The United Nations World Water Development Report 3

WATER IN A CHANGING WORLD

World Water Assessment Programme

UN WATER

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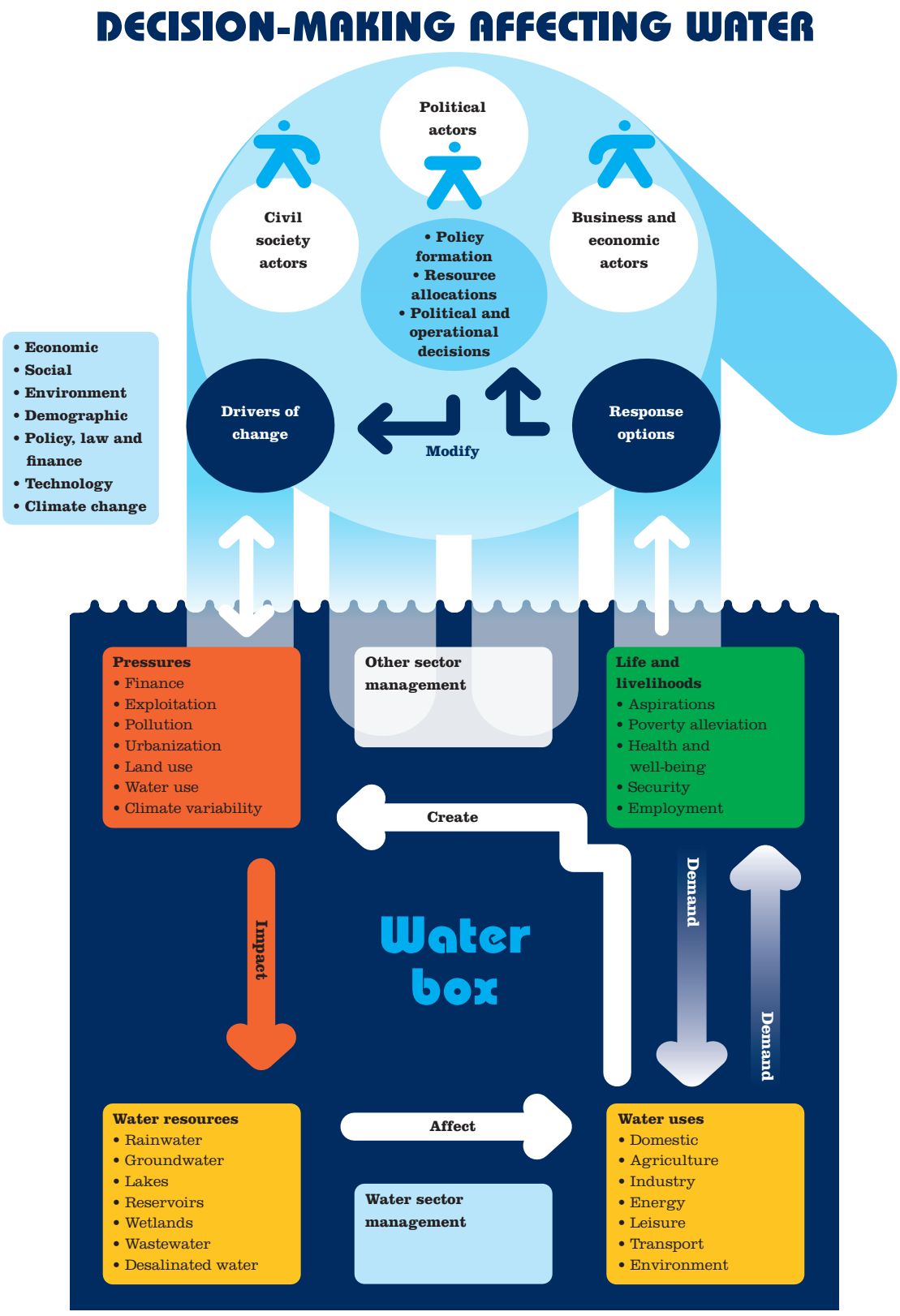
GETTING OUT OF THE BOX – SPHERE OF DECISION-MAKING ABOUT WATER. Many paths to sustainable development are linked to water, but the decisions that determine how water resources are used or abused are not made by water managers alone. That central theme of *The United Nations World Water Development Report 3* is illustrated in this figure (which also appears in chapter 1).

The lower section of the figure, titled *Water box,* is the realm of *water sector management.* Here, water managers inside the water box and *managers of other sectors* oversee their own management–resource-use interactions. Above them are the actors who make or influence broad socioeconomic policies that affect water.



The cycle begins with political-process actors – in *government, civil society and business* – deciding on socio-economic development objectives and *formulating policy* and *operational decisions* to achieve them. Their decisions, which respond to *life and livelihoods* requirements, are implemented in a context of externalities – often beyond their direct control – that interact with and modify *drivers of change,* creating *pressures* on land and water resources (among others).

Water resources managers address the demands of *water uses* to meet the *life*-sustaining requirements of people and other species and to create and support *livelihoods.* In doing so, they may add to – or reduce – the *pressures* caused by these drivers. However, their actions may fall short of their objectives because of constraints related to inadequate water, financial or human resources or because the external forces are behaving in unforeseen ways. Making progress thus requires returning to the original political actors in the decision-making process for responses that take these constraints into account.

Needed in place of this discontinuous decision-making process is one in which water managers inform the initial decision-making and participate in planning the appropriate responses, interacting with the principal actors and with the managers of other sectors.

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Foreword by Ban Ki-moon, Secretary-General, United Nations

It is well known that water is life; what this Report shows is that water also means livelihoods. It is the route out of poverty for individuals and communities. Managing water is essential if the world is to achieve sustainable development.

This challenge is even more pressing as the world confronts the triple threats of climate change, rising food and energy costs, and the global economic crisis. All three are exacerbating poverty, inequality and underdevelopment.

The United Nations has responded by consolidating our work and joining with partners who can make a difference through UN-Water, which brings together more than two dozen UN agencies and other stakeholders. The initiative's World Water Assessment Programme is setting an example of system-wide cooperation based on the understanding that water is such a central consideration that it must be an integral part of all planning and investments.

Developing countries and countries in transition are striving to manage their water resources more effectively. I call on the bilateral donors to support those efforts by increasing water's share of official development assistance above the current level of 5.4%.

This is important not only for development; it is a matter of security, too. Lack of basic services can contribute to political instability. Armed conflicts can further disrupt these services.

There has been a widespread failure to recognize water's vital role in providing food, energy, sanitation, disaster relief, environmental sustainability and other benefits. This has left hundreds of millions of people suffering from poverty and ill health and exposed to the risks of water-related diseases.

This situation is unconscionable. Governments and the international development community must make more and immediate investments in water management and related infrastructure. We must all work together to address this matter of life and livelihoods. This Report is meant to spur such action, and I commend it to a wide global audience.

Ban Ki-moon
Secretary-General
United Nations

Foreword by Koïchiro Matsuura, Director-General, United Nations Educational, Scientific and Cultural Organization

With the release of this third edition of *The United Nations World Water Development Report,* it is clear that urgent action is needed if we are to avoid a global water crisis. Despite the vital importance of water to all aspects of human life, the sector has been plagued by a chronic lack of political support, poor governance and underinvestment. As a result, hundreds of millions of people around the world remain trapped in poverty and ill health and exposed to the risks of water-related disasters, environmental degradation and even political instability and conflict. Population growth, increasing consumption and climate change are among the factors that threaten to exacerbate these problems, with grave implications for human security and development.

The current Report provides a comprehensive analysis of the state of the world's freshwater resources. It also, for the first time, shows how changes in water demand and supply are affected by and affect other global dynamics. It represents a considerable collaborative achievement for the 26 UN agencies that make up UN-Water and are engaged in the World Water Assessment Programme (WWAP), which leads the monitoring and evaluation behind the Report. UNESCO is very proud to have played a pivotal role in the launch of this flagship programme and to continue to support its work by housing the WWAP Secretariat. I am confident that this third volume will prove crucial as a working tool for policy-makers and other stakeholders, providing solid evidence from which to develop an effective and sustainable approach to water issues.

The Report could not come at a more important time. We have passed the halfway point towards the 2015 target date for achieving the Millennium Development Goals, and despite progress, massive challenges remain. Millennium Development Goal 7 calls for halving the proportion of people without sustainable access to safe drinking water and basic sanitation. While the world is on track to achieve the water target globally, large regions of the world and many countries lag behind, and some risk backsliding. This is particularly the case in sub-Saharan Africa and low-income Arab states. On current trends the sanitation target will be missed by a wide margin in the majority of developing countries. But water is linked not only to Millennium Development Goal 7. It also directly affects, as this Report establishes, the achievement of all eight Millennium Development Goals, including, notably, the first goal, the eradication of extreme poverty and hunger.

Water is a cross-cutting issue that demands a coordinated approach. Our success in avoiding a global water crisis is directly linked to our ability to address other global challenges, from poverty eradication and environmental sustainability to fluctuating food and energy costs and financial turmoil in world economies. It is therefore imperative that global risks, including those associated with water, be dealt with in an integrated manner. We must develop interdisciplinary tools that can take into account different drivers such as climate change and financial markets to achieve sustainable water management. This

requires the engagement of all stakeholders, particularly government leaders, as well as global coordination through the UN system.

Water is essential to facing today's global challenges and achieving the Millennium Development Goals. As such, it should be a priority for the United Nations and the global community as a whole. Be assured that UNESCO stands ready to play its part in this process.

Koïchiro Matsuura
Director-General
United Nations Educational, Scientific and Cultural Organization

Preface

In 1999 the United Nations system resolved to issue regular editions of *The United Nations World Water Development Report.* An expert group, convened by the United Nations Department of Economic and Social Affairs, developed recommendations for the objectives and targeted audience of the report (box 1).

The first edition, *The United Nations World Water Development Report: Water for People, Water for Life,* was released in March 2003 at the 3rd World Water Forum in Kyoto, Japan. The second, *Water, a Shared Responsibility,* was released in March 2006 at the 4th World Water Forum in Mexico City. The first report provided an inaugural assessment of progress since the 1992 United Nations Conference on Environment and Development in Rio de Janeiro. Both reports were based on key challenge areas (such as water for food, water for energy, and challenges for governance). Stand-alone assessments were prepared by UN agencies. The assessments included pilot case studies on which the Report drew in developing appropriate assessment methodologies and lessons learned.

This third edition embraces a holistic structure and focuses on the second objective established by the expert group – to accelerate coverage and investments for basic human water needs (drinking water supply, sanitation and health, food security, mitigation of floods and droughts and prevention of conflicts), giving priority to developing countries.

Contents of the Report

A major theme of this Report is that important decisions affecting water management are made outside the water sector and are driven by external, largely unpredictable forces – forces of demography, climate change, the global economy, changing societal values and norms, technological innovation, laws and customs and financial markets. Many of these external drivers are dynamic, and changes are accelerating. The conceptual framework

Box 1 **Objectives and targeted audience of *The United Nations World Water Development Report***

It is recommended that *The United Nations World Water Development Report* be targeted for national decision-makers and water resources managers, with two complementary objectives:

- To strengthen and stimulate national capacities and cross-sector institutions in integrated water development planning and in sustainable management of water resources at river basin and aquifer levels.
- To stimulate an acceleration of coverage and investments, in priority, for basic human water needs (drinking water supply, sanitation and health, food security, mitigation of floods and droughts and prevention of conflicts), giving a priority to developing countries.

A more effective and targeted support of the international community for such local and national efforts would also be an important objective of this awareness-raising and action-oriented report.

Source: United Nations Expert Group Meeting to Examine Methodologies for the Preparation of a Biennial 'World Water Development Report', convened and organized by the UN Department of Economic and Social Affairs, New York, 11-14 January 2000.

that evolved for the Report is on the inside front cover of the Report and in figure 1.1 in chapter 1. The figure illustrates how developments outside the water domain influence water management strategies and policies. The Report emphasizes that decisions in other sectors and those related to development, growth and livelihoods should incorporate water as an integral component, including responses to climate change, food and energy challenges and disaster management.

At the same time, the Report's analysis of the state of the world's water resources is imbedded in a more expansive context of what can be accomplished through water management. The analysis leads to a set of responses and recommendations for action that differ from those that have emerged from more introspective analyses of the water sector because they incorporate the contribution of water to sustainable development.

This Report offers a holistic approach to links between water and climate change, food, energy, health and human security. Human security, broadly conceived, includes basic needs for food, water, health, livelihoods and a place to live – issues addressed in the Millennium Development Goals. As the second part of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), released in April 2007, demonstrates, poor people are likely to suffer most from the effects of climate change.[1]

New processes

In keeping with the Report's broader view on policy options, new processes were applied in preparing this Report. Fuller treatment is given to such topics as climate change, business and trade, financing, the role of the private sector, water transport and innovations and new technologies.

The United Nations Expert Group recommendation to involve countries in preparing the reports was reflected in the first edition in case studies based on 10 countries (including 10 national river basins) with different physical, climate and socioeconomic conditions. This method was followed in the second edition and in this Report, which presents the case studies in a companion volume to the main report. The World Water Assessment Programme is also launching a series of supporting publications that include scientific side papers, topic and sector reports and dialogue reports, taking the programme out of its rigid three-year cycle.

The preparatory process for this Report has followed an inclusive, participatory approach benefiting from opinion and feedback from the scientific, professional and decision-making communities from within and outside the water sector.

Broader input to the Report and the World Water Assessment Programme processes in general has been achieved through four mechanisms:

- A Technical Advisory Committee of 11 prominent individuals from around the world with water sector expertise and broader policy-making experience in their countries and internationally.

- Expert groups on indicators, monitoring and data/metadata bases; scenarios; climate change and water; policy relevance; business, trade, finance and the private sector; legal issues and water storage.

- A Report team composed of UN-Water member agencies, their professional and non-governmental organization partners and the broader community of water and water-related sectors.

- Stakeholder engagement through the World Water Assessment Programme Website and review processes, including public as well as solicited input and feedback from hundreds of individuals and organizations.

1. 'Poor communities can be especially vulnerable, in particular those concentrated in high risk areas. They tend to have more limited adaptive capacities and are more dependent on climate-sensitive resources such as local water and food supplies.' (IPCC, 2007, Summary for Policymakers. In *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* eds., M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson, Cambridge, UK: Cambridge University Press, p. 9).

This Report marks a transition from the first two reports – a transition from being a report primarily for water managers to being a report for leaders at all levels of government, the private sector and civil society, whose decisions depend on the availability of water resources and make demands on water management. The Expert Group on Policy Relevance consulted hundreds of such leaders to obtain their views on policy issues relevant to the water sector. At the same time, the Report continues to provide useful data for water managers on the state and use of this precious resource. Past reports have looked at trends based on historical data. It is clear that change is accelerating and that the effects of change are not easily projected from trends. To help us understand possible futures and how to cope with their impact on water resources, the World Water Assessment Programme process looks at the development of scenarios that will serve the fourth *World Water Development Report.* This scenario effort takes into account the main drivers of water, including demographics, climate change, social and economic processes and technology, along with their interactions.

In preparing this Report new data were available to update only a third of the 60-plus indicators that were reported in the second edition. And some indicators were found to be no longer valid. The lack of data was echoed by the coordinators and authors of this Report, who found that indicators and data were often not available for analysing and reporting on issues considered important. As a consequence, a new process was developed for indicators and monitoring that aims at a better understanding of the trends and developments, including changes, in the state of water resources, their uses and the interface between the state and water uses and between water and other sectors. This reflects a recommendation of Agenda 21 – a comprehensive plan of action agreed at the Rio Summit for all areas of human impact on the environment – that a detailed data collection for both fluxes of 'exploitable water resources' and of 'associated costs and finances' be conducted within a comprehensive plan for water development at the basin level.[2]

To this end, the World Water Assessment Programme established an Expert Group on Indicators, Monitoring and Data/Metadata Bases, and UN-Water established a Task Force on Indicators, Monitoring and Reporting, which is coordinated by the World Water Assessment Programme. Their results will be reported by the World Water Assessment Programme in a process leading to the fourth *World Water Development Report* and by UN-Water. A table showing the status of indicators reported on in this Report is presented in appendix 1. More detailed information may be found at www.unesco.org/water/wwap.

Few countries know how much water is being used and for what purposes, the quantity and quality of water that is available and that can be withdrawn without serious environmental consequences and how much is being invested in water management and infrastructure. Despite the availability of new remote sensing and geographic information system technologies that can simplify monitoring and reporting and despite the growing need for such information in an increasingly complex and rapidly changing world, less is known with each passing decade. Strengthening such information systems is vital not only at a national scale but also at a global scale – to inform the construction of global models of the hydrologic cycle and decisions on where interventions, including external aid, would be most useful. Chapters 10 and 13 of the Report, in particular, treat this subject.

Challenges remain in managing water resources for development

The contribution of sustainable access to safe drinking water and adequate sanitation to achieving the Millennium Development Goals is well established. Largely ignored, however, is the fact that water resources are at the core of many of the Millennium Development Goals on which progress is lagging. This Report and others elaborate the direct and indirect contributions of water management across all the Millennium Development Goals.

It is not enough to hope that the trickle-down effects of economic growth will result in equitable distribution that includes the poor. The economic growth and poverty-reducing contributions of water resources must be made explicit and specific at the country level. Intergovernmental efforts must support such actions and maintain the momentum of the global commitments made since the Millennium Declaration in 2000.

2. United Nations, 1992, Agenda 21, Chapter 18, Protection of the Quality and Supply of Freshwater Resources: Application of Integrated Approaches to the Development, Management and Use of Water Resources, New York: Department of Economic and Social Affairs, United Nations.

While mitigation of anthropogenic climate change is vital, the blunt reality is that all countries – particularly developing countries that will be hit hardest and earliest – and business sectors must also adapt to climate change. Even if greenhouse gas concentrations stabilize in the coming years, some impacts from climate change are unavoidable. These include increasing water stress in many regions, more extreme weather events, the potential for large population migration and the disruption of international markets. These challenges cannot be separated from the challenges of sustainable development in a complex global context.

This report provides evidence of the need for public investments in water resources infrastructure and implementation capacity. It also provides evidence of the vital importance of water resources and environmental sustainability to engage the private sector, civil society and communities to invest and become involved, offering examples of how this can be done.

Bilateral donors, important in funding water investments, must avoid the temptation to reduce their aid budgets during the current global financial and economic crises. Multilateral aid could be an important source of financing for many years to come. Yet both bilateral and multilateral donors appear not to recognize the contribution of the water sector to growth: the water sector's share of official development assistance has remained below 6% for some time. This said, the flow of official development assistance has increased in recent years and so has the water component in dollar terms. But most of the increase has gone to water supply (and sanitation, to a lesser degree), while aid flows to other water sectors have stagnated in dollar terms and fell as a percentage of total assistance.

Like other physical infrastructure, water infrastructure deteriorates over time and needs repair and replacement. Investment is also required in operation and maintenance and in developing the capacity of the sector so that infrastructure meets appropriate standards and functions efficiently.

The case of sub-Saharan Africa

Sub-Saharan Africa, in particular, remains mired in poverty. Its progress towards achieving the Millennium Development Goals lags behind that of other regions. The percentage of the population living in absolute poverty is essentially the same as it was 25 years ago. About 340 million Africans lack access to safe drinking water, and almost 500 million lack access to adequate sanitation. Countries in sub-Saharan Africa store only about 4% of their annual renewable flows, compared with 70%-90% in many developed countries, yet water storage is essential to ensure reliable sources of water for irrigation, water supply and hydropower and to provide a buffer for flood management.

The need to act now

The challenges that face decision-makers are numerous. The context in which they must make decisions is not well defined. This Report does not attempt to provide a full set of answers. But it identifies the key issues that must be faced. It describes some of the ways that decision-makers have dealt with these challenges, providing options for consideration across levels of government and sectors.

Despite the many unknowns, we need to act now – with decisions about investments in water infrastructure and in implementation capacity to enable environmentally sustainable economic growth and social development and with decisions on safety nets to ensure basic services that protect the poor.

We hope that this third *United Nations World Water Development Report* will stimulate decision-makers in government, the private sector and civil society to act.

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Integration meeting – 19-25 April 2008 – Perugia, Italy

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Workshop on indicators, monitoring and databases – 18-20 June 2008 – Perugia, Italy

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Workshop on policy relevance – 28 July – 1 August 2008 – Perugia, Italy

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Real-time Delphi survey on scenarios, October 2007

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Real-time Delphi survey on storage, February 2008

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Real-time Delphi survey on policy relevance, March 2008

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Electronic survey for water leaders and water experts, July 2008

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Overview of key messages

The amount of freshwater on Earth is finite, but its distribution has varied considerably, driven mainly by natural cycles of freezing and thawing and fluctuations in precipitation, water runoff patterns and evapotranspiration levels. That situation has changed, however. Alongside natural causes are new and continuing human activities that have become primary 'drivers' of the pressures affecting our planet's water systems. These pressures are most often related to human development and economic growth.

History shows a strong link between economic development and water resources development. There are abundant examples of how water has contributed to economic development and how development has demanded increased harnessing of water. Such benefits came at a cost and in some places led to increasing pressure on the environment and increasing competition among users. Our requirements for water to meet our fundamental needs and our collective pursuit of higher living standards, coupled with the need for water to sustain our planet's fragile ecosystems, make water unique among our planet's natural resources.

Important decisions affecting water management are made outside the water sector and are driven by external, largely unpredictable drivers – demography, climate change, the global economy, changing societal values and norms, technological innovation, laws and customs, and financial markets. Many of these external drivers are dynamic and changing at a faster pace. Developments outside the water domain influence water management strategies and policies. Decisions in other sectors and those related to development, growth and livelihoods need to incorporate water as an integral component, including responses to climate change, food and energy challenges and disaster management. The analysis of these issues leads to a set of responses and recommendations for action that incorporate the contribution of water to sustainable development.

Chapter 1. Getting out of the box – linking water to decisions for sustainable development

The news media today are full of talk of crises – in climate change, energy and food supplies and prices, and troubled financial markets. These global crises are linked to each other and to water resources management. They arise against a background of continuing poverty for a large part of the world. Unless resolved, they may lead to increasing political insecurity and conflict at local and national levels.

- The 'water box' dilemma must be resolved. Leaders in the water sector – in water supply and sanitation, hydropower, irrigation and flood control – have long been aware that water is essential to sustainable development, but they do not make the decisions on development objectives and the allocation of human and financial resources to meet them. These decisions are made or influenced by leaders in government, the private sector and civil society, who must learn to recognize water's role in obtaining their objectives.
- Water is essential for achieving sustainable development and the Millennium Development Goals. Properly managing water resources is an essential component of growth, social and economic development, poverty reduction and equity – all essential for achieving the Millennium Development Goals.

Leaders in the water sector have long been aware that water is essential to sustainable development, but they do not make the decisions on development objectives and the allocation of human and financial resources to meet them. These decisions are made by leaders in government, the private sector and civil society

Alongside the natural forces affecting water resources are new human activities that have become the primary 'drivers' of the pressures affecting our planet's water systems

- Water is linked to the crises of climate change, energy and food supplies and prices, and troubled financial markets. Unless their links with water are addressed and water crises around the world are resolved, these other crises may intensify and local water crises may worsen, converging into a global water crisis and leading to political insecurity and conflict at various levels.

Specialists and managers in water supply and sanitation, hydropower, irrigation and flood control have long been aware of this. But they often have a narrow, sectoral perspective that blinds many decisions on water. And they do not make the decisions on development objectives and financial resources needed to meet these broader objectives.

Action is required now. Lives and livelihoods depend on water for development. After decades of inaction, the problems are enormous. And they will worsen if left unattended. But while the challenges are substantial, they are not insurmountable. The Report has examples of how some countries and regional and local governments have solved similar challenges. Recognizing the links between water resources and other crises around the world and between water resources and development, leaders in the water domain and decision-makers outside it must act together now to meet these challenges.

Part 1. Understanding what drives the pressures on water

Alongside the natural forces affecting water resources are new human activities that have become the primary 'drivers' of the pressures affecting our planet's water systems. These pressures are most often related to human activities and economic growth. Our requirements for water to meet our fundamental needs and our collective pursuit of higher living standards, coupled with the need for water to sustain our planet's fragile ecosystems, make water unique among natural resources.

Drivers should not be considered in isolation of related socioeconomic and political factors or of other drivers. Many natural links also influence how drivers affect changes, directly and indirectly. Water properties are governed by biological, chemical and physical laws that define the quantity and quality of water resources, regardless of human influences, and that are linked in various ways. Superimposed on these natural processes are human activities that intensify these processes and disrupt the natural balance of water systems.

Economic growth, a principal driver of water use, is affected by a wide range of policy decisions, from international trade to education and public health, while the potential rate of economic growth can be affected by demographic variables such as population distribution (local workforce availability) and social characteristics (workforce capacity and the role of women) and by the availability of new technologies. Water availability is also directly subject to the impacts of climate change, which also can exert additional pressures on the other drivers.

The result of these combined and interacting forces is a continuously increasing demand for finite water resources for which there are no substitutes. When water resources of acceptable quality can no longer be provided in sustainable quantities, the outcome can be overexploitation of aquatic ecosystems. The ultimate losers are the exploited aquatic ecosystems and the organisms (including humans) dependent on them for survival and well-being.

Chapter 2. Demographic, economic and social drivers

Human activities and processes of all types – demographic, economic and social – can exert pressures on water resources and need to be managed. These pressures are in turn affected by a range of factors such as technological innovation, institutional and financial conditions and climate change.

Demographic drivers. Population dynamics (growth, gender and age distribution, migration) create pressures on freshwater resources through increased water demands and pollution. Changes in the natural landscape associated with population dynamics (migration, urbanization) can create additional pressures on local water resources and the need for more water-related services.

Economic drivers. Growth and changes in the global economy are having far-reaching impacts on water resources and their use. Growing international trade in goods and services can aggravate water stress in some countries while relieving it in others through flows of 'virtual water' (water embedded in products and used in their production, particularly in the form of imported agricultural commodities).

Social drivers. Social drivers are mainly about individual rather than collective actions and about the way people think and act on a day-to-day basis. Social drivers influence

human perceptions and attitudes about the environment, including water resources, in turn influencing the pressures people exert on water through water demands and uses. Changes in lifestyles represent one of the principal drivers of change. They reflect human needs, desires and attitudes (as illustrated in consumption and production patterns), which are influenced by such social drivers as culture and education and by economic drivers and technological innovation; the rapid global rise in living standards combined with population growth presents the major threat to the sustainability of water resources and the environment.

Chapter 3. Technological innovation

Technological innovation is driven largely by both human wants and needs. It can create both positive and negative pressures, sometimes simultaneously, resulting in increased or decreased water demand, supply and quality. One of the most unpredictable drivers, technological innovation can create rapid, dramatic and unexpected changes, both in pressures and solutions. Impediments to the dissemination of technology must be overcome for developing countries to benefit from innovations developed in richer countries.

Chapter 4. Policies, laws and finance

Efforts to implement water management effectively and efficiently and to properly inform the decision-making process are facilitated by the adoption of water resources management laws, policies and strategies that reflect links between water and the social and economic sectors. Good examples can be found in many countries.

But even if all the necessary policies and laws are in place, development of water resources will not take place without adequate funding of infrastructure and the institutional and human capacity of the sector.

Policies and laws. Effective policies and legal frameworks are necessary to develop, carry out and enforce the rules and regulations that govern water use and protect the resource. Water policy operates within a context of local, national, regional and global policy and legal frameworks that must all support sound water management goals.

Legitimate, transparent and participatory processes can effectively mobilize input for designing and implementing water resources policy and create a strong deterrent to corruption. Corruption remains a poorly addressed governance issue in the water domain. It can lead to uncontrolled pollution of water sources, overpumping and depletion of groundwater, lack of planning, degradation of ecosystems, weakened flood protection, urban expansion leading to heightened water tensions, and other harmful effects.

Finance. Although water is often described as a 'gift of nature', harnessing and managing it for the wide variety of human and ecological needs entail financial costs. While there may appear to be many financing options for water resources development, governments still have only three basic means of financing them: tariffs, taxes and transfers through external aid and philanthropy.

Although water is often described as a 'gift of nature', harnessing and managing it for the wide variety of human and ecological needs entail financial costs

Policy-makers need to make political decisions on socially and environmentally acceptable trade-offs among different objectives and on who bears the costs of such compromise. Commitments have been made by the donor community to increase assistance to the broad water sector, but this has led mainly to an increase in allocations for water supply and sanitation in dollar terms (although its share of total official development assistance has stagnated at 4%), and the percentage of total aid allocated to the water sector remains below 6% and has been declining.

Chapter 5. Climate change and possible futures

The external drivers of change, strongly connected, create complex challenges and opportunities for water managers and decision-makers in government, the private sector and civil society. Climate change and variability, while seldom the main stressors on sustainable development, can impede or even reverse development gains.

Climate change. There is evidence that the global climate is changing and that some of the change is human-induced. The main impacts of climate change on humans and the environment occur through water. Climate change is a fundamental driver of changes in water resources and an additional stressor through its effects on external drivers. Policies and practices for mitigating climate change or adapting to it can have impacts on water resources, and the way we manage water can affect the climate.

Public policy, so far dominated by mitigation, could benefit from a better balance between mitigation and adaptation. Carbon is a measure of the anthropogenic causes of climate change – water is a measure of its impacts. The international community also has to balance investing for tomorrow's likely problems of greater climate variability and global warming against investing for today's problems of climate variability to

Steadily increasing demand for agricultural products to satisfy the needs of a growing population, and the desire for a more varied diet, continues to be the main driver behind water use

prevent losses from droughts and floods. While both are vital, focusing on today's problems can also create greater resilience for dealing with the problems of tomorrow.

Possible futures. Each of the external water drivers is dynamic and continues to evolve, as do the direct and indirect pressures they exert on water resources. Thus, it is difficult to draw a comprehensive picture of the future by examining each driver independently. Because the drivers can have even more of an impact on future water resources collectively than they can individually, future scenarios that consider these interactions offer a more holistic picture. Existing global water scenarios are outdated, incomplete or sectoral and do not fully incorporate each of the external drivers. The evolution of the drivers and the logic behind their storylines need to be examined and possibly redefined in view of developments both inside and outside the water sector that have occurred over the past decade.

Part 2. Using water

History shows a strong link between economic development and water resources development. There are abundant examples of how water has contributed to economic development and how development has demanded increased harnessing of water. Steadily rising demand for agricultural products to satisfy the diverse needs of growing populations (for food, fibre and now fuel) has been the main driver behind agricultural water use.

The effects of water-depleting and water-polluting activities on human and ecosystem health remain largely unreported or difficult to measure, and the need grows stronger for effective protection of ecosystems and the goods and services they produce – on which life and livelihoods depend. As competition among demands on water increases, society will need to respond with improved water management, more effective policies and transparent and efficient water allocation mechanisms.

Chapter 6. Water's many benefits

Water has always played a key role in economic development, and economic development has always been accompanied by water development. Investment in water management has been repaid through livelihood security and reductions in health risks, vulnerability and ultimately poverty. Water contributes to poverty alleviation in many ways – through sanitation services, water supply, affordable food and enhanced resilience of poor communities faced with disease, climate shocks and environmental degradation. Water of the right quality can improve health through better sanitation and hygiene and, when applied at the right time, can enhance the productivity of land, labour and other productive inputs. In addition, healthy freshwater ecosystems provide multiple goods and services essential to life and livelihood.

The importance of water services is especially apparent in societies where normal social life and political structures have broken down. In these fragile states the government cannot or will not deliver core functions to most of its people, including the poor. While each fragile state is fragile in different ways and for different reasons – war, post-conflict recovery, major natural catastrophe, prolonged mismanagement and political repression – a striking commonality in reports from aid agencies is the prominence of water and sanitation in relief and reconstruction programmes. The rapid restoration of viable water services is often a crucial ingredient of nation-building in these fragile states.

Chapter 7. Evolution of water use

While most of the old challenges of water supply, sanitation and environmental sustainability remain, new challenges such as adaptation to climate change, rising food and energy prices, and ageing infrastructure are increasing the complexity and financial burden of water management. Population growth and rapid economic development have led to accelerated freshwater withdrawals.

Trends in access to domestic water supply indicate substantial improvement in the past decade, putting most countries on track to achieve the water supply target of the Millennium Development Goals. However, sanitation is lagging well behind, and most sub-Saharan African countries and many rural areas still show unsatisfactory records for both water supply and sanitation.

Steadily increasing demand for agricultural products to satisfy the needs of a growing population continues to be the main driver behind water use. While world population growth has slowed since the 1970s and is expected to continue its downward trend, steady economic development, in particular in emerging market economies, has translated into demand for a more varied diet, including meat and dairy products, putting additional pressure on water resources.

After agriculture, the two major users of water for development are industry and

energy (20% of total water withdrawals), which are transforming the patterns of water use in emerging market economies. Water and energy share the same drivers: demographic, economic, social and technological processes put pressure on both energy and water. The recent acceleration in the production of biofuel and the impacts of climate change bring new challenges and add to the pressures on land and water resources.

Freshwater ecosystems provide an extensive array of vital services to support human well-being. A variety of economic and recreational activities such as navigation, fisheries and pastoral activities depend on direct use of water in healthy ecosystems. Yet some environmental services receive inadequate policy attention and are endangered by the way development sectors use water.

Chapter 8. Impacts of water use on water systems and the environment

The pattern and intensity of human activity have disrupted – through impacts on quantity and quality – the role of water as the prime environmental agent. In some areas depletion and pollution of economically important river basins and associated aquifers have gone beyond the point of no-return, and coping with a future without reliable water resources systems is now a real prospect in parts of the world.

While the intensity of groundwater use, partly encouraged by subsidized rural electrification, has led to the emergence of many groundwater-dependent economies, their future is now threatened by aquifer depletion and pollution. Prospects for relaxing use of these key aquifers, remediating water quality and restoring groundwater services to ecosystems look remote unless alternative management approaches are developed.

Our ability to maintain the environmental services we depend on has improved but remains constrained by an incomplete understanding of the magnitude and impact of pollution, the resilience of affected ecosystems and the social institutions that use and manage water resources systems. A failure to monitor the negative impacts of water use on the environment and institutional weaknesses in many developing countries prevent effective enforcement of regulatory provisions.

Relevant information about pollution loads and changes in water quality is lacking precisely where water use is most intense – in densely populated developing countries. As a result, the often serious impacts of polluting activities on the health of people and ecosystems remain largely unreported. Still, there are signs of progress in how pollution and the risks of pollution can be mitigated and trends in environmental degradation reversed.

Chapter 9. Managing competition for water and the pressure on ecosystems

Competition for water and shortcomings in managing it to meet the needs of society and the environment call for enhanced societal responses through improved management, better legislation and more effective and transparent allocation mechanisms.

Challenges include wise planning for water resources, evaluation of availability and needs in a watershed, possible reallocation or storage expansion in existing reservoirs, more emphasis on water demand management, a better balance between equity and efficiency in water use, inadequate legislative and institutional frameworks and the rising financial burden of ageing infrastructure.

Water management choices should emerge from informed consultation and negotiation on the costs and benefits of all options after considering basin interconnectedness, relationships between land and water resources, and the consistency and coherence of decisions with other government policies.

Part 3. State of the resource

The uneven distribution over time and space of water resources and their modification through human use and abuse are sources of water crises in many parts of the world. In many areas hydrologic extremes have increased. Deaths and material damage from extreme floods can be high, and more intense droughts, affecting increasing numbers of people, have been observed in the 21st century. Worldwide, water observation networks are inadequate for current and future management needs and risk further decline. There are insufficient data to understand and predict the current and future quantity and quality of water resources, and political protocols and imperatives for sharing data are inadequate.

Chapter 10. The Earth's natural water cycles

Water resources are made up of many components associated with water in its three physical states (liquid, solid and gas). The components of the water cycle (rainfall,

Water and energy share the same drivers: demographic, economic, social and technological processes put pressure on both energy and water

Most climate scientists agree that global warming will result in an intensification, acceleration or enhancement of the global hydrologic cycle, and there is some observational evidence that this is already happening

evaporation, runoff, groundwater, storage and others) therefore all differ in their chemical and biochemical qualities, spatial and temporal variability, resilience, vulnerability to pressures (including land use and climate change), susceptibility to pollution and capacity to provide useful services and to be used sustainably. A consequence of this variability is that while human pressures have resulted in large modifications to the global hydrologic cycle, the directions and degrees of change are complex and difficult to ascertain. The uneven distribution of water resources over time and space and the way human activity is affecting that distribution today are fundamental sources of water crises in many parts of the world. Adding complexity, climate change and variability also influence the water supply, demand and buffering system, although their precise impacts can be difficult to isolate.

Chapter 11. Changes in the global water cycle

Most climate scientists agree that global warming will result in an intensification, acceleration or enhancement of the global hydrologic cycle, and there is some observational evidence that this is already happening. While trends in precipitation have been noted in some parts of the world, in other areas precipitation patterns have remained about the same within the period of observed data. Changes have been observed in snow cover extent and snow water equivalent and in the frequency with which precipitation falls as snow. More than 15% of the world's population live where water resources availability depends heavily on snowmelt from ephemeral snowpacks or perennial glaciers. Despite the evidence of temperature changes, there is little evidence of detectable changes in evaporation and evapotranspiration.

Climate change is being superimposed on an already complex hydrologic landscape, making its signal difficult to isolate, and yet making its influence felt throughout the water supply, demand and buffering system. Data limitations in record length, continuity and spatial coverage contribute to the uncertainty, while natural climate variability and multiyear variability associated with large-scale atmospheric circulation patterns influence the interpretation of many trends in ways that are not yet fully understood.

Despite the limitations of global datasets, many studies have shown changes in runoff and streamflow. Many have focused on low (drought) or high (flood) extremes. Except in regions with flows affected by glacier meltwater, the general conclusion is that global trends are not present or cannot be detected at this stage, although climate change-related trends are evident in some regions. Groundwater resources have been heavily used for human supply and agriculture for many years. While many groundwater abstraction schemes access fossil water (water unrelated to current conditions), renewable groundwater resources depend on highly variable recharge volumes.

It is thus realistic to expect future recharge regimes to reflect changes in the driving hydrologic processes (such as precipitation and evapotranspiration) that might result from anticipated climate changes. It is increasingly clear that the assumption of statistical stationarity is no longer a defensible basis for water planning.

Among the consequences of a changing hydrologic cycle is its interaction with the terrestrial carbon cycle. The terrestrial biosphere may have taken up roughly 25% of anthropogenic carbon emissions during the last century; it is unclear how long this can continue.

Chapter 12. Evolving hazards – and emerging opportunities

Water-related hazards can be naturally occurring or anthropogenic. Hazards can result from too much water (floods, erosion, landslides and so on) or too little (droughts and loss of wetlands or habitat) and from the effects of chemical and biological pollution on water quality and in-stream ecosystems. The natural variability of water resources and changes, whatever the cause, can provide opportunities for management strategies to respond to potential climate change threats by implementing more resource-sustainable policies and practices.

In many places climate-related water events have become more frequent and more extreme. In developing countries extreme floods can result in many deaths, while in developed countries they can result in billions of dollars in damages. More intense droughts in the past decade, affecting an increasing number of people, have been linked to higher temperatures and decreased precipitation but are also frequently a consequence of the mismanagement of resources and the neglect of risk management. The increased exposure to potential climate change hazards has led to more awareness of water resources management.

Changes in flow and inputs of chemical and biological waste from human activity have altered the water quality and

ecological functioning of many of the world's rivers. Global warming is expected to have substantial effects on energy flows and matter recycling through its impact on water temperature, resulting in algal blooms, increases in toxic cyanobacteria bloom and reductions in biodiversity.

In areas of increasing water stress groundwater is an important buffer resource, capable of responding to increased water demands or of compensating for the declining availability of surface water.

Chapter 13. Bridging the observational gap

Worldwide, water observation networks provide incomplete and incompatible data on water quantity and quality for properly managing water resources and predicting future needs – and these networks are in jeopardy of further decline. Also, no comprehensive information exists on wastewater generation and treatment and receiving water quality on a regional or global scale. While new technologies based on satellite remote sensing and modelling present opportunities, their value is limited by our ability to ground-truth and validate the simulated information.

Management of the world's water resources requires reliable information about the state of the resource and how it is changing in response to external drivers such as climate change and water and land use. There is little sharing of hydrologic data, due largely to limited physical access to data, policy and security issues; lack of agreed protocols for sharing; and commercial considerations. This hampers regional and global projects that have to build on shared datasets for scientific and applications-oriented purposes, such as seasonal regional hydrologic outlooks, forecasting, disaster warning and prevention, and integrated water resources management in transboundary basins.

Improving water resources management requires investments in monitoring and more efficient use of existing data, including traditional ground-based observations and newer satellite-based data products. Most countries, developed and developing, need to give greater attention and more resources to monitoring, observations and continual assessments of the status of water resources.

Part 4. Responses and choices

We have many of the answers. Across the planet we have already shown that it can be done! But there is no one-size-fits-all solution. The best mix of responses to a country's development objectives and policy priorities to meet its water challenges depends on the availability of water in space and in time and the country's technical, financial, institutional and human capacities – its culture, political and regulatory frameworks, and markets.

Options within the water domain are distinct from those outside it. Leaders in the water domain can inform the processes outside their domain and implement decisions for the water domain; but it is the leaders in government, the private sector and civil society who determine the directions that will be taken. Responses outside the water domain strongly affect the macro changes that influence how water is used and allocated. They also make water adaptation measures more (or less) effective and less (or more) costly.

Many countries face multiple challenges but have limited financial and natural resources and implementation capacities. Countries need to fully use synergy opportunities and to make trade-offs and difficult decisions on how to allocate among uses and users to protect their water resources. To achieve results, many actors need to participate in these decisions.

Chapter 14. Options inside the water box

There are many practical examples of solutions within the water domain. Some options show particular promise. Preparing institutions to deal with current and future challenges requires support for institutional development through such reforms as decentralization, stakeholder participation and transparency, increased corporatization where feasible and fair, partnerships and coordination (public-private, public-public, public-civil society), and new administrative systems based on shared benefits of water, including when water crosses borders. Decision-makers need to consider the influence of water law, both formal and customary, including regulations in other sectors that influence the management of water resources.

Decision-making is improved by consulting with stakeholders and ensuring accountability in planning, implementation and management as well as building trust within the water and related sectors and fighting corruption and mismanagement. Strengthening organization structures and improving the operating efficiency of water supply utilities will help to improve service

Worldwide, water observation networks provide incomplete and incompatible data on water quantity and quality for properly managing water resources and predicting future needs – and these networks are in jeopardy of further decline

Unsustainable management and inequitable access to water resources cannot continue. We might not have all the information we would like to have before acting, but we do know enough now to begin to take significant steps

quality and increase the coverage and density of connections, while also boosting revenues and creating a more viable financial base to attract further investment.

Innovation and research are critical for developing appropriate solutions. And greater institutional capacity and human capacity are needed, both within the water domain and in areas or sectors outside the water domain. Capacity development can occur through traditional forms of education, on-the-job training, e-learning, public awareness raising, knowledge management and professional networks.

Sound management accountability and good governance within the water sector contribute to creating a favourable investment climate. This should include new approaches such as payment for environmental services.

Chapter 15. Options from beyond the water box

Dealing with risk and uncertainty has long been a routine challenge for water resources managers and policy-makers across sectors and the world. However, issues like climate change and demographic dynamics have made the risks greater and the task more complex. Risk management is now much more important – indeed essential – to analysis and decision-making.

Drivers and policies outside the water sector have more impact on water management than do many policies championed and implemented by water-related ministries. Identifying trade-offs and synergies between water and other policy sectors can enhance policy impacts in all sectors and avoid some adverse effects on water. Because governments, civil society and business leaders make decisions every day that can affect water, it is important to identify where such decisions can also lead to improvements in water sector management and in water sector and environmental services.

Examples of win-win situations abound – whether created by governments, communities or businesses – that point to promoting deliberate cooperation between water and non-water actors and integrating water issues into external decisions. International organizations, notably the UN system, can provide support and expertise to governments, help civil society build capacity and catalyse leadership in the private sector.

Chapter 16. The way forward

Water and water systems must be managed to achieve social and economic development objectives and to sustain development. Water resources, properly managed, are critical to the survival and well-being of individuals. They can ensure equity and security in water and sanitation for families, businesses and communities. And they can ensure adequate water for food, energy and the environment as well as protection from floods and droughts.

Decision-making on water requires seeking synergies and selecting appropriate trade-offs. It also requires distinguishing between short-term 'fire-fighting' – responding to the urgent issues of the day – and long-term strategic development. Developing multi-purpose water schemes and reusing water wherever feasible can lessen the need for trade-offs by enabling the same volumes of scarce water to deliver multiple outcomes.

The donor community can incorporate water into the broader frameworks of development aid and focus assistance on areas where it is needed most – in sub-Saharan Africa, in Asian and Latin American slums and in states recovering from conflict. Recent G-8 efforts in this direction are promising.

The chief executives of the UN agencies, following the example of their joint discussions of and collective responses to climate change, can convene to examine the role of water, water systems and water management in development and environmental services, providing direction to agencies and advice to member countries.

The World Water Assessment Programme and its partners are working to help reduce uncertainty, facilitate decision-making and accelerate investment by highlighting the links between socioeconomic development and investment in water management capacity and infrastructure in other sectors.

The challenges are great, but unsustainable management and inequitable access to water resources cannot continue. We might not have all the information we would like to have before acting, but we do know enough now to begin to take significant steps. Actions must include increased investment in water infrastructure and capacity development. Leaders in the water domain can inform the processes outside their domain and manage water resources to achieve agreed socioeconomic objectives and environmental integrity. But leaders in government, the private sector and civil society will determine the direction that actions take. Recognizing this responsibility, they must act now!

Chapter

1

Getting out of the box – linking water to decisions for sustainable development

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Chapter 1

Getting out of the box – linking water to decisions for sustainable development

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Key messages

- The 'water box' dilemma must be resolved. Leaders in the water sector – in water supply and sanitation, hydropower, irrigation and flood control – have long been aware that water is essential to sustainable development, but they do not make the decisions on development objectives and the allocation of human and financial resources to meet them. These decisions are made or influenced by leaders in government, the private sector and civil society, who must learn to recognize water's role in obtaining their objectives.
- Water is essential for achieving sustainable development and the Millennium Development Goals. Properly managing water resources is an essential component of growth, social and economic development, poverty reduction and equity, and sustainable environmental services – all essential for achieving the Millennium Development Goals.
- Water is linked to the crises of climate change, energy and food supplies and prices, and troubled financial markets. Unless their links with water are addressed and water crises around the world are resolved, these other crises may intensify and local water crises may worsen, converging into a global water crisis and leading to political insecurity and conflict at various levels.

The media today are full of talk of crises – in climate change, energy and food supplies and prices, and troubled financial markets. These global crises are linked to each other and to water resources. Unless resolved, they may lead to increasing political insecurity and conflict at local and national levels.

These crises arise against a background of continuing poverty for much of the world. Managing water resources is essential to social and economic development, poverty reduction and equity and to achieving the Millennium Development Goals. Sustainable development depends on managing the costs of service provision using existing infrastructure along with additional investments in new water infrastructure and rehabilitation, both physical and institutional.

Specialists and managers in water supply and sanitation, hydropower, irrigation and flood control have long been aware that water is essential to sustainable development. But they often have a narrow, sectoral perspective that blinds many decisions on water. And they do not make the decisions on development objectives and the allocation of human and financial resources needed to meet these broader objectives. These decisions are made or influenced by leaders in government, the private sector and civil society. These leaders must learn to recognize water's role in attaining their objectives and act accordingly.

An understanding of water issues and of the support needed for investments, institutions, incentives, information and capacity inside the 'water sector' requires partnerships between those responsible for the economy-wide benefits of water and those responsible for managing water

And they must act in a changing world, a world driven by forces that they often do not control – forces of demography, the global economy, changing societal values and norms, technological innovation, international law, financial markets and climate change.

Opening the water box

Until the 1990s (and continuing in some countries) water subsectors generally worked independently, with specialists in water supply and sanitation, hydropower, irrigation, flood control and so on interacting very little.[1] As population growth and other pressures on water ('water drivers') brought more and more basins near closure (the allocation of all of the water in a basin), the need to manage water across subsectors at the basin level became evident. Water management was expanded during the 1990s to incorporate efficient water use, equitable sharing of benefits, and environmental sustainability – what came to be called integrated water resources management. And in 2002 the World Summit on Sustainable Development in Johannesburg set for all countries the goal to develop integrated water resources management plans by 2005.

Many countries are applying integrated water resources management at the basin level. But management is still largely confined to the water sector, where it is well understood that water is essential to all life on the planet (human and other species) and to human livelihoods. The sector is beginning to recognize that decisions by people outside the water sector determine how water will be used, but the other sectors are seen as cross-cutting in water management. The approach within the sector has been to invite those working in other socioeconomic sectors to join in integrated water resources management. But the societal and political questions that determine the real allocation and management of water resources also need to take into account the technological aspects of integrated water resources management.

The sphere of decision-making and the water box

Within government, water use is decided by the interaction of decision-makers in the main socioeconomic sectors – health, education, agriculture, housing, industry, energy, economic development and environment. In many countries this interaction occurs through a cabinet of ministers presided over by the prime minister or president. Parallel mechanisms may exist at a regional, state (provincial) or local (municipal) government level. The role of these government structures is critical in water management.

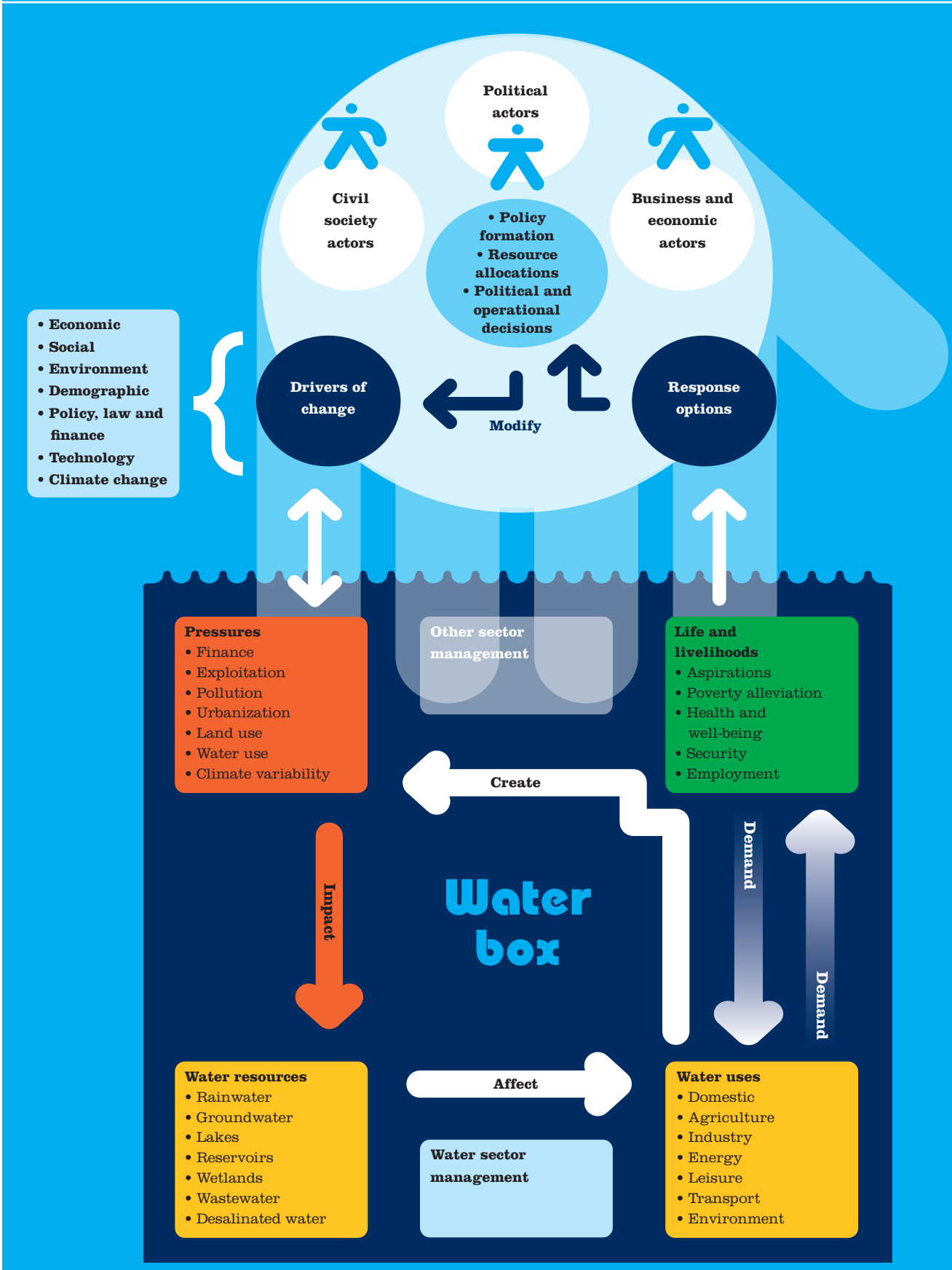
In many countries government directly controls only a small fraction of investments in the economy, but it determines the conditions that will attract or discourage investment. To be most effective, decisions should be taken through an interactive process that involves leaders in business (finance, industries, commerce) and civil society (community-based organizations and other non-governmental organizations).

Ideally, government, business and civil society leaders would work together in the interest of society. Because of the implications of their decisions for water use, an understanding of water issues and of the support needed for investments, institutions, incentives, information and capacity inside what has traditionally been considered the 'water sector' requires partnerships between those responsible for the economy-wide benefits of water and those responsible for managing water. Leaders in the water sector must thus ensure that these leaders outside the 'water box' know the constraints and options for water resources and help them implement their decisions efficiently and effectively.

Among the decisions that affect water the most are those relating to how a country meets its objectives for energy and food security, employment, disaster preparedness, environmental sustainability and other societal goals. These decisions are made in broader political frameworks and not by water managers, who subsequently deal with their implications for water and with other outcomes that touch on water. Figure 1.1 illustrates this process.

Outside the water sector is an area of synergy, tradeoffs, coordination and integration, involving higher-level, multisectoral decision-making processes. Water professionals, stakeholders and individuals can inform and influence decisions in this area, affecting outcomes. But they need to have a seat at the decision-making table and to respond by implementing water management effectively and efficiently and by properly informing the decision-making process. These efforts are facilitated in the many countries that have adopted water resources management laws, policies or strategies that reflect links between water and the social and economic sectors.

Figure 1.1 **Decision-making affecting water**



Source: Authors' construction.

Everywhere decisions related to development of necessity incorporate water development decisions, whether explicitly recognized or not

Decision-makers and water management

Providing water is but a means of achieving a country's development objectives – generally job creation, food security, GDP growth and social goals including poverty reduction. In pursuing these objectives, decision-makers are challenged by trade-offs between possible investments and possible synergies between sectors. Making trade-offs and searching for synergies require cooperation between those responsible for different sectors of the economy.

Where there has been sustained development, the role of government has generally been to facilitate action by others and to regulate the process.[2] The role of water managers has been to inform decision-makers of the constraints and opportunities of water resources management and water infrastructure development and then to act in accordance with the national development strategy.

Partnerships have been strongly promoted in the water sector, particularly for service provision. Public-private partnerships have been the predominant model, some functioning as intended, and some with mixed impacts. Water user associations in participatory irrigation management have become widespread in a number of countries, with some success in improving irrigation scheme management. But whether the operator is a private company, a public corporation or a municipal service, the successes have clearly demonstrated the importance of the complementary roles of public decision-makers and authorities on the one side and service operators on the other. In the long-term neither can succeed without the other.

Other types of partnerships include civil society organizations, municipalities and the private sector. A recent study on Latin America concluded that proper institutional frameworks, incentives and mutual trust are keys to successful partnerships.[3] River basin organizations are increasingly playing an important role. Broad coalitions of development partners, including different levels of government; donors; multinational, international and regional agencies; and local non-governmental organizations are being created in some countries, such as Mozambique,[4] to advise on priorities for public expenditures. Speaking at the Davos economic summit in January 2008, U.K. Prime Minister Gordon Brown said that the Millennium Development Goals will not be met 'unless there is a private, voluntary and government partnership'.[5] He added that 'governments have to understand that they have to make it possible for companies to affect change' and at times have to see companies as providers not just of resources but also of resourcefulness.

Where development is occurring rapidly and growth is viable, greater emphasis will be on private sector engagement and market-based mechanisms. Where development is slower and growth prospects are weaker, greater emphasis will be on providing basic services, including safety nets targeting society's poorest. Where governments and institutions are weak (fragile states) emphasis will be on reconstruction and rehabilitation. And where there are humanitarian crises, conflicts and natural disasters, emphasis will be on emergency responses. Working across many countries simultaneously, regional approaches emphasize integration, regional security and equity. Thus, although development is taking place in very different settings, with different integrating frameworks and processes and different sets of actors, everywhere decisions related to development of necessity incorporate water development decisions, whether explicitly recognized or not.

More important than trying to quantify the relative 'market share' of the public and private sectors is recognizing that they face similar challenges, constraints and difficulties. The task for decision-makers and political leaders is to create the framework conditions under which operators of all kinds – public, private, mixed, community providers and others – can provide services and investments effectively over the long term.

Sustainable development as the framework for water management

In the overview of *The Growth Report* of 2008 the Commission on Growth and Development argues that

> Growth is not an end in itself. But it makes it possible to achieve other important objectives of individuals and societies. It can spare people *en masse* from poverty and drudgery. Nothing else ever has. It also creates the resources to support health care, education, and the other Millennium Development Goals to which the world has committed itself. In short, we take the view that growth is a necessary, if not sufficient, condition for broader development, enlarging the scope

for individuals to be productive and creative.[6]

Sustained growth requires water

Growth requires access to natural resources. *The Growth Report* acknowledges that we may be entering a period in which natural resources, broadly defined, impose new limits on growth. But the report makes no major reference to the essential role of water resources. *World Water Development Report 3*, which places more emphasis on development than its predecessors, makes the case that the availability of water resources and their management are determinants of a country's growth strategy.

Africa provides a good example because both growth and water are major challenges there. The African heads of state recognized the importance of water to development when they gathered in Sharm el-Sheikh, Egypt, in mid-2008 and adopted a declaration explicitly noting the role of water as a key to sustainable development in the region (box 1.1).

Societies do not become wealthy first and then invest in water management; they find ways to manage water and risk first, which then leads to wealth. If they are wise, they do this in a way that avoids pollution, cares for equity and otherwise ensures the sustainability of the resource.

Investment in water infrastructure is required to meet basic needs in rural areas and to enhance agricultural productivity through better management of water. As development proceeds, with the shift to commercial and industrial activities in urban areas, water has to be managed for energy and food production, transportation, flood control, and drinking water and sanitation, as well as for industrial and commercial activities.

Asian Water Development Outlook 2007 highlights the significant global development challenge this represents.[7] That report emphasizes a 'multidisciplinary and multi-sector perspective [on water] around the Asia and Pacific region' in facing the challenges of sustaining growth. It highlights

> important topics that have been neglected or are being inadequately considered in most countries of the region. Among these is the urgent need to address the inherent interrelationships between water and other important development-related sectors, like energy, food, and the environment.

It has little in the way of a detailed roadmap for water resources development, however.

Box 1.1 Commitment of African heads of state to water as a key to sustainable development

WE, the Heads of State and Government of the African Union, meeting at the 11th Ordinary Session of our Assembly in Sharm el-Sheikh, Arab Republic of Egypt, from 30 June to 1 July 2008,

Recognizing the importance of water and sanitation for social, economic and environmental development of our countries and Continent; . . .

Recognizing that water is and must remain a key to sustainable development in Africa and that water supply and sanitation are prerequisites for Africa's human capital development;

Concerned that there is an underutilization and uneven sharing of water resources in Africa, and that remains a growing challenge in the achievement of food and energy securities. . . .

WE COMMIT OURSELVES TO:

(a) *Increase* our efforts to implement our past declarations related to water and sanitation.

(b) *Raise* the profile of sanitation by addressing the gaps in the context of the 2008 eThekwini Ministerial Declaration on sanitation in Africa adopted by [the African Ministers Council on Water].

(c) *Address* issues pertaining to agricultural water use for food security as provided for in the Ministerial Declaration and outcomes of the first African Water Week.

And particularly;

(d) *Develop and/or update* national water management policies, regulatory frameworks, and programmes, and prepare national strategies and action plans for achieving the [Millennium Development Goal] targets for water and sanitation over the next seven (7) years;

(e) *Create* conducive environment to enhance the effective engagement of local authorities and the private sector;

(f) *Ensure* the equitable and sustainable use, as well as promote integrated management and development, of national and shared water resources in Africa;

(g) *Build* institutional and human resources capacity at all levels including the decentralized local government level for programme implementation, enhance information and knowledge management as well as strengthen monitoring and evaluation;

(h) *Put in place* adaptation measures to improve the resilience of our countries to the increasing threat of climate change and variability to our water resources and our capacity to meet the water and sanitation targets;

(i) *Significantly increase* domestic financial resources allocated for implementing national and regional water and sanitation development activities and call upon Ministers of water and finance to develop appropriate investment plans;

(j) *Develop* local financial instruments and markets for investments in the water and sanitation sectors;

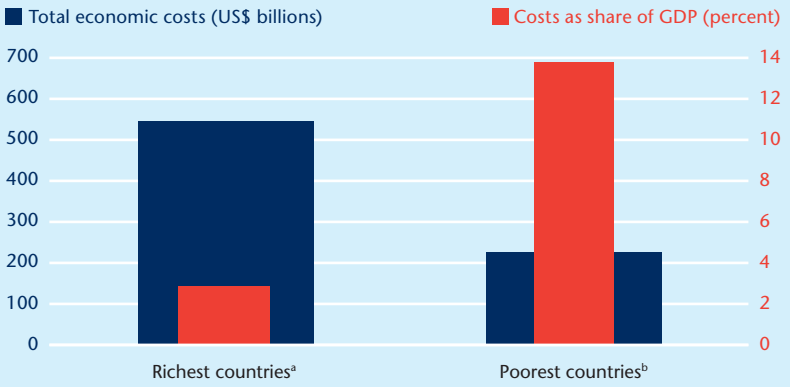
(k) *Mobilize* increased donor and other financing for the water and sanitation initiatives. . . .

Source: African Union 2008.

Benefits from investing in water

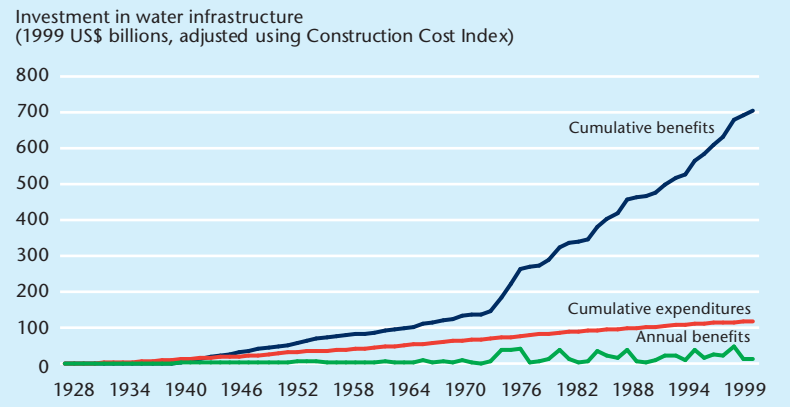
Many water investments have been evaluated by the rate of return of single-purpose schemes without considering the additional benefits possible from multipurpose projects.[8] Increasingly, evidence is emerging of the direct economy-wide benefits of investments in water (see chapter 6). For example, there is evidence that local action on water management in China has delivered measurable improvements in local GDP.[9] In the 335 counties in China with primary electrification from hydropower, annual average income per

Figure 1.2 **The costs of disasters as a share of GDP are much higher in poor countries than rich countries**



a. Annual GDP per capita above $9,361.
b. Annual GDP per capita below $760.
Source: Delli Priscoli and Wolf 2009.

Figure 1.3 **US government investments in water infrastructure during 1930-96 yielded $6 in damages averted for each $1 invested**



Source: Based on Delli Priscoli and Wolf 2009.

Box 1.2 **Economic impacts of lack of adequate sanitation facilities in South-East Asia**

Cambodia, Indonesia, the Philippines and Viet Nam lose an estimated $9 billion a year because of poor sanitation (based on 2005 prices), or approximately 2% of their combined GDP, according to the first regional study on the economic impacts of poor sanitation, undertaken in South-East Asia by the World Bank Water and Sanitation Project. The highest economic costs ($4.8 billion for the four countries combined) are from sanitation- and hygiene-related diseases. Poor sanitation also contributes substantially to water pollution, adding to the cost of providing safe water for households and reducing the production of fish in rivers and lakes ($2.3 billion). There are also environmental losses (loss of productive land, $220 million) and tourism losses ($350 million). Universal sanitation would lead to an annual gain of $6.3 billion in the four countries. Implementing ecological sanitation approaches (latrines separating urine and fæces for use as fertilizer) would be worth an estimated $270 million annually.

Source: Hutton, Haller, and Bartram 2007.

farmer rose 8.1% a year, nearly 3 percentage points more than the national average. In those communities 30 million people upgraded their livelihoods from marginalized farming to off-farm labourers in the industrial and services sector without any negative impact on agricultural production.

Evidence is also growing of the macroeconomic returns to investments in water management – and the costs of failures to invest. Disasters such as floods (resulting from typhoons and hurricanes and from rainfall exceeding the carrying capacity of channels) and droughts hurt poor economies more than wealthy ones, which are better prepared to cope with such disasters (figure 1.2).

Investments in environmental sustainability and water management to prevent water-related disasters can have large payoffs, so countries need not wait to invest until they have achieved middle- or high-income status. Investments in water infrastructure by the US Army Corps of Engineers between 1930 and 1999, for example, yielded returns of $6 for each $1 spent and controlled flood damage despite rising population numbers and property value at risk over the period (figure 1.3). The World Health Organization (WHO) estimates returns of $3-$34, depending on the region and technology, for each $1 invested in safe drinking water and basic sanitation.[10] There is thus a strong case that improved coverage of drinking water and sanitation contributes to economic growth. Policy-makers can use these data to justify their actions, identify areas of deficiency and better prioritize actions.[11]

Policy-makers also need to better understand the benefits for national development that result from sustainable water management and provision of safe water. Expanding safe drinking water and sanitation services would drastically cut the loss of life from water-related illness and free up scarce health resources in developing countries. Five thousand children die each day from diarrhoea alone – one every 17 seconds.[12] Upgrading water supply and sanitation services can also improve education, allowing more girls to attend school instead of spending hours each day collecting water. Improved access would also save millions of work days. The overall economic loss in Africa alone due to lack of access to safe water and basic sanitation is estimated at $28.4 billion a year, or around 5% of GDP.[13] Box 1.2 estimates the

costs of lack of access to adequate sanitation facilities for four South-East Asian countries.

Environmental degradation from water pollution and excessive withdrawals also has negative economic impacts. For example, the damage cost of environmental degradation in the Middle East and North Africa has been estimated at some $9 billion a year, or 2.1%-7.4% of GDP.[14] Industrial countries are learning the enormous costs associated with restoring essential ecosystems. In the United States the costs have been estimated at more than $60 billion and continue to rise as more becomes known (box 1.3).

Investing in water

Investment flows to uses with the highest economic rate of returns. Currently, water often gives very low returns for very long payback periods primarily because of the way it is governed (see chapter 4). Much political interaction in the water sector drives operations to 'structural bankruptcy'. It is not surprising that new investors are not eager to enter the water sector. Yet public investment in infrastructure is declining. And so the needs of the water sector go unmet.

The challenges in financing water services have been well described in recent years. Proposed solutions and innovative responses are presented in the reports of the World Panel on Financing Water Infrastructure[15] and the Task Force on Financing Water for All.[16] Ultimately, there are only three sources of financing: user tariffs, public expenditure and external aid (official or philanthropical). Recourse to these sources should be preceded and accompanied by efficiency measures to control operating costs and by careful project selection and design to ensure the best return to scarce resources.

Many studies have attempted to estimate the total investments that would be required to provide adequate infrastructure for water supply and sanitation. Typically presented as global or regional estimates, they often ignore the essential precondition of investments in institutions, reform, and implementation and management capacities and in replacement of ageing infrastructure. Because water can be managed only locally, investments must also be managed locally. Investing in water requires a holistic approach (figure 1.4). Sound financial management, as illustrated in figure 1.4, will make it possible for water authorities and governments to attract loans or external aid to supplement their own sources of capital.

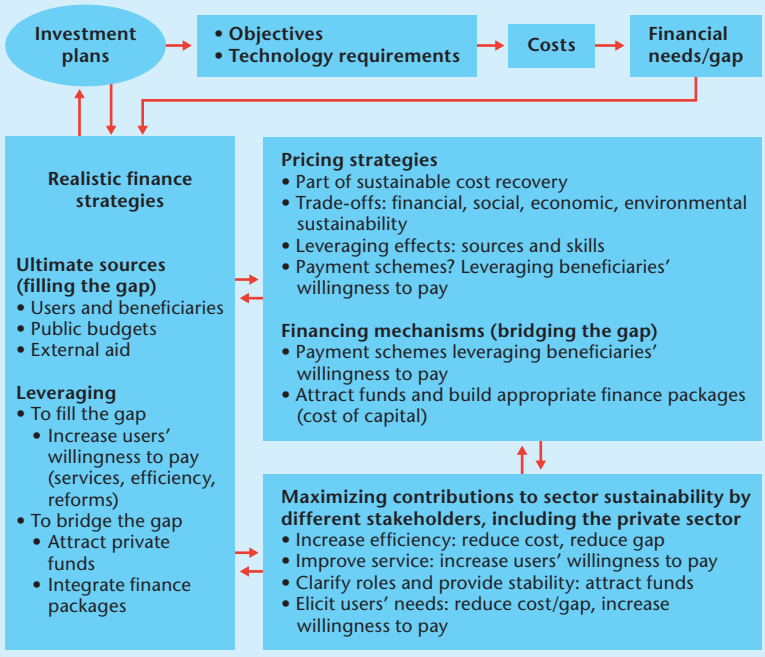
Nonetheless, many developing countries, having applied all of the measures implied by such a process, will still lack the capital required to meet basic needs through

Box 1.3 Estimated costs of restoring essential ecosystems in the United States

The following are estimates for restoring major essential ecosystems in the United States. The cost exceeds $60 billion, and the total is likely to be higher still as more information becomes available.

- Everglades Restoration: $10.9 billion. Groundwork laid for Everglades restoration, but projects are experiencing delays (www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=11754).
- Restoration of the Upper Mississippi River: $5.3 billion for a 50-year ecosystem restoration plan (www.nationalaglawcenter.org/assets/crs/RL32470.pdf).
- Restoration of Coastal Louisiana: $14 billion towards a Sustainable Coastal Louisiana by 2050 (www.coast2050.gov/2050reports.htm).
- Restoration of Chesapeake Bay: $19 billion for the Chesapeake Bay Program (www.chesapeakebay.net/fundingandfinancing.aspx?menuitem=14907).
- Restoration of Great Lakes: $8 billion for Great Lakes restoration and protection priorities (www.cglg.org/projects/priorities/PolicySolutionsReport12-10-04.pdf).
- Restoration of California Bay Delta: $8.5 billion (first seven years) for large-scale ecosystem restoration initiatives (www.nemw.org/calfed.htm).
- Restoration of Missouri River – to be determined.

Figure 1.4 Water investment requires a holistic approach – links between pricing, financing and stakeholders



Source: Authors' construction.

Today, poverty reduction strategies still offer only the prospect of aligning action on water with poverty reduction, as few current poverty reduction strategies give anything but superficial attention to action on water

water resources development and service delivery. In those cases it is relevant to question how much external aid is available, where it is applied and whether the amount can or should be increased.

Distributing the benefits of growth

The 2007 U.K. Department for International Development policy paper 'Growth and Infrastructure' stated that 'Growth is the single most important way of pulling people out of poverty'.[17] It cites empirical literature attributing more than 80% of recent poverty reduction worldwide to growth and less than 20% to redistribution (social protection). It gives the examples of China, where 450 million people have been lifted out of poverty since 1979, helped by exceptionally high growth rates, and Viet Nam, which experienced the most rapid reduction in poverty rates on record, from 75% in the late 1980s to less than a third in 2002, thanks to high growth rates.

That poverty reduction is the overriding policy concern is evidenced by the primacy of poverty reduction strategies and national development plans as the governing mechanisms for partnerships and finance from the international community. As of mid-2008, 59 countries had prepared full poverty reduction strategies and 11 more had completed preliminary poverty reduction strategies. This represents a significant change. For many years action on water that could deliver benefits to the poor lacked government frameworks that prioritized poverty reduction and mobilization of financing. Today, poverty reduction strategies still offer only the prospect of aligning action on water with poverty reduction, as few current poverty reduction strategies give anything but superficial attention to action on water.

Public expenditure reviews are another tool to help decision-makers allocate public funds. These reviews of government spending can boost efficiency and equity, development impact and the accountability of public spending. They can also increase the accountability and transparency of results and support governance reforms and anticorruption programs.

Economic justification for water investments come from their translation into economy-wide growth through employment, capital and labour productivity, taxes, government expenditure, revenue control, debt, purchasing power, balance of payments, foreign exchange reserves, trade balances, accelerator impacts on capital investment, business confidence and the stock market.

In India water development evened out the seasonal demand for labour, resulting in major gains for the country.[18] Forecasts by the New Partnership for Africa's Development concerning African agriculture's contribution to growth and poverty reduction are founded on the economic justifications of reduced food import bills, more predictable import profiles, increased export revenues and reduced poverty at the household level.[19]

To attract development-oriented finance, the growth-increasing and poverty-reducing contributions of water resources must be made explicit and specific at the country level. Such specifics will influence the sources, costs, viability, sustainability and instruments of finance. National, basin and local action plans are needed to align water resources, economic growth and poverty reduction. Making such alignments and other essential connections will be more successful within frameworks such as a round of poverty reduction strategies, public expenditure reviews and national development plans.

Reducing poverty, which limits access to water

The world must acknowledge the crisis of persistent underdevelopment and poverty. Since the end of the Second World War more than 3 billion people have benefited from economic development, but at least 2 billion people remain in need. Some 1.4 billion people lived in 'absolute poverty' in 2005,[20] a number that does not take into account the recent wave of increases in energy and food prices.[21] These women, men and children daily face the consequences of poverty – disease, malnutrition and hunger. They have no capacity to prepare for natural disasters, such as earthquakes and floods, or to respond when they strike. The world community has set the Millennium Development Goal target of halving the proportion of people living in poverty by 2015. But we are far from being on track, particularly in regions where the need is highest.

Human Development Report 2006 considers the experience of water and sanitation as reinforcing the 'long-standing human development lesson' that rates of coverage in access to water and sanitation rise with income on average (figure 1.5).[22] *Global Monitoring Report 2005* notes that in South Asia an improving investment climate and

stronger policies, along with gains in basic service delivery, have sustained rapid economic growth since 1990 and contributed significantly to poverty reduction and to reaching the Millennium Development Goals in some countries.[23]

The case for investing in Africa

Where investment in water has been weak, GDP growth has been constrained – by as much as 10% where the effects of droughts, floods and natural hydrologic variability are compounded in less developed economies. Where weak economic growth has been accompanied by inadequate investment in social protection, the gap in achieving the Millennium Development Goals has worsened in many countries, with devastating social impacts.

Africa, in particular, remains mired in poverty (figure 1.6) despite recent economic growth trends in some countries. In developed countries water storage ensures reliable sources of water for irrigation, water supply and hydropower as well as a buffer for flood management. Countries in Africa store only about 4% of annual renewable flows, compared with 70%-90% in many developed countries. About 340 million Africans lack access to safe drinking water, and almost 500 million lack access to improved sanitation facilities. The First African Water Week, convened in Tunis in March 2008, opened with a call for greater efforts to ensure water security nationally and regionally. Donald Kaberuka, president of the African Development Bank Group, emphasized that

> it is no longer acceptable that the African continent continues to utilize only 4% of its water resources, when a huge proportion of the people do not have access to safe water, and when large populations are faced with frequent floods and drought, in addition to food and energy shortages. Action is urgently needed.[24]

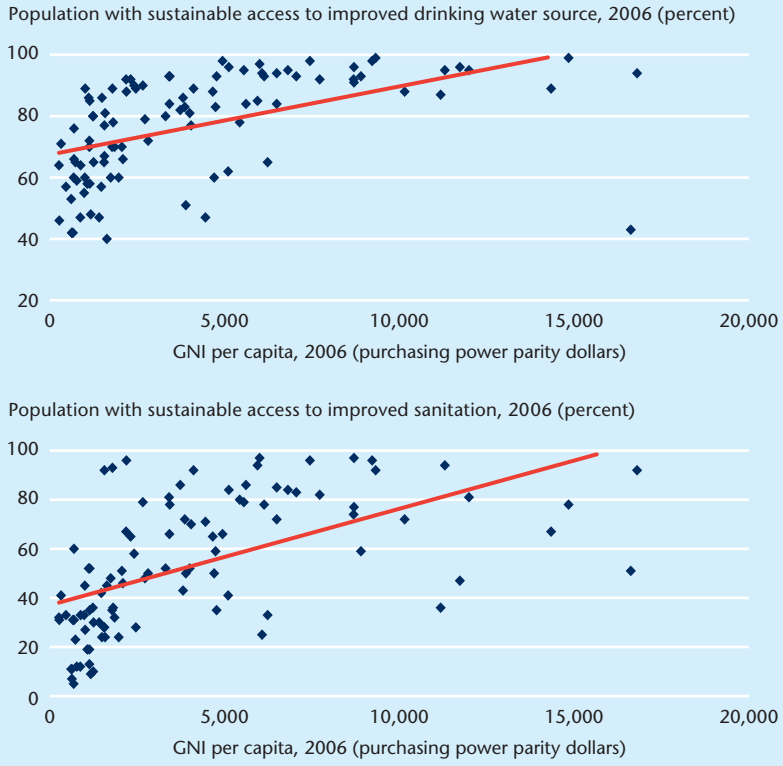
In June 2008 the MDG Africa Steering Group published a number of concrete recommendations for scaling up opportunities to address poverty in Africa.[25] Their recommendations related to achieving the Millennium Development Goals in Africa are summarized in table 1.1.

Investing in water to reach the Millennium Development Goals

This third edition of the United Nations *World Water Development Report* is being published just beyond the half-way point along the timeline from the Millennium Summit of 2000 and the 2015 target date for attaining the Millennium Development Goals. Making progress towards those goals will rise even higher on political agendas within the next six years.

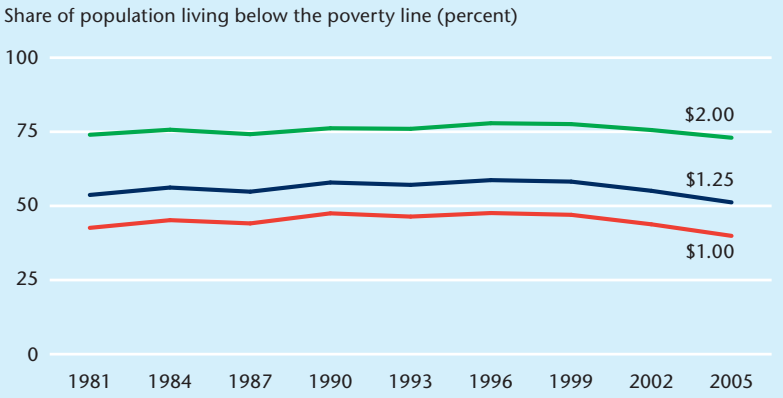
The Millennium Declaration placed safe drinking water and basic sanitation firmly among the development objectives, making it a target of Millennium Development Goal 7. But while adequate progress is

Figure 1.5 Access to water and sanitation rises with income



Source: Based on data from WHO Statistical Information System (www.who.int/whosis/en/).

Figure 1.6 Poverty remains high in sub-Saharan Africa



Note: Poverty lines in 2005 prices.
Source: Based on Chen and Ravallion 2008, p. 41.

Table 1.1 **Summary of scaling-up opportunities related to achieving the Millennium Development Goals in Africa**

Scaling-up opportunity	Summary of key results	Policy leadership	Key multilateral financing mechanisms (among several funding sources)	Estimated public external financing needs by 2010 from all funding sources
Achieving the Millennium Development Goals in Africa	Comprehensive cross-sector public expenditure programmes against clear quantitative targets	Secretary-General and MDG Africa Steering Group, G-8 leadership, African Union, private sector, foundations	All multilateral, bilateral and private mechanisms providing high-quality, predictable financing	Some $72 billion a year, of which $62 billion (in 2007 terms) from Development Assistance Committee members (following the Gleneagles G-8 meeting, Monterrey Consensus and EU official development assistance targets), with additional financing from non-Development Assistance Committee donors, developing country collaboration, private foundations and innovative private co-financing

Source: Based on MDG Africa Steering Group 2008, p. 32.

Box 1.4 **Progress in meeting the Millennium Development Goal target on water supply and sanitation**

The world is on track to meet the Millennium Development Goal target on drinking water. Current trends suggest that more than 90% of the global population will use improved drinking water sources by 2015.

The world is not on track to meet the Millennium Development Goal sanitation target. Between 1990 and 2006 the proportion of people without improved sanitation decreased by only 8 percentage points. Without an immediate acceleration in progress, the world will not achieve even half the sanitation target by 2015. Based on current trends, the total population without improved sanitation in 2015 will have decreased only slightly, from 2.5 billion to 2.4 billion.

Source: WHO and UNICEF Joint Monitoring Programme 2008, pp. 8 and 23.

being made towards the provision of safe drinking water, the sanitation target is far from being met (box 1.4).

And despite progress, the scale of the challenge remains massive. While the water supply target is being attained at a global level, large regions of the world and many countries are far from the target, and some risk backsliding. This is particularly the case in sub-Saharan Africa and low-income Arab states. In many places the sanitation targets will be missed by a wide margin.

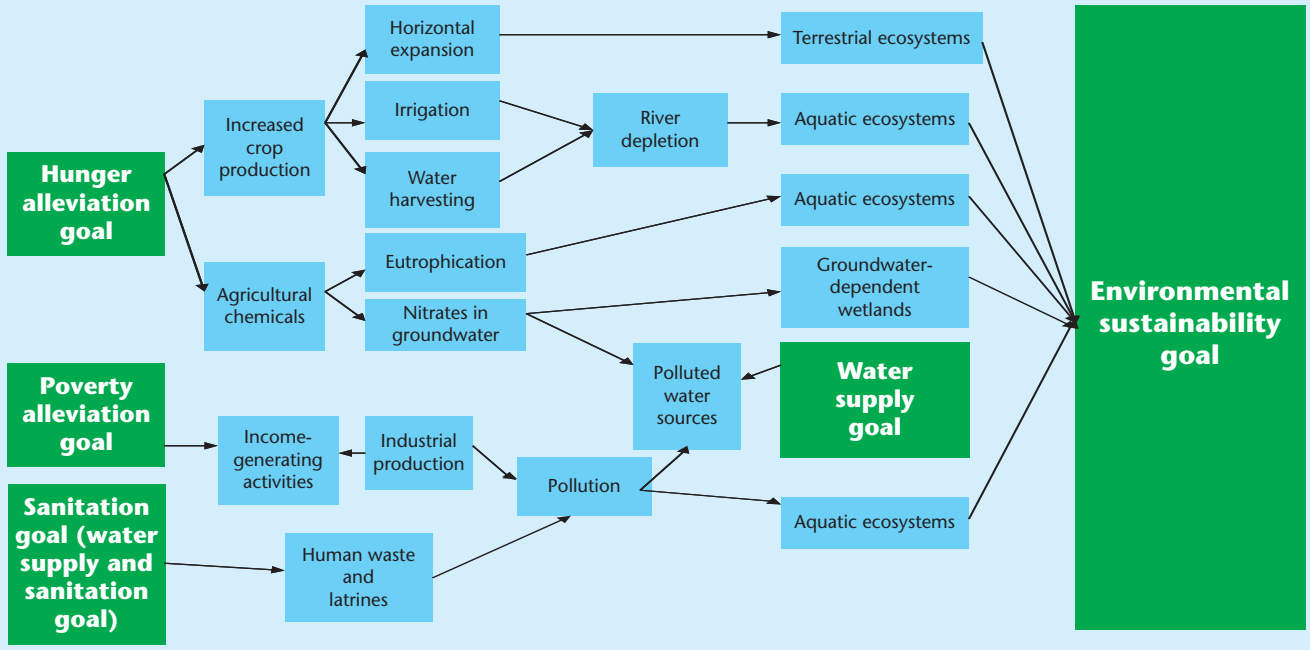
Both the drinking water and sanitation targets are vitally important. The contribution of improved drinking water and sanitation to the achievement of all the Millennium Development Goals is now well established.[26] This report demonstrates this link throughout; others have elaborated the direct and indirect contributions of water management across all the Millennium Development Goals.[27] Figure 1.7 depicts these links graphically. These links served as an important advocacy instrument during the International Year of Sanitation in 2008. High-profile international attention has focused on basic services in recent years, including declarations at Brasilia (2003), Beppu (2007), eThekwini (2008), Tunis (2008) and Sharm el-Sheik (2008). Gaps in drinking water and sanitation, in particular, have attracted political attention at the highest levels.

Development partnerships are helping countries that are off track for achieving the Millennium Development Goals get back on track. Intergovernmental efforts are working to maintain the momentum of the global commitments made since the Millennium Declaration and of water-specific processes such as the G-8 Evian Action Plan[28](box 1.5). New initiatives, such as the 2007 launch of the Millennium Development Goal Africa Initiative by the UN system, have sought to reinvigorate the efforts of countries that are off track in their progress towards achieving the Millennium Development Goals.

Sustaining the environment

Environmental sustainability, broadly, refers to the ability of the environment to continue to support progressive social and economic development and to provide many types of ecosystem services (table 1.2). Multistakeholder processes, such as the World Commission on Dams, have seen environmental sustainability rise in prominence as a factor influencing water development decisions. And such international conventions as the United Nations Convention to Combat Desertification and the United Nations Convention on Biodiversity have made water a global issue.

Figure 1.7 **Cause-effect chains and links between water and the Millennium Development Goals**



Source: Based on Cosgrove 2006, p. 38.

Today, water management crises are developing in most of the world. UN-Water reports that in just one week in mid-November 2006 national media sources reported local but high-profile shortages in parts of Australia, Botswana, Canada, China, Fiji, Kuwait, Liberia, Malawi, Pakistan, Philippines, South Africa, Uganda, the United Arab Emirates and the United States.[29]

Generally regional phenomena, water crises can emerge as water shortages and droughts, floods or both, now aggravated by the consequences of climate change. They may be natural or caused by demands that exceed supply, lack of infrastructure or poor water management. They may be the result of waste or abuse resulting in pollution. Together they threaten the lives and livelihoods of billions of people and risk irrevocably altering the planet's ecosystems.

Every year in developing countries an estimated 3 million people die prematurely from water-related diseases. The largest proportion of these deaths are among infants and young children, followed by women, from poor rural families who lack access to safe water and improved sanitation (box 1.6).[30] More than 1 million people die annually from malaria, the vast majority in poverty-stricken Africa. Another 1 million people die from air pollution in urban areas. And everywhere the poor suffer most.

Box 1.5 **High-Level Event on the Millennium Development Goals, United Nations, New York, 25 September 2008: Extract from compilation of partnership events and commitments**

The event [Water and Sanitation for All] reiterated the strong political and diplomatic support for international efforts needed to address the water and sanitation issues and enhance human security. It promoted good water cycle management and the application of Integrated Water Resources Management. It reaffirmed the importance of formulation and implementation of national assistance strategies building on the 'Paris Declaration on Aid Effectiveness', while considering the specific needs and resources of the recipient countries.

The event emphasized the importance of mobilizing adequate international and national financial resources for the implementation of the national strategies and the need to strive towards using sector-wide approaches; and developed partnerships with civil society organizations, local authorities and the private sector to implement national strategies and action plans to improve the accessibility and quality of water and sanitation services as well as initiatives to establish a 'Framework for Action' to focus on the off-track countries, including the possible consideration for a 'Fast Track Initiative' with catalytic funding to install a High-Level 'Task Force' to reach [Millennium Development Goal 7], and to make one annual global progress report and to hold one annual high-level review meeting.

Japan committed to establish a Water Security Action Team for Africa to provide safe drinking water for 6.5 million people and implement a water supply capacity-building program that would train 5,000 people over the next five years. Tajikistan said it would host the International Freshwater Forum in 2010 as a venue for a preliminary discussion of achievements, challenges and experiences within the International Decade Water for Life, 2005-15.

The Netherlands said it would help provide access to safe drinking water and sanitation for at least 50 million people by 2015 having already signed various agreements that will benefit almost 30 million people, at a cost of around €1.3 billion. Germany will continue to train Central Asian water experts. The Netherlands and the United Kingdom committed €106 million in joint funding for water and sanitation initiatives in developing countries over the next five years.

Source: UN 2008.

Table 1.2 Types of ecosystem services

	Forests	Oceans	Cultivated/ agricultural lands
Environmental goods	• Food • Freshwater • Fuel • Fibre	• Food • Fuel	• Food • Fuel • Fibre
Regulating services	• Climate regulation • Flood regulation • Disease regulation • Water purification	• Climate regulation • Disease regulation	• Climate regulation • Water purification
Supporting services	• Nutrient cycling • Soil formation	• Nutrient cycling • Primary production	• Nutrient cycling • Soil formation
Cultural services	• Aesthetic • Spiritual • Educational • Recreational	• Aesthetic • Spiritual • Educational • Recreational	• Aesthetic • Educational

Source: Based on MEA 2005.

Box 1.6 Malnutrition attributable to environmental risks

Experts estimate that poor water and sanitation services and hygiene practices and inadequate water resources management contribute to half of all cases of infant and child underweight, an estimate corroborated by a World Bank technical review of 38 recent cohort studies (confidence interval of 39%-61%). Evidence from several of those studies demonstrates that exposure to environmental health risks in early childhood leads to permanent growth faltering, lowered immunity and increased mortality. A recent large study from Bangladesh reveals that dysentery and watery diarrhoea together can retard weight gain by 20%-25% compared with periods of no infections.

Source: Prüss-Üstün and Corvalán 2006; World Bank 2008; Alam et al. 2000.

Box 1.7 Water as capital

Classical economists recognized land (all natural resources), labour and produced capital as the basic sources of wealth. Neoclassical economists focused only on labour and capital, treating 'land' as another interchangeable form of capital. Natural resources were considered abundant relative to demand and therefore not an important focus for economics, whose task was to allocate scarce resources – those whose use constrained alternative economic opportunities. There was little consideration of the environment's dual role as a source of valuable inputs and as a sink for the economy's waste and pollution. Nor was much thought given to the possibility that the world might reach a scale of resource exploitation at which the capacity of both the source and sink functions of the environment could become binding constraints on economic growth.

The focus on produced rather than natural capital is particularly misleading for water. Prices are typically related to the capital outlays required to deliver water (that is, for the infrastructure and operations and maintenance charges), with little or no value attributed to the resource itself. Not only do undervalued water resources tend to be overused, but undervaluation also induces distorted prices that provide poor information about whether investments make sense. Focusing only on capital costs provides no insight into whether economic activities are creating value or whether the resource is running out and needs to be conserved.

Water delivery is highly capital-intensive, so produced capital will remain a crucial focus for financial and economic analyses of water investments. But the value of water resources also matters, and water's availability, quality and timing cannot simply be assumed.

Source: Bergkamp and Sadoff 2008.

The value of water goes well beyond its productive value (box 1.7). Citizens who realize this are calling for action to protect water, joined by business people who recognize the importance of protecting the sources of the water on which they depend. Many are even paying for such protection.[31]

Also to be considered is the impact of climate change on environmental sustainability. At the High-Level Event on the Millennium Development Goals at the United Nations in September 2008 discussion focused on the need for new adaptation strategies and for climate-resilient national development plans, especially for the least developed countries:

> Linkages between financing for development and international climate change financing were discussed. It was also agreed that all countries, including donor countries, the UN system and the Bretton Woods institutions, need to clarify the budgetary implications of adaptation; ensure that adequate finance mechanisms are in place; and help meet the additional costs that climate-resilient development will entail.[32]

Global crises and water

While climate change will create important pressures on water, it is not currently the most important driver of these pressures outside the water sector. The most important drivers – forces and processes generated by human activities – are demographics and the increasing consumption that comes with rising per capita incomes (see chapter 2).

In the early stages of development population growth is the most important driver. But most of the projected growth in demand comes not from high-population-growth countries but from countries with high rates of economic growth and large current populations. As incomes permit, people consume more. To start with, there will be a requirement for more water to produce food for tens of millions of people moving from one meal to two meals a day. Later, still more water will be needed for food production as people include more meat in their diets. Changes in lifestyles will require large amounts of water to produce and process non-food goods and services (virtual water), further increasing pressures on the quantity and quality of water resources. Other demographic

drivers include rural-urban migration and migration in response to political conflict and environmental crises.

Other external forces that may create either positive or negative pressures on water resources include pricing policies and subsidies for water and water-related goods, trade patterns, developments in science and technology, consumption patterns, evolution of policies and laws, social movements and global and national politics.

Except for climate change, these forces will not create pressures directly (or only) on water management. The pressures will be felt first at the level of sector ministers, whose responses will translate into strategies that affect the water sector. These ministers will have to make decisions under conditions of risk and uncertainty. The better informed they are, the more likely they are to make the right decisions. For water managers this means being able to provide reliable information about where and when water is available, of what quality, where and how it is used, what happens to wastewater, how much water leaves the country in exports of goods that use water in their production (virtual water) and how much enters the country in imports. This will be a challenge for water managers in most countries, which lack the necessary measurements and do not systematically collect the necessary data. But when the information is available, it will be possible to calculate the country's water balance and the water footprints (volume of water used) of various users. Using this information, water managers can advise decision-makers in other sectors of the feasibility of their plans and the implications for water.

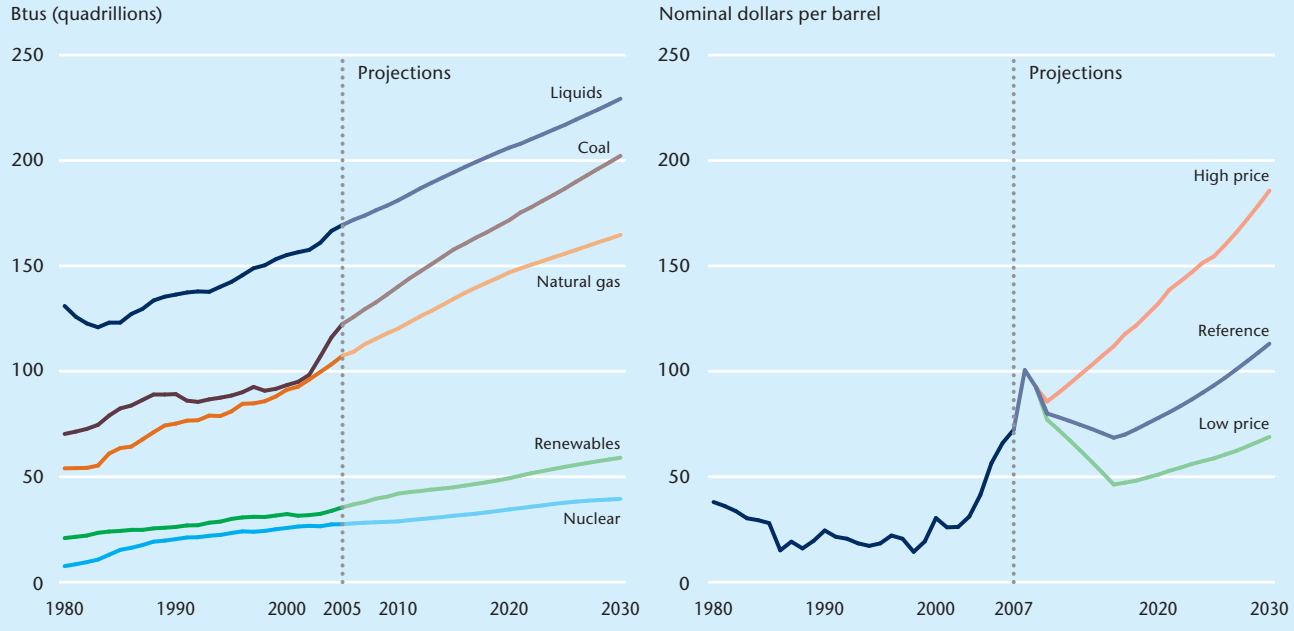
The Report provides ample evidence of all these facts. This is not the first time that professionals in the water sector have attempted to bring them to the world's attention. But this time the effort may be more successful, because this time the world is facing other global crises – in energy, food and climate change and global warming – that cannot adequately be addressed without considering the role of water.

The world is facing global crises in energy, food, and climate change and global warming that cannot adequately be addressed without considering the role of water

Water for energy

Demand for energy – for heat, light, power and transportation – is increasing rapidly (see chapter 7). The price of energy commodities has been rising as well. Volatile, the nominal price of oil – the benchmark commodity – rose from less than $25 a barrel eight years ago to about $100 early in 2008 and more than $140 in June 2008. Within two months it fell below levels projected for the longer term by the Energy Information Administration of the U.S. Department of Energy and was at $35 a barrel on December 19, 2008 (figure 1.8). Energy

Figure 1.8 **Historical and projected energy demand and oil prices show steadily rising demand and rapidly rising prices**



Note: The reference case assumes average GDP growth of 2.4% a year, the high case assumes 3.0% a year, and the low case assumes 1.8% a year.
Source: Based on EIA 2005, 2008a.

The number of countries without enough water to produce their food is rising. The situation can be remedied by investing in water infrastructure, markets, credit, agricultural technology and extension services

prices, particularly the oil prices that drive them, earlier reflected rising world demand and constraints. The recent financial crisis, which has slowed economic growth throughout the world, reducing anticipated demand, was largely responsible for the low price of oil at the end of 2008.

The combination of high prices and a desire to substitute other sources of fuel led to the recent increase in the production of bioenergy, which has potentially important impacts on water quality and availability. Hydropower may be a renewable and non-polluting source of energy in some countries. Water for cooling is needed for all thermal sources of power, including nuclear. In the United States water withdrawn for cooling (39%) equals agriculture's share of water use. At the same time energy is required to lift groundwater, pump it through pipes and treat both groundwater and wastewater. An estimated 7% of all energy produced is used for such purposes.[33] Increased demand for water through desalination may increase energy demand in some countries, although marginally on a global scale.

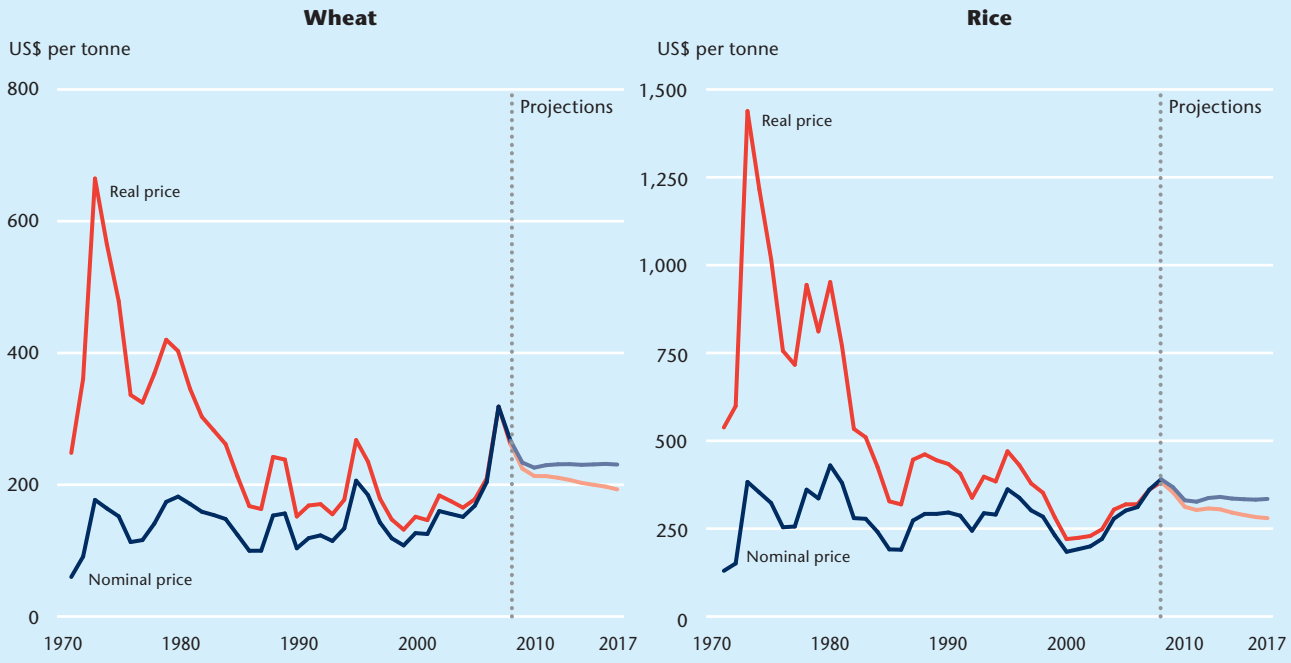
Water for food

Agriculture is by far the largest consumer of freshwater – about 70% of all freshwater withdrawals go to irrigated agriculture (see chapter 7). The recent steep rise in food prices (figure 1.9) has severely hurt many food-importing countries. Rising demand for food caused by growing populations and shifting diets, production shortfall in some countries, increased costs for key agricultural inputs such as fertilizers (driven in turn by energy costs), bioenergy-related incentives in some countries and possible financial speculation have all contributed to the problem. The High-Level Conference on World Food Security: The Challenges of Climate Change and Bioenergy, a Food and Agriculture Organization summit in Rome on 3 June 2008, adopted a declaration acknowledging 'an urgent need to help developing countries and countries in transition expand agriculture and food production, and to increase investment in agriculture, agribusiness and rural development, from both public and private sources'.[34] It calls on donors to provide balance of payments and budget support to low-income food-importing countries.

At the summit Robert B. Zoellick, president of the World Bank, said that the Bank recognizes that the energy-food nexus means that food prices will stay high and that the 'task is two-fold, to handle today's danger to those for whom securing food has become a daily struggle, and turn higher food prices into an opportunity for developing world agriculture, and

Figure 1.9 **Wheat and rice prices have risen sharply in recent years**

Historical and projected prices of wheat and rice, 1970-2017



Source: Based on OECD and FAO 2008.

for farmers in developing countries'.[35] The summit highlighted the strong links among food security, economic development, climate change, markets, development assistance and energy and how actions have implications for other sectors. While the role of water in agriculture was discussed at the summit, the final declaration did not mention water and water's strong links with these and many other issues.

Water scarcity may limit food production and supply, putting pressure on food prices and increasing countries' dependence on food imports. The number of countries and regions without enough water to produce their food is rising as populations increase. The situation can be remedied in many developing countries by investing in water infrastructure, markets, credit, agricultural technology and extension services.

Underinvestment in water

The energy and food crises are taking place during a time of global financial crisis. A credit crunch has followed the financial crises that began in the United States and Europe in 2007 and spread around the globe. The credit crunch has resulted in a slowdown in economic growth around the world. The International Monetary Fund forecast in January 2009 that all industrial countries would face a period of recession and that some developing countries are more at risk than others (box 1.8).[36] According to the Commission on Growth and Development 'developing countries are most vulnerable to sudden stoppages of credit and sudden switches of international custom or supply.'[37]

Developing countries most at risk include those exporting directly to crisis-affected countries, those whose exports are experiencing falling world prices and those whose exports have high income elasticity (luxury goods, including tourism). Declining tourism revenues and employment will directly affect the poor. Countries dependent on foreign direct investment, remittances and development funds to finance the current account deficit will also be at risk. Oil-importing countries have already been hard hit by the period of high oil prices.

The high rates of global savings and strong productivity growth in the three decades before the financial crisis – when the stock of financial assets grew three times faster than GDP – were not accompanied by investments in physical assets, and their levels are below those in the last decade.

While other factors may also have contributed to these lower levels of investment, economic uncertainty is a major factor. Uncertainty about the policy environment in developing and emerging market economies has always been a concern, but its influence has strengthened in the currently highly competitive global markets.[38]

The impact on developing countries will vary. Budgetary spending on infrastructure is often cut during periods of financial tightening, although for governments that can afford it, investing in infrastructure can help counter an economic slowdown. Private investment may also suffer, but since the private sector's contribution to the water sector has been relatively small, the sector is less exposed to any financial tightening. Countries dependent on aid face uncertain times. Bilateral donors, important in funding water investments, may be tempted to reduce their aid budgets. Multilateral aid could be an important source of financing for the next few years, especially following recent record multiyear replenishments of the International Development Association, African Development Fund and European Development Fund. Yet both bilateral and multilateral aid donors still appear not to recognize the contribution of the water sector to growth, as indicated by the sector's small share of total official development assistance in recent years (less than 4%; see table 4.4 in chapter 4).

Inadequate information on water and water crises

Managing water is made more difficult by the lack of knowledge and information required for decision-making and long-term planning. Few countries know how much water is being used and for what purposes, the quantity and quality of water that is available and that can be withdrawn without serious environmental consequences

Few countries know how much water is being used and for what purposes, the quantity and quality of water that is available and that can be withdrawn without serious environmental consequences and how much is being invested in water management and infrastructure

Box 1.8 International Monetary Fund updated economic forecast for 2009

World growth is projected to fall to 0.5 % in 2009, its lowest rate since World War II. Despite wide-ranging policy actions, financial strains remain acute, pulling down the real economy. A sustained economic recovery will not be possible until the financial sector's functionality is restored and credit markets are unclogged.

Financial markets are expected to remain strained during 2009. In the advanced economies, market conditions will likely continue to be difficult until forceful policy actions are implemented to restructure the financial sector, resolve the uncertainty about losses, and break the adverse feedback loop with the slowing real economy. In emerging economies, financing conditions will likely remain acute for some time – especially for corporate sectors that have very high rollover requirements.

Source : IMF 2009, pp. 1-2.

Scarcity – low available water per capita – is forecast to worsen where population growth is still high, as in sub-Saharan Africa, South Asia and some countries in South America and the Middle East

and how much is being invested in water management and infrastructure (see chapter 13).

Underfunding of observation, monitoring and information systems leads to weaknesses in infrastructure, research and development, and training and to reduced efficiencies. Less is known with each passing decade, despite the availability of new remote sensing and geographic information system technologies that can simplify monitoring and reporting and despite the growing need for such information in an increasingly complex and rapidly changing world. Such information is vital not only at a national scale but also at a global scale – to inform the construction of global models of the hydrologic cycle and decisions on where interventions, including external aid, would be most useful. One move in that direction is the United Nations Economic Commission for Europe Convention on the Protection and Use of Transboundary Watercourses and International Lakes, which requires signatories to exchange data on water quality and quantity and pollution sources and the environmental conditions of transboundary waters.

Climate change and water

Some parts of the world have no shortage of water. Others, such as North and Southern Africa, the Middle East and parts of South Asia, South-East Asia and South America, suffer scarcity because of low annual rainfall. Others suffer seasonal scarcity. Yet others suffer from extreme rainfall, causing floods. Some suffer from both low and extreme rainfall, at different times. In some large countries, such as Mozambique and the United States, parts of the country may experience damaging intensive rainfalls while other parts suffer prolonged drought. These variations matter most where they affect large populations. Scarcity – low available water per capita – is forecast to worsen where population growth is still high, as in sub-Saharan Africa, South Asia and some countries in South America and the Middle East.

Adapting to climate change adds a critical challenge to this picture for all countries, particularly for developing countries, whose capacity to adapt is low, and for cities in coastal areas (see chapter 5). Even if greenhouse gas concentrations stabilize in the coming years, some impacts from climate change are unavoidable. These include growing water stress, more extreme weather events, higher levels of migration and the disruption of international markets. Climate models show that extremes of rainfall are likely to worsen, resulting in more floods and droughts in regions already affected – often regions with low income levels per capita, widespread absolute poverty, high population growth and rapid urbanization. If climate change brings significant shifts in the availability of water resources, patterns of human migration could be affected.

These challenges cannot be separated from the challenges of sustainable development. For some developing countries the incremental costs of adapting to climate change will soon approach the current value of aid inflows. The leaders of the G-8, meeting in Hokkaido, Japan, in July 2008, committed to accelerating action on technology development, transfer, financing and capacity building to support adaptation (box 1.9). Such action must include water resources, which will be most affected by climate change. A recent United Nations Framework Convention on Climate Change document on adaptation noted that:

> sector-specific adaptation planning and practices were discussed in the areas of agriculture and food security, water resources, coastal zones and health. Those sectors were selected based on their importance to Parties and organizations as highlighted in their submissions.[39]

The world is right to be concerned about climate change, which poses major threats to humans and ecosystems. The 2007 United Nations Climate Change Conference in Bali, Indonesia, acknowledged that

Box 1.9 **Extracts from Declaration of Leaders Meeting of Major Economies on Energy Security and Climate Change at the G-8 Hokkaido, Toyako, summit, 9 July 2008**

Climate change is one of the great global challenges of our time. Conscious of our leadership role in meeting such challenges, we, the leaders of the world's major economies, both developed and developing, commit to combat climate change in accordance with our common but differentiated responsibilities and respective capabilities and confront the interlinked challenges of sustainable development, including energy and food security, and human health.

We will work together in accordance with our Convention commitments to strengthen the ability of developing countries, particularly the most vulnerable ones, to adapt to climate change. This includes the development and dissemination of tools and methodologies to improve vulnerability and adaptation assessments, the integration of climate change adaptation into overall development strategies, increased implementation of adaptation strategies, increased emphasis on adaptation technologies, strengthening resilience and reducing vulnerability, and consideration of means to stimulate investment and increased availability of financial and technical assistance.

Source: G-8 2008.

even the minimum predicted shifts in climate for the 21st century, at more than twice the 0.6° Celsius increase that has occurred since 1900, would be significant and disruptive. The intergovernmental response has focused primarily on mitigation of climate change, embracing wide-ranging measures, including reducing greenhouse gas emissions, transferring clean technologies and protecting forests. These measures may slow climate change. They will not halt or reverse it.

It will be two generations before these measures begin to have an effect. And even if successful, they imply a considerably changed future climate. (They are not aimed at reversing changes already under way.) In the meantime people must be protected from the consequences of global climate change through adaptation measures. Adaptation, as embodied in the Nairobi Work Programme of the United Nations Framework Convention on Climate Change, is based on gaining a better understanding of the impacts of climate change and making informed decisions on practical measures.[40]

The water situation and the vulnerability of poor communities present a strong case for action on climate change. Projections warn of changes in water availability and quality that could have disastrous consequences. Water is the principal medium through which climate change will affect economic, social and environmental conditions. Changes in water availability will have economy-wide impacts.

Yet while the world appears motivated to respond to the impacts of future climate change, it remains unmotivated to act on the water crises that are with us today. Even without climate change, development is threatened in many regions by factors that we have already failed to address time and again. The Intergovernmental Panel on Climate Change's April 2008 report on water points this out clearly (box 1.10).

Security and water

Climate change, especially its implications for scarce water resources, is a matter of collective security in a fragile and increasingly interdependent world. At a 2007 UN Security Council debate on the impact of climate change on peace and security UN Secretary-General Ban Ki-moon noted that climate change has implications for peace and security, as well as serious environmental, social and economic implications, especially 'in vulnerable regions that face multiple stresses at the same time – pre-existing conflict, poverty and unequal access to resources, weak institutions, food insecurity and incidence of diseases such as HIV/AIDS.'[41] He outlined 'alarming, though not alarmist' scenarios, including limited or threatened access to energy increasing the risk of conflict, a scarcity of food and water transforming peaceful competition into violence, and floods and droughts sparking massive human migrations, polarizing societies and weakening the ability of countries to resolve conflicts peacefully.

In Africa alone by 2020, 75-250 million people may be exposed to increased water stress due to climate change. If coupled with increased demand, this will hurt livelihoods and exacerbate water-related problems.[42] Research centres such as the Oxford Research Group[43] are underpinning the security concerns of the United Nations, the European Union[44] and national governments[45] about climate change and its impacts on water. The forces at work are global in scale, the aggregate result of the behaviour of all countries. Dealing with them will require international cooperation and coordination. Yet at the same time national leaders must continue to act and make decisions at a national level.

As climate change and adverse water impacts increase in politically charged areas, conflicts will likely intensify, requiring new and rapid adaptive security strategies. Hydrologic shocks that may occur through climate change increase the risk of major national and international security threats, especially in unstable areas (box 1.11). Adverse changes in internal, interjurisdictional and transboundary waters can put food, social, health, economic, political and military security at risk.

Some fragile states (map 1.1) have experienced widespread conflict that has resulted in the destruction of economic

While the world appears motivated to respond to the impacts of future climate change, it remains unmotivated to act on water crises that are with us today

Box 1.10 Intergovernmental Panel on Climate Change Technical Report on Water and Climate Change

Current water management practices may not be robust enough to cope with the impacts of climate change on water supply reliability, flood risk, health, agriculture, energy and aquatic ecosystems. In many locations, water management cannot satisfactorily cope even with current climate variability, so that large flood and drought damages occur. As a first step, improved incorporation of information about current climate variability into water-related management would assist adaptation to longer-term climate change impacts. Climatic and non-climatic factors, such as growth of population and damage potential, would exacerbate problems in the future. (*very high confidence*)

Source: IPCC 2008.

Box 1.11 UN Secretary General Ban Ki-moon warns that water shortages are increasingly driving conflicts

'The challenge of securing safe and plentiful water for all is one of the most daunting challenges faced by the world today.

'Until only recently, we generally assumed that water trends do not pose much risk to our businesses. While many countries have engaged in waste-water treatment and some conservation efforts, the notion of water sustainability in a broad sense has not been seriously examined.

'Our experiences tell us that environmental stress due to lack of water may lead to conflict and would be greater in poor nations.

'Ten years ago – even five years ago – few people paid much attention to the arid regions of western Sudan. Not many noticed when fighting broke out between farmers and herders, after the rains failed and water became scarce.

'Today everyone knows Darfur. More than 200,000 people have died. Several million have fled their homes.

'There are many factors at work in this conflict, of course. But almost forgotten is the event that touched it off – drought. A shortage of life's vital resource.

'We can change the names in this sad story. Somalia. Chad. Israel. The occupied Palestinian territories. Nigeria. Sri Lanka. Haiti. Colombia. Kazakhstan. All are places where shortages of water contribute to poverty. They cause social hardship and impede development. They create tensions in conflict-prone regions. Too often, where we need water we find guns. . . .'

Source: Ban Ki-moon 2008.

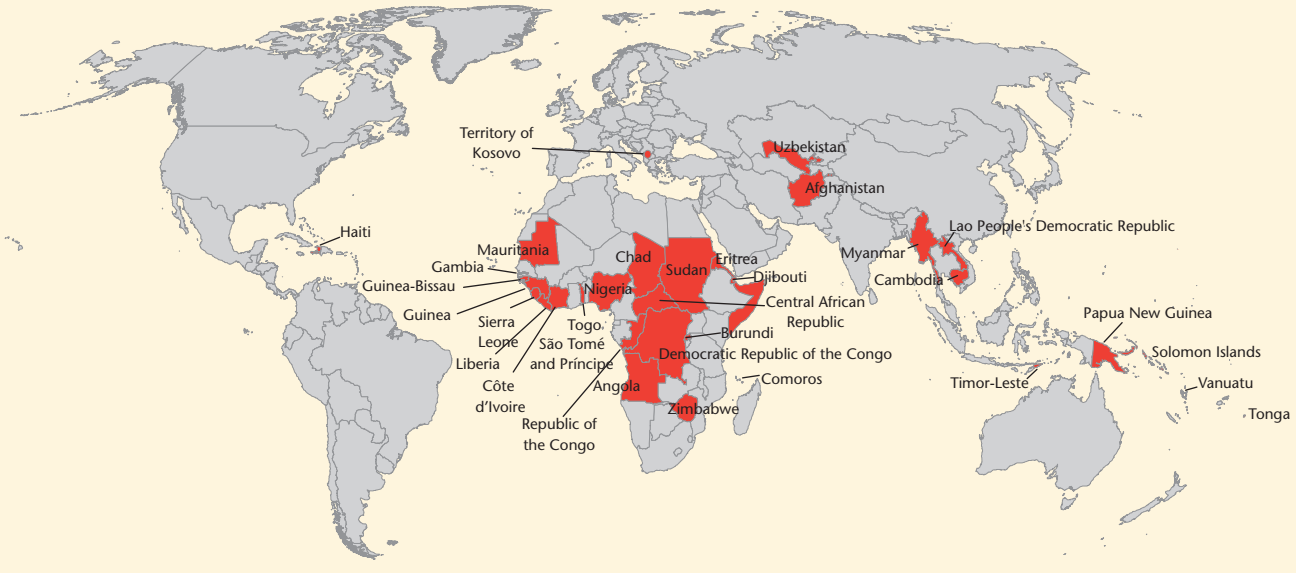
infrastructure. The vulnerability of affected populations is worsened by the state's loss of control over the forces of law and order and ultimately by its loss of political legitimacy. Installing infrastructure and renewing institutional capacity following conflict have the potential to set post-conflict nations on a path to recovery. For example, rehabilitation of damaged irrigation infrastructure and expansion of water supply and sanitation formed a significant part of the 2006 Somali Rehabilitation and Reconstruction Plan.[46] Similarly, rehabilitation of infrastructure after major natural disasters provides an opportunity to address long-standing infrastructure deficits.

The need for action – now

Water has remained too low on the list of political priorities for too long, a situation that cannot be allowed to continue. Action is required now. Lives and livelihoods depend on water for development. Changes in human behaviour and activity are accelerating, affecting demand for water and its supply. Because investments have been neglected, development is lagging, people are suffering and the environment is deteriorating. The resources needed to address the problems of water management are minuscule compared with the financial resources that have been pledged and secured to deal with carbon emissions or the current financial crisis. After decades of inaction, the problems are enormous. And they will worsen if left unattended.

Although substantial, the challenges are not insurmountable. In part 4 the Report shows how some countries and regional and local governments have solved similar challenges. The decisions on development objectives and the allocation of human and financial resources needed to meet

Map 1.1 Fragile states as defined by the International Development Association



Note: Fragile states are low-income countries that score below a threshold on the International Development Association's Country Policy and Institutional Assessment, a tool used to assess the quality of country policies. The list is prepared annually.
Source: Based on IDA 2007.

them are made or influenced by leaders in government, the private sector and civil society. They are the ones who must recognize the role of water in attaining their objectives – and demonstrate the will to act now.

Structure of the Report

The Report has four parts. Part 1 examines water drivers – or what drives the pressures on water. Externalities, mostly human-induced, create pressures on water. Human activities and processes of all types – demographic, economic and social – can exert pressures on water resources that need to be managed. These pressures are affected by a range of factors such as technological innovation, climate change, and policies, laws and financial conditions

Part 2 is about using water. History shows strong, mutual links between economic development and water development. Steadily increasing demand for agricultural products to satisfy the diverse needs of a growing population (for food, fibre and now fuel) has long been the main driver behind agricultural water use. In a situation of tight balance between food supply and demand, climate events – droughts in particular – have an increasingly strong impact on food price volatility. There is a growing need to protect ecosystems and the goods and services they produce and on which life and livelihoods depend. As competition among demands on water increases, society will need to respond more effectively through improved water management, policies and transparent and efficient water allocation mechanisms.

Part 3 explores the state of water resources. The uneven distribution over time and space of water resources, and how that distribution is being modified, are fundamental sources of the water crisis. Global warming is expected to result in an intensification, acceleration or enhancement of the global hydrologic cycle. There is some observational evidence that this is already happening. In many places climate extremes have become more frequent or more intense, with droughts and floods affecting increasing numbers of people. Worldwide, water observation networks are inadequate for current needs and are at risk of further decline. The data to understand and predict water quantity and quality are lacking.

Part 4 is on responses and choices. It shows that we can do what it takes to manage water resources properly to avert crises and promote sustainable socioeconomic development. Others have already shown the way. But there is no one-size-fits-all solution. The best mix of responses to a specific country's development objectives and policy priorities to meet various water challenges depends on the availability of water of acceptable quality for its intended use and the country's technical, financial, institutional and human capacities and its culture, political and regulatory frameworks and markets.

Leaders within the water domain can inform the processes outside their domain and manage water resources to achieve agreed socioeconomic objectives. But it is the leaders in government, the private sector and civil society who determine the directions that development will take. Recognizing this, they must act now!

The decisions on development objectives and the allocation of human and financial resources needed to meet them are made or influenced by leaders in government, the private sector and civil society – not by water managers or specialists

Notes

1. There were exceptions, such as the development of the Tennessee River in the United States beginning in the 1930s under the Tennessee Valley Authority.
2. Commission on Growth and Development 2008.
3. Phumpiu and Gustafsson 2007.
4. See www.pap.org.mz.
5. Speaking at the session Re-Thinking Social Responsibility on 25 January 2008, as cited in Maidmont 2008.
6. Commission on Growth and Development 2008, p. 1.
7. ADB 2007, p. vi.
8. The benefits of investing in water are presented in greater detail in chapter 6.
9. SIWI 2005.
10. Hutton and Haller 2004.
11. Schuster-Wallace et al. 2008.
12. UN-Water 2008.
13. WHO 2006.
14. Hussein 2008.
15. Winpenny 2003.
16. van Hofwegen 2006.
17. DFID 2007, p. 2.
18. World Bank 2003.
19. NEPAD 2002.
20. Originally defined as $1.00 per day and revised to $1.25 in 2005 to reflect evolving purchasing power parity
21. Chen and Ravallion 2008.
22. UNDP 2006, p. 6.
23. World Bank 2005.
24. Kaberuka 2008.
25. MDG Africa Steering Group 2008.
26. WELL 2005.
27. Poverty-Environment Partnership 2006.
28. G-8 2003.
29. UN-Water 2007.
30. World Bank 2008.
31. Worldwatch Institute 2008, pp. 117-21.
32. United Nations 2008.
33. Hoffman 2004.
34. FAO 2008.
35. Zoellnick 2008.
36. IMF 2009.
37. Commission on Growth and Development 2008, p. 103.
38. Rajan 2006.

39. UNFCCC 2007.
40. UNFCCC 2005.
41. UN Security Council 2007.
42. IPCC 2008.
43. The Oxford Research Group, in a briefing paper on sustainable security, argues that the effects of climate change – displacement of peoples, food shortages, social unrest – have long-term security implications far greater than those of terrorism and notes that the U.S. Department of Defense's Office of Net Assessment takes the same view (Abott, Rogers, and Sloboda 2006, p. 7).
44. Such as the statement by the European Commission and the Secretary General/High Representative for Foreign and Security Policy Javier Solana (2006, p. 2): 'Investment in mitigation . . . as well as ways to adjust to the unavoidable should go hand in hand with addressing the international security threats created by climate change.'
45. Such as U.K. Foreign Secretary Margaret Beckett's statement in the 2007 UN Security Council debate on the impact of climate change on peace and security that climate change exacerbates many threats (UN Security Council 2007) and the testimony of Deputy Director of National Intelligence for Analysis (NIA) Thomas Finger before a Joint House committee that an NIA assessment found that sub-Saharan Africa, the Middle East and Central and South-East Asia are most vulnerable to warming-related drought, flooding, extreme weather and hunger (House Permanent Select Committee on Intelligence and U.S. House Select Committee on Energy Independence and Global Warming 2008, p.13).
46. UNDP and World Bank 2007.

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Understanding what drives the pressures on water

PART 1

Chapter	
2	Demographic, economic and social drivers
3	Technological innovation
4	Policies, laws and finance
5	Climate change and possible futures

Chapters 2-5
Coordinator
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PART
1

Authors: Richard Connor and Walter Rast

The amount of freshwater on Earth is finite, but its distribution has varied considerably, driven mainly by natural cycles of freezing and thawing and fluctuations in precipitation, water runoff patterns and evapotranspiration levels.

That situation has changed, however. Alongside natural causes are new and continuing human activities that have become primary 'drivers' of the pressures affecting our planet's water systems. These pressures are most often related to human development and economic growth. Our requirements for water to meet our fundamental needs and our collective pursuit of higher living standards, coupled with the need for water to sustain our planet's fragile ecosystems, make water unique among our planet's natural resources.

Chapters 2-5 describe these water drivers and their interactions as they relate to the sustainability of water resources and systems. They also examine how to make reasonable predictions about the future. Such forecasts are relevant for policy-making directed to water resources and for development activities, investment planning and other activities generally considered to be outside the domain of the water sector – or 'outside the water box'.

Part 1 examines the processes behind the rising pressures on our water supplies, identify the ones most likely to have the greatest impact on the world's water resources in the coming decades and describe the context within which water will be managed. These chapters describe what we know about the current situation and recent trends and forecast possible futures related to processes that we refer to as drivers of change and define as:

> a set of fundamental processes that are external to the water sector and that directly or indirectly co-determine the evolution of the water system in terms of the quality, quantity and spatial distribution of the resource.

At the turn of the century the World Water Vision exercise of the World Water Council – the first and largest international effort to develop global water scenarios – identified a series of 'driving forces' that 'represent key factors, trends or processes which influence the situation, focal issues or decisions, and actually propel the system forward and determine the story's outcome'.[1] Using this definition, the Vision team selected major drivers and organized them into six clusters: demographic, economic, technological,

social, governance and environmental. This part of the Report draws on these clusters, with the exception of the environment, which is defined as a use and is covered extensively in part 2. To this list we have added climate change, discussed in chapter 5 and throughout the Report. This part of the Report also describes many of the complex links between the drivers, which can cause both positive and negative feedback impacts.

In describing drivers 'external to the water sector', we have sought to identify key forces or processes of change over which water sector users, managers and decision-makers have little direct influence. Thus, water use sectors (agriculture, energy, domestic and industrial) are not drivers even though they have a major impact on the resource because they are not external to the water sector. The drivers of agriculture – and its demand for water – are such fundamental processes as population growth, changes in dietary preferences as living standards rise, and increasing demand for non-food agricultural products such as bioenergy. The drivers of change are the demographic, economic and social forces that, in combination, exert pressures on the agriculture sector. This leads to an evolution in agriculture practices, which can also be influenced by technological innovation and agricultural and trade policies, all of which eventually affect the quality and quantity of water.

These drivers should not be considered in isolation of related socioeconomic or political factors and other drivers. Many natural links influence how drivers affect changes, directly and indirectly. Water properties are governed by biological, chemical and physical laws that define the quantity and quality of water resources and that are linked in various ways. Temperature, a physical factor, can affect the metabolism of aquatic organisms, a biological process. The excessive biological production (such as excessive algal growth) associated with increased temperature can degrade water quality, a chemical property.

Superimposed on these natural processes are human activities that exacerbate these processes, disrupting the natural balance of water systems. The growth of algae or aquatic plants in a lake, for example, is stimulated by excessive nutrients and minerals washed into the lake as a result of human activities, accelerating natural growth processes to levels that can cause water quality degradation and interfere with beneficial water uses.

Drivers are thus the forces and processes generated by human activities. Consider governments' efforts to improve citizens' livelihoods and standards of living by increasing economic growth. Economic growth is affected by a wide range of policy decisions, from international trade to education and public health, while the potential rate of economic growth can be affected by demographic variables such as population distribution (local workforce availability) and social characteristics (workforce capacity) and by the availability of new technologies. Economic activity also requires adequate quantities of natural resources, including freshwater. And water availability is directly subject to the impacts of climate change, which can exert additional pressures on other drivers.

A rising standard of living is typically accompanied by increased consumption and production of goods, along with rising demands for water-related household services and water resources to facilitate economic growth and related activities. Rising demand for meat and fish in urbanized and emerging market economies, for example, has increased fishery activities and livestock production, generally a water-intensive activity. The feedback loop of degraded water quality from livestock feedlot runoff can diminish fish production or alter its quality. There is also sociological evidence that urbanization shifts fishing pressures from natural water systems to artificial systems. Thus, urbanization and globalization, with changes in diets and lifestyles, are strong drivers of water use, even though decisions made outside the water sector are driving them.

The result is a continuously increasing demand for finite water resources for which there are no substitutes. When water resources of acceptable quality can no longer be provided in sustainable quantities to meet such demands, aquatic ecosystems can be overexploited as each sector or user group tries to satisfy its own water needs at the expense of others. The ultimate loser is the sustainability of the exploited aquatic ecosystems and the organisms (including humans) dependent on them for survival and well-being.

Note

1. Gallopín and Rijsberman 2000, p. 18.

Chapter 2

Demographic, economic and social drivers

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Key messages

- Human activities and processes of all types – demographic, economic and social – can exert pressures on water resources and need to be managed.
- These pressures are in turn affected by a range of factors such as technological innovation, institutional and financial conditions and climate change.
- The rapid global rise in living standards combined with population growth presents the major threat to the sustainability of water resources and environmental services.

Demographic drivers

Authors: Richard Connor, Anne Goujon, Molly Hellmuth and Koko Warner

Contributors: Walter Rast and David Wiberg

Key messages

- Population dynamics (growth, age distribution, urbanization and migration) create pressures on freshwater resources through increased water demands and pollution.
- Changes in the natural landscape associated with population dynamics (migration, urbanization) can create additional pressures on local freshwater resources and the need for more water-related services.

Demographic processes such as population growth, age distribution, urbanization and migration create some of the greatest pressures on water resources quantity and quality. These demographic processes directly affect water availability and quality through increased water demands and consumption and through pollution resulting from water use. They affect water resources indirectly through changes in land use and water use patterns, with significant implications at local, regional and global levels. And the availability and quality of water as well as trends in water use can influence demographic processes.

The world's population is growing by about 80 million people a year, implying increased freshwater demand of about 64 billion cubic metres a year.[1] An estimated 90% of the 3 billion people who are expected to be added to the population by 2050 will be in developing countries, many in regions where the current population does not have sustainable access to safe drinking water and adequate sanitation.[2] Many governments lack the financial resources and institutional capacity to provide for these needs, while countries that have experienced gains in the number of people with access to water supply and sanitation services since 1990 may see these gains eroded by population growth.

The demographics of the global population are changing, with important implications for water resources. By 2050, 22% of the world's population is expected to be 60 years old or older, up from 10% in 2005. At the same time, the world has more young

The world will have substantially more people in vulnerable urban and coastal areas in the next 20 years. In areas with already-scarce water resources water managers will have to look beyond the water sector for solutions

people than ever, with nearly half the world population being under the age of 25.

While the world's urban population grew rapidly during the 20th century (from 220 million to 2.8 billion), the next few decades will see an unprecedented scale of urban growth across developing countries. In Africa and Asia the urban population is expected to double between 2000 and 2030. By 2030 the towns and cities of the developing world will make up an estimated 81% of urban humanity.[3]

Today, there are an estimated 192 million migrants worldwide, up from 176 million in 2000.[4] Coastal areas, with 18 of the world's 27 megacities (populations of 10 million or greater), are thought to face the largest migration pressures.[5] About 75% of people residing in low-lying areas are in Asia, with the most vulnerable being poor people. International migration is increasing as a result of such factors as demographic changes, economic disparities, trade liberalization, environmental changes and new communication technologies. Impacts of climate change can substantially accelerate migration (see chapter 5). Demographic changes affect international migration in two ways. Rapid population growth, combined with economic difficulties, push people to cities, while a declining and ageing population induces countries to accept migrants, who are typically willing to work at much lower wages than native workers. Water shortages and hazards, particularly where people are directly dependent on the environment for their livelihood, can also induce migration.

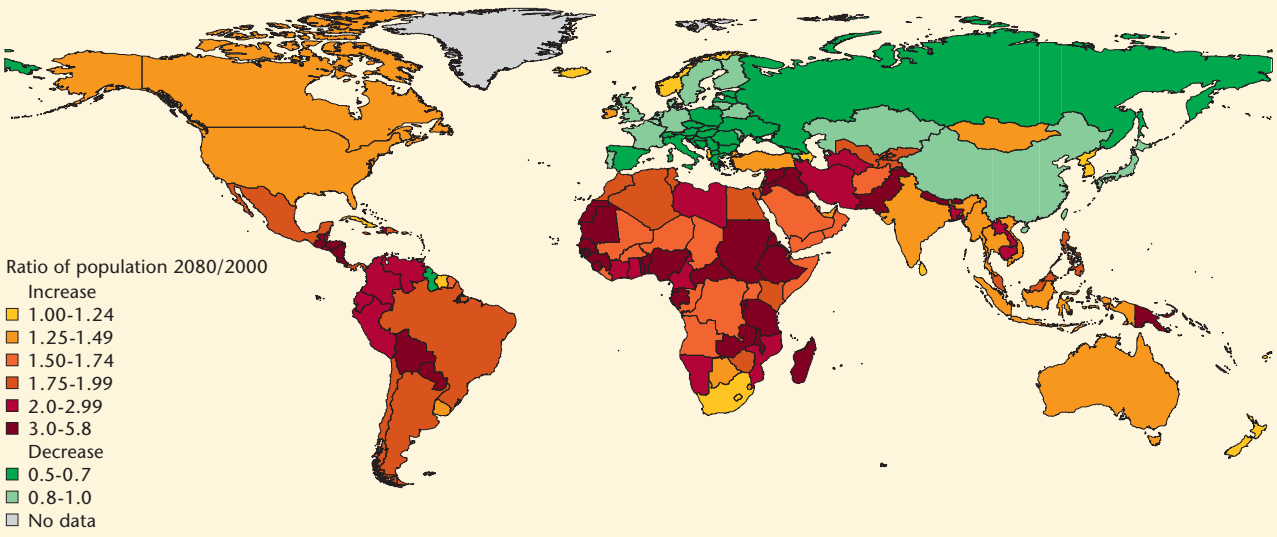
The net implication of these demographic processes is clear: the world will have substantially more people in vulnerable urban and coastal areas in the next 20 years. The rate of slum formation is nearly the same as the rate of urban growth. In areas with already-scarce water resources water managers will have to look beyond the water sector for solutions. They will have to work closely with leaders in other sectors, such as education, health, social services and agriculture, to respond effectively to the demographic challenge.

Population growth

We live in a demographically divided world, with population still growing rapidly in some regions (Africa and the Middle East), ageing rapidly in others (Europe and East Asia) and already declining in others (Europe; map 2.1).

Besides Eastern Europe and the former Soviet Union, where annual population growth is already negative, Australia, China, Japan, New Zealand and Western Europe will also soon see shrinking populations. Around 2060 South Asia and Pacific will also experience negative population growth rates. Other regions are less susceptible to negative population growth forces. Sub-Saharan Africa and the Middle East will continue to experience high rates of population growth well into the future. This timing will characterize most of the problems of water scarcity.

Map 2.1 **Expected areas of population growth and decline, 2000-2080**



Source: Lutz, Sanderson, and Scherbov 2008.

Most population growth will occur in developing countries, mainly in regions that are already in water stress and in areas with limited access to safe drinking water and adequate sanitation facilities. More than 60% of the world's population growth between 2008 and 2100 will be in sub-Saharan Africa (32%) and South Asia (30%). Together, these regions are expected to account for half of world population in 2100. Such rates of population growth will have major social and environmental impacts, given the level of economic development in many affected countries.

Age distribution

The age of the population will influence consumption and production patterns, with attendant impacts on natural resource needs, including freshwater. The resource needs and services associated with increasing longevity will include greater provision of medicines, medical facilities and health-care providers. For younger people the globalization of trade and advertising tempts those in developing countries to want more and those in developed countries who already have more to want even more. These needs and wants translate into higher consumption and production patterns, requiring additional resources, including freshwater.

Urbanization and the growth of informal human settlements

In 2008 world population was estimated to be equally split between urban and rural areas, marking the transition from a rural dominated to an urban dominated world. By 2030 the number of urban dwellers is expected to be about 1.8 billion more than in 2005 and to constitute about 60% of the world's population (figure 2.1), while the number of rural inhabitants is expected to decline slightly from 3.3 billion to 3.2 billion. Almost all (95%) of the increase in urban populations is expected in developing countries, especially in Africa and Asia, where the urban population is projected to double between 2000 and 2030.[6] Urbanization rates are much lower in developed countries and are even declining in some countries.

Despite the continuing growth of megacities – which require natural resources and create waste in quantities not seen in human history – most of the world's urban populations live in cities with fewer than 500,000 inhabitants. The growth of small and mid-size cities will have significant impacts on water resources. In most established or formal urban areas access to water supply and sanitation services is believed to be better than in rural areas. But in informal urban areas residents have little access to safe drinking water or adequate sanitation services, increasing the danger of water- and sanitation-related diseases. It is through such informal urban areas that most urban growth occurs.

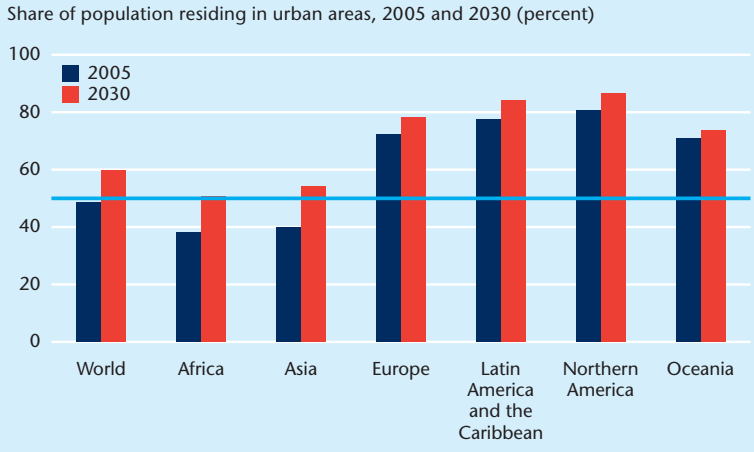
In addition to the sociological and health implications of increased population density in urban settlements, urbanization has unique environmental impacts. Urbanization is accompanied by the transformation of natural land surfaces into impervious surfaces, such as streets, parking lots, roofs and other types of structures that block the percolation of rainwater and snowmelt into soil. Such construction increases the flow velocity of water over the land surface, carrying polluting materials into receiving water systems, degrading water quality and causing local pollution problems. This urban drainage effect has increased the frequency of flash floods, causing casualties and infrastructure damage.

Migration

Migratory populations include traditional groups of subsistence-level pastoralists and agriculturalists, as well as family groups and individuals seeking greater opportunities and refugees fleeing the consequences of war, conflict or natural disasters. Refugees often pass through camps or informal settlements that may be artificially sustained by aid agencies or governments. The result is the rapid denuding of the surrounding area as people search for water and fuel wood in order to survive – leading to soil degradation, deforestation, land clearing and a scarcity of potable water. Migratory pastoralists

Most population growth will occur in developing countries and mainly in regions that are already in water stress, in areas with limited access to safe drinking water and adequate sanitation facilities

Figure 2.1 **By 2030 about 60% of the world's population is expected to live in urban areas**



Note: Regions are official UN regions.
Source: United Nations 2006b.

The relation between water and migration is two-way: water stressors drive migration, and migration contributes to water stress

and agriculturalists can also have significant localized impacts on the surrounding landscape through such practices as overgrazing of livestock and slash and burn agriculture. While generally considered rural dwellers, these migrants frequently constitute a large share of those seeking better economic opportunities and better access to water and sanitation services, shelter, health services and food stocks in established urban areas, leading to the proliferation of informal communities on the fringes of cities.

The relation between water and migration is two-way: water stressors drive migration, and migration contributes to water stress. Water stressors, such as water scarcity and flooding, can trigger migration decisions. The social, economic and political context in which water stresses occur will influence the migration response. And if the natural environment becomes inhospitable, people are motivated to move to areas where their locally specific knowledge may no longer apply. Once people move, their places of destination must provide them with water resources, which can lead to further environmental stresses.

In these situations the arrival of additional people can worsen existing water crises and strain the capacity of the urban infrastructure. Water conflicts can be exacerbated through migration or the presence of refugees, and the fragile balance of human populations and water resources can be upset. Increasingly, links between environmental issues, including water, and security issues, including migration, have become a topic of scientific research and policy debate. Climate change, which is predicted to lead to greater frequency and intensity of extreme weather events, is likely to result in an overall increase in the displacement of people in the future (see chapter 5).

Estimates of potential environmentally displaced people range from 24 million to almost 700 million who could be displaced by water-related factors, including development projects designed to relieve future water availability stresses.[7] Part of the complexity in unraveling the connection between migration and environmental factors such as water resources is that people rely indirectly or directly on the environment for their livelihoods. In addition, development policies and political and economic stability – or the lack of it – can affect both migration and water resources. Given these complexities, it is difficult to estimate the magnitude of potential migration as a result of environmental factors.

One positive outcome of migration is the lessening of the pressures on the vacated lands, which may allow some ecosystems to recover. In Europe and North America the rural exodus has resulted in the growth of new parklands in some locations.

Challenges

With rapidly ageing populations in some places and rapidly ageing populations combined with a shrinking population in others, it is important to consider the quality dimensions of education and health as well as the quantitative dimensions of population size and age structure in addressing the water needs of evolving communities. To meet the challenges of rapid urban population growth, decision-makers can focus on positive factors that affect fertility decline – social development, investments in health and education, empowerment of women and better access to reproductive health services – in contrast to antimigration approaches.

Economic drivers

Authors: Richard Connor, Walter Rast and James Winpenny

Contributor: Arjen Hoekstra

Key messages

- Growth and changes in the global economy are having far-reaching impacts on water resources and their use.
- Growing international trade in goods and services can aggravate water stress in some countries while relieving it in others through flows of 'virtual water', particularly in the form of imported agricultural commodities.

Global economic expansion affects water through growth in the number of consumers and through changes in their consumption habits, in the way goods and services are produced and in the location of activities, all of which affect international trade. Growth in global output is currently estimated to slow to 2.2% in 2009, though this will likely be less because of the economic volatility arising from the global financial crisis.[8] The growth output is also unevenly distributed. Several emerging market economies are registering continuously high growth rates, transforming them into major global economic forces. Brazil, China, India and the Russian Federation are, on Goldman Sachs' latest forecast, expected to overtake the combined economic strength of the G-8 by 2032.[9] Even sub-Saharan Africa, long a growth straggler, is experiencing

growth rates of 6% or more, fuelled largely by oil and commodities.

Water is affected by economic forces, while the state of water resources has a strong feedback to the economy. In periods of water shortages public authorities are likely to close factories and divert water from farmers to release water supplies for households. Water contamination from industrial effluents may result in factory closures and relocation, while the depletion and contamination of groundwater may compel industries to relocate. Lack of water storage infrastructure may cause heavy economic losses from flooding and drought. Polluted water has high costs for human health. In short, adequate investments in water management, infrastructure and services can yield a high economic return by avoiding such related costs.[10]

Globalization – used here as shorthand for the increasing international flows of goods and services, people, investments and finance – may make the situation worse, but it can also provide solutions. Producing and exporting goods and services with a large water footprint (the volume of water used in producing the goods and services consumed) could aggravate the problems of a water-scarce economy. Yet such an economy could gain from importing goods with a high water content (importing virtual water). Companies can escape their local water problems by relocating to other countries. However, growing corporate awareness of a firm's water footprint is leading to greater transparency about the impact of a firm's supply chain on its water environment. Globalization is also enabling the spread of water expertise provided by international firms and through global communications of service providers in other countries. These companies are a key part of water solutions through the desalination, re-use and wastewater treatment technologies they bring with them.

The following sections focus on economic processes that have exerted pressures on water resources and how they are managed. In addition to globalization, these processes include the global food and fuel crises and international trade (virtual water and increasing awareness of the water footprints of production and services).

Globalization

While economic integration is a dominant feature of globalization, social, cultural, political and institutional aspects are also important. Changes in consumption patterns through growing demands and easier access to goods and services, increased transport and energy needs and global access to innovation and knowledge all play a role in globalization – and all have an impact on water resources and the environment.

The gains from globalization have not been evenly distributed: many people remain on the fringes, and some have fallen further behind

Globalization has raised the productivity and living standards of people in the countries that have opened themselves to the global marketplace. However, the gains from globalization have not been evenly distributed. Many people remain on the fringes, and some have fallen further behind. Exclusion, grinding poverty and environmental damage create dangers. An estimated 1.4 billion people – often referred to as the 'bottom billion' – live on just $1.25 a day.[11] Those who suffer the most usually have the least to start with – indigenous peoples, women in developing countries, the rural poor and their children.

In many cases rapid economic growth has failed to provide opportunities for these poorest of the poor. Social services remain severely unfunded, and environmental and energy problems, including water quality and lack of service delivery, are acute. In advanced economies increased economic insecurity has been associated with rising inequality and the squeezing of social provisioning. In middle-income countries economic shocks, accelerated trade liberalization and premature deindustrialization have constrained economic diversification and formal job creation. Elsewhere, intractable poverty has fed a vicious circle of economic insecurity and political instability and, on occasion, communal violence.[12] Such situations increase the threat of degrading water resources and reducing environmental services.

In addition to these indirect pressures are the direct pressures, such as proliferation of invasive species. Related to the increasing exchange of goods through international shipping, invasive species have caused enormous environmental damage to aquatic and terrestrial ecosystems.

The global food crises and the rising cost of fuel and energy

Reversing decades of low prices, the two-year period 2006-08 has seen sharp, and largely unanticipated, increases in food prices. Because poor people spend one-half to three-quarters of their income on food, a steep increase in the price of rice, grains and edible oils is tantamount to a large reduction in income. While in the long run higher food prices are an opportunity for those who live and work in rural areas (especially if they have the technology and

The world will need almost 60% more energy in 2030 than in 2002. Water is needed for the production of energy of all types, so expansion of energy supply will affect water resources

the inputs – including water – needed to raise their productivity to its full potential), in the short run higher prices create a crisis for the urban and rural poor. Although Africa and other low-income countries are particularly vulnerable, even middle-income countries are at risk if they lack well developed safety nets.

According to the Commission on Growth and Development, there are many potential causes for the steep food price increases. Contributing factors include rising demand, shifting diets, droughts, increased costs of agricultural inputs (such as fertilizers) and policies that encourage the use of agricultural land and output for bioenergy production. Although there is no consensus yet on the relative importance of these factors, many believe that policies favouring bioenergy over food need to be reviewed.[13] The 2008 Declaration of the High-Level Conference on World Food Security: The Challenges of Climate Change and Bioenergy cautions:

> We are convinced that in-depth studies are necessary to ensure that production and use of biofuels is sustainable in accordance with the three pillars of sustainable development and takes into account the need to achieve and maintain global food security.[14]

Other longer-term factors may also have been at play. The low agricultural prices prevailing until recently may have led governments to neglect investments in rural infrastructure, research and development, storage and food security programmes that were once a priority. In parallel, agricultural policies in many countries encouraged non-food commodities such as bioenergy, fibres and narcotics over food commodities. Many major food-producing countries have reacted to the crisis by restricting exports to help contain prices at home, driving international prices still higher. Global markets in food have become temporarily fragmented. The recent food crisis has encouraged countries to re-consider food self-sufficiency, giving it prominence over purely economic considerations. This will likely have an impact on national food and agriculture policies for several years, with implications for water resources management.

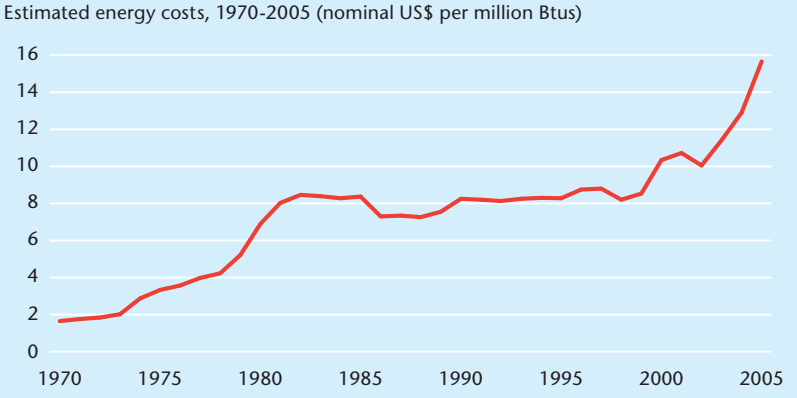
A drive towards food self-sufficiency would have undesirable consequences for national water security, especially for countries in arid regions. Such policies, though beneficial for rural development, increase a country's national water footprint and forfeit growth in higher-income, less water-intensive sectors.

Crude oil prices have also risen sharply in recent years – from under $25 a barrel in 2002 to more than $150 in July 2008 before dropping back to just under $40 in early January 2009. Among the likely contributing factors to the rise is increased demand linked to economic growth in emerging market economies. This growing demand has also increased pressure to exploit new sources of oil. Many of these, such as the tar sands in Western Canada, have a very high water – and environmental – footprint (see chapter 3). Increasing oil prices are also likely linked to the overall increase in the cost of energy, which has been rising steadily since the early 1970s (figure 2.2).

Like food security, energy security is important for GDP growth. According to the International Energy Agency, the world will need almost 60% more energy in 2030 than in 2002, with economic growth in developing countries driving most of the increase.[15] Development of hydropower is one energy strategy to reduce dependence on fossil fuels and limit greenhouse gas emissions, and developing countries possess significant hydropower potential. Water is needed for the production of energy of all types (see chapter 7), so expansion of energy supply will affect water resources and related environmental services. Energy to support growth within urban centres will depend largely on water resources management responses to centralized power production. Growth in small towns will likely rely more on off-grid renewable energy sources.

High prices can provide incentives for greater efficiency in fuel consumption and agricultural production and can generate

Figure 2.2 **The cost of energy to consumers has been rising since the 1970s**



Source: Based on EIA 2008.

more income for people in rural areas. High fuel prices are likely to spur the development of alternative energy types like wind and solar, which require little water, and many countries also benefit from higher tax proceeds when energy prices rise – resources that could be used for further investments in efficiency and development.

Water and trade: virtual water and growing awareness of water footprints

The concepts of water footprints and virtual water are used to describe the relations among water management, international trade and politics and policies, and water resources use as it pertains to human consumption. Water footprints measure how much water is used in the production and consumption of goods and services (as well as how much pollution is generated), while virtual water is a tool for determining the movement of water through international trade.

Because water is heavy relative to its value, it is not feasible to transport it in bulk over long distances, with the exception of limited schemes for drinking water. Thus, water is predominantly a local concern, although it becomes a regional issue where rivers or lakes cross national boundaries. What transforms water into a global issue is trade in goods and services with a substantial water content either in the finished product or in its production (so-called virtual water). Providing water and wastewater services to households, industries and farmers can also have implications for international trade.

Countries with water shortages can import water-intensive goods and services, while water-abundant countries can take advantage of their bountiful water supplies through exports. While this beneficial trade happens broadly at a regional level (box 2.1), many countries have trade patterns that do not promote or benefit from this advantage. Through patterns of consumption and imports, countries can aggravate water shortages and pollution of their water supplies. Trade distortions and failure to properly price water resources may worsen the water-related problems of trading partners (see map 7.3 in chapter 7 and map 8.1 in chapter 8).

Many companies are beginning to understand the need to measure their water footprint, including that of their supply chains, and to relieve water stress in the communities where they operate.

Countries with water shortages can import water-intensive goods and services, while water-abundant countries can take advantage of their bountiful water supplies through exports

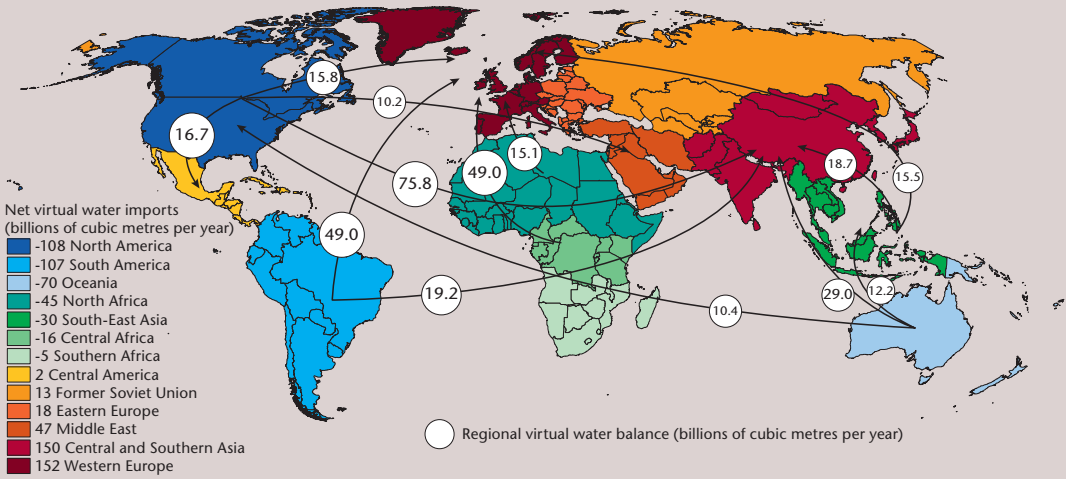
Box 2.1 Virtual water

Water-intensive products are heavily traded over large distances, as countries import and export water in virtual form as agricultural and industrial commodities. The global volume of virtual water flows in commodities is 1,625 billion cubic metres (m^3) a year, accounting for about 40% of total water consumption. About 80% of these virtual water flows relate to agricultural products trade, and the remainder to industrial products trade.

Global virtual water trade can save water if products are traded from countries with high water productivity to countries with low productivity. For example, Mexico imports wheat, maize and sorghum from the United States, which requires 7.1 billion m^3 of water a year in the United States to produce. If Mexico produced the imported crops domestically, it would require 15.6 billion m^3 a year. From a global perspective this trade in cereals saves 8.5 billion m^3 of water a year. Despite some trade from countries with low water productivity to countries with high productivity, global water savings through international trade of agricultural products has been estimated at about 350 billion m^3 a year, equivalent to 6% of the global volume of water used for agricultural production.

Many countries, including Japan, Mexico and most countries in Europe, the Middle East and North Africa, have net virtual water imports (see map). Water security in many countries thus strongly depends on external water resources (see chapter 7).

Regional virtual water balances and net interregional virtual water flows related to trade in agricultural products, 1997-2001



Source: Based on Hoekstra and Chapagain 2008.

A growing middle class is consuming much more milk, bread, eggs, chicken and beef, the production of which is more water-intensive than the simpler diets they are replacing

Motivating companies to assess their water footprints is the desire to gain the goodwill of customers and potential customers and the need for cost control and risk management, including safeguarding access to the water essential for their operations. Recent business initiatives to support sustainable water management include the CEO Water Mandate launched at the 2007 UN Global Leadership Forum, the World Economic Forum's call for a 'coalition' of businesses to engage in water management partnerships and the World Business Council for Sustainable Development's creation of a water diagnostic tool and water scenario planning supports.[16]

Water is increasingly viewed as a potential threat and constraint to economic growth. As an example, China's remarkable economic growth has been accompanied by serious environmental problems, most notably water shortages in the north and pollution from wastewater effluents across the country (box 2.2). Massive projects begun to divert extensive water resources from the south to its more populated north will doubtless result in major environmental and social issues.

Trade and investment patterns are ultimately driven by demand, and changes in consumption and lifestyle accompany rising income levels in all countries. 'How much water do people drink?' (on average, 2-5 litres a day in developed countries) is much less relevant than 'How much water do people eat?' (3,000 litres a day in developed countries, according to one estimate).[17] Economic growth in emerging market economies is driving the growth of a middle class that is consuming much more milk, bread, eggs, chicken and beef, the production of which is more water-intensive than the simpler diets they are replacing.[18] Likewise in the services sector, tourism and recreation are creating an increasingly large water footprint in host societies.

The concepts of virtual water and water footprints are useful in illustrating the true influence of economic activity on water. With greater awareness should come measures to improve water productivity ('output per drop') in water-stressed environments and to reduce the polluting side effects of production.

Challenges

Globalization is bringing increasing economic opportunities to many, while leaving behind some who need them most: the world's poorest people living in the least developed countries. The first challenge is to shift this balance so that the less fortunate can have access to basic products and services, including sustainable access to safe drinking water and adequate sanitation services.

A second major challenge is to ensure that the cumulative action of economic activities and all other water drivers does not overwhelm nature's ability to provide for human needs. The expansion and growth of the global economy, and the resulting increases in human consumption, drive human demands to use more natural resources, including freshwater. However, the goods and services provided by ecosystems (such as water, biodiversity, fibre, food, feed and climate) are finite and vulnerable. Balancing economic development and environmental sustainability – and all the drivers influencing these links – remains a core requirement for sustainable development.

Box 2.2 Water: a brake on economic growth and corporate prospects

While the scarcity of freshwater is felt acutely in Africa and West Asia, water scarcity is already an economic constraint in major growth markets such as China, India and Indonesia, as well as commercial centres in Australia and the western United States. If current consumption patterns continue, two-thirds of the world's population will live in water-stressed conditions by 2025. Compounding – and politicizing – these challenges is the reality that fully a third of the world's population lacks access to sufficient quantities of safe water to meet their basic needs.

In the next two to five years many companies will need to adapt to water availability concerns, including water stress and flooding; water quality concerns, including increasingly contaminated surface and groundwater supplies; and water access concerns, specifically competition with other water users. Corporate leaders who prepare careful water strategies for managing medium-term business risks and opportunities will not only be prepared to meet the future – gaining advantage in some of the key, and most water-constrained, global markets – but can also help shape it.

Source: Pacific Institute 2007.

Social drivers

Authors: Gunilla Björklund, Richard Connor, Anne Goujon, Patrick Moriarty, Walter Rast and James Winpenny

Key messages

- Social drivers influence human perceptions and attitudes about the environment, including water resources, in turn influencing the pressures people exert on water through water demands and uses.

- Changes in lifestyles are one of the principal drivers of change. They reflect human needs, desires and attitudes (as illustrated in consumption and production patterns), which are influenced by such social drivers

as culture and education and by economic drivers and technological innovation; the rapid global rise in living standards combined with population growth presents the major threat to the sustainability of water resources and the environment.

Social drivers are mainly about individual rather than collective actions and about the way people think and act on a day-to-day basis. The four social drivers considered here are poverty, education, cultures and value systems, and lifestyles and consumption patterns.

Poverty

Poverty leaves people with few choices. They must do what is necessary for their survival, whatever the environmental consequences. Slash-and-burn agricultural practices, overexploitation of inland fisheries and the proliferation of informal settlements around urban areas in developing countries attest to this reality. And even as many developing countries have addressed problems of hunger and malnutrition, water quality has been degraded and per capita water availability has worsened. The poorest communities are also commonly in areas most vulnerable to the impacts of climate change and variability, including unstable hillsides and low-lying coastal areas, and lack the capacity to cope with natural disasters.

The inadequate water resources and sanitation facilities associated with poverty result in such environmental consequences as water pollution and degraded aquatic ecosystems, often the source of poor people's livelihoods. High levels of water-associated disease (such as schistosomiasis, malaria, trachoma, cholera and typhoid) are also common. And many people living in poverty engage in artisanal activities, such as metal working, that can generate large quantities of water pollutants.

Poor people often pay the highest relative prices for water. Inhabitants of informal settlements, for example, do not normally receive water delivery services from central water supply agencies, but typically pay exorbitant prices for drinking water (sometimes of dubious quality) from local water dealers. And in rural areas in developing countries people can spend hours each day fetching water.

History suggests that some initial level of economic development may be necessary before attention is given to environmental sustainability. However, there is sufficient evidence to believe that the two may not necessarily be in conflict. First, some processes are irreversible (for example aquifer depletion and contamination) and need to be halted now. Second, the state of water resources – and the environment in general – affects the poor disproportionately, so attention to environmental sustainability must especially recognize their urgent needs. And third, investments in environmental protection, water management and water supply and sanitation services, among others, can have high pay-offs in economic benefits.

But whatever actions are taken to reduce poverty, it must also be recognized that increasing the economic well-being of the very poor will ultimately translate into higher demand for natural resources, including water. This will require trade-offs, especially where these resources are lacking or over-exploited.

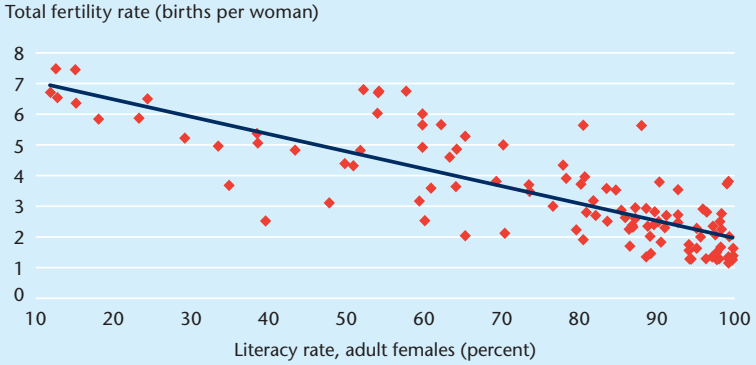
Whatever actions are taken to reduce poverty, it must also be recognized that increasing the economic well-being of the very poor will ultimately translate into higher demand for natural resources, including water

Education

An educated populace typically has a better understanding of the need for sustainable use of aquatic ecosystems and the important environmental goods and services they provide. Education can also lead to greater water use efficiency. For example, knowledge of water systems, new materials and emerging technologies (such as package treatment plants) can help extend water services to informal areas. Knowledge of water conservation practices also facilitates improved water use efficiency in these areas.

More education enables people to improve their economic circumstances, leading to empowerment, better health and longer life expectancy. At the community level the education of broad segments of society can accelerate the demographic transition, through declines in fertility and infant mortality rates (figure 2.3). An educated

Figure 2.3 **The fertility rate declines with rising female literacy, 1990**



Source: Institute for Statistics 2006; World Population Prospects Database.

An educated populace typically has a better understanding of the need for sustainable use of aquatic ecosystems and the important environmental goods and services they provide. Education can also lead to greater water use efficiency

society is also more likely to be democratic and politically stable, working to reduce inequity and promote the acceptance of cultural diversity. Thus, education not only fosters economic growth, but also increases expectations of a better quality of life for individuals, their families and society.

While education is fundamental to improved economic and social well-being, in many fast-growing countries in Africa, South Asia and elsewhere, the predicted growth in population is likely to depress school enrolment. Because of budget and capacity constraints, schools may not be able to cope with the growth in the number of children to be enrolled.

In many settings access to schooling also is linked to improved access to safe drinking water and sanitation facilities. Separate sanitation facilities in schools for boys and girls have been shown to increase the attendance of girls and are also important for maintaining a minimum comfort level for female teachers. Improving access to water and sanitation facilities, by increasing family incomes, enables households to pay for school fees and equipment. And a reduced incidence of water- and sanitation-related diseases contributes to less absenteeism and better performance.

Culture and values

Culture describes the patterns of human activities and the symbolic structures that impart significance and importance to these activities (such as art, institutions, science, beliefs and moral systems). Because such structures are passed from generation to generation, culture can be defined as the way of life for an entire society.

In several regions the empowerment of women has emerged as an important driver, particularly at the household and community levels. As described in box 2.3, this ongoing process brings about social, environmental and health benefits that can have positive repercussions for the community as a whole in how water services are received and managed.

The perceived values of natural resources reflect cultural perspectives as well as economic perspectives. Lakes and reservoirs, for example, provide many valuable services, including water for drinking and sanitation, agriculture, industry and livestock uses and, in the case of reservoirs, for electricity generation. They serve as buffers against water shortages and excesses and as contaminant sinks for their drainage basins. They provide food and economic livelihoods through fisheries, aquaculture and environmental tourism. They are important aquatic ecosystems and provide habitat for rare and threatened species. And they can possess important cultural and religious values that emphasize humanity's connections to the natural world. Which of these uses are pursued or emphasized depends largely on the cultural perspectives and economic values assigned to them by society.

One of the most powerful manifestations of cultural values is religious belief. Many religions describe the role of humanity as both a moulder and a steward of the environment. Virtually all of the world's major religions see a spiritual challenge in the ecological crises evident today.[19] Religious beliefs that highlight humanity as a steward, rather than master, of the environment can be a powerful influence in developing and sustaining the awareness of societies and communities of their roles in using and conserving natural resources, including water.

Box 2.3 The role of women within the water sector and the importance of gender mainstreaming

In most developing countries gender inequity persists in access to and control of a range of productive, human and social capital assets. Consequently, the core components of poverty (capability, opportunity, security and empowerment) differ along gender lines.

In the water sector women labour to provide water for household needs while men make decisions about water resources management and development at both the local and national levels. Women draw water for household use, transport it home and store it until it is used for cooking, cleaning and washing. In areas of low water coverage women collect water from drains, ditches or streams that are often infected with pathogens and bacteria, causing severe illness or even death. In addition, women spend considerable time collecting water at the expense of income-generating activities. This also exposes them to sexual abuse and other forms of violence and leaves less time for girls to attend school.

Lessons from Africa and the rest of the world have demonstrated that increased participation by women in decision-making leads to better operation and maintenance of water facilities, better health for the community, greater privacy and dignity for women, more girls attending school and increased income opportunities for women.

The immediate action by water sector participants is to ensure gender mainstreaming in any planned action, including legislation, policies and programmes in all areas and at all levels. This will ensure that the voices of marginalized and disadvantaged women and men are integrated in design, implementation, monitoring and evaluation of policies and programmes and therefore help to achieve sustainable water provision for all.

Source: Adapted from Mutagamba 2008.

Religious beliefs can also sometimes accelerate the degradation of these resources. One example is the Hindu practice of cremating their deceased family members in funeral pyres and placing their ashes into the Ganges River, which is considered holy. However, incomplete cremation results in incompletely burned human remains being put into the river, causing degraded water quality and increasing the potential for the transmission of waterborne diseases. The custom is deeply rooted in religious beliefs, making it difficult to address with a strictly scientific rationale. Religious significance has been observed for water systems in other societies around the world.

Lifestyles and consumption patterns

Lifestyles and associated consumption choices are increasingly considered the most important drivers affecting water resources, along with population growth. And the pressures these drivers generate can be transmitted through trade and investment activities to other regions. As standards of living rise in developing countries and countries undergoing economic transition, the demand for larger homes and for 'luxury' items such as kitchen appliances, cars and other vehicles and the energy to run, heat and or cool them is increasing the demand for the resources required to produce, generate and operate them. Thus, humanity's environmental footprint is expanding dramatically. And despite some laudable efforts to develop cleaner technologies to shrink this footprint (see chapter 3), population growth and the changing lifestyles and consumption choices associated with rising living standards will continue to threaten the sustainability of water resources and the environment.

The evolution of eating habits and changes in diets as living standards rise are among the most important drivers of agricultural water use for several crops in many countries. The quantity of water used per person for food production depends on a society's dietary habits, in particular on the relative importance of meat and dairy products in diets. Massive social and economic changes taking place in many developing countries are lifting millions of people out of poverty and creating a new middle class with increasing demands for such food as milk, bread, eggs, chicken and beef to complement their traditional and less water-intensive diets.[20]

A simple calculation illustrates the impacts of changing food habits on water resources. It is estimated that the Chinese consumer who ate 20 kilograms (kg) of meat in 1985 will eat more than 50 kg in 2009,[21] increasing demand for grain to feed livestock. Assuming that 1 kg of grain requires 1,000 liters of water to produce, the annual water footprint of this change in diet for some 1.3 billion Chinese will translate into a need for 390 cubic kilometres (km^3) of water. Similar changes are taking place in other countries with growing economies. For the extremely poor, eating even two meals a day instead of one can substantially increase per capita water consumption (see box 7.4 in chapter 7).

As this example suggests, lifestyles and consumption patterns are, in essence, the sum of all drivers. They bring together economic growth, technological innovation, the evolution of culture and values, population dynamics (population growth and the number of people who have reached a certain standard of living) and governance (how wealth is distributed).

Challenges

Once people's survival needs are met, their wants become more prominent. These wants usually focus on increasing human comfort and convenience and are generally associated with rising consumption of material goods and non-essential services such as travel and leisure. The desire for a better lifestyle is arguably one of the most powerful human motivations, and the rapid global rise in living standards, combined with population growth, poses the major threat to the sustainability of water resources and the environment. The production of goods to satisfy these growing human wants is often not possible without the overuse of natural resources. Further, it is accompanied by the production of wastes and other non-useful by-products. Unrestrained fulfillment of the desire for a better lifestyle will be accompanied by environmental stresses, many of them unprecedented.

The major challenge is to reconcile human needs and human wants with the ability of nature to provide or replenish the resources to produce them. Global society must address the dual goal of enhancing human well-being and lifestyles while ensuring the sustainability of the ecosystems and environmental conditions that provide the desired goods and services. Achieving this goal will prove impossible unless humans recognize and better understand the links between their actions and the condition and sustainability of the natural environment. Raising awareness to bring about behavioural change is one approach, but a still elusive goal.

The desire for a better lifestyle is arguably one of the most powerful human motivations, and the production of goods to satisfy these growing human wants is often not possible without the overuse of natural resources

Notes

1. Hinrichsen, Robey, and Upadhyay 1997.
2. United Nations 2007.
3. UNFPA 2007.
4. United Nations 2006a.
5. Morton, Boncour, and Laczko 2008.
6. UNFPA 2007.
7. Klaus Töpfer, former head of the United Nations Environment Programme, talks of 22-24 million environmental migrants (Biermann 2001), whereas Norman Myers (2005) reports 'at least' 25 million in 1995 (latest date for a comprehensive assessment), especially in the African Southern Sahara, Central America, China and South Asia. Myers expects the number to reach 50 million by 2010. The United Nations Refugee Agency (UNHCR 2002, p. 12) estimated that there were approximately 24 million people around the world who fled their homes because of floods, famine and other environmental factors. Christian Aid released a report in 2007 estimating that up to 685 million people were forced to move because of environmental factors, including development projects such as dams that inundated large areas of inhabited land. All of these estimates are from OSCE (2007).
8. More information on the revised forecast can be found in IMF 2008a.
9. Poddar and Yi 2007.
10. SIWI 2005.
11. World Bank 2008.
12. United Nations 2008.
13. Commission on Growth and Development 2008.
14. High Level Conference on World Food Security 2008, article 7.f.
15. IEA 2006.
16. WBCSD 2006.
17. World Economic Forum 2008.
18. Wiggins 2008.
19. Bassett, Brinkman, and Pedersen 2000.
20. Wiggins 2008.
21. Wiggins 2008.

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Chapter 3

Technological innovation

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Key messages

- Technological innovation is driven largely by both human wants and needs.
- Technological innovation can create both positive and negative pressures, sometimes simultaneously, resulting in increased or decreased water demand, supply and quality.
- Technological innovation is one of the most unpredictable drivers. It can create rapid, dramatic and unexpected changes, both in pressures and solutions.
- Impediments to the dissemination of technology must be overcome if developing countries are to benefit from innovations developed in richer countries.

Technological change takes different forms, each with different potential impacts on the environment. Some innovations reduce environmental pressures (by lowering emissions or using water resources more efficiently, for example), while others increase them (by increasing water demands for their production, for example). Most innovations create both positive and negative pressures on the environment, while the main purpose of technology is to make processes (production, transformation and communication, for example) more efficient, which generally means more cost-effective, the environmental benefits of some technologies have also yielded broader economic benefits. In recent decades, for example, greater environmental regulation and corporate social responsibility, combined with pressures from society, have prompted cleaner and more environmentally friendly technologies and increased their overall value.

Disseminating technology is as important as developing it. Controls on the dissemination of technology, especially from developed countries (where much of the technology is generated) to developing countries (which are less able to afford or generate it), inhibit the ability of developing countries to stay economically and environmentally competitive.

In the water sector the expansion of scientific knowledge and technological applications is changing the way water is used, cleaned and reused to meet human, economic and environmental needs. Industries are investing in new technologies and processes that reduce water use and wastewater discharges. Household consumers are being offered water-saving technologies such as low-flush toilets, low-flow showers and faucet aerators. Agricultural productivity is being leveraged by drip irrigation and maintained by soil fertility and conservation techniques. Water supplies are being enhanced in many countries through innovative wastewater treatment and reuse techniques. And breakthroughs continue in desalination: advances in technologies and energy efficiency in the past decade have made

Water supplies are being enhanced in many countries through innovative wastewater treatment and reuse techniques

desalination an economic option for water supplies in coastal cities (see figure 9.3 and box 9.5 in chapter 9).[1]

This chapter looks at six areas – in which water-related technologies are emerging rapidly – that are likely to exert strong pressures on the supply, use and management of water resources: environmental research and development, renewable energy, information and communications technology, biotechnology, bioenergy and nanotechnology. It also describes the challenges and difficulties associated with the dissemination of technology, which is especially important for developing countries.

Recent trends and advances in science and technology

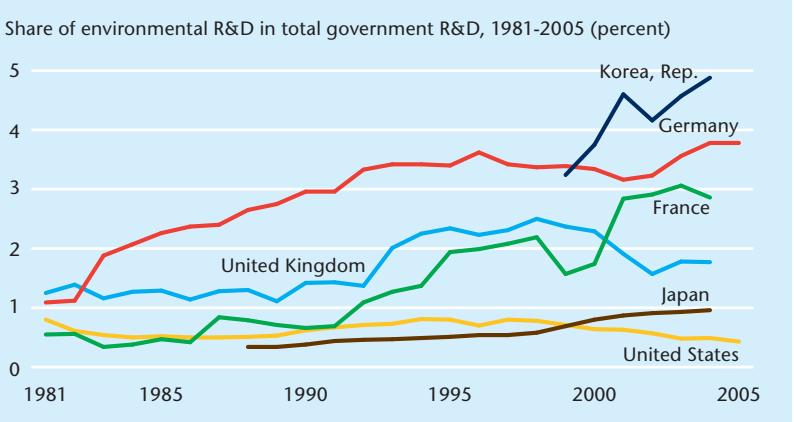
Key message

- Technological innovation is driven largely by both human wants and needs.

People are the ultimate drivers of change on a global scale, through both their needs (their requirements for survival) and their wants (their desires for products and services that enhance safety, comfort and well-being). Although not true everywhere or to the same degree, technological advances that address these wants and needs are a major reason why many people enjoy a standard of living that includes access to safe drinking water and adequate sanitation.

It is sometimes difficult to determine whether technology development drives water demands or whether increasing water demands associated with human activities drive technology. Some new technologies can have positive benefits – reducing water demand and increasing water availability (for example, rainwater harvesting) – while others can increase water demands (such as using crops to produce bioenergy). In analysing technological advances and interventions, it is also useful to distinguish their structural elements (such as construction of a plant, dam or irrigation system) and their non-structural elements (including public awareness campaigns, educational programmes and information sharing). This section outlines some key technology areas and provides some insight on how new developments can affect water resources.

Figure 3.1 **Many developed countries have increased their investment in environmental research and development**



Source: Based on OECD 2008.

Environmental research and development

Many developed countries have increased their investment in environmental research and development (R&D) to encourage new technologies to improve environmental quality (figure 3.1). Perhaps more important, developed countries also encourage research by the private sector through subsidies and tax incentives for specific types of research. This has been much less the case in most developing countries, however, because of the many competing claims on their limited financial resources. Thus, the main path of technology transfer is from developed countries to developing countries.

The focus of the R&D activities varies with national sustainable development priorities and interests and available funding. Germany, for example, has focused on clean processes and production technologies, Norway on energy and the environment and the United States on climate, water and hydrogen as an energy source.

There also appears to be a correlation between environmental regulations and environmental technology, with regulation spurring industries and water use sectors to address water availability and water quality. Environmental regulations may be counterproductive in facilitating environmental technology in some situations, however, since once required standards are met, incentives to engage in further technology development may dissipate.

Renewable energy

The renewable energy sector has seen remarkable innovation over the past two decades. Innovation has accelerated in response to recent public and political pressure to reduce greenhouse gas emissions thought to be contributing to global climate change. First-generation

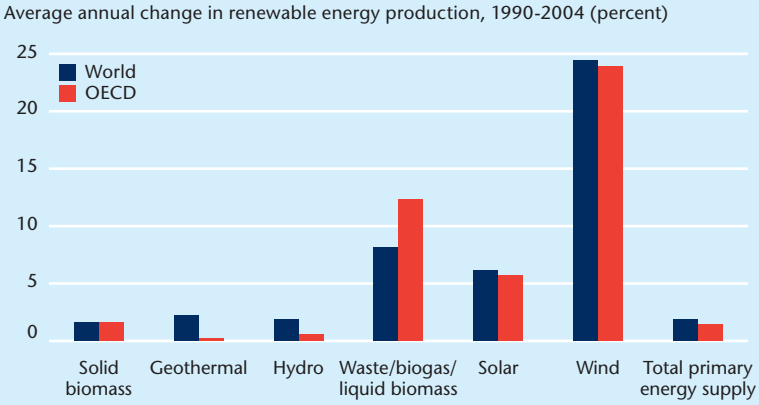
(hydropower and biomass combustion) and second-generation (solar heating and wind power) technologies are now being followed by third-generation technologies such as concentrated solar power, ocean energy, enhanced geothermal systems and integrated bioenergy systems. As these innovations have lowered relative costs, the use of renewable energy resources has risen worldwide (figure 3.2).

If current policies are maintained, global energy demands are expected to grow by as much as 55% through 2030, according to the International Energy Agency.[2] China and India alone would account for about 45% of this projected increase (based on conservative economic growth figures), and developing countries overall for 74%. Electricity generation from hydroelectric and other renewable energy resources is projected to increase at an average annual rate of 1.7% between 2004 and 2030, for an overall increase of 60%. Although renewable energy would still account for only a small part of total energy demand, the increase in renewable energy production could have a large impact on water resources, especially increases in hydropower generation.

Future development of hydropower will be limited by two main factors. One is the spatial and geophysical potential for new hydropower installations. In many developed countries, including Australia, the United States and much of Western Europe, most of the suitable sites for hydropower installations have already been developed (see map 7.6 in chapter 7). The second limiting factor is financial investment capacity, which has been the primary constraint in developing countries, including in most of Africa. Pressure from environmental groups opposed to dams, particularly to large dams, may also constrain future hydropower development.

Since renewable energy resources alone are not sufficient to meet the predicted dramatic increase in energy demands through 2030, fossil fuel extraction and development of nuclear energy will continue to increase, as will their impacts on water resources and the environment. Coal consumes about 2 cubic metres (m^3) of water per megawatt hour of electricity generated, nuclear power about 2.5 m^3 and petroleum about 4 m^3. Extracting petroleum from Canada's tar sands, which have received much criticism as an 'unclean' source of oil, consumes an estimated 20-45 m^3 of water per megawatt hour, nearly 10 times that for conventional oil extraction. Thus, as fossil fuel sources become increasingly inaccessible, the water footprint of oil tar sands is likely to increase dramatically.

Figure 3.2 **The use of renewable energy sources rose worldwide between 1990 and 2004**



Source: Based on OECD 2008.

Information and communications technology

Advances in information and communications technology can affect the cost and effectiveness of monitoring ecosystem health and quality. Reductions in the costs of sensors, coupled with satellite-based wireless data transfer, have greatly facilitated the monitoring of water resources (water quality, water levels, flow rates and so on) and the delivery of water-related services, all in real time.

Improved monitoring through advanced information and communications technology can intensify the environmental effectiveness of policy measures, from the improved tracking of potentially hazardous materials to the monitoring of emissions from large stationary and smaller diffuse (non-point) and mobile sources. The greatest number of patents for monitoring environmental impacts between 1978 and 2002 was granted for water pollution treatment, attesting to the importance of information and communications technology innovations in the sustainable management of water resources. Still lacking, however, are adequate original field data required for ground-proofing, monitoring and forecasting data and for informed decision-making (see also chapter 14).

Biotechnology and genetically modified organisms

Plant and animal breeding has increased agricultural productivity and therefore affected water productivity. Progress has been concentrated in crop and animal productivity and resistance to pests, disease and weather extremes.

Biotechnology can have a valuable role in addressing water scarcity and quality challenges in both developed and developing countries, especially in agriculture

The green revolution of the 1970s and 1980s is an example of the dramatic effects of how taking advantage of technological advances can improve the livelihoods and incomes of the poor. The principal technologies involved in the green revolution were irrigation, fertilizer and pest control, together with high-yielding varieties of maize, wheat and rice. The green revolution in Asia doubled cereal production during 1970-95, while increasing the land area devoted to cereals by only 4%. By the late-1990s it was clear that many people, including segments of the poorest population groups, had reaped substantial benefits from higher incomes, less expensive food and increased demand for their labour associated with the green revolution.

The green revolution also demonstrates that unintended consequences can accompany new technologies. The excessive use of agrochemicals has polluted waterways, while wasteful irrigation has contributed to water scarcity in some areas and to water logging and soil salinization in others. High livestock concentrations have contributed to the spread of disease. As monoculture of crops for export or for use as animal feed replaced traditional polyculture techniques, the economic outcomes for some small farmers deteriorated as increased production of cereal crops caused prices to fall and crop susceptibility to pests and plant diseases spread. Increased agricultural production also led to higher water demands, exacerbating water scarcity problems in some arid and semi-arid regions (see chapter 8).

Genetically modified organisms are a more recent agricultural advance. A genetically modified organism is an organism whose genome has been altered through genetic engineering. A large share of food crops, such as corn, cotton and soybeans, have been genetically modified to increase yields and resistance to pests and chemical herbicides. Although this technology offers the potential for developing drought-resistant crops, with obvious advantages for water-scarce regions, little progress has been made towards this goal, and no breakthrough is expected in the near future.

Micro-organisms are an especially promising avenue, since there is considerable knowledge and experience in genetic experimentation with them. As decomposers of organic material, they are capable of breaking down or otherwise neutralizing many types of polluting materials in the environment. Micro-organisms are currently used, for example, in biological processes in municipal wastewater treatment plants to treat or break down organic materials in wastewater. Micro-organisms that can more efficiently break down oil pollution in aquatic ecosystems and soils following oil spills or other industrial accidents are receiving attention. Similar avenues may become evident for research into the treatment of other types of water pollutants.

Bioenergy

Bioenergy, derived most commonly from plant materials, is a renewable energy source that is less likely to increase carbon dioxide emissions that contribute to global warming (in contrast to fossil fuels, which return long-stored carbon to the atmosphere). Cellulose, including agricultural residues, waste products and woody biomass, is also showing promise as a bioenergy source (see chapter 7).

This new technology is not without problems. For maize and sugarcane used to create bioenergy, a major problem is the need for large quantities of water to grow the crops (see box 7.2 in chapter 7) and for considerable quantities of fossil fuel energy for tillage, fertilizers, pesticides, irrigation, harvesting and transport machinery, and processing.[3] Research is currently focused on the development of second-generation bioenergy, converting wood, crop residues and other biomass sources into liquid biofuel. Non-food crops such as jatropha do not require the intensive management and soil quality that food crops need and therefore may not compete directly with food crops for resources (water and good agricultural land). Second-generation bioenergy technology has the potential to increase energy yields significantly, but may not be commercially viable for 5-10 years.

Producing bioenergy from crops traditionally grown as food will require additional agricultural production to make up for the lost food sources, and more water as well. Increased bioenergy production has also resulted in a significant increase in some food prices by diverting grain traditionally grown for food.[4] More than one-third of maize production in the United States in 2008 was being used to produce ethanol[5] and about half the vegetable oils produced in the European Union were being used for biodiesel fuel.[6] Although the impact is extremely difficult to assess, bioenergy production is estimated to have caused up to 70%-75% of the rise in the global prices of some food stocks, including approximately 70% of the increase in maize

prices.[7] Higher energy prices worldwide and a weak US dollar are believed to have caused the remainder.[8]

Bioenergy production also causes environmental impacts unrelated to climate, particularly impacts arising from agricultural practices (see chapter 7). Examples include tillage-based soil erosion, eutrophication from fertilizer runoff, increased pesticide loads to aquatic habitats and biodiversity loss from land use changes. Further, the use of bioenergy could spawn other problems, as reductions in greenhouse gas emissions (from switching from fossil fuels to biofuels) could be offset by the clearing of new land to make room for more crop production. Cutting down forests could release carbon dioxide and reduce biodiversity. Under conditions of water scarcity, producing fuel for automobiles instead of producing food to feed a growing population becomes less socially acceptable, especially in developing countries.

Nanotechnology

Nanotechnology, the design and manufacture of extremely small electronic circuits and mechanical devices built at the molecular level of matter, shows particular promise for water resources. Key areas are desalinization (see box 9.5 in chapter 9), water purification, wastewater treatment and monitoring. The first three areas involve the use of nanofiltration technology, nanomaterials and nanoparticles to remove or reduce water contaminants. Monitoring involves the use of nanosensors.

Many nanotechnology-based approaches are less a major departure from traditional methods of addressing such issues than a means of improving existing applications and devices.[9] Seawater desalinization plants are already in operation around the world, and many technologies can effectively remove microbes and other contaminants from water. And although operation efficiencies vary, wastewater treatment plants also exist in many developed and developing countries.

Nanotechnology has the potential to greatly improve water quality and quantity through water treatment or remediation. Nanofiltration membranes and other advanced filtration materials can facilitate water desalinization and increased water reuse and recycling, improving desalinization efficiency and reducing associated costs (especially for energy). Another emerging area is the development of nanomaterials, which can act as a 'sponge' to enhance the removal of specific heavy metals from water supplies. Research is exploring the use of nanoparticles as catalysts for chemical reactions of other materials as a means of degrading them and for removing salts and heavy metals. Such treatments could be targeted to chemicals for which existing technologies are inefficient or costly and could eventually permit human use of heavily polluted and saline water for drinking, sanitation and irrigation.

For water monitoring nanotechnology encompasses new and enhanced sensors for detecting biological and chemical water contaminants present in very low concentrations. New sensor technology, coupled with micro- and nanofabrication technology, may eventually lead to the development of highly accurate and portable sensors.

There are also impediments to the large-scale use of nanotechnologies to address water resources issues. While many nanotechnologies are already in use, many are still at varying stages of research or development. Thus, although such technology could help developing countries increase water treatment or remediation efficiency and reduce costs associated with traditional treatment methodologies, it is unclear when nanotechnology-based applications will be ready for wide-scale use. And even though nanotechnologies may prove very efficient and cost-effective over the long term, initial acquisition and application costs are high in many cases. Using such technologies also will require the technical capacity to maintain and operate them.

There also are some risks associated with nanotechnology-based approaches, specifically the possibility that engineered nanoparticles used to catalyse chemical reactions may end up in water systems. Little is yet known about how such materials may interact with biological organisms, so the possibility of toxicity to humans and ecosystems must be considered.

Nanotechnology shows particular promise for desalinization, water purification, wastewater treatment and monitoring

The technology dissemination challenge

Key message

- Technology is constantly evolving, and the availability of technologies can differ widely between developed and developing countries because of impediments to dissemination of research and adaptation to local conditions.

With the bulk of technological innovation originating in developed countries, introducing appropriate technologies into developing countries is a key challenge of development

Technological progress is both a determinant and an outcome of rising incomes. At the national level it can occur through invention and innovation, the adoption and adaptation of existing but new-to-the-market technologies and the spread of technologies across individuals, firms and the public sector within a country.

With the bulk of technological innovation originating in developed countries, introducing appropriate technologies into developing countries is a key challenge of development. It requires both the willingness to transfer the technology and the capacity to pay for, absorb, adapt and use the technology so that it generates long-term benefits.

Exporting technology to developing countries

The number of patents and scientific journal articles focusing on technology is strongly correlated with GDP per capita.[10] Most developing countries lack the ability to generate innovations at the technological frontier. Moreover, relatively undeveloped domestic technology sectors and the lure of better economic and scientific opportunities abroad draw highly educated nationals from many developing countries to cutting-edge research sectors in high-income countries.

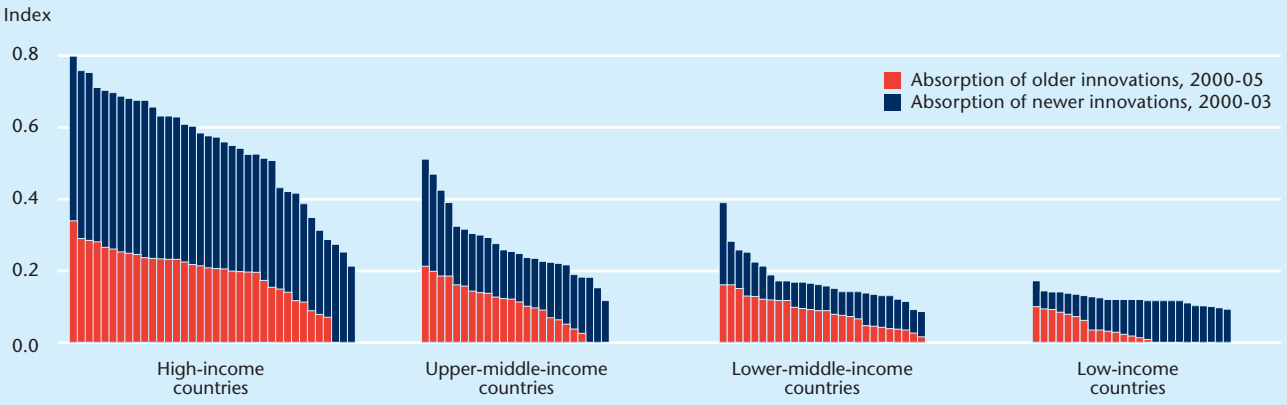
The lack of advanced technological competence in developing countries means that technological progress occurs there mainly through the adoption and adaptation of existing technologies. The penetration of older technologies, such as fixed-line telephones, electric power networks, transportation, health care and water services – many ultimately provided by governments – has tended to lag behind that of newer technologies (figure 3.3). Many of these older technologies require infrastructure that is expensive to create and maintain and that relies on large numbers of people with scarce technical skills. In addition, the diffusion of older technologies today depends on the intensity and efficiency with which government services were delivered in the past, many of which have a poor record.

The rates of acceptance and application of newer technologies have been higher than those of older technologies because rates of acceptance and application are more directly correlated with income. The infrastructure for newer technologies such as mobile phones and the Internet is generally less expensive to create and requires fewer (although more skilled) workers to operate and maintain. Moreover, with regulatory reform in many countries the private sector now offers these services in a competitive environment, rather than in the state-owned, monopolistic environments of the past. Supplying such new technologies has thus been more responsive to market demands and less constrained by the stringencies of government budgets or state enterprises. Furthermore, demands for such products have been boosted by low end-user costs, resulting from competitive pricing strategies, and the characteristics of some newer technologies that lend themselves to sharing more readily than do some older technologies.

Absorptive capacity for technology

Most technological progress in developing countries has been achieved through absorption and adaptation. A country's ability to absorb, adapt and apply foreign technologies depends mainly on its exposure to foreign technologies (the pace at

Figure 3.3 **The absorption of older and more recent technologies depends on more than income**



Note: Each bar represents a single country.
Source: Based on World Bank 2008.

which technologies diffuse across countries) and its ability to absorb, adapt and use the technologies to which it is exposed (the pace at which technologies diffuse within a country). Successful use depends on the technological absorptive capacity of the economy – the macroeconomic and governance environment, which influences the willingness of entrepreneurs to take risks on new and new-to-the-market technologies – and the level of technological literacy and advanced skills in the population.

Government policy also has a crucial role. Governments are often the primary delivery channel for technologies such as electricity, fixed-line telephones, transportation infrastructure and medical and educational services. And government policy can create a business environment that facilitates firm entry and exit and that is not hostile to exploiting new technologies. Too often, government regulations or features of the domestic market prevent firms from making money by exploiting a new technology, thus impeding the spread of technology within a country. Policy should also ensure that R&D and dissemination efforts give priority to creating and introducing products for which a market (domestic or foreign) exists and to helping firms exploit those opportunities.

Investing in research and development

Countries do well to invest in technology research and development. Research and extension programmes in agriculture, the sector that consumes the most water, have exceptionally high internal economic rates of return (table 3.1).

Many resource constraints can be overcome by technological capital and supporting institutions. Productivity gains, including genetic improvements that enable more production per unit of land, also enable more production per unit of water. For most developing countries gains in agricultural productivity arise from investments in adaptations of inventions produced in developed countries.

Challenges

A major technology challenge is how to balance the benefits and risks of new technologies. For the first time in human history, technology has provided humanity with the means to reshape the structure and functioning of the natural environment and thus to alter the possibilities for future development. The natural environment has an internal system of checks and balances for its own maintenance and that of the animals and plants that inhabit it. Humanity has acquired technologies that can radically affect these natural checks and balances.

Many positive impacts are associated with technological advances, such as a reduced burden of disease and loss of life due to medical advances, decreased malnutrition due to the green revolution and other agricultural advances, and increased economic livelihoods due to industrialization and urbanization and attendant technologies. But maintaining a sustainable relationship between people and the natural environment requires maintaining a balance between the technologies we develop to meet human needs and nature's ability to supply them. And there is ample evidence that this balance is not being achieved in many places around the world, as demonstrated by excessive water abstractions, degraded water quality, and damaged aquatic ecosystems and biological communities. Some of these impacts result from ignoring the environmental consequences of human development actions. Others result from ignorance of the many, often subtle, interactions between the natural environment and the human activities that fundamentally affect it.

Consider crop-based bioenergy production. The increased production and use of bioenergy to reduce greenhouse gas emissions associated with the burning of fossil fuels must be balanced against the rising need for water resources, associated pollution and sufficient agricultural land on which to grow the crops to supply crop-based bioenergy. An unintended impact has been rising prices for some foods, as cereal crops are currently used for the production of bioenergy rather than for food. Our choices of technology require appropriate consideration of their benefits and costs, including their negative environmental impacts.

Maintaining a sustainable relationship between people and the natural environment requires maintaining a balance between the technologies we develop to meet human needs and nature's ability to supply them

Table 3.1 **Return on investments in agricultural research and extension**

Investment	Median internal rate of return (percent)[a]
Agricultural extension programmes	41
Applied research	49
Pre-invention science	60

a. The internal rate of return is the rate of discount at which the present value of benefits is equal to the present value of costs.

Source: FAO 2000.

Notes

1. Bergkamp and Sadoff 2008.
2. IEA 2007.
3. Pimentel and Patzek 2005.
4. Mitchell 2008.
5. US Department of Agriculture 2008.
6. Mitchell 2008.
7. Mitchell 2008.
8. FAO 2008.
9. Hillie et al. 2005, p. 43; Berger 2008.
10. World Bank 2008.

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Chapter 4

Policies, laws and finance

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Key messages

- Effective policy and legal frameworks are necessary to develop, carry out and enforce the rules and regulations that govern water use and protect the resource.
- Water policy operates within a context of local, national, regional and global policy and legal frameworks that must all support sound water management goals.
- Legitimate, transparent and participatory processes can effectively mobilize input for designing and implementing water resources policy and create a strong deterrent to corruption.
- Although water is often described as a 'gift of nature', harnessing and managing it for the wide variety of human and ecological needs entail financial costs.
- While there may appear to be many financing options for water resources development, governments still have only three basic means of financing them: tariffs, taxes and transfers through external aid and philanthropy.
- Policy-makers need to make political decisions on socially and environmentally acceptable trade-offs among different objectives and on who bears the costs of such compromise.

Policies and laws

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Effective policy and legal frameworks are necessary to develop, implement and enforce rules and regulations for controlling water uses. Although policy and law go hand in hand, they are fundamentally different. Policy serves mainly as a guide for decision-makers. Law provides a set of enforceable rules.

Water policy, developed at international and national levels, can lead to the establishment of international, national and local laws. Effective implementation and enforcement require an adequate institutional and governance framework – one that is legitimate, transparent and participatory and that has proper safeguards against corruption. The legal system within which water law operates can be a strong instrument of change – or a severe impediment to progress.

Water law sets the framework for stakeholders' use of water resources and responds to pressures from demographic, economic and social drivers. Policy-makers

Because the political negotiations involved in global and regional conventions or water-sharing agreements are meant to avoid conflicts between different uses or users of water, they serve as drivers for water management

use water law to establish the rules of the game for water users within a given community, country or region.

International and regional water policy

International goals and objectives for water resources, negotiated at UN meetings, conferences and summits or in ministerial-level sessions of the World Water Forum, can be viewed as political benchmarks. Because the political negotiations involved in global and regional conventions or water-sharing agreements are meant to avoid conflicts between different water uses or users, they serve as drivers for water management. The global policy framework for water began with the Stockholm Declaration of 1972, followed by other important international milestones over the years (see appendix 2).

Ratifying conventions means assenting to implement the actions and activities agreed to by the involved parties. Implementation requires that the proper institutions exist, that national laws are compatible with convention requirements and that political and financial measures are in place to ensure popular participation. It also requires a policy framework with operational goals, objectives and follow-up processes. As an example, the EU Water Framework Directive, negotiated by the EU member states, requires intranational, multilevel institutional structures, including legal systems, to ensure implementation of the directive for transboundary river basins and groundwater as well as national river basins (box 4.1).

International and regional legal frameworks

International water law is part of public international law. The rules of international law apply to sovereign states. But because there is generally no higher authority to enforce such rules, individual countries must generally ensure their own compliance. The first step in enforcement is identifying the applicable rules.

These rules are found in treaties, international custom, general principles of law and the writings of 'learned publicists'.[1] Treaties usually provide the most accessible source of law, but the other sources cannot be ignored. In the non-navigational uses of international watercourses, rules of customary law are often invoked by countries in the absence of codified law. A treaty applies only to parties to the treaty and only after the treaty has come into force and is thus legally binding. Finally, the normative content (requirements) of the treaty rules must be established and agreed to by all parties involved to determine whether a country's actions are in accordance with its treaty obligations.

Law may also be developed at a regional level. Such law typically supersedes national law. Treaties may operate regionally between two or more countries. Regional bodies such as the European Union may also create law for their members. EU law, unlike international law, can be directly binding on its members and has strong enforcement mechanisms.

In most cases the directly applicable law is national law, which ensures implementation of any international treaties that a country has signed. Within national law the specific law-making powers and hierarchies of laws are determined by the constitutional arrangements within a jurisdiction. National law also includes customary law as well as water laws directly relating to water resources (for example, pollution control and water abstraction permits). In addition to the formal legal framework and the customary laws that national law formally codifies and recognizes, there are also water rules and rights by which water user collectives and other actors abide.

Box 4.1 The EU Water Framework Directive – uneven implementation

The EU Water Framework Directive for water protection and management provides for the identification of European waters and their characteristics on the basis of individual river basin districts and the adoption of management plans and measures for each water body. Entered into force 22 December 2000, the directive seeks to prevent and reduce pollution, promote sustainable water use, protect the aquatic environment, improve the status of aquatic ecosystems and mitigate the effects of floods and droughts through the management of inland surface waters, groundwater, transitional waters and coastal waters.

Within four years of the directive's entry into force, member states were to complete an analysis of the characteristics of each river basin district, a review of the impacts of human activities on their water resources, an economic analysis of water use and a registry of areas requiring special protection. Within nine years they were to produce a management plan and programme for each river basin district.

In a 2007 report the European Commission noted that several EU member states may fail to meet the targets, particularly because of the physical deterioration of aquatic ecosystems as a result of overexploitation of water resources, and the high levels of pollution from diffuse sources. The report also cited problems in meeting the deadlines for incorporating the directive into national law. However, the establishment of river basin districts and the designation of competent national authorities appear to be well under way. The European Commission finished with recommendations for addressing the reported shortcomings, integrating sustainable management of water resources into national policies, maximizing public participation and giving advance notice of its plans for future European water management policy.

Source: European Parliament and Council 2000; CEC 2007.

These hybrid sets of water rules, common in most parts of the world, are often crucial in everyday water affairs and conflict resolution.

There are also many other areas of law not directly addressed to water issues that nevertheless affect management of the water environment. These include land use planning, environmental assessment, nature conservation and environmental law. Public health laws influence the supply of water and sanitation, as does land tenure reform. Individuals are reluctant to invest in sanitation where they have no security of tenure, nor will water companies lay pipes in such land. Legal provisions on freedom of information and access to justice, human rights and other constitutional measures are also important parts of a governance framework.

Conflicts and regional instability (or stability) can influence water demand and use, particularly in water-scarce regions. This is the case where competition arises between different water uses within a country or where water disputes exist between countries, as between Bangladesh and India over the Ganges River and among the riparian countries along the Danube River. (This subject is discussed further in chapter 9.) There are more than 400 registered agreements over shared watersheds,[2] most between two riparian countries. Although the UN Convention on the Law of the Non-navigational Uses of International Watercourses was adopted by the UN General Assembly in 1997, it has not yet been ratified by a sufficient number of countries to enter into force. One of the most successful conventions on water resources is the regional United Nations Economic Commission for Europe Convention on the Protection and Use of Transboundary Watercourses and International Lakes, convened in Helsinki in March 1992.[3] This convention, entered into force in 1996 and currently ratified by 35 countries, serves as a driver for water management in participating countries.

National legal framework: managing water resources and service delivery

Law and policy are interconnected, with particular legislation derived from water policy in many cases.[4] Making laws operational is often a painstaking process, because of the need to develop implementation regulations and manuals on interpreting the law. Often implementation is by trial and error, requiring feedback and the establishment of practices and cases on how to interpret aspects of water law.

For developing countries the long-term goal of such legislation is poverty reduction through a well managed and sustainable water sector. Associated goals include efficient service delivery, protection of consumer rights, financial sustainability and service coverage to the poor in both urban and rural areas.

Governance of the water sector is complex and involves actors beyond the water sector. The actors can be national legislatures and governments, other sector agencies, local governments, river basin authorities, representatives of indigenous peoples, consumer bodies, private companies and others. Who is involved may differ with the issues concerned – for example, surface waters, groundwater, coastal waters or wetlands. Effective action on such a complex group of interests requires open communication and strong coordination facilitated by an appropriate legislative and regulatory framework. The Government of Australia recognized this need when it adopted the Commonwealth Water Act in 2007 and subsequent regulations (box 4.2).[5]

There are fundamental differences between managing water resources and delivering water services. Managing water resources involves a wide range of institutions at local, state, national, regional and international levels. Delivering water services (including administration) usually falls under the authority of elected local officials and specific local institutions. It is misleading, therefore, to discuss resources management and services delivery in the same institutional context.

Decentralization, for example, can affect how water resources and water distribution services are managed. It is a political process, however, not necessarily a water-specific solution to providing improved water services. It requires that water institutions integrate the physical watershed and administrative boundaries, nesting these within each other at different scales. Success with such integration for catchment bodies below the river basin scale has been limited, however, with evidence from countries like South Africa suggesting that such integration may often be too complex to implement.

Table 4.1 shows the range of measures required to address water rights and water management. Table 4.2 shows additional measures that may be required to address the provision of water services. The tables draw from a study across four jurisdictions

There are fundamental differences between managing water resources and delivering water services. It is misleading, therefore, to discuss resources management and services delivery in the same institutional context

Box 4.2 Australian water law reform

Australian states have been reforming their water laws within a framework set out by the Commonwealth government, called the National Water Initiative. The initiative is intended to provide security of entitlements to water, including ecosystems use. It has a formula for sharing risk between government and users should water availability change in the future due to climate change or other factors.

The National Water Initiative and related policies require water trading, which enables water to be properly valued and allocated to higher-value uses. But this means that water rights have to be separated from land rights, which can in turn make it difficult for small-scale farms to survive. This has implications for equity and the potential need for structural adjustment funds. It also has consequences for supportive legal regimes. For example, there may be a need for a secure registry of water rights, similar to a registry of land rights.

There are also consequences for infrastructure. For example, Queensland separates the ownership and management of distribution facilities (irrigation networks) from the storage infrastructure (dams), and users of the irrigation networks cannot opt out of operating costs without the consent of the licence holder, to avoid leaving the system without an owner. If water were to be traded out of an irrigation area, the previous owners might no longer pay for the system, leaving the new owners with a liability but no income.

However, Australian states do not rely on water trading to manage water. In every state there will be a structure for river basin management and stakeholder engagement through water resources plans produced by the states. These plans will allocate water, and only when a plan is in place will it be possible to trade water, as for example under the Queensland Water Act of 2000.

The first requirement is thus to have a sound system to manage water and allocate it to users, which should be the focus of water law reforms, especially where human and financial resources are limited. Only a planned system can account for the public good elements of water. Markets alone cannot.

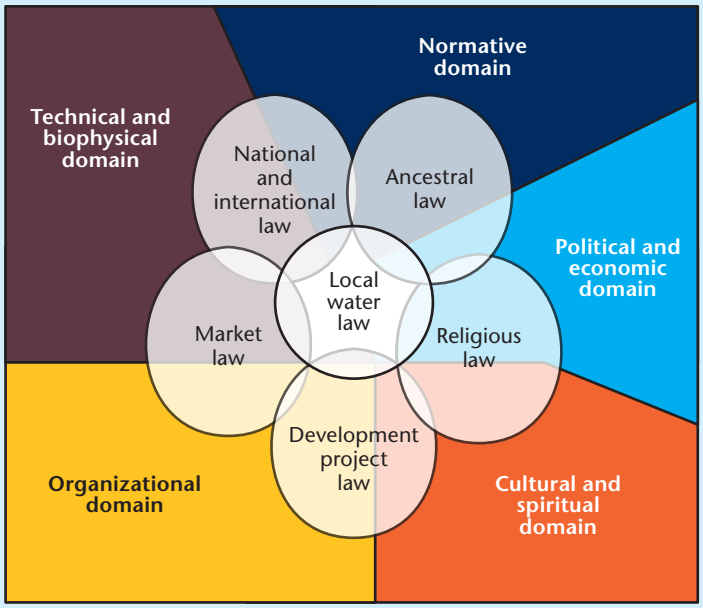
Source: www.nwc.gov.au/nwi/index.cfm; Roper, Sayers, and Smith 2006; Queensland Government 2000; Hendry 2006.

– Scotland, England, South Africa and Queensland, Australia.[6]

Key policy and regulatory issues

Although water allocation systems can be difficult to establish, managing competing water uses requires clear, widely accepted allocation rules, especially where water is scarce. Water allocation systems should balance equity and economic efficiency. Environmental concerns also require equal attention, though they are often neglected in the process. In Chile, for example, the environment is not granted any water licences, while in South Africa decision-makers are debating how to put water law on environmental protection into practice. Lawmakers must address public policy implications, including equity and water reallocations in times of drought or other emergencies. And permit systems should be sufficiently flexible to adapt to global changes and climate variability.

Figure 4.1 **Formal and informal legal framework of water rights**



Source: Based on Boelens 2008.

Much water governance takes place outside formalized legal systems, particularly in developing countries (figure 4.1). Such 'traditional' rights systems form a dynamic mixture of rules, principles and organizational forms of different origins. They combine local, national and global rules and often mix indigenous, colonial and contemporary norms and rights. Important sources for these complex, local rights systems tend to be state laws, religious laws (whether formal or indigenous), ancestral laws, market laws and the rights frameworks of multiple water project interventions, which often set their own regulations.

Local water rights thus exist in conditions of legal pluralism, where rules and principles of different origins and legitimization coexist and interact.[7] In the eyes of water users in many parts of the world, legitimate water authority and water rights are not restricted to official law. Water users also clearly distinguish water rights as defined by lawyers (officially codified or recognized) from their own, living rights systems.

Table 4.1 **Laws addressing water rights and water management**

Legislative requirement	Options for provision		
	Integrated water resources management and river basin planning	**Water rights and abstraction licensing**	**Water quality and water pollution**
High-level principles, purposes and duties	• Primary law • Ownership or trusteeship of resource • Equity, water efficiency and integration • Priority uses in law or policy (e.g., basin plans)	• Ownership or trusteeship of resource if not in water resources management law • High-level duties on water users (e.g., sustainable and beneficial use) • Priority uses in law or policy (e.g., basin plans)	• High-level duties on water users (e.g., sustainable and beneficial use, no waste, efficiency)
Catchment planning	• Catchment based • Alignment with administrative boundaries • Coordination with other strategic planning processes (e.g., land use, biodiversity)	• Licence in accordance with catchment plans if they exist	• Licence in accordance with catchment plans if they exist
Define water environment	• Surface and groundwater • Coastal waters • Wetlands	Control all waters: • Surface and groundwater • Coastal waters • Wetlands	Control all waters: • Surface and groundwater • Coastal waters • Wetlands
Regulatory structure	Water authority: • Government department • Agency • Stakeholder-led	Water authority: • Government department • Agency • Stakeholder-led	Water authority or environmental authority: • Coordination mechanisms
Participation	Stakeholder engagement for planning in primary law	Stakeholder engagement through water resources management framework	Stakeholder engagement through water resources management framework
Licensing	Status of plan: • Regulatory (direct licensing) • Indirect (sets targets) • Managerial (sets targets, incentives)	Integrated water use licences for abstraction and discharge?	Integrated water use licences for abstraction and discharge (dependent on regulatory structure)?
Tiered system (proportionate)		• Tiered system (e.g., general rules and full licences) • Exemptions (e.g., domestic use, subsistence use, volume limits)	• Tiered system (e.g., general rules and full licences) • Emission, quality and ecological standards – progressive approach • Management of diffuse pollution
Licence conditions		Duration, review periods and tests for grant, review and reallocation	Duration, review periods and tests for grant, review and reallocation
Water trading		Prohibit, permit and encourage	

Source: Hendry 2008.

Understanding the nature of water rights in each system and water territory thus requires taking into account their multi-layered bundles: their rights to use and withdraw, operate, supervise and manage, and control. Focusing only on the local level is clearly inadequate. Multistakeholder platforms or other arenas for achieving common goals and establishing patterns of governance – which include recognizing informal water rights, empowering marginalized social and ethnic groups and representing all interested parties in allocation and decision-making – have the potential to ensure fairer and smoother reallocation of water resources (box 4.3).

Participatory water management

Participants in the consensus-building World Water Vision exercise indicated that the Vision could be achieved only if empowered individuals and communities participated at all levels of decision-making on water resources management. Their concerns were pragmatic, driven more by considerations of governance systems than by equity. Thus the *World Water Vision* report concluded that

> Both public and private management of water will improve through greater accountability, transparency, and rule of law. Incentives

Table 4.2 **Laws addressing provision of water services**

Legislative requirement	Options for provision	
Regulators Economic, duties of supply and quality standards Environmental	• Ministry, sector agency (e.g., water industry commission, office of water services) or multiutility (e.g., competition authority) • Ministry or environment agency • Separate consumer body?	
Providers	• Local government • Water board or agency	• Private company
Vertical disintegration and integration Horizontal disaggregation and aggregation	• Abstraction, treatment, distribution and supply • Regional ('competition by comparison'?)	
Private sector involvement	• Forbidden? • Public sector preference? • Short-term contracts	• Build-operate-transfer • Leases and concessions • Divestiture
Constitutional and human rights	• High level • Additional enforcement mechanisms	
High-level duties (on regulators, providers and users)	• Universal service obligation • Conservation, efficient use (water efficiency) • Sustainable and secure supply	• Consumer protection • Competition • Economic efficiency and return on capital
Duties of supply	• Universal (progressive?) • In service areas	• Reasonable cost • Drinking water customer service standards
Tariffs, metering and disconnections	• Banded • Two-part • Free basic service • Participation in tariff-setting	• Presumption of metering • Powers to disconnect or limit supply for non-payment
Emergency powers	• Climate and drought • Pollution incident	• Infrastructure failure • Ministers, water providers and regulators
Storm water	• Incorporate storm water management into water services provision (and potentially into abstraction licensing and pricing)	
Conservation and demand management	• High-level duties on conservation and efficient use • Highest appropriate standards for built environment, grey water reuse	

Source: Hendry 2008.

must improve for all stakeholders. More community participation will provide a sense of ownership and empowerment to local stakeholders. The role of education in making this process possible cannot be overestimated. Public access to information will provide an incentive to elected officials and private operators, who will be held responsible for results, including maximizing social welfare. It will also reduce opportunities for corruption and for capture of the system by powerful elites.[8]

Role of non-governmental organizations. Non-governmental organizations (NGOs) can play a valuable role in a country or local community. Normally operating outside the formal government, NGOs may be community-based organizations, poverty-focused large external organizations such as Oxfam and the Bill and Melinda Gates Foundation, and charities funded by religious organizations. Issue-related organizations such as the Council of Canadians and IUCN–International Union for Conservation of Nature may also be important contributors at a national or regional scale. Where such organizations exist, they should be involved in the participatory processes. A thorough analysis of the contributions of the NGO sector to the Millennium Development Goals and to water management, showing the unique characteristics of different kinds of NGOs, their contributions, their limitations and a perspective on their future role would be a useful contribution to the related literature.

Participation in the irrigation sector. Along with market tools (such as privatization and removal of subsidies), water management policies have been shaped by calls for a more participatory development approach that advocates smaller government and local participation in governance, management and financing. At the

same time, to comply with the structural adjustments required by international financial institutions in the last few decades, governments have decreased public spending in most sectors and disengaged from them. Such strategies have led to major changes in water management, particularly in irrigation, where governments have embarked on reform.[9]

One of the most important and far-reaching reforms is the irrigation management transfer that has been taking place in more than 57 countries on 5 continents (box 4.3). Overall, this transferring of responsibility and authority for managing irrigation systems from the public sector to the community has forced a new look at how services are provided to users and a move from supply-driven to demand-driven approaches. And the closer involvement of water user associations has resulted in increased accountability, transparency and responsibility, as has been reported in China and Mexico, for example.[10]

Participation reduces corruption

Global Corruption Report 2008: Corruption in the Water Sector estimates that corruption in the water sector can raise the investment costs of achieving the Millennium Development Goals target for water and sanitation by almost $50 billion.[11] Corruption in the sector includes falsified meter readings, distorted site selection of boreholes or abstraction points for irrigation, collusion and favouritism in public procurement and nepotism in the allocation of public positions.

Corruption remains a poorly addressed governance issue in the water domain. This domain is a high-risk sector for corruption because water service provision is a near natural monopoly. The resource is becoming increasingly scarce in many countries, and the water domain involves large and often complex construction contracts. Furthermore, water has multifunctional characteristics and is used and managed by a mix of private and public stakeholders.[12]

Corruption – on a petty or grand scale – occurs across the water spectrum and among all water sector actors. According to *Global Corruption Report 2008,* in some countries corruption siphons off as much as 30% of the budget.[13] By diverting funds from investment or operation and maintenance, corruption reduces access to water. And for many poor people, paying bribes is the only means of securing access to water supplies.

Corruption undermines poverty reduction efforts and impedes economic, social and sustainable development. Poor people generally suffer most from corruption, overpaying for water service delivery or bearing the health burdens arising from lack of sustainable access to safe drinking water. The indirect costs of corruption are also high. There is a strong correlation between access to adequate water and sanitation and infant mortality (see chapter 6).

Corruption can lead to uncontrolled pollution of water sources, overpumping and depletion of groundwater, lack of planning, uncontrolled degradation of ecosystems, weakened flood protection, urban expansion leading to heightened water tensions, and other harmful effects. In water-scarce southern Spain tens of thousands of properties have been developed illegally, particularly in seaside resorts. In the Andalucian city of Ronda this practice led to a severe governance crisis, and pollution now jeopardizes water supplies.[14] Where corruption is widespread, achieving the Millennium Development Goals will take much longer – not only with much higher cost in direct investment in services and management, but also in indirect costs, such as water-related diseases and loss of lives, ecosystems and productive capacities. It also threatens

Corruption remains a poorly addressed governance issue in the water domain

Box 4.3 Experience with irrigation management transfer

Irrigation management transfer is the transfer of responsibility and authority for managing irrigation systems to water user associations. It began in the 1960s in Taiwan, Province of China; Bangladesh; and the United States; in the 1970s in Mali, New Zealand and Colombia; and in the 1980s in the Philippines, Mexico, Tunisia and the Dominican Republic. It peaked in the 1990s in Turkey, Morocco, Australia, Peru, Albania and Zimbabwe, but still continues in countries such as Pakistan and Sudan (2000), India (2001) and China (2002), each with unique experiences and results.

The Food and Agriculture Organization of the United Nations and International Water Management Institute database on experience with irrigation management transfer provides information on the key factors that motivated adoption of the new policy. The most commonly cited is a shortage of government funds for operating and maintaining the system, followed by difficulties with fee recovery.

Overall, the results have been mixed. Financial sustainability and lack of clarity about the financial and technical assistance provided to water user associations by the government have been a concern. Monitoring and evaluation are essential. The concept of 'farmer participation' was often translated into a fixed set of principles, such as volumetric control, cost recovery, water pricing, economic, water use efficiencies and downstream control, that were not relevant in all contexts. For example, Andean farmer-managed irrigation systems typically have upstream control techniques and management structures, which provide transparency and ease of operation. For them, participating in water distribution usually means involving everyone in the system's management and decisions on water distribution to individual fields.

Source: Garces-Restrepo, Vermillion, and Muñoz 2007; Boelens 2008.

Corruption is an important driver of uncontrolled pollution of water sources, overpumping and depletion of groundwater, lack of planning and uncontrolled degradation of ecosystems, diminishing flood protection, urban expansion leading to heightened water tensions and other harmful effects

existing achievements by undermining institutions and the sustainability of infrastructure.

Legitimate, transparent and participatory processes can be effective in garnering support for the design and implementation of water resources policy and of deterring corruption. But participatory processes require adequate institutional, policy, legal and economic instruments. Political leadership is required to put these processes in place and demonstrate support for them. International assistance and interventions to reduce corruption will have only limited effect if political will is absent.

Implementing regulations

Water resources management is underpinned by a functioning legal system that includes:

- Water resources legislation, the province of the legislature and the executive.
- Implementation and administration of legislation, the province of the executive.
- Adjudication of civil disputes among water litigants, the province of the judiciary.
- Prosecution of criminal offenders by the executive and the judiciary.

Following adoption of a law by the legislature, the executive needs to address relevant details not included in the legislation by preparing implementation regulations. Neither legislation nor implementation regulations will make much difference, however, unless they are effectively administered by the water resources administration. Nor will they secure rights in the resource unless a judiciary can adjudicate disputes effectively, impartially, expeditiously and transparently. Finally, the legislation needs vigorous enforcement and systematic monitoring, using a set of indicators to gauge effectiveness and improve system performance.

Challenges

Water resources development and management in the interests of national development objectives require effective policy and legal frameworks that also respect deeply rooted customary practices. Participatory processes that take account of the social, economic and cultural characteristics of the country or community will make a significant contribution to meeting this challenge. But a greater challenge is to ensure that such laws and the regulations that support them make a difference on the ground by effectively administering and enforcing them. And the security of rights in the resource must be adjudicated by an effective, impartial, expeditious and transparent judicial system.

Financing – the missing link

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Virtually all water-related activities, whether structural (infrastructure) or not (planning, data collection, regulation, public education and so on), require money to develop, implement and carry out. Even if all the necessary policies and laws are in place, lack of funding will bring necessary actions to a standstill. Adequate funding and the willingness to invest in water management and infrastructure are therefore major determinants of the availability of sufficient quantities of water of acceptable quality.

Although water is often described as a 'gift of nature', harnessing and managing water for human and ecological needs entail financial costs. These costs are often widely ignored, underestimated or underfunded, with the result that important functions and assets are neglected and underprovided, while existing assets and services deteriorate.

Three functions are involved in water management, each with associated costs:

- Water resources management and development, including watershed and river basin development, storage, flood-risk management, environmental protection and pollution abatement.
- Water services to municipalities and households, commerce and industry, agriculture, and other economic sectors, including the costs of wastewater treatment, rehabilitation, operations and maintenance and inadequate infrastructure.
- Integrative functions, such as water sector policy development, research, monitoring, administration, legislation (including compliance and enforcement) and public information.

The costs associated with these functions are either capital (investment) costs or annual recurrent costs, both variable and fixed. To function properly, the water sector must cover all costs – not just those of major physical infrastructure – in a sustainable way. That means ensuring reliable, predictable finance from government revenues (taxes), the sale of water services or long-term aid commitments.

Financing is often a limiting factor in effectively managing the water sector. The solution is to focus not only on increasing flows of funds to the sector but also on achieving a realistic balance between the demand for and supply of financing to ensure financial sustainability. Demand for funds needs to be rationalized by developing realistic investment plans, minimizing the recurrent costs of service delivery and ensuring the sustainability of water resources and the safe and reliable delivery of services to maintain users' willingness to pay.

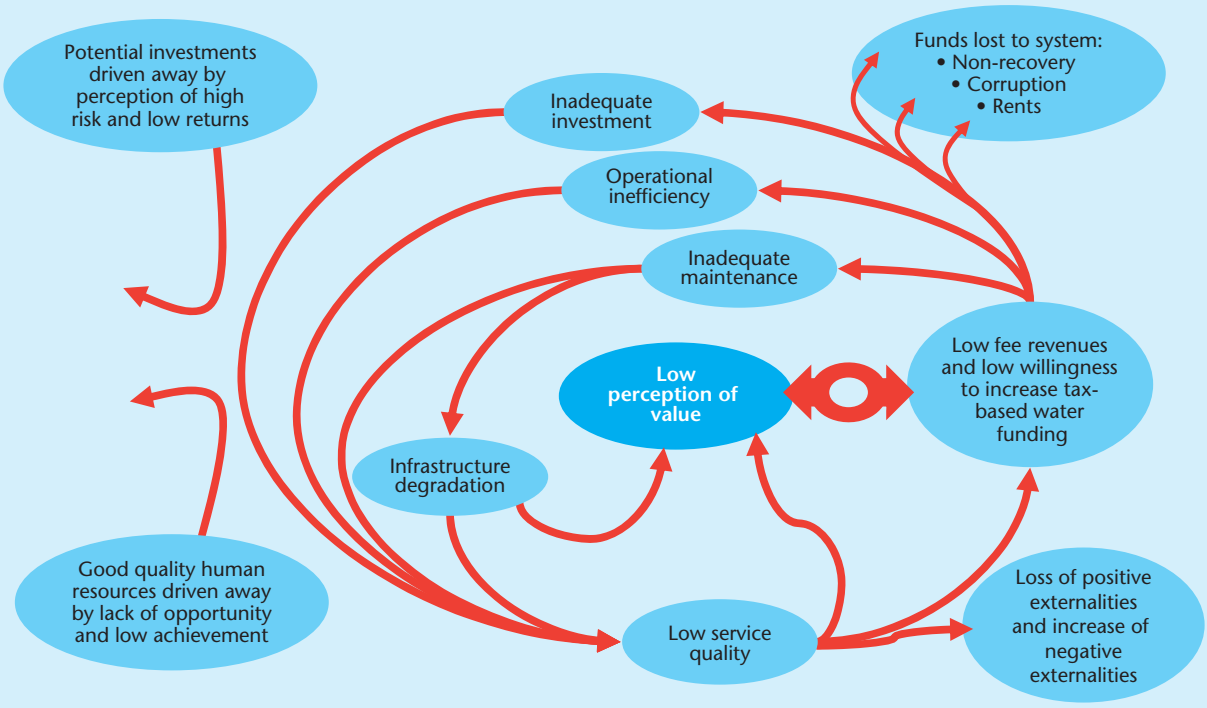
The logic differs for the three sources of finance for the water sector. The rationale for local user financing is users' consumption of the resource and local authorities' responsibility in most cases for the main decisions about water services and tariffs. The rationale for national government finance is often the national or regional benefits to be gained from managing the resource. Capital investment costs tend to be covered largely by governments, except where assets are privately owned (for example, farmers who have their own infrastructure). The international community provides mainly 'catalytic' funding to jumpstart projects, which includes providing financial guarantees. Decisions made at the international and national government levels are most likely to be outside the 'water box', while local user concerns more directly address specific systems for water supply and sanitation.

Investment in water management capacity

The water sector has been plagued by lack of political support, poor governance, underresourcing and underinvestment. These ills are manifested in non-transparency, lack of accountability, unsustainable economics, high levels of unaccounted for water and low revenue collection. They have led to infrastructure deterioration, the breakdown of services and ultimately customer dissatisfaction. Figure 4.2 illustrates how this combination of factors creates a vicious cycle of low funding, weak political support and poor service provision. Breaking this vicious cycle will require more than investments in hardware.

Lack of political support, poor governance, underresourcing and underinvestment in the water sector have led to infrastructure deterioration, the breakdown of services and ultimately customer dissatisfaction

Figure 4.2 **If the vicious cycle of low funding is reversed, the benefits to society will be enormous**



Source: J. Moss based on ideas from A. Mathys; Moss et al. 2003.

In most urban public water systems charges barely cover the recurrent costs of operation and maintenance. In rural areas neglect of operation and maintenance and cost recovery contribute to widespread non-functionality

Investment is also required in the operation and maintenance of physical infrastructure so that it meets appropriate standards and functions efficiently. Operations and maintenance are neglected nearly everywhere in favour of new infrastructure investments, regardless of the country's level of development. In the United States bringing water supply and sewerage infrastructure up to current standards will cost more than $1 trillion over the next 20 years, with hundreds of billions more required for dams, dikes and waterway maintenance.[15] The World Business Council for Sustainable Development estimates that the total costs of replacing ageing water supply and sanitation infrastructure in industrial countries may be as high as $200 billion a year.[16] Investment in physical infrastructure must be accompanied by the 'soft' infrastructure of policies and legal systems (as described earlier) and human capacity.[17] Yet much bilateral aid for sanitation and drinking water fails to achieve a balance between soft and hard infrastructure (figure 4.3).

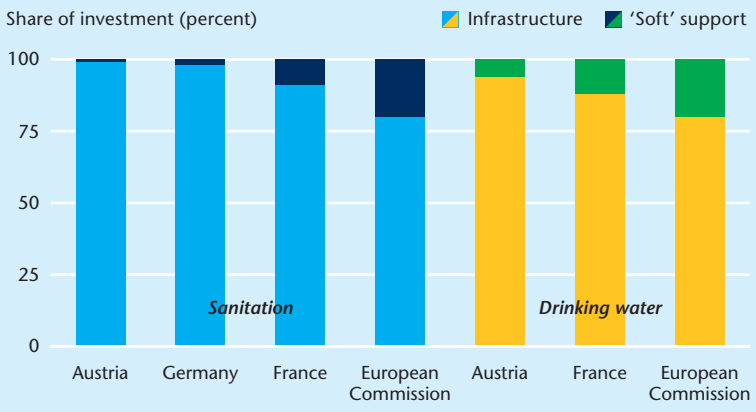
In most urban public water systems charges often barely cover the recurrent costs of operation and maintenance, leaving little or no funds to recover the capital costs of modernization and expansion. A survey of such systems in 132 cities in high-, middle- and low-income countries found that 39% did not recover even their operation and maintenance costs (true of 100% of cities in South-East Asia and the Maghreb).[18]

Moreover, water infrastructure deteriorates over time. To keep it functioning properly requires routine repairs, service and replacement of worn parts. These activities, easy to postpone, are widely neglected. The result is infrastructure that deteriorates to a level that can no longer provide reliable access to safe drinking water to those who are nominally receiving the service. Leakage (loss) rates of 50% are not uncommon in urban distribution systems. Much of the apparatus for treating wastewater is also failing. According to a report by the Task Force for the Implementation of the Environmental Action Program for Eastern Europe, Caucasus and Central Asia, municipal water utilities have now become the main polluters of surface waters in many East European, Caucasus and Central Asian countries. The task force reports that up to 90% of nitrogen and phosphorus discharges into the Black and Caspian Seas originate from riverine inputs, which mostly transport municipal wastewaters.[19]

In rural areas neglect of operation and maintenance budgets and cost recovery contribute to widespread non-functionality. A recent survey of almost 7,000 rural water schemes in Ethiopia found that 30%-40% were non-functional.[20] A shortage of finance for wages, fuel, materials and spare parts was a common factor.

The deficit in financing, especially for operation and maintenance costs, is a substantial addition to the investment costs of achieving the Millennium Development Goals. Although governments often turn to external aid to fill financing gaps, donors also seem to favour financing new infrastructure over operation and maintenance (see figure 4.3).

Figure 4.3 **New infrastructure seems to dominate donor investments in drinking water and sanitation**



Note: Soft support includes support for policies, legal systems and human capacity building.
Source: Based on data from UN-Water 2008.

High costs of new and remedial infrastructure

While operation and maintenance costs have been especially neglected, water infrastructure has not been funded at anything close to the required level. Many networks and installations in mature economies are ageing and deteriorating. Member states of the European Union are committed to upgrading their water and wastewater treatment systems to comply with EU environmental legislation. But many urban water systems in Eastern Europe, Caucasus and Central Asia are in poor condition, with no similar plans for upgrades. In developing and emerging market economies the pace of growth and urbanization, combined with rising environmental expectations, is creating the need for costly new investments.

Table 4.3 gives a sense of the magnitude of investment requirements over the next

20 years for water supply and wastewater services infrastructure and the gap between financing needs and projected revenues, by region. These calculations do not include other sizeable funding requirements, such as water resources development and management and water governance.[21] Raising and spending these huge sums will require quickening the pace of reform (including water pricing) across the water services industry, with implications for both regulators and consumers.

The cost of rehabilitating or decommissioning existing infrastructure is likely to be enormous. Repairing, strengthening or modifying older dams, for instance, will entail sizeable outlays. In extreme cases decommissioning a dam may be a rational decision (where it has outlived its purpose, where it is old and unsafe, where sedimentation is high or where river flows need to be maintained for fisheries and other ecosystems). Rehabilitating or decommissioning also depends on whether the costs of maintaining the dam exceed its expected future economic and financial benefits. Both rehabilitation and decommissioning costs are site specific.[22]

The cost of new water supply is rising. In developed countries and in many places elsewhere, the easiest investments for exploiting water resources have already been made. With available dam sites decreasing, water tables falling and the distances between the point of abstraction and water use increasing, the costs of exploitation and supply are rising. Costs are also pushed up by the growing need to treat water before use.

Sanitation has been severely neglected. Estimates of the cost of achieving the 2015 Millennium Development Goal target for sanitation vary widely, due to differences in approach and a weak information base. The World Health Organization estimates the total annual cost of meeting the target at just over $9.5 billion.[23] If estimates of current costs are correct, resources in the sanitation sector would have to be almost doubled to meet the 2015 target (although estimates of current spending probably underestimate the contributions by households to their own sanitation services). If the full cost of tertiary wastewater treatment for waste streams in urban areas is added, the total rises to $100 billion, the current value of total annual official development assistance. More cost-effective alternatives need to be explored – urgently – if the sanitation target is to be met.

Table 4.3 **Annual capital requirements for water supply and wastewater services and water financing gaps, by region, 2006-25**

(US$ billions)

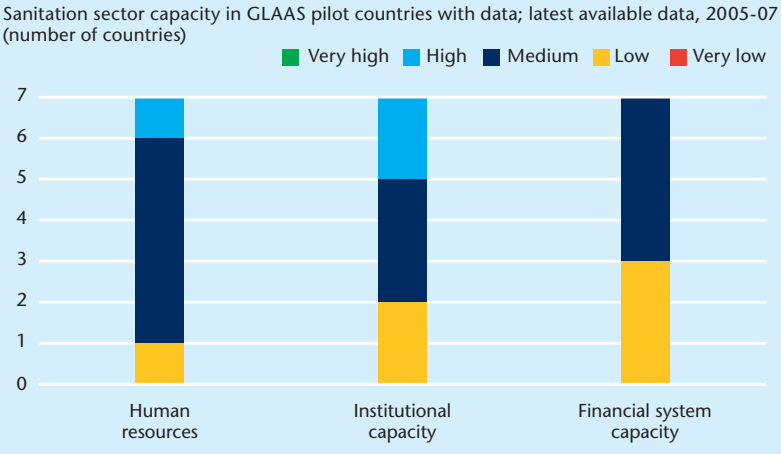
Region	Capital needed	Low gap	Medium gap	High gap
Eastern Europe, Caucasus and Central Asia	28.1-40.5	13.4	20.0	26.1
North America	23.9-46.8	3.3	4.9	21.4
Latin America	4.3-6.5	2.9	4.0	5.1
Developed Asia and China	38.2-51.4	29.5	32.9	36.5
Rest of world	14.3-22.6	18.5	22.4	26.1
Total	92.4-148.0	67.5	84.2	115.2

Note: The gaps refer to the difference in projected investment needs for three different estimates of their size and existing sources of revenue from tariffs, official development assistance and government budgets and loans.
Source: Owen 2006.

UN-Water Global Annual Assessment of Sanitation and Drinking-Water: 2008 Pilot Report – Testing A New Reporting Approach (GLAAS report) looks at the constraints to progress towards the sanitation target from the human resources, institutional capacity and financial system capacity perspectives (figure 4.4).

Operation, maintenance and rehabilitation remain critical challenges. Respondents to the GLAAS survey indicated that flooding events and earthquakes were the main causes of damage to infrastructure.[24] Increased weather variability linked to

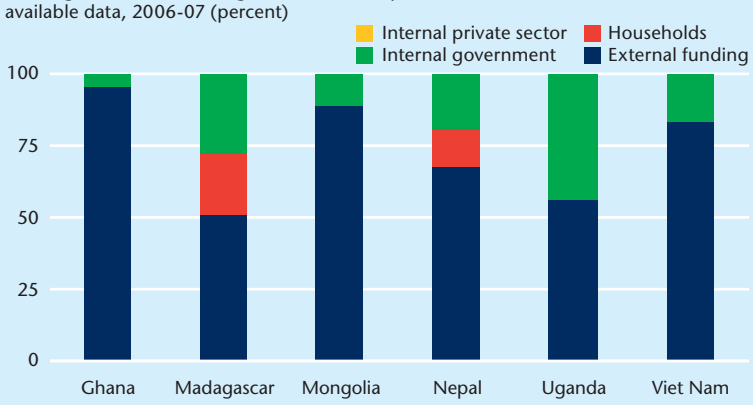
Figure 4.4 **In the few countries surveyed financial system constraints weighed heavily on achieving the Millennium Development Goals sanitation target**



Note: GLAAS is Global Annual Assessment of Sanitation and Drinking-Water.
Source: Based on data from UN-Water 2008.

Figure 4.5 **Household expenditure and private sector investments in drinking water supply are generally unknown**

Funding sources for drinking water in GLAAS pilot countries with data, latest available data, 2006-07 (percent)



Note: GLAAS is Global Annual Assessment of Sanitation and Drinking-Water.
Source: Based on data from UN-Water 2008.

climate change and armed conflict bring added risk.

African countries, recognizing the urgency of the situation, signed the eThekwini Declaration in February 2008 in Durban, South Africa, committing them to prepare or update national sanitation and hygiene policies, allocate budget funds for sanitation, improve sanitation information and monitoring tools and increase capacity. The declaration also called on external support agencies to provide financial and technical assistance for sanitation and hygiene promotion and to improve aid coordination.

Sources of financing

There are three sources of revenue for financing water supply and sanitation services:

- User tariffs, including payment for environmental services, which can include cross-subsidies within the sector or from other sectors (for example, electricity or other municipal services).
- Public expenditures funded by taxation.
- Transfers in the form of external aid, from official or philanthropic sources.

External borrowing (debt, equity and bonds, facilitated by risk-management instruments such as guarantees) can help spread payments over time for large up-front investments and manage the overall cost of financing.

The 2008 GLAAS pilot report raises concerns about countries' limited resources to invest in operation, maintenance and capital rehabilitation for drinking water and sanitation systems.[25] These expenditures are difficult to assess because many are hidden in sector budgets or are not accounted for, as in the case of many private sector and household investments (figure 4.5). Data in the GLAAS report, available for three of the seven pilot countries, indicate that external funding – for many countries the main source of funds for drinking water and sanitation system investments – is directed mainly to infrastructure projects.

Reviewing and revising investment needs (the demand side of financing) by reducing costs are as important in closing the financing gap as finding new sources of funds. The full cycle of expenditures has to be considered, from operation and maintenance to technological choices about equipment and its eventual replacement or upgrading. For example, improving collection efficiency and reducing unaccounted for losses in distribution systems can make more water available for new consumers and help fund operations. Demand-side considerations also include such underlying determinants as coverage levels, services levels and environmental regulations.

Fund disbursements can also be accelerated, so that disbursement delays do not cause new funding to be postponed. Inefficient budgeting and budget allocation processes can lead to such disbursement delays. To ensure that funds are disbursed more efficiently during the budget period, funds can be allocated to regions of a country or to local authorities according to their relative capacity to implement projects. Finalizing the budget process before the budget year starts makes it possible to begin disbursements in the first quarter of the year.

A strategic financial plan, based on an in-depth examination of all demand- and supply-side aspects affecting the financing gap, will help ensure the financial sustainability of projects. It will direct investment choices towards the most financially and functionally appropriate processes and technologies, thus maximizing benefits. And it will make projects more attractive to external financiers by reducing the perception of risk.

A lot of funds move through the water system but is used inefficiently. Examples include high payments to informal providers outside the public networks, payments

to corrupt operators to obtain water from networks and large public subsidies that end up in the wrong hands. Households spend large sums on coping strategies, such as time and money spent on alternative sources of water and on household water filters.

Tariffs – pricing water and willingness to pay. The obvious source of finance for the recurrent costs of water services is user charges, supplemented by government subsidies. The continuing underpricing of water to consumers encourages waste and use of water for low-value purposes in all sectors, depriving the sector of essential funds. This is a major contributor to underinvestment in water infrastructure, management and services and imposes heavy costs on society.

Maintaining the quality and reliability of services is essential (box 4.4), even if there is a parallel push for increased access, since these characteristics affect users' willingness to pay. Transparency, accountability and operational efficiency in service provision are also essential to user satisfaction. Affordability also needs to be determined. It is based on macroaffordability – of investment choices (driven by coverage, service levels, technology and other choices) and the cost efficiency of service provision – and household affordability, determined by current expenditure on water and sanitation services (including the hidden costs of securing access when people lack access to formal services and the consequences of access to unsafe services) and their willingness to pay for improved service levels.

Charging for water. Although prices can be strong drivers of positive change in a well functioning economic system, in practice, prices have had a relatively minor role in managing water demand. Many people are deeply ambivalent about using water prices to manage water resources or are strongly opposed to pricing water at the cost required to deliver it to consumers, especially in the politically sensitive segments of agriculture and urban households. As a result, water is often grossly underpriced.

One survey of municipal water utilities in low-income countries found that 89% had no cost recovery measures in place, 9% had partial cost recovery of operation and maintenance costs, and only 3% made any effort to recoup the costs of capital outlays.[26]

A common yardstick for assessing the affordability of water charges for households is that payments should not exceed 3% (in some cases 5%) of net household income. In practice, surveys show that in developed countries households connected to urban public systems pay on average 1% of incomes on water bills, including the cost of sewerage, which may be double that for water. Such an average is not a very reliable indicator, however, especially given the wide variability among income levels in a country. Generally speaking, poorer groups tend to pay a higher share of household income for water. In developing countries the picture is complicated by the widespread use of informal and small-scale private water distributors charging full market prices; in these cases the poorest households can pay 3%–11% of income on water.[27]

As recognition of this inequitable economic burden on the poor has spread, pressure on governments and service providers has increased to ensure delivery of a minimal supply of potable water to all households at a reasonable price. Achieving this objective would require tariff rates based on a household's ability to pay and subsidies that cover the excess cost of service delivery for those who can least afford to pay.

Where pricing is used to cover water supply costs (for example, cities committed to water demand management, private irrigation schemes, markets for irrigation water and penalties for water pollution), it is an important driver of reforms. Where

Box 4.4 Dalian water supply project in China – successful expansion of services

Dalian, a port city at the southern end of the Liaodong Peninsula, in northeastern China, was declared an 'open' coastal city in 1984 and given considerable autonomy in its economic planning. The Dalian Economic and Technology Development Zone, established in 1988, has become one of China's most successful economic zones. By the early 1990s, however, water shortages had become a serious constraint to economic growth. Many areas had water service for only a few hours a day. Frequent service disruptions had major public health implications. The Dalian Water Supply Project, begun in the mid-1990s, provided new infrastructure to address the water shortages and meet increasing water demands.

The project achieved its objectives. All constructed facilities were operating satisfactorily, and the 73,000 residential water connections in Dalian exceeded the predicted number. The project also increased water supply to commerce and industry, removing potential constraints to economic expansion and improving the investment environment. The project evaluation confirmed two important findings. Local government commitment was the most important contributor to the success of the project. And water consumers will accept the need for higher tariffs once they are convinced that services are adequate and reliable. Water tariffs were increased substantially from 1995 to 2001, at an average annual rate of 12.8%.

Source: ADB 2004.

Where prices cannot adjust to financial realities, stresses emerge as water shortages, water waste, inefficient water use, inadequate water infrastructure investments and poor water-related services

prices cannot adjust to financial realities, stresses emerge as water shortages, water waste, inefficient water use, inadequate water infrastructure investments and poor water-related services. Water quality may be inconsistent, and maintenance and rehabilitation of distribution systems may be neglected. Capital investment may also be inadequate, resulting in the failure to develop adequate water supply and sanitation services. However, even in situations where pricing is actively used to cover water supply costs, the long history of water as a public good means that water prices have been heavily subsidized by tax-funded distributions from individuals and corporations that may not be direct beneficiaries of the services provided.

In agriculture some farmers rely on public irrigation systems while others have private arrangements (for example, groundwater and water harvesting systems). In privately owned systems energy subsidies (for pumping water) are a key factor affecting efficiency. Farmers using public irrigation systems often pay little or nothing towards recurrent costs and usually nothing towards the capital costs of the irrigation infrastructure. This affects how farmers use water, as one survey in India discovered:

> Farmers have no incentive to use water efficiently as charges are too low and are based on the area irrigated. Inefficient water use has led to severe environmental problems – rising groundwater levels, water-logging and soil salinity. Administration is ineffective. Assessment and collection of fees is often carried out by different departments, or a department not related to irrigation. Farmers need to be involved in setting rates, because at present they simply oppose any suggestion of an increase in price.[28]

Though widely accepted, the 'polluter pays' principle has not had a major impact on polluters' behaviour or on raising funds that could be allocated for environmental purposes, with the exception of developed countries and a much smaller number of developing countries. Although not a financing source, the alternative method of water pollution quotas has similarly been limited to the industrial, urbanized economies, with almost negligible successful examples from developing countries (see chapter 8).[29]

Multipurpose water projects that cross-subsidize irrigation and household water use from hydropower revenues are another form of tariff-based financing. The hydropower components of dams and water storage schemes tend to perform better financially than the associated irrigation projects, which often fail to recover both operating and capital costs. Thus, the power element cross-subsidizes irrigation and other water users – and often navigation, flood control and other public goods as well. In the United States this kind of cross-subsidy was a planned part of the management of the Grand Coulee Dam in the Columbia River Basin and of the major river basin development works of the Tennessee Valley Authority.[30]

Role of the private sector. Several reports conclude that the private sector provides very few water supply and sanitation services in developing countries. The United Nations Development Programme's *Human Development Report 2006,* for example, estimates that although the number of people served by the private water sector grew from roughly 50 million in 1990 to 300 million in 2002, less than 3% of people in developing countries are covered by private or partially private companies.[31] These figures almost certainly understate the real scale of private sector service provision, since they consider only larger-scale private operations and investments. Private operators also include small and medium-size companies with fixed or mobile distribution systems as well as the much larger spread of informal operators that cover huge swathes of low-income urban areas.

The substantial role of small and medium-size entrepreneurs and operators is just beginning to be studied (figure 4.6). A World Bank report found 10,000 small service providers in a limited sample of 49 countries,[32] while an International Institute for Environment and Development study estimates that the global number may exceed 1 million.[33] In addition, the provision of infrastructure by property developers has not been examined but could be substantial.

The landscape for private water operators today is very different from that of a decade ago. Several major multinationals have withdrawn from international projects, leaving just two or three to pursue system concessions, build-operate-transfer and management contracts, especially in the Middle East, China and South-East and East Asia. The gap is being

filled by new private water companies based mainly in China, South-East Asia, the Russian Federation and Latin America, servicing emerging local and regional markets. Small-scale and informal water providers have continued to enlarge their share of urban markets in developing countries.

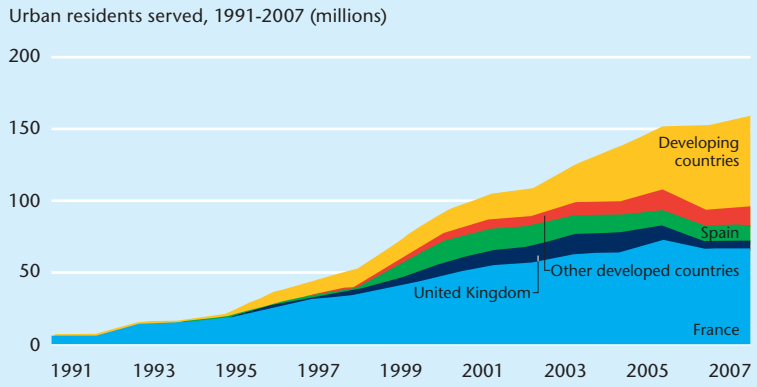
A high proportion of the contracts won by the new market entrants are for desalination and wastewater treatment, which address the growing water scarcity in arid regions and the serious pollution caused by untreated municipal wastewater. The diversity of the new market entrants, their access to local sources of finance and their typically good political connections augur well for successful implementation.

External private investment in the water sector is significant, of the same order as that of official development assistance (figures 4.7 and 4.8). The domestic private sector is becoming a water funding source in some middle-income countries, where powerful local conglomerates are moving into water services, drawing on their own equity and that of other local commercial sources. Further down the financial scale small informal operators dominate large portions of the water market in urban and peri-urban communities. Although some of these operators invest in networks, most use mobile facilities, financed by their own equity or short-term credit. At the street level bottled water sellers have proliferated. A necessity in many areas across developing countries, where failing public supply systems are often contaminated by wastewater or storm water, the use of bottled water is a lifestyle choice in developed countries.

Government financing from public revenues. The public sector accounts for more than 70% of investment in the water sector.[34] There are marked differences in how – and how much – governments finance and subsidize the water sector. In many poor countries, where fiscal constraints are severe, water supply is only one of many priority sectors that governments are under domestic pressure or international commitment to finance.

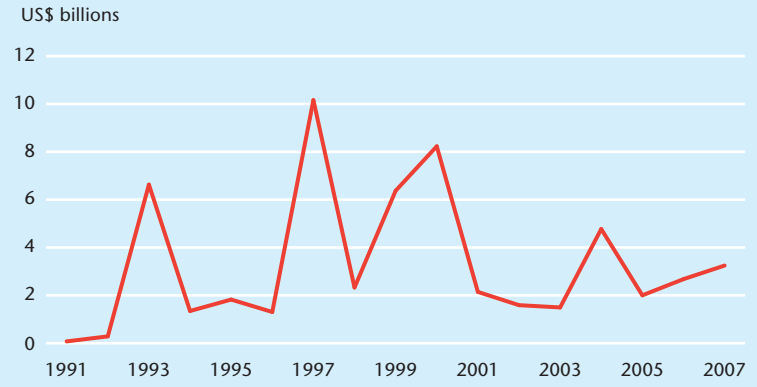
Funding for infrastructure has varied with economic development and urbanization. At earlier stages the central government generally supports infrastructure provision through subsidies and administrative assistance (box 4.5). As countries develop, the portion of central government support declines, and the cost of environmental

Figure 4.6 Private water operators have a substantial role in developing and developed countries



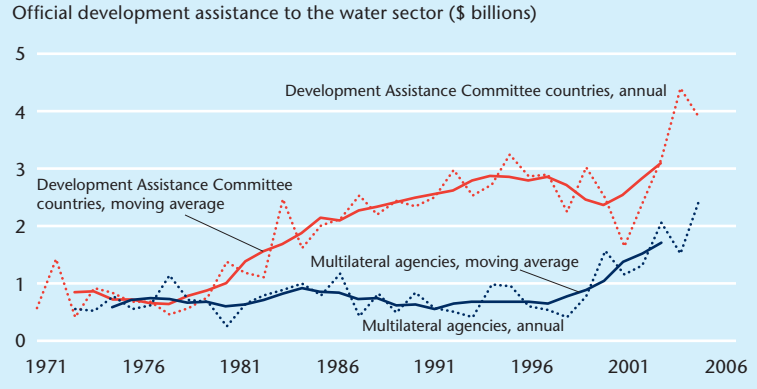
Source: Based on data from Marin 2009.

Figure 4.7 External private investment in the water sector, though variable, has been significant since the early 1990s



Note: Refers to management and lease contracts, concessions (or management and operation contracts with major private capital commitments), greenfield projects and divestitures for potable water generation and distribution and sewerage collection and treatment.
Source: World Bank Private Participation in Infrastructure Database (http://ppi.worldbank.org).

Figure 4.8 Official development assistance to the water supply and sanitation sector is rising again after a decline during the 1990s



Source: Based on OECD-DAC 2008.

G-8 leaders in June 2002 made a commitment to give priority to the water sector

services is transferred to users, polluters and local governments.

Some countries that have benefited from debt relief or from the oil and commodities boom have transformed their public finances, but this has not necessarily translated into improved water service provision. Several emerging market economies, with large concentrations of poor, unserved populations, are in stronger budgetary positions than they were a decade ago, though this is being placed at risk by the recent fluctuations in the cost of oil, power and food and the global financial crisis, with subsidies rising accordingly. Improving budgetary circumstances provide opportunities for increasing investments in the development of the water sector.

Financing through external aid. Official development assistance from donor countries and multilateral donors to the water supply and sanitation sector increased during the 1970s and 1980s but decreased during the 1990s, with less aid for large infrastructure, before rising again in 2000 (see figure 4.8).

Support from multilateral agencies remained relatively stagnant from the 1970s – when it was about the same as bilateral assistance – until about 2000, when both sources of financial aid began to increase. But it still remained substantially less than official development assistance from bilateral sources.

Leaders at the meeting of the G-8 in Evian, France, in June 2002 made a commitment to give priority to the water sector. Official development assistance increased substantially in the years immediately thereafter. While the amount going to the water supply and sanitation sector increased, aid to the other water sectors remained relatively unchanged (table 4.4). However, overall lending for water remained at less than 6% of total official development assistance, and the share of total lending declined.

External assistance from philanthropic sources, such as foundations and religious groups, highlights an awareness of the importance of water and sanitation. Although these funds are generally much lower than those from multilateral and bilateral sources, a few of the largest foundations (for example, the Bill and Melinda Gates Foundation) can rival some bilateral sources.

Box 4.5 Subsidizing water supply and sanitation in the Republic of Korea

In the Republic of Korea the central government provides direct subsidies for water supply and sanitation infrastructure to local governments or service providers. The amount of the subsidy depends on the size of the city and the type of facility. Subsidies differ for construction and operation. Typically, subsidies are 50%-80% for water source development in rural areas and 50% for local waterworks improvements. Wastewater treatment is eligible for a 50% grant, and sludge treatment for loans of 30%-70%.

For municipal water supply, revenue from tariffs now covers an increasing share of production costs, rising from 69% in 1997 to 83% in 2005. For regional water supply systems supplied by the national water company, Korea Water Resources Corporation (K-water), full cost recovery was achieved by 2004. Tariffs still fall short of actual costs for sewage treatment. During 1997-2004 the central government paid 53% of the total investment costs for sewage treatment, using proceeds from the national liquor tax.

Source: OECD forthcoming.

Table 4.4 Commitments of official development assistance from bilateral and multilateral agencies, 2004-06

(US$ millions)

Sector	2004	2005	2006
Water transport	416	503	304
Hydropower plants	755	480	652
Agricultural water resources	608	830	790
Water supply and sanitation	3,127	4,405	3,879
Total water sector	4,951	6,218	5,625
Total all sectors	79,431	107,078	104,369
Water sector as share of all sectors (%)	6.2	5.8	5.4

Source: OECD, DCD/DAC 2007.

Recent financing initiatives – a new financing agenda

Over the last five years there have been several key initiatives on shaping the agenda of international water financing, notably the World Panel on Financing Water Infrastructure (chaired by Michel Camdessus), the Task Force on Financing Water for All (chaired by Angel Gurria) and the UN Secretary-General's Advisory Board on Water and Sanitation (UNSGAB). *Financing Water for All,* the report of the World Panel on Financing Water Infrastructure, addresses the financial architecture of the global water sector, including many proposals to improve its governance.[35] The Gurria task force report focuses on factors influencing the demand for finance and the scope for developing the financial capacity of subnational entities.[36] The UNSGAB stresses the importance of capacity building, especially in local authorities, and inspired creation of the Global Water Operators Partnership Alliance for peer group support.[37]

These initiatives occurred while domestic savings in emerging market economies were growing rapidly and local capital markets were developing. Sharp rises in the price of oil and other primary commodities had enriched producer countries and transformed their public finances, while causing budgetary problems in primary-commodity-importing countries. International commercial finance for water has become sharply polarized. Lenders and portfolio[38] investors have eagerly pursued opportunities in sound water companies, solvent municipalities and profitable projects (such as desalination), but many countries and municipalities have been relegated to financial backwaters.

Lenders and investors have pursued opportunities in sound water companies, solvent municipalities and profitable projects, but many countries and municipalities have been relegated to financial backwaters

Recent policy developments

A number of policies and financing tools have been developed to respond to this new agenda:[39]

- *Increasing commitments of official development assistance for water – and in more user-friendly forms.* International aid for water has bottomed out and commitments are starting to rise, led by a few donor agencies.

- *Using official development assistance to leverage other financial sources.* An approach that has made a promising beginning in Kenya and elsewhere is to use output-based aid to promote microfinance.

- *Establishing national water financing strategies.* Governments in Africa, Eastern Europe and the Caucasus and Central Asia and elsewhere are producing coherent financing strategies, supported by programmes of the Organisation for Economic Co-operation and Development, the EU Water Institute, the World Bank Water and Sanitation Program and other agencies and programmes.

- *Promoting finance to subsovereign entities.* In most countries responsibility for water services is devolved to subsovereign layers of administration. Donors have been adapting their products and procedures to facilitate the provision of finance to subsovereign agencies.

- *Establishing facilities to provide finance at decentralized levels.* Much of the development of household water and sanitation services arises from community initiatives, organization and finance. Among recently created finance facilities that operate at this level are the African Water Facility, the EU Water Facility and the Rural Water Supply and Sanitation Initiative of the African Development Bank.

- *Developing guarantees and risk-sharing instruments.* Guarantees and other forms of credit enhancement can lift local borrowers and bond issuers over the critical threshold of creditworthiness and mitigate specific risks. International financial institutions and other agencies have improved their capacity for risk sharing, and several new bodies have been formed specifically for this purpose (such as GuarantCo).[40]

- *Developing local capital markets and local-currency finance.* A number of countries (such as India and South Africa, some countries in Latin America and South-East and East Asia) have municipalities and utilities with sufficient financial standing to attract loan finance or to issue their own bonds. A significant proportion of the unserved populations (almost a half for water and more than a third for sanitation) live in countries classified as middle income, with the potential to raise subsovereign finance of this type.

- *Increasing role of small-scale local water providers.* It is estimated that small-scale providers serve 25% of the urban population in Latin America and East Asia and 50% in Africa and South East Asia.[41]

- *Instituting tariff reform and the principle of sustainable cost recovery.* In most cases tariffs will be the main source of revenue for covering the recurrent costs of water services, although full cost recovery through tariffs is rarely feasible in poor countries. Sustainable cost recovery focuses on securing all three of the basic sources of revenue for water and sanitation services (tariffs, taxes and external aid) as predictable sources of revenue for water operators, which can be used to leverage other sources of funding.

- *Paying for environmental services.* Environmental goods and services take many forms, including potable water supply, irrigation water, flood control benefits, water for transportation and aesthetic benefits. Payment

systems for such environmental services are easier to implement and administer for more visible and direct uses (such as admission costs for recreational uses).

Challenges

Developing and managing water resources to meet human needs and maintain essential ecosystems entail financial costs. The challenge is both to have more funds flow to the water sector and to ensure its financial sustainability. Sound, strategic financial planning is needed to balance funding requirements with cost-effective management that focuses on demand as well as supply. Full cost recovery has been advocated as a solution to the water financing crisis for many years. In the real world, however, water resources management and services delivery always receive some level of subsidy. Keeping in mind the obligation to meet the basic water services needs of all, the challenge for policy-makers is to make decisions about the acceptable trade-offs among different objectives and about who bears the costs.

Notes

1. United Nations 1945.
2. Transboundary Freshwater Dispute Database (www.transboundarywaters.orst.edu).
3. www.unece.org/env/water/.
4. This section draws on Boelens 2008.
5. Government of Australia 2008.
6. Hendry 2008.
7. See von Benda-Beckmann, von Benda-Beckmann, and Spiertz 1998.
8. Cosgrove and Rijsberman 2000, p. 64.
9. Garces-Restrepo, Vermillion, and Muñoz 2007.
10. Garces-Restrepo, Vermillion, and Muñoz 2007.
11. Transparency International 2008.
12. Stålgren 2006.
13. Transparency International 2008.
14. Transparency International 2008.
15. ASCE 2008.
16. WBCSD 2005.
17. United Nations 2008, p. vii.
18. Global Water Intelligence 2004.
19. EAP Task Force 2007.
20. Winpenny 2008.
21. Rees, Winpenny, and Hall 2008.
22. World Commission of Dams 2000.
23. Hutton and Haller 2004.
24. UN-Water 2008.
25. UN-Water 2008.
26. Olivier 2007.
27. UNDP 2006.
28. Bosworth et al. 2002.
29. Kraemer et al. 2003.
30. World Commission on Dams 2000.
31. UNDP 2006.
32. Kariuki and Schwartz 2005.
33. McGranahan and Owen 2006.
34. UNDP 2006.
35. Winpenny 2003.
36. van Hofwegan and Task Force on Financing Water for All 2006.
37. UNSGAB 2006.
38. Purchase of a fixed-interest security, such as a bond, or equity shares giving less than 10% ownership of a company.
39. For a full description of these and other policies and tools, see Winpenny 2003 and van Hofwegen and Task Force on Financing Water for All 2006.
40. Winpenny 2005.
41. Dardenne 2006; McIntosh 2003.

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Chapter 5

Climate change and possible futures

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Key messages

- There is evidence that the global climate is changing. The main impacts of climate change on humans and the environment occur through water.
- Climate change is a fundamental driver of changes in water resources and an additional stressor through its effects on other external drivers.
- Policies and practices for mitigating climate change or adapting to it can have impacts on water resources, and the way we manage water can affect the climate.

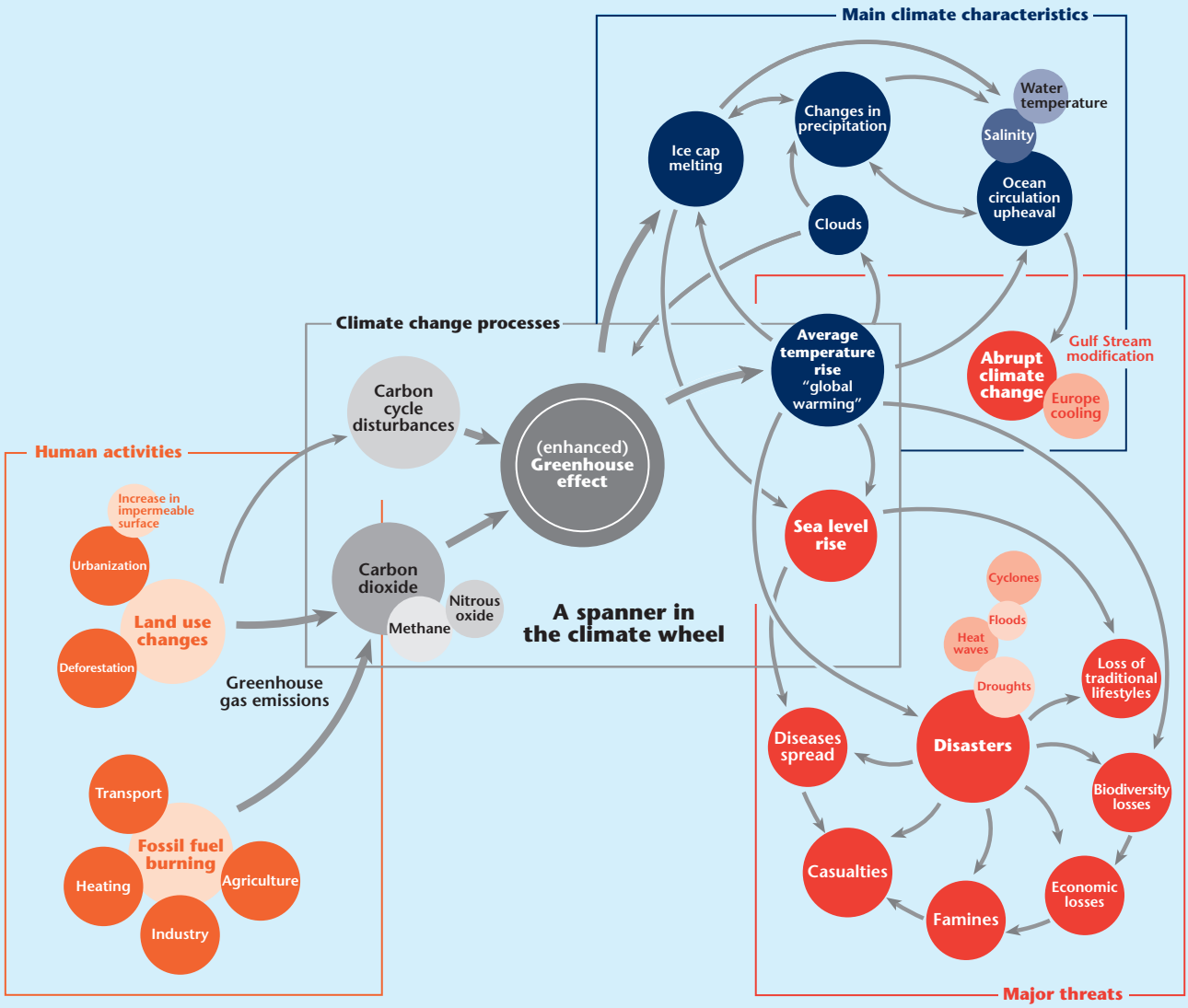
Chapters 2-4 have described how external drivers exert pressure on water resources. These drivers of change are strongly interconnected, creating complex challenges and opportunities for water managers and decision-makers. Apart from extreme events (such as droughts and floods), climate change is seldom the main stressor on sustainable development, although the direct and indirect impacts of increasing climate variability can impede and even reverse development gains (see figure 5.1 for a depiction of climate change processes, characteristics and major threats). Climate change may not fundamentally alter most of the world's water challenges, but as an additional stressor it makes achieving solutions more pressing.

All of the potential impacts of climate-related disasters, including economic losses, health problems and environmental disruptions, will also affect – and be affected by – water.

Climate change differs from the other drivers. It is the only supply-side driver, ultimately determining how much water we have; the other drivers are demand-side drivers, influencing how much water we need. Climate change can directly affect the hydrologic cycle and, through it, the quantity and quality of water resources (see chapter 11). It can lower minimum flows in rivers, affecting water availability and quality for its flora and fauna and for drinking water intake, energy production (hydropower), thermal plant cooling and navigation. Anthropogenic climate change can also directly affect demand for water, when demand for crops increases in certain seasons, for instance (see chapter 7 for the implications of climate change on uncertainty in agriculture). The other drivers, by contrast, exert pressure on various water use sectors that, in turn, affect water resources.

Managing water has always been about managing naturally occurring variability. Climate change threatens to make this variability greater, shifting and intensifying the extremes, and introduces greater uncertainty in the quantity and quality of supply over the long term (see part 3). More subtly, climate change may alter the timing, magnitude and duration of precipitation events, which could pose problems

Figure 5.1 **Climate change: processes, characteristics and threats**



Source: Based on UNFCCC 2007a.

for the sustainability of water supplies and the continuity of treatment.

The decisions and policies put in place today for mitigation (such as reducing greenhouse gas emissions, applying clean technologies and protecting forests) and adaptation (such as expansion of rainwater storage and water conservation practices) can have profound consequences for water supply and demand both today and over the long term.[1] Climate change also adds to the uncertainty surrounding all the other drivers. Thus, examining climate change forces considerations of the interconnectedness of all the drivers. This chapter focuses on the pressures that climate change can exert on the other drivers and outlines a process for taking these interlinking pressures into account in identifying scenarios, or 'possible futures'.

The influence of climate change on the other drivers of change

The relationships between climate change and the other drivers are complex and interwoven. This section summarizes the influence of climate change on the other five major drivers: demographic processes, economic growth, social change, technological innovation and policies, laws and finance.

Demographic processes

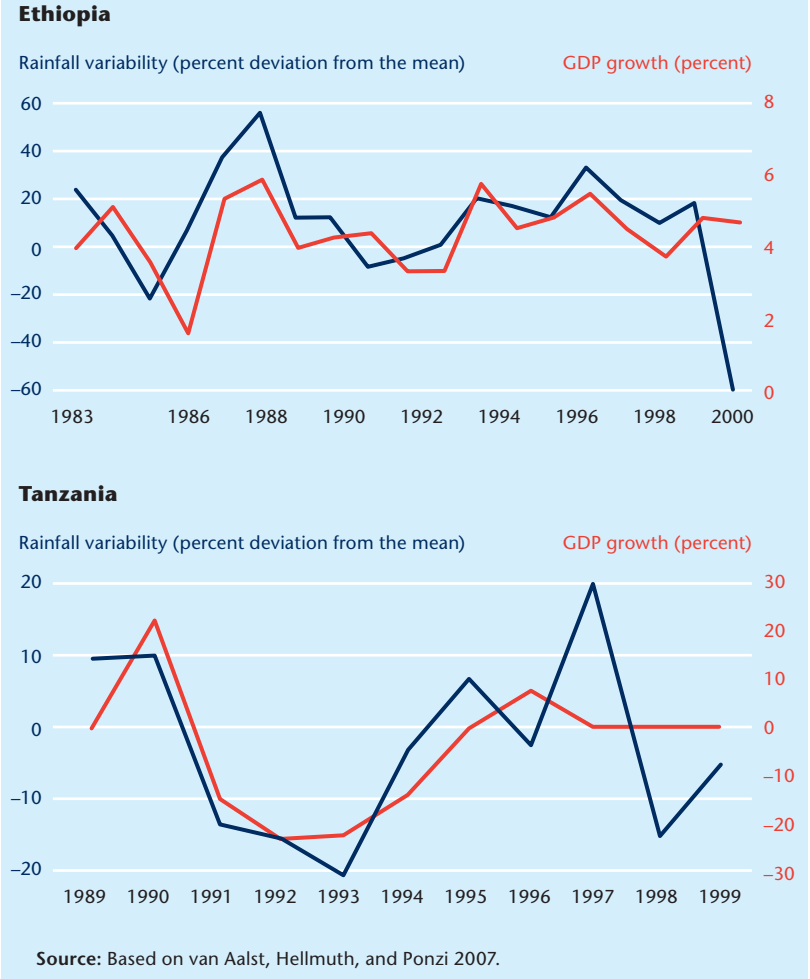
The impacts of anthropogenic climate change, including increased water scarcity and flooding and accelerated glacial

Weather-related disasters such as floods and droughts are undermining economic development in many of the world's least developed countries, causing human suffering and disrupting economic activities

melting and sea level rise, have the potential to accelerate human migration. Drought, desertification and other forms of water scarcity are already estimated to affect as many as one-third of the world's people and are predicted to worsen.

The recent Intergovernmental Panel on Climate Change (IPCC) report notes that millions of people in densely populated low-lying coastal areas risk increasing exposure to flooding by storm surges over the 21st century.[2] The IPCC expects sea level rise to exacerbate floods, storm surges, erosion and other coastal hazards. Global warming can expand the endemic zones of water-related infectious diseases like dengue, malaria and schistosomiasis, making it increasingly difficult for people to remain in affected areas. Recurring floods or storm surges, if not managed effectively, could drive large numbers of people permanently from their homes. Current IPCC projections of rising temperatures and sea levels and increased intensity of droughts and storms suggest that substantial population displacements will take place within the next 30-50 years, particularly in coastal zones. All of these climate change refugees will require shelter, water and sanitation services.

Figure 5.2 **GDP growth tracks rainfall variability in Ethiopia (1983-2000) and Tanzania (1989-99)**



Source: Based on van Aalst, Hellmuth, and Ponzi 2007.

Economic growth

Climate change and its accompanying risks have direct and indirect effects on development and economic growth. Sea level rise, climate variability and weather extremes such as heat waves, floods and droughts are severe, direct threats to human life and property (see chapter 12). Tackling them requires mobilizing resources that may have to be reallocated from other investments. Their damage can substantially harm a country's gross domestic product (GDP). Economic performance is especially affected in developing countries because of their high and direct dependence on natural resources, notably rain-fed agriculture (see chapter 7), and their inadequate access to economic and technological resources.

Adverse climate conditions such as increased floods and droughts can also result in the underperformance of investments. Climate uncertainty and unpredictability can be powerful barriers to investments, and ultimately to economic growth, even in years when climate conditions are favourable. The changing climate also complicates infrastructure design and long-term investment planning. And internal and cross-border migration, driven by growing pressure on natural resources, can create tension among population groups and between countries.[3]

There is clear evidence of a relationship between climate variability and economic performance in countries in which agriculture is a large share of GDP, as in Ethiopia and Tanzania (figure 5.2). Evidence also suggests a strong relationship between economic development and vulnerability to disaster. Across developing countries losses associated with disasters are so large as to undermine development and poverty reduction goals. And yet climate risks are seldom adequately considered in infrastructure designs, agriculture investments and water management plans.

Weather-related disasters such as floods and droughts are undermining economic development in many of the world's least developed countries, causing human suffering (see table 12.1 in chapter 12) and disrupting economic activities (table 5.1). And substantial financial and other development resources are being diverted each year to post-disaster relief, emergency

assistance, reconstruction and rehabilitation. Poorly managed climate risks also exact an indirect toll by discouraging private investment. With climate change and inadequate climate risk management, investors lack the reliable infrastructure, predictable human resources and stable markets needed to promote investment.

An estimated 40% of development investments are currently at risk, according to analyses by the Organisation for Economic Co-operation and Development (OECD).[4] These analyses indicate that while many development efforts contribute to reducing vulnerability to climate variability and change, climate risks are seldom explicitly factored into development projects and programmes. Similar issues affect sector and national development strategies.

The potential impacts of climate change on the global economy received international attention with the release of *The Stern Review* in 2006.[5] It concluded that by 2050 extreme weather could reduce global GDP by 1% and that, unabated, climate change could cost the world at least 5% in GDP each year. If even more dramatic predictions come to pass, the cost could rise to more than 20% of GDP. Such declines could in turn lead to an overall drop in official development assistance, exacerbating the struggle of poor people and countries to adapt and develop their water resources. Some other estimates of the costs of adapting to climate change are in box 5.1.

Social change

Unlike the more obvious effects of climate change on demographic processes or the global economy, the additional pressures that climate change is likely to exert on social change are often more subtle. Managing climate-related risk is a key enabler of development. Identifying and reducing the risks associated with climate-related hazards – including droughts, floods, cyclones, rising sea levels and extreme temperatures – can help to protect people, livelihoods and assets, thereby promoting the achievement of economic development goals.

Climate change and greater climate variability will increasingly affect the poorest and most marginalized groups, making them even more vulnerable to the impacts of climate change. Climate uncertainty – the inability to anticipate climate extremes – hurts investment and innovation and limits the success of other development interventions. In inhabited hazard-prone areas disasters and losses are inevitable unless societal exposure and vulnerability are reduced.

The most likely societal effects of climate change will come from changes in lifestyle and consumption patterns. Reflecting human needs and wants, changes in lifestyle and consumption patterns are among the most important drivers of change (see chapter 2). In emerging market economies rising standards of living are boosting demand for high-level goods and services, many with a large ecological and water

Table 5.1 **Economic impacts of flood and drought in Kenya, 1997-2000**

Impact area	Costs ($ millions)	Share of total (percent)
1997-98 El Niño flood impact		
Transport infrastructure	777	89
Health sector	56	6
Water supply infrastructure	45	5
Total flood impact	878	
Share of GDP 1997-98 (percent)		11
1998-2000 La Niña drought impacts		
Industrial production	1,400	58
Hydropower	640	26
Agricultural production	240	10
Livestock	137	6
Total drought impact	2,417	
Share of GDP 1998-2000 (percent)		16

Source: World Bank 2004.

Box 5.1 **The cost of adapting to climate change**

Estimates of the costs of climate change impacts vary because they depend on future greenhouse gas emissions, mitigation measures and assumptions about anthropogenic climate change itself and about how effectively countries will adapt to it. The following are some estimates of the costs of adaptation for developing countries:

- World Bank estimates of the additional costs to adapt or climate-proof new investments range from $9 to $41 billion a year. And a recent update by the United Nations Development Programme put the mid-range of the costs of adaptation at about $37 billion a year in 2015.
- The United Nations Framework Convention on Climate Change estimates additional investments for adaptation to climate change at $28-$67 billion and as high as $100 billion a year several decades from now. Estimates of the additional investments needed in water supply infrastructure in 2030 are $11 billion, 85% of it in developing countries.
- Oxfam estimates the current costs of adaptation to climate change for all developing countries at more than $50 billion a year.

While there is considerable debate about these estimates, they provide useful order-of-magnitude numbers for assessing resources available for adaptation. Current Global Environment Facility funds (about $160 million) are several orders of magnitude too little to meet these projected needs.

Source: World Bank 2006; UNDP 2007; UNFCCC 2007b; Oxfam 2007.

Some interventions in the water system might be counterproductive when evaluated in terms of mitigation of climate change

footprint. In the world's richest countries, meanwhile, growing awareness of climate change is slowly inducing people to alter their lifestyles and live in a more sustainable manner. Large cars are being replaced by smaller, more energy-efficient vehicles in some places, and governments are offering subsidies for purchasing energy-efficient appliances. But these changes alone are unlikely to substantially counteract the pressure from rising living standards in emerging market economies.

Technological innovation

Climate change will be a major driver of technological innovation and transfer.[6] Massive amounts of new investments will be required over the next 30 years to meet the growing energy needs of developing countries. Investments in adaptation will be necessary to safeguard vulnerable groups and infrastructure.

The relationship between climate change mitigation measures and water can be reciprocal. Mitigation measures can adversely influence the quantity and condition of water resources and their management, while some water management policies and measures can increase greenhouse gas emissions and affect other sectoral mitigation measures. Thus, interventions in the water system might be counterproductive when evaluated in terms of mitigation of climate change.

For example, many developed countries are shifting energy production from thermal energy plants that burn fossil fuels and emit large quantities of greenhouse gases to 'clean' energy sources. Thus, significant increases in the development of hydroelectric installations, a source of clean electricity, could be anticipated as the global community unites to combat climate change, although in many developed countries most of the 'best' sites for hydropower installations have already been developed (see map 7.6 in chapter 7). Some of the climate-related benefits of hydropower are illustrated in box 5.2.

However, there is evidence that hydroelectricity generation can also generate considerable amounts of greenhouse gases, which are released from sediment and decaying organic matter at the bottom waters of reservoirs.[7] Artificially flooded reservoirs of sufficient depth can experience anaerobic conditions as organic matter decomposes and, when the bottom waters are disturbed, emits large quantities of methane and other greenhouse gases. The problem arises most frequently in warmer climates, where reservoirs are prone to stratification and where there is year-round algal growth.

Biofuels, an alternative to fossil fuels in transport, are another means of reducing greenhouse gas emissions. Higher oil prices in recent years have made bioenergy more competitive. *World Energy Outlook 2006* projected an average rate of growth of bioenergy production of 7% a year.[8] By 2030 biofuels are expected to meet 4% of road-transport fuel demand worldwide, up from 1% today. But careful attention also must be given to minimizing negative externalities associated with producing bioenergy, such as upward pressure on food prices and the impact on food security.[9]

Developing countries will need to rely on technology development and transfer in mitigating and adapting to climate change. That will require removing obstacles to technology transfer and providing incentives for accelerating and scaling up transfers, along with cooperating on research and development (see chapter 3). According to the United Nations Framework Convention on Climate Change (UNFCCC), most technologies for adapting to climate change are already available in developing countries, and examples of successful implementation and operation abound, from coastal revetment to vaccination programmes.[10]

Policies, laws and finance

Climate change can stress political governance structures by increasing management and budget requirements for public services to mitigate climate change or to cope with its impacts, including public health care (box 5.3), disaster risk reduction and

Box 5.2 Micro-hydro plants in Nepal are expected to provide electricity access to 142,000 households and to reduce greenhouse gas emissions

Nepal has vast hydro resources. And while only about 27% of rural households are connected to a power grid (the urban share is 90%), off-grid power generated by micro-hydro plants provides many rural households with electricity for lighting, milling and other needs. The generating capacity of these plants varies from 5 to 500 kilowatts.

Through a project supported by the World Bank, the United Nations Development Programme and the governments of Denmark and Norway, micro-hydro plants are being installed for local communities by prequalified private companies that receive subsidies and technical assistance. Installation of micro-hydro plants will be phased in until 2011. The micro-hydro power plants, which qualify for emission reduction credits under the Clean Development Mechanism, will reduce greenhouse gas emissions by replacing diesel fuel used for lighting and milling.

Source: http://go.worldbank.org/9G19LTLEH0.

public security. As stress mounts, the resilience of already unstable social and political structures lessens, especially in countries with limited resources. At the international level pressures build on governance systems to combat climate change, mainly through the UNFCCC and growing public awareness.

Most efforts have focused on mitigation strategies, which are especially important for policies in energy (a major water use sector), international trade and transportation. In many countries climate change issues fall under the authority of the ministry for environment or natural resources. But as regional carbon trading markets emerge and as economies become ever more carbon-constrained, the ministries of finance and planning will need to become more directly involved.

Most governance structures today are too weak to tackle current water problems, much less prepare for emerging problems, including climate change. And there is still very little evidence about which types of governance responses work in which contexts and what their impacts are on water equity, efficiency and sustainability. Water reforms in most countries have not considered the implications of climate change or other major drivers of water use and the need for long-term planning.

Effective funding mechanisms are lacking for developing countries to support adaptation to climate change, which affects development at many levels. In Africa the impacts of climate change are expected to range from increased energy shortages, reduced agricultural production, worsening food security and malnutrition to the increasing spread of disease, more humanitarian emergencies, growing migratory pressures and increased risks of conflict over scarce land and water resources. Africa is least able to meet the costs of adapting to these impacts, yet it receives the least from current carbon finance mechanisms. Its governance structures and capacity are not ready for the intersectoral action that adaptation requires.[11]

Supporting developing country efforts to design adaptation strategies also requires better analysis. Information is needed at the local level, incorporating country-specific characteristics and sociocultural and economic conditions. At the macro-level information on both rich and poor countries is required to support international negotiations and to identify the overall costs of adapting to climate change.

Box 5.3 Health and climate change

Climate change can affect health through multiple pathways, such as greater frequency and intensity of heat waves, fewer cold-related illnesses, increased floods and droughts, changes in the distribution of vector-borne diseases and effects on the risk of disasters and malnutrition. The overall balance of impacts on health is likely to be negative, and populations in low-income countries are likely to be particularly vulnerable to the adverse effects. However, many of the projected impacts of climate change on health are avoidable. Climate change is expected to exacerbate some health problems rather than cause new diseases to emerge. Strengthening public health prevention strategies, including improving water supply and sanitation services and disease surveillance, would be an essential part of any effective response.

Source: Haines et al. 2006; Campbell-Lendrum, Corvelan, and Neira 2007.

Challenges for the impact of climate change on water resources and management

One of the most pressing challenges of climate change is addressing the vulnerability of human populations, particularly the poor, to the impacts of extreme hydrologic events, such as floods, storm surges and droughts. Over the longer term the effects of incremental climate change are likely to influence decisions about food security, energy security and land use, all with vital implications for water resources and management and environmental sustainability (see chapter 7). In this context climate change can intensify existing pressures, thereby increasing risk, vulnerability and uncertainty.

For water managers anthropogenic climate change poses a new set of challenges – because they can no longer plan, design and operate hydrologic systems based on historical statistics. Climate change means learning to manage under increased uncertainty. Climate change is a new risk to be taken into account in policy development, planning and operations at the global, basin, national, local and company levels. It calls for increasing use of 'climate knowledge' to better understand climate variability at different time scales, to assess the socioeconomic impacts observed in the past, to monitor current conditions of relevant environmental factors (climate, vegetation, water, diseases) and to provide the best possible information on future climate, from seasons to decades, for specific decisions and activities. Addressing the threats and opportunities of climate change and its impacts on water resources and supplies is vital for even the most remote rural areas as part of a broader developmental agenda.

The water drivers interact and can have even more of an impact on future water resources collectively than they can individually

Although water is an important component in most energy-generating processes, its role in climate change mitigation policy is minor. Where water and climate change are most strongly linked is in adaptation policy, which functions in highly dynamic hydrologic, social, economic and demographic contexts. For water adaptation measures to be effective, however, there must be complementary climate change mitigation measures outside the water sector.

Because climate variability and change affect all the major water drivers, adaptation measures are needed in all sectors. Over the long term adaptation means applying a long-term, climate-focused approach to existing policies and programmes. But because the poor are the most vulnerable and the least able to cope with change, it is particularly important to strengthen the link between adaptation to climate change and economic development – a difficult challenge. Over the shorter term the best approach might be to manage climate variability by prioritizing risk-reduction strategies and reinforcing the capacity of hydrometeorological services to provide information for development needs.

Each country will face its own challenges and must determine how to respond in the short, medium and long run. With multiple challenges but limited financial and natural resources and capacities, countries will need to make hard choices about water use and allocation.

There tends to be a push and pull effect between identifying adaptation needs based on a climate change rationale and anchoring response options in baseline development activities. This separation between climate adaptation and development is artificial. Governments need to design climate-smart development policies and programmes, in part by strengthening sectoral capacities.

Identifying possible futures: the need for scenarios

Each of the water drivers is dynamic and continues to evolve, as do the direct and indirect pressures they exert on water resources. Thus, it is difficult to draw a comprehensive picture of the future by examining each driver independently. The drivers interact and can have even more of an impact on future water resources collectively than they can individually. Future scenarios that consider these interactions offer a more holistic picture.

Scenarios, which are sets of equally plausible futures, differ from forecasts, which are individual interpretations of a most probable future based on extrapolation of the best available information. Scenarios are not forecasts. Because the real world is so complex, forecasts are often wrong – especially those involving a time horizon of 20 years or more. Scenarios provide a means of looking beyond the water sector in search for an adequate causal understanding of different water issues.

Scenarios can contribute to several goals in the pursuit of sustainable water resources:

- *The need for a long-term view.* A long-term view of water for sustainable development requires taking into account the slow unfolding of some hydrologic, environmental and social processes and allowing time for waterworks investments and water mitigation schemes to yield results.

- *The need to make decisions in a context of high uncertainty.* Decision-makers in the water sector must often address water management issues against a background of rapidly changing environmental conditions and increasing uncertainty. The uncertainty results from both a limited understanding of human and ecological processes and the intrinsic indeterminism of complex dynamic systems. Further, water resources futures depend on future human choices, which are unknown.

- *The need to include non-quantifiable factors.* The world's water system includes and is influenced by many factors that are difficult to quantify (such as cultural and political variables and processes), as well as factors that can be quantified and modelled mathematically (such as hydrologic and climatological dynamics and economic factors). Qualitative scenario analyses can provide insight into these factors that simulation models cannot.

- *The need for integration and breadth.* Water resources must be viewed holistically, considering both their natural state and the need to balance competing demands – domestic, agricultural, industrial and environmental – to ensure sustainability. Decisions on land use can affect the availability and condition of water resources, while decisions about water resources can also affect the environment and land

use. Decisions about economic and social futures can affect hydrology and ecosystems. And decisions at the international, national and local levels are connected. Sustainable management of water resources requires systemic, integrated decision-making that recognizes the interdependence of decisions; scenarios are particularly helpful for this purpose.

- *The need for perspective.* Qualitative scenarios provide guidance, perspective and context for computer models and sectoral studies, while models and studies provide consistency and feasibility checks for some elements of water scenarios, as well as numerical estimates of the modelled variables. Further, global scenarios provide a context for scenarios on a smaller geographic scale (local, watershed, national or regional). Many important changes in a river basin are determined by factors from outside the study area.

- *The need to organize understanding for decision-making.* Decision-makers may have difficulty identifying the elements from different studies that are most relevant for their decisions. Scenarios are developed with decision-making in mind. They are constructed to focus attention on causal processes and decision points, the unfolding of alternatives and the branching points at which human actions can significantly affect the future.

- *The need for an arena for conversation among water stakeholders.* Scenarios provide common frameworks for mapping and highlighting critical concerns of diverse stakeholders and identifying alternatives – setting the stage for discussions, debates and negotiation.

Over the past decade several global scenarios have been developed for the water sector. One of the most comprehensive was the scenario work for the World Water Vision in 2000.[12] The Vision generated three scenarios: a technology, economics and private sector scenario in which private sector initiatives lead research and development and globalization drives economic growth, but the poorest countries are left behind; a values and lifestyles scenario in which sustainable development is a global priority, with emphasis on research and development in the poorest countries; and a business-as-usual scenario.

In 2006 the World Business Council for Sustainable Development (WBCSD) produced three scenarios focusing on the role of business and water.[13] Its three storylines focus on efficiency (more value per drop), security (meeting the basic needs of all) and interconnectivity (a 'whole system' approach; table 5.2). In another example using driver categories similar to those in this Report, the *Global Environment Outlook* (GEO4) report of 2007 generated four different scenarios: markets first, policy first, security first and sustainability first.[14]

Despite these recent endeavours, experience indicates that new global water scenarios are needed. Existing global water scenarios do not fully incorporate each of the drivers described in this chapter. The scenarios are either outdated (those of the World Water Vision) or partial, incomplete or sectoral (WBCSD, GEO4). In addition, the evolution of the drivers and the logic behind their storylines need to be examined and possibly redefined in view of developments both inside and outside the water sector since 2000. Finally, important new policy initiatives have emerged since the last world water scenarios, such as the adoption of the Millennium Development Goals.

New global water scenarios are needed. Existing global water scenarios do not fully incorporate each of the drivers described in this chapter

Challenges for summarizing the pressures of external drivers on water resources

Multiple external drivers exert pressures on water resources through changes in water demands and uses. Some of these pressures are summarized in the table at

Table 5.2 **The three water scenarios of the World Business Council for Sustainable Development, to 2025**

Scenario	'Hydro'	'Rivers'	'Ocean'
Water challenge	Efficiency (more drops for less and more value per drop)	Security (quantity and quality for all)	Interconnectivity (taking the whole system into account)
Business challenge	Innovation	Social license to operate	Business role in water governance
The five key story themes	• Hard times in huge towns • Huge opportunities • High-stakes innovation • Hydro economy • Beyond legacy systems	• The security deficit • Two sides of the river • The trust deficit • Access and equity • Political reallocation – local solutions	• Unintended consequences • Global Fair Water Movement • The tipping point • Accountability tools • Networked global water governance

Source: WBCSD 2006.

the beginning of part 2. The challenge is to get decision-makers inside and outside the water sector to adopt appropriate measures to reduce the negative pressures on water and increase the positive pressures.

Making this challenge more difficult are the links between drivers (as illustrated by the pressures imposed by rising living standards), which involve demographic, social and economic factors but are also influenced by technology and governance. Generating a picture of this complex future would be greatly assisted by the development of a set of future scenarios.

Notes

1. IPCC 2008.
2. Nicholls et al. 2007.
3. van Aalst, Hellmuth, and Ponzi 2007.
4. OECD 2005.
5. Stern 2006.
6. IPCC 2008.
7. Giles 2006.
8. IEA 2006
9. FAO 2008.
10. UNFCCC 2006.
11. van Aalst, Hellmuth, and Ponzi 2007.
12. Cosgrove and Rijsberman 2000.
13. WBCSD 2006.
14. UNEP 2007.

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