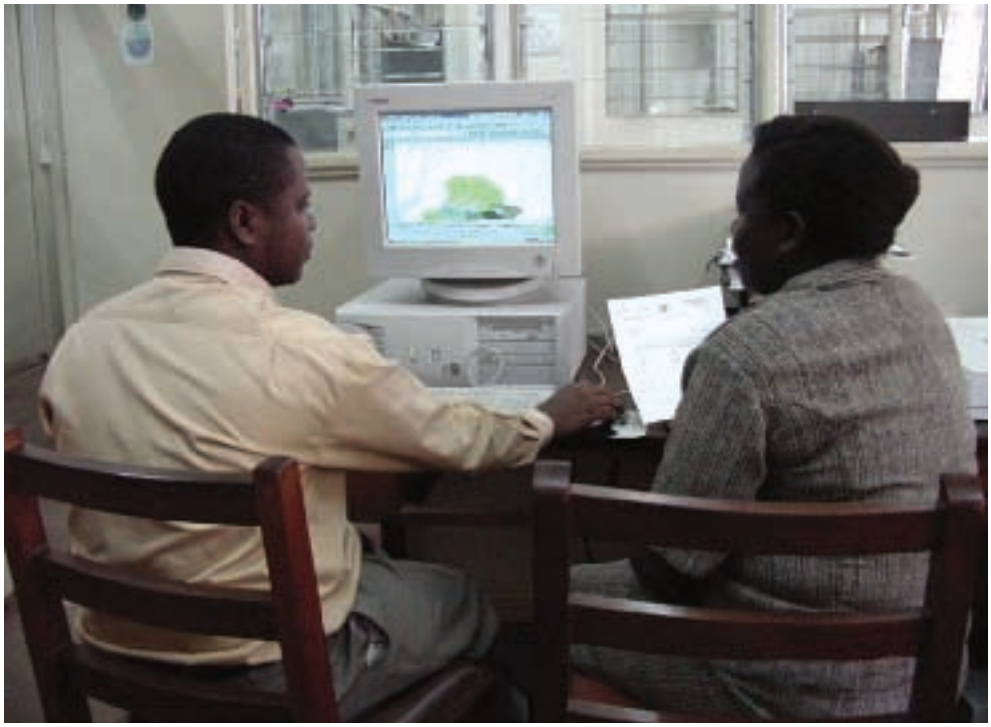
### *CLIMATE CHANGE ADAPTATION PRIORITIES IN THE MEKONG RIVER BASIN*

At the Dialogue on Water, Wetlands and Climate Change in the Mekong River Basin, participants observed that the Mekong River Commission and several other institutions are starting to incorporate climate change into their work. Governments in Thailand and Vietnam appear to be in a better position to initiate activities than Laos and Cambodia, where government structures are more in need of strentghtening. Climate change could be another area in which cooperation can occur, reinforcing the growing trend towards regional collaboration.

Across the countries sharing the Mekong area, local adaptation capacities may be high among communities given their access to and control of natural resources. Most rural communities in the Mekong have diverse livelihood options and these should be reinforced and supported. State-led initiatives to promote mono-crop farming – such as intensive irrigated rice cultivation – is likely to reduce the adaptive capacity of farmers. Ongoing manipulation of hydrological regimes through the development of infrastructure can also increase vulnerability. Key adaptation objectives could include:

- diversifying agricultural production to cope with changes in water availability;
- addressing incentives that currently promote maladaptive practices, including economic policies and regulations that shape resource use;
- employing sustainable natural resource management with effective community participation;
- improving information sharing and development;
- raising public and political awareness; and
- improving water use efficiency.

Several partners were identified that could play a major role in moving climate change adaptation forward in the Mekong region. These potential partners include the Mekong River Commission, Asian Development Bank, Southeast Asia START Centre, IUCN The World Conservation Union, Oxfam Mekong Initiative, International Rice Research Institute, International Water Management Institute, Mekong Environment and Resource Institute, and Asia Disaster Preparedness Centre. Other relevant entities in the Mekong countries include national universities, ministries of water, agriculture, and environment, and national committees on climate change and on the Mekong.



GIS operators looking at land use planning in Kampala, Uganda

Training for water quality monitoring in Mauritania

opportunities identified and articulated by water users and managers. A major challenge will be to ensure that adaptation measures provide services of high quality and reliability as soon as is practicable, especially to the most vulnerable. Only when individuals and communities view it as in their individual or collective interest to engage will genuine adaptation truly get underway. Knowing stakeholder preferences and involving them in policy formulation, planning and implementation will therefore be critical. Establishing an inclusive process and securing local stakeholders' involvement will help develop a common approach based on insight, on-the-ground experience and community support.

### *MEDITERRANEAN ACTIONS TOWARDS ADAPTATION ON CLIMATE CHANGE*

Participants at the Mediterranean Dialogue on Water, Wetlands and Climate Change indicated that several measures to cope with increased climate variability have already been incorporated into water resource development and management. However, there remains plenty of scope for existing measures that reduce vulnerability to be reinforced, while other maladaptive policies need to be eliminated. In the northern Mediterranean, many activities that are consistent with climate change adaptation are encouraged through the EU Framework Directives on Water Resources and Management.

The region's water resources have been planned, designed and managed largely on the basis of past hydrological conditions. Adjusting existing management regimes to account for the growing uncertainty of climate change will become a defining feature of water resource planning over the next few years. Key objectives include:

- reducing current vulnerability through measures such as flood zoning and land use controls;
- closing the demand-supply gap, developing demand-side management and drought preparedness programmes, reducing water supply leakage, and mobilizing non-conventional sources of water; and
- maintaining and restoring key wetland functions, introducing environmental flow policies that can cope with a range of conditions and are linked to drought measures, and restoring and maintaining wetlands and watersheds.

In Greece, the government has begun to inform farmers about the potential impacts of climate change. In France, drought preparedness and prevention schemes are part of the legal framework on water resource development. The French Government is also seeking to speed up the implementation of Plans for the Prevention of Risks and to improve flood warning systems. Upstream measures such as reforestation are being implemented to prevent floods as part of catchment management. Morocco has taken steps to increase the number of wastewater plants and wetlands protection measures to reduce current vulnerability to water scarcity. In Italy, actions linked to the 2002 Environmental Action Strategy have focused on three priorities - water conservation, water quality, and sustainable water pricing. In Cyprus, measures have been implemented to increase the efficiency of water supply and develop non-conventional sources of water, such as desalination, which now makes up more than 10% of freshwater supply. Institutional capacities such as the National Drought Observatory in Morocco can help ensure that drought management addresses both current and future climate vulnerability.

## *ADAPTATION OPTIONS FOR SOUTHERN AFRICA*

A number of institutions are working in Southern Africa to lessen the impacts of climate change by strengthening disaster preparedness efforts. Participants at the Regional Dialogue on Climate Change, Water and Wetlands in Southern Africa, identified a number of technical, financial and socio-economic options to improve the adaptive capacity of the region to climate change. Some of the options identified include improved forecasting, retrofitting infrastructure with additional safety features, increasing water storage capacity, instituting water demand management, implementing water reclamation, and supporting flood and drought insurance.

Tackling the challenge of climate change provides a new opportunity for collaboration and partnership, since none of the countries has the resources or capacities to adapt successfully on its own. Participants at the Regional Dialogue recommended that a "network of champions" be created in Southern Africa to support and drive a new regional initiative on adaptation. Institutions that should be included in the network include river basin commissions and committees, the Southern African Development Community, national committees on climate change, wetlands and water, the Global Water Partnership, IUCN The World Conservation Union, and Global Legislators for a Balanced Environment (GLOBE). The main tasks of this network would be to raise public and political awareness for incorporating climate change into water and wetland resource planning and management.

## *EXPERIMENTING WITH ALTERNATIVE APPROACHES TO WATER RESOURCES ALLOCATION INCREASES YIELDS IN ANDRA PRADESH.*

In Andra Pradesh, India, experiments growing paddy rice with a minimum amount of water during dry years has resulted in an overall reduction of water demand by farmers. Traditionally, no crops are grown in the irrigation tank command areas before the tanks are half-full of water, which usually happens towards the end of August. This is in spite of the fact that enough soil moisture would be available in the command areas earlier. Experimentation with early deep seeding and weeding in June demonstrated that under specific conditions a crop can be grown with considerably less water. The experience has important implications for management of the command area during dry years when not enough water would be available in the tanks and reservoirs. Using the new technique allows the entire command area to receive supplemented irrigation during the critical flowering and yield formation periods. Experiments carried out during a drought showed that though the yields per hectare would decrease by about 10 percent, the total yield in the command area would increase by as much as 50%. These types of experiments will need further support if societies are to adapt to changes in the hydrological cycle due to climate change.[40]

The new type of uncertainty resulting from climate change means that past records, science, and expertise now provide a less secure basis for choice than in the past. The choices that need to be made should be based on public participation and consent. This may result in a somewhat confusing social process. Just as issues such as health care and genetically modified organisms have generated much debate, wide public discussions on how best to deal with climate change will provide an opportunity to generate public and political support for sharing the burden (and the benefits) of the impacts.

*"IT IS UNREALISTIC TO EXPECT THAT ADAPTATION WILL SIMPLY HAPPEN BECAUSE IT 'SOUNDS LIKE THE RIGHT THING TO DO'."*

Involving the public in this process will require building adaptation strategies and measures around the water manager's and user's current abilities. Endeavouring to overcome resistance to unpopular actions is unlikely to yield quick results. In addition, training will be needed to clarify climate change issues and introduce possible alternative adaptation measures. Demonstrations and peer review of innovative measures can be extremely useful. Through training, stakeholders' commitment and a personal identification with the issues can be developed.

Adapting water resources management to climate variability and change will need to bring short-term as well as long-term benefits. Actions that promote near-term paybacks to the people involved will be important –it is unrealistic to expect that adaptation will simply happen because it "sounds like the right thing to do". On the contrary, one major difficulty with the uncertainty of climate change is that costly adaptation measures may prove to have been unnecessary when the climate does not change as expected. When discussing adaptation measures it will therefore be important to focus on "no-regrets" or "win-win" solutions. These measures would provide significant benefits even if climate change does not manifest itself in quite the ways predicted.

### *IN HONDURAS, TRADITIONAL TECHNIQUES COULD BECOME THE STARTING POINT FOR EXPERIMENTATION*

An example of the sort of adaptation a coalition might support comes from the remote village of Guarita in Honduras. The village was one of the few places in the region that successfully avoided the worst of the destruction wrought by Hurricane Mitch in 1998. The traditional Quezungal farming method practised by the local villagers had protected the upper-catchment and reduced the loss of crops to only 10 per cent. Their traditional farming involves planting crops under trees whose roots anchor the soil, pruning vegetation to provide nutrients to the soil and conserve soil water, and terracing to reduce soil erosion. Unfortunately, the methods taught at agricultural colleges and employed in surrounding areas caused much damage, as they were suited more for cultivation of plains rather than for farmland located on more hilly terrain. The traditional Quezungal method avoids widespread slash-and-burn techniques and improves soil fertility. It is now being actively promoted by the Government of Honduras in collaboration with the UN Food and Agriculture Organisation (FAO). This example illustrates that building and supporting traditional knowledge and techniques can be a valuable part of an adaptive management strategy for climate change.[38]

### *A BROAD COALITION COULD HELP TO IMPLEMENT INNOVATIVE CLIMATE ADAPTATION SOLUTIONS IN THE NETHERLANDS*

A coalition could materially assist a proposal in the Netherlands to support peat-bog areas to counteract the impacts of land subsidence and sea level rise. "Growing with the sea" is a Dutch initiative to link coastal defence to nature conservation and restoration. The planned inundation of low-lying areas to store freshwater, facilitate purification and create wetlands is being proposed. The measure would counteract the ongoing subsidence of 40-50 centimetres in some peat-bog areas. The peat bogs would function as buffers against excess rainwater and would supply water for industry, agriculture and human consumption. They would also provide a habitat for important plant and animal species and provide various recreational opportunities. The innovative idea combines long-term aspects of adapting to climate change with direct, short-term benefits to society.[41]

### *POLITICAL LEADERS IN CALIFORNIA USE DROUGHTS TO MAKE PROGRESS WITH WATER LEGISLATION*

Leaders can help increase public acceptance and generate political will to change long-standing (and often legally-binding) constraints. Working with a National Adaptation Coalition can increase the ability to seize upon an event to push for much-needed reforms to adapt to climate change. For instance, droughts have been used to promote reforms in water supply, management and even demand. In California, the serious drought that occurred in the 1980s prompted Congress to remove legislative constraints on the operational flexibility of California's Central Valley Project. This allowed water to be reallocated for in-stream uses to protect aquatic habitats. This change, combined with strict adherence to water quality standards, provided the basis for addressing the impacts of droughts while also targeting key environmental concerns.[17]

### *PUBLIC INFORMATION CAMPAIGNS IN COSTA RICA REDUCE ENERGY CONSUMPTION IMPACTED BY CLIMATE VARIABILITY*

With the support of leaders, a coalition can also undertake public information campaigns and incentives such as those carried out in Costa Rica to reduce hydropower energy consumption affected by climate variability. Costa Rica's Electricity Institute has developed a nationwide strategy to reduce energy consumption and encourages users to be more efficient when using energy. With a 98% dependency on hydropower, Costa Rica's energy supply is directly dependent on its water resources and strongly affected by climatic variability. Through a newspaper, radio and television campaign the government is working to reduce energy demand. In addition, incentives are provided to directly reduce energy consumption. The policy assists in establishing a societal process in which people value energy and water resources and assume responsibility for actions towards sustainable water management[42]

## 5.3 Kick-Starting Adaptation by Catalysing Innovation

National Adaptation Coalitions can play a key role in catalysing innovation. They can create opportunities for innovation and develop into an effective network of innovators working on adaptation to climate change. Encouraging innovative, entrepreneurial behaviour could be a main task of the coalitions. This means creating an environment where water professionals and water users are encouraged to experiment with small-scale innovations that make incremental improvements on present practice. Ensuring widespread recognition of those championing innovation would also help the cause of adaptation.

Coalitions can foster innovation by establishing small "path-finding" teams that bring together a variety of actors. The role of these teams would be to identify innovative or cutting-edge practices used by water users and managers, and to work with these people in identifying further initiatives.

*"SMALL TEAMS COULD IDENTIFY INNOVATIVE OR CUTTING-EDGE PRACTICES."*

Innovation often thrives where an open exchange of ideas and even "random interactions" between people and organizations are encouraged. Creating both formal and informal opportunities for water actors to communicate and share ideas about their latest innovative projects or initiatives would contribute to this.

Using loosely-coupled project teams in a flexible manner is known to be an extremely effective way to identify innovative solutions. Organizational fluidity will be essential in establishing and maintaining coalitions that would generate effective communication within and between existing government, business and societal structures. To develop this, a mechanism will be required to encourage less formal and hopefully more creative and innovative activities outside of the mainstream. Small grants funds can be used to achieve this. Such activities should be linked to an overall learning strategy that fosters feedback amongst participants. Disseminating information on lessons learned from unsuccessful efforts will also be a part of this process.

Maintaining the momentum will remain a challenge throughout the process. Therefore, focusing on a "results-first" approach that expedites innovative, tangible actions appears to be most desirable. During the early stages of the adaptation process, coalitions could focus on stimulating lower risk ideas that can achieve clear results in the short term. In this way they can develop the confidence and momentum needed to mainstream innovative thinking among a wider group of water actors.

## 5.4 Engaging Leaders to Support and Communicate the Adaptation Process

Securing support from key political and other leaders for adaptation and the need for National Adaptation Coalitions is crucial. The minister of water resources, the head of the water authority, and leaders of businesses and non-governmental organizations can play a critical role in defining and communicating the set of core values that will guide adaptation and catalyse the process.

The core values of the adaptation process should feature prominently in the coalition's communications. These values ought to be identified early on and should be consistent with the core values of modern water management. Defining these core values will be an essential part of creating the political buy-in from key interest groups within the coalition.

As the adaptation process continues, the role of political leaders and other key figures will be to repeat and pay explicit attention to the core values in order to guide further policies, strategies and actions. The leaders involved should articulate a clear message in order to instil the core values and communicate their perspectives with the public. As well as political figures, well-known entertainers, sports celebrities and business leaders can all play a role within the adaptation process.

Leaders will need to communicate a sense of urgency and enthusiasm throughout the adaptation process. A communication style that is open and confronts issues in a straightforward manner will be needed. Given the large uncertainties, some de-politicising of the issues will be required to encourage people to become involved in finding the most suitable adaptation measures. Given the multi-stakeholder nature of adaptation, a number of leaders from different societal groups will be needed to communicate effectively on adaptation.

*"SECURING SUPPORT FROM KEY POLITICAL AND OTHER LEADERS IS CRUCIAL."*

Once some successful adaptation approaches and measures have been developed, leaders can slowly but surely lead the diffusion process. Good communication to the appropriate target audiences will again be needed. Small-scale events, such as presentations and demonstrations to practitioners, is often effective as a catalyst for further action. The National Adaptation Coalitions will need to devote time and energy to developing appropriate slogans, catchphrases, and other key messages that confirm core values and best practice. Leaders involved in the adaptation process should encourage public enthusiasm and recognition for the innovative climate adaptation actions being undertaken.

Planning meeting in Costa Rica

## *ADAPTATION OPTIONS FOR WEST AFRICA*

There are numerous relevant initiatives in West Africa that relate to climate change in general or to water and the environment, according to participants attending the recent Regional Dialogue on Water, Wetlands and Climate Change in West Africa. While some initiatives are research activities, others are undertaken as part of the implementation of international conventions on desertification, wetlands, biodiversity and climate change. A good starting point is therefore to build on and complement what is already being done. In this regard, efforts should be made to develop synergies with existing international treaties and conventions, in order to ensure that climate change issues are adequately reflected in national action plans and strategies. Efforts to increase the available resources for data collection and analysis should also be supported, in order to increase the region's capacity in climate impact analysis and climate change forecasting.

One of the core elements of the adaptation strategy identified during the Regional Dialogue is the strengthening of the capacity of government actors and other entities. An action plan is needed to improve the sub-region's capacity to adapt to climate change impacts on water resources and ecosystems. Participants agreed on the following objectives for adaptation:

1) Improving knowledge on the region's climate, water resources, and ecosystems, and on the impacts of climate change and variability on these different elements.
2) Strengthening the networks of data collection for improved quality and quantity of information, especially in the areas of climate, hydrology, water quality, and water uses.
3) Strengthening the information base for forecasting and early warning to prevent or minimize the consequences of climate variability.
4) Strengthening the capacity of the basin organizations and other sub-regional institutions involved in managing the effects of climate variability.
5) Promoting Integrated Water Resources Management (IWRM) together with the ecosystem management approach.
6) Increasing decision makers' awareness and support governments in their efforts to implement environmental conventions (including the Ramsar Convention on Wetlands, the Convention to Combat Desertification, and the Framework Convention on Climate Change).
7) Strengthening capacities at all levels on aspects related to water and climate.
8) Promoting any form of adaptation that ensures better management of water resources and ecosystems in the sub-region.

Participants stressed the need to build on and develop synergies with other major initiatives underway in the sub-region, including the New Partnership for Africa's Development (NEPAD), the African Ministerial Conference on Water (AMCOW), the European Initiative on Water, the African Funds on Water, and the Canadian Initiative on Water.

# References


1 Intergovernmental Panel on Climate Change, Climate Change 2001: Impacts, Adaptatoin and Vulnerability, Summary for Policymakers and Technical Summary of the Working Group II Report, IPCC Geneva.

2 Emsley, J. (Ed.) 1996. The global warming debate. Report by the European Science and Environmental Forum. Bourne Press Limited, Bournemouth (UK), 288pp.

3 Arnell, N.W. 1999. The effect of climate change on hydrological regimes in Europe: a continental perspective. Global Environmental Change, 9: 5 – 23.

4 United Nations Framework Convention on Climate Change, 1992.

5 Smith, J.B., Bhatti, N., Menzhulin, G.V., Benioff, R., Campos, M., Jallow, B., Rijsberman, F., Budyoko, M.I., Dixon, R.K. 1996. Adapting to climate change: an international perspective. Springer-Verlag, New York

6 IPCC CZMS. 1992. "A common methodology for assessing vulnerability to sea level rise," in IPCC CZMS, Global Climate Change and the Rising Challenge of the Sea. Report of the Coastal Zone Management Subroup, Response Strategies Working Group of the Intergovernmental Panel on Climate Change, Ministry of Transport, Public Works and Water Management, The Hague, Appendix C.

7 Magalhaes, A.R. 1996. Adapting to climate variations in developing regions: a planning framework. In: Smith, J.B., Bhatti, N., Menzhulin, G.V., Benioff, R., Campos, M., Jallow, B., Rijsberman, F., Budyoko, M.I., Dixon, R.K. 1996. Adapting to climate change: an international perspective. Springer-Verlag, New York, p 44-54.

8 ICWE 1992. Dublin Statement and report of the conference, 26-31 January 1992.
UN-ESA 1992. Chapter 18 - Agenda 21. http://www.un.org/esa/sustdev/agenda21chapter18.htm
WB 1993. Water Resources Management - A World Bank Policy Paper. The World Bank, Washington DC, 140pp.
ICOLD 1997. Dams and the Environment. ICOLD Position Paper.
http://genepi.louis-jean.com/cigb/chartean.html
EC 1998. Towards sustainable water resources management - a strategic approach. Guidelines for water resources cooperation. European Commission, Brussels, 351 pp.
ADB 2000. Water For All. The Water Policy of Asian Development Bank. http://www.adb.org/Documents/Policies/Water/default.asp?p=policies
GWP 2000. Integrated Water Resources Management. TAC Background Papers, no 4, 67 pp. http://www.gwpforum.org/gwp/library/Tacno4.pdf
WCD 2000. Dams and development - a new framework for decision-making. Earthscan, London, 404 pp.
IHA 2001. IHA Comments on the Final Report of the WCD - February 2001.
ICID 2000. Strategy to implement ICID's concerns emanating from the Vision for Water, Food and Rural Development. ICID, Cape Town. http://www.icid.org/index_e.html

9 IUCN 2000. Vision for Water and Nature. A world strategy for conservation and sustainable management of water resources in the 21st century. Gland, Switzerland, 52 pp. http://www.iucn.org/webfiles/doc/WWRP/Publications/Vision/VisionWaterNature.pdf

10 Truffer, B., Cebon, P., Dürrenberger, G., Jaeger, C., Rudel, R., S. Rothen 1998. Innovative social responses in the face of global climate change. In: Views from the Alps. Regional Perspectives on Climate Change, edited by Cebon, P., Dahinden, U., Davies, H., Imboden, D., Jaeger, C. Boston, MIT Press. p.351-434.

11 Rees, J.A. 2002. Risk and Integrated Water Management. TAC Background Papers, Global Water Partnership, Stockholm.

12 Knight, 1971. The Meaning of Risk and Uncertainty. In: Knight, F. (Ed). Risk, Uncertainty, Profit, Chicago: Chicago University Press.

13 Blaikie P., Cannon, T., Davis, I., and Wisner, B. 1994. At risk: natural hazards, people's vulnerability and disaster. Routledge, London, 284p.

14 Redaud, J.L., Noilhan, J., Gillet, M., Huc, M., and Begni, G. 2002. Climate change and its impacts on the water regime in France. MEDIAS/GB/db/2002/162. Ministère de l'Ecologie et du Dévelopment Durable. Toulouse, November 2002. Guerrieri L. 2002. Adaptation strategies for improved flood management in the Mediterranean.

15 Abramovitz, J., T. Banuri, P. Girot, B.Orlando, N.Scheider, E.Spanger-Siegfried, J.Switzer, and A.Hammil. (2001). Adapting to Climate Change: Natural Resource Management and Vulnerability Reduction. Background Paper to the IUCN-IISD-SEI Task Force on Climate Change, Adaptation and Vulnerable Communities.

16 Menon, M. 2002. The crops of truth. Wasteland News, May-July 2002: 53-55.

17 Stakhiv, E.Z. 1996. Managing water resources for climate change adaptation. In: Smith, J.B., Bhatti, N., Menzhulin, G.V., Benioff, R., Campos, M., Jallow, B., Rijsberman, F., Budyoko, M.I., Dixon, R.K. 1996. Adapting to climate change: an international perspective. Springer-Verlag, New York, p 243-264.

18 Querner, E.P. 2002. Analysis of basin response resulting from climate change and mitigation measures. In: Van Lanen, H.A.J. and Demuth, S. Friend 2002 – Regional hydrology: bridging the gap between research and practice. IAHS Publication no. 274: p77-84.

19 Easterling, W.E. 1996. Adapting North American agricultur to climate change in review. Agricultural and Forest Meteorology, 80, 1-53.

20 Boggess, W. G. and Curtis, B.C. 1985. Importance, causes and management responses to farm risks: evidence from Florida and Alabama. J. Agric. Econ. 17(2): 105-116.

21 Reilly, J. and Schimmelpenning, D. 2000. Irrerveribility, uncertainty and learning: portraits of adaptation to long-term climate change. Climate Change, 45: 253 – 278.

22 Adger, N. 2000. Institutional adaptation to environmental risk under the transition in Vietnam. Annals of the Association of American Geographers, 90(4): 738-758.

23 Pelling, M. 1998. Participation, social capital and vulnerability to urban flooding in Guyana. J. Int. Dev., 10: 469-486.

24 Putman, R. 1995. Bowling alone: America's declining social capital. Journal of Democracy, 6: 65-78.

25 Nilson, J. and van Dijk, G. 1997. Strategies and structures in the Agro-food industries. Van Gorchum, The Netherlands.

26 Sit, V. and B. Taylor (editors) 1998. "Statistical Methods for Adaptive Management Studies" Land Management Handbook No 42. Res. Br. B.C. Min. For. Res. Br., Victoria. B.C.

27 Jiggins, J. and Röling, N. 2002. Adaptive management: potential and limitations for ecological governance of forests in a context of normative pluriformity. In: Oglethorpe, J.A.E. (Ed.) 2002. Adaptive management: from theory to practice. IUCN, Gland, Switzerland and Cambridge, UK.: p15-38.

28 Roe, E. 1999. Report to the Rockefeller Foundation. www.instantvision.com/rockefeller_report

29 Maarveveld, M. and C. Dangbégnon, 1999, Managing natural resources: A social learning perspective, Agriculture And Human Values, 16: 267-280, cited in Buck, Wollenberg and Edmunds, Social learning in the collaborative management of community forests: Lessons from the field, pp. 1-20, in Wollenberg et al. , Eds., 2001 Social Learning in Community Forests, CIFOR and East West Center.

30 Engel,P.G.H, 1995. Facilitating innovation: An Action oriented approach and participatory methodology to improve innovative social practice in agriculture. Wageningen Agriculural University. Published doctoral dissertation, cited in Joan Anderson, 2002, Decision Making in Local Forest Management: Pluralism, Equity, and Consensus, in Oglethorpe J. Ed., 2002, Adaptive Management-From Theory to Practice, SUI Technical Series Vol.3, pp. 53:65, IUCN, The World Conservation Union, Gland, Switzerland and Cambridge, UK.

31 Argyris C. and D. A. Schön, 1996. Organizational Learning II: Theory, Method and Practice, Addison-Wesley Publishing Company, Inc., Reading, MA. 1996

32 Wollenberg E., D. Edmunds, L. Buck, J. Fox and S. Brodt, Eds. 2001. Social Learning in Community Forestry, Center for International Forestry Research (CIFOR) and East-West Center

33 http: www.worldbank.org/education/tertiary/

34 Gonzalez, R.M. 2002. GIS-assisted joint learning: a strategy in adaptive management of natural resources. In: Oglethorpe, J.A.E. (Ed.) 2002. Adaptive management: from theory to practice. IUCN, Gland, Switzerland and Cambridge, UK.: p15-38.

35 Buckles, D. and Rusnak, G. 1999. Conflict and collaboration in natural resource management. In: Buckles, D. (Ed) 1999. Cultivating Peace - Conflict and Collaboration in Natural Resource Management, IDRC/World Bank, 300 pp.

36 Borrini-Feyerabend, G., Farvar, M.T., Nguinguiri, J.C., and Ndangang, V.A. 2000. Co-management of natural resources: organising, negotiating and learning-by-doing. GTZ & IUCN, Kasparek Verlag, Heidelberg (Germany), 95pp.

37 Werner, M. 2001. Complex problems, negotiated solutions. Tools to reduce conflict in community development. ITDG publishing, London, 149 pp.

38 Gunson, P. 1998. ``Honduran Villagers Survived Mitch with a Method as old as the Hills.`` *The Gardi*an. January 23.

39 Walker, S. 2001. Opportunities for balancing conflicting economic, social and environmental pressures in river basins through an integrated approach with stakeholder involvement. In: Schuman, A.H., Acreman, M.C., Davis, R. Marino, M.A., Rosjberg, D. and Xia, J. (Eds) 2001. Regional management of water resources. IAHS Publication no. 268: p175 – 182.

40 Rao, H. Technology for better irrigation water management in Andhra Pradesh. Wasteland, May-July 2002: 70-73.

41 Klein, R.J., Smit, M.J., Goosen, H. , Hulsberge, C.H. 1998. Resilience and vulnerability: coastal dynamics or Dutch dikes? The Geographical Journal, 164 (3): 259-268.

42 Campos, M., Sanchez, A. and Espinoza, D. 1996. Adaptation of hydropower generation in Costa Rica and Panama to climate change. In: Smith, J.B., Bhatti, N., Menzhulin, G.V., Benioff, R., Campos, M., Jallow, B., Rijsberman, F., Budyoko, M.I., Dixon, R.K. 1996. Adapting to climate change: an international perspective. Springer-Verlag, New York, p 44-54.

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