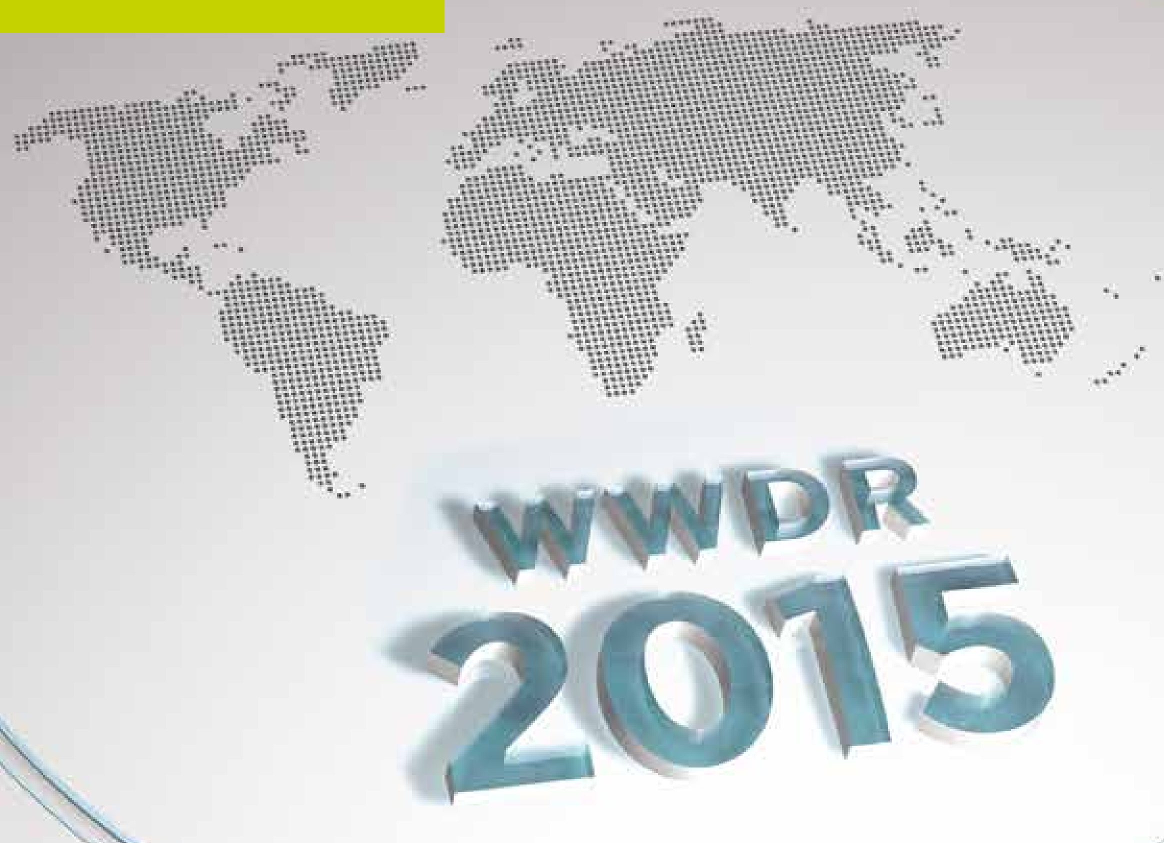
UN WATER

Report

The United Nations World Water Development Report 2015

WATER FOR A SUSTAINABLE WORLD



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The United Nations World Water Development Report 2015

WATER FOR A SUSTAINABLE WORLD

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FOREWORD

by Ban Ki-moon
Secretary-General of the United Nations

Water flows through the three pillars of sustainable development – economic, social and environmental. Water resources, and the essential services they provide, are among the keys to achieving poverty reduction, inclusive growth, public health, food security, lives of dignity for all and long-lasting harmony with Earth's essential ecosystems.

Water issues have risen in prominence in recent years, reflecting growing understanding of water's centrality as well as the world's success in achieving the Millennium Development Goal target of halving the proportion of people without sustainable access to safe drinking water. Between 1990 and 2010, 2.3 billion people gained access to improved drinking water sources, such as piped supplies and protected wells.

The publication of the *World Water Development Report 2015*, "Water for a Sustainable World", comes as Member States strive to build on the gains made under the MDG framework, articulate an inspiring post-2015 development agenda and reach an ambitious agreement on climate change. The report illustrates the complex linkages between water and critical areas such as human health, food and energy security, urbanization, industrial growth and climate change. It also describes the status of the world's water resources, including an overview of the impacts of unsustainable growth on freshwater resources, and suggests possible responses to these challenges.

The *World Water Development Report 2015*, coordinated by UNESCO's World Water Assessment Programme, brings together 31 UN-Water Members and 37 Partners, and offers data and information aimed at policy- and decision-makers, inside and outside the water sector. The decisions that determine how water resources are used (or abused) are not made by water managers alone. Progress towards sustainable development thus requires engaging a broad range of actors. I appeal to Government leaders as well as civil society and the private sector to join forces to protect and share our most precious resource, and to build a more sustainable future for all.

Ban Ki-moon

FOREWORD

by Irina Bokova
Director-General of UNESCO

This report comes at a critical moment, when freshwater resources face rising pressure to provide for the social, economic and environmental needs of a growing world population. 2015 is also a year of high expectations and hopes, as the deadline for the Millennium Development Goals, and when States will define a new global sustainable development agenda to follow.

Water is inextricably linked to the development of all societies and cultures. At the same time, this development also places considerable pressure on water resources — agriculture, energy and industry all have impacts on the use and governance of water. More than two decades after the first summit on sustainable development, many countries still face the challenges of eliminating poverty and promoting economic growth, ensuring health and sanitation, preventing land degradation and pollution, and advancing rural and urban development. Around 748 million people today still do not have access to an improved source of drinking water, and water demand for manufacturing is expected to increase by 400 per cent between 2000 and 2050 globally.

The 2015 World Water Development Report sets both an aspirational and a realistic vision for the future of water towards 2050. Water is essential for promoting inclusive sustainable development, as it supports human communities, maintains the functions of ecosystems and ensures economic development. Translating this vision into reality requires efforts by all, through concrete and interrelated actions that go from establishing the legal and institutional framework to ensure sustainable water management and increasing investments and financial support for water development to enhancing and improving access to water supply, sanitation and hygiene services.

To these ends, UNESCO is deeply committed to ensuring equitable and inclusive quality education and lifelong learning for women and men across the world. In many contexts, this calls for freeing women and children from the burden of fetching water for hours every day to provide them with opportunities for their empowerment and fulfilment. This is essential for advancing respect for human rights and for eliminating poverty. This is why the 2015 Report has mainstreamed the needs of the most vulnerable, as well as those of minorities, women and children, throughout its approach and analysis.

I am confident that the 2015 World Water Development Report will contribute significantly to the discussion of the 69th United Nations General Assembly and to shaping an ambitious new global sustainable development agenda, with water at its heart. In this respect, I wish to thank all members and partners of UN-Water, under the coordination of United Nations World Water Assessment Programme, for their contribution to this report and commitment to the goals we share. I see this as a powerful example of the United Nations delivering as one on key issues for all member States. The Secretariat of the United Nations World Water Assessment Programme has played a particularly important role in coordinating this important work. In this respect, I wish to express my gratitude also to the Government of Italy and the Umbria Region for hosting the United Nations World Water Assessment Programme and supporting its work.

The sustainable use and management of water is vital for welfare of all humanity today, and it is essential for building the future we want for all. This is why this Report is so important.

Irina Bokova

FOREWORD

by Michel Jarraud
Chair of UN-Water and Secretary-General of WMO

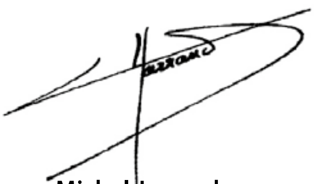
2015 is when the Millennium Development Goals will come to term and the new sustainable development agenda will come to light. This year we have an unprecedented opportunity to be bold, brave and vigorous when creating the future we want.

Water is truly at the core of sustainable development. It is inextricably linked to climate change, agriculture, food security, health, equality, gender and education, and there is already international agreement that water and sanitation are essential to the achievement of many sustainable development goals.

In my capacity as Chair of UN-Water, I am proud of this year's World Water Development Report. With a broad and ambitious scope, the Report provides a thorough understanding of water and sanitation challenges and how to transform them into opportunities.

The production of this Report was only made possible by the hundreds of hours of inter-agency collaboration that went into it. Therefore, I would like to sincerely thank all of my UN-Water colleagues for their contributions. I would also like to express my profound appreciation to the United Nations Educational, Scientific and Cultural Organization (UNESCO) for its World Water Assessment Programme, which coordinates the production and publication of the Report on behalf of UN-Water.

This 2015 Report is a must-read to understand the role of water and sanitation in the Post-2015 Development Agenda and it is my hope that this Report can inspire strategies, policies and actions for years to come.



Michel Jarraud

PREFACE

by Michela Miletto, WWAP Coordinator a.i.
and Richard Connor, Lead Author

In its 1987 report, *Our Common Future*, the United Nations' World Commission on Environment and Development (the Brundtland Commission) defined 'sustainable development' as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*." Since then, several other definitions have been proposed and debated, and countless papers, articles and books have been published, each seeking to broaden our understanding of the concept and the types of actions it implies.

With the 1992 UN Conference on Environment and Development (the Rio Summit) through to the 2000 United Nations Millennium Declaration and its eight Millennium Development Goals (MDGs), sustainable development has become integrated into the UN System as the organizing principle for sustaining the finite resources necessary to provide for the needs of future generations of life on the planet. 2015 marks yet another critical milestone in this evolution. As the MDG cycle draws to a close, a new cycle of Sustainable Development Goals (SDGs) is poised to guide national governments and the international community in our common quest to achieve a sustainable world.

As the second in a new series of annually released theme-oriented reports, the 2015 edition of the United Nations *World Water Development Report* (WWDR) clearly shows how water is critical to sustainable development. Indeed, water is *the* essential primary natural resource upon which nearly all social and economic activities and ecosystem functions depend. Sustainable development requires that we properly manage our freshwater resources and equitably share its benefits.

The linkages between water and sustainable development are numerous, complex and often subtle. In addition to describing the relationship between water and its social, economic and environmental dimensions, this WWDR also examines water's role in addressing several of the most pressing developmental challenges of our time, from food and energy security to urbanization and climate change. The Report is further enriched by regional perspectives, and provides decision-makers and practitioners with specific examples of measures, actions and approaches to addressing these interconnected challenges through water.

Like its predecessors, the WWDR 2015 is primarily targeted at national-level decision-makers and water resources managers. However, it is hoped the Report will also be well received by academics and the broader developmental community as well by those who care about the common future of our planet.

This latest edition of the WWDR is the result of a concerted effort between WWAP, the ten Lead Agencies (FAO, UNDESA, UNDP, UNEP, UNESCO, UN-Habitat, UNICEF, UNIDO, WHO and WMO) responsible for the thematic part of the Report and the five Regional UN Economic Commissions who provided geographically-focused perspectives on water and sustainable development.

The Report has also benefitted to a great extent from the inputs and contributions of several UN-Water Members and partners, as well as from dozens of scientists, professionals and NGOs who provided a wide range of excellent material. The members of WWAP's Technical Advisory Committee were particularly active and generous in providing their guidance and knowledge to the production team. In line with the previous publications of WWAP, this Report is gender-mainstreamed thanks to the support of UN Women, the WWAP Advisory Group on Gender and the UNESCO Division for Gender Equality.

The report begins by describing a world in the not-so-distant future in which water resources and water-related services are managed in such a way that the benefits derived from water are maximized and shared equitably throughout the world. This vision is not merely a fictional utopian outlook; it is a future that we believe is entirely achievable – a future in which water is recognized and managed as the fundamental resource that supports all aspects of sustainable development. This vision represents a new and innovative approach to the WWDR which we hope will prompt readers to reflect on how our world *could* be, provided we make appropriate changes to the ways we do things.

Although the concept of sustainable development may be straightforward, different stakeholders tend to see the challenges and potential solutions from their particular – and often varying – perspectives. We have endeavoured to present a fact-based, balanced and neutral account of the current state of knowledge, covering the most recent developments pertaining to water and sustainable development. As we move towards a new paradigm of sustainable development, whether via a new set of development goals, the decoupling of water and economic growth, or the 'greening' of economies, it is our sincere hope that this factual Report is received as a useful, informative and credible tool that will support and strengthen proactive discussions pertaining to our common future, and ultimately help to identify and adopt appropriate responses.

On behalf of WWAP's Secretariat, we extend our deepest appreciation to the UN-Water Lead Agencies and Regional Commissions, to the members and partners of UN-Water, and to the authors, writers, editors and other contributors for collectively producing this unique and authoritative report. A special recognition goes to the UNDP, who provided outstanding support from the very beginning of the Report's development through to the final editing process.

A particular thanks goes to Ms Irina Bokova, Director-General of UNESCO, for her crucial support for WWAP and the production of the WWDR.

We are profoundly grateful to the Italian Government for funding the Programme, and to the Umbria Region for hosting the WWAP Secretariat in Villa La Colombella in Perugia. Their contribution has been instrumental to the production of the WWDR.
Finally, we extend our most sincere gratitude to all our colleagues at the WWAP Secretariat, whose names are listed in the acknowledgements. This report could not have been completed without their dedication and professionalism.

Michela Miletto **Richard Connor**

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WWDR 2015 benefitted from the significant reviews, comments and guidance of WWAP's Technical Advisory Committee.

We wish to express our earnest thanks to Ms Irina Bokova, the Director-General of UNESCO, whose support was instrumental in preparing the Report.

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EXECUTIVE SUMMARY

Cascata delle Marmore (Marmore Waterfalls), Terni, Umbria (Italy)
Photo: Antonio Picascia

Water is at the core of sustainable development. Water resources, and the range of services they provide, underpin poverty reduction, economic growth and environmental sustainability. From food and energy security to human and environmental health, water contributes to improvements in social well-being and inclusive growth, affecting the livelihoods of billions.

Vision 2050: Water in a sustainable world

In a sustainable world that is achievable in the near future, water and related resources are managed in support of human well-being and ecosystem integrity in a robust economy. Sufficient and safe water is made available to meet every person's basic needs, with healthy lifestyles and behaviours easily upheld through reliable and affordable water supply and sanitation services, in turn supported by equitably extended and efficiently managed infrastructure. Water resources management, infrastructure and service delivery are sustainably financed. Water is duly valued in all its forms, with wastewater treated as a resource that avails energy, nutrients and freshwater for reuse. Human settlements develop in harmony with the natural water cycle and the ecosystems that support it, with measures in place that reduce vulnerability and improve resilience to water-related disasters. Integrated approaches to water resources development, management and use – and to human rights – are the norm. Water is governed in a participatory way that draws on the full potential of women and men as professionals and citizens, guided by a number of able and knowledgeable organizations, within a just and transparent institutional framework.

The consequences of unsustainable growth

Unsustainable development pathways and governance failures have affected the quality and availability of water resources, compromising their capacity to generate social and economic benefits. Demand for freshwater is growing. Unless the balance between demand and finite supplies is restored, the world will face an increasingly severe global water deficit.

Global water demand is largely influenced by population growth, urbanization, food and energy security policies, and macro-economic processes such as trade globalization, changing diets and increasing consumption. By 2050, global water demand is projected to increase by 55%, mainly due to growing demands from manufacturing, thermal electricity generation and domestic use.
Competing demands impose difficult allocation decisions and limit the expansion of sectors critical to sustainable development, in particular food production and energy. The competition for water – between water 'uses' and water 'users' – increases the risk of localized conflicts and continued inequities in access to services, with significant impacts on local economies and human well-being.

Over-abstraction is often the result of out-dated models of natural resource use and governance, where the use of resources for economic growth is under-regulated and undertaken without appropriate controls. Groundwater supplies are diminishing, with an estimated 20% of the world's aquifers currently over-exploited. Disruption of ecosystems through unabated urbanization, inappropriate agricultural practices, deforestation and pollution are among the factors undermining the environment's capacity to provide ecosystem services, including clean water.

Persistent poverty, inequitable access to water supply and sanitation services, inadequate financing, and deficient information about the state of water resources, their use and management impose further constraints on water resources management and its ability to help achieve sustainable development objectives.

Water and the three dimensions of sustainable development

Progress in each of the three dimensions of sustainable development – social, economic and environmental – is bound by the limits imposed by finite and often vulnerable water resources and the way these resources are managed to provide services and benefits.

Poverty and social equity

While access to household water supplies is critical for a family's health and social dignity, access to water for productive uses such as agriculture and family-run

Fisher and her husband pulling in the net (Timor Leste)
Photo: UN Women/Betsy Davis

businesses is vital to realize livelihood opportunities, generate income and contribute to economic productivity. Investing in improved water management and services can help reduce poverty and sustain economic growth. Poverty-oriented water interventions can make a difference for billions of poor people who receive very direct benefits from improved water and sanitation services through better health, reduced health costs, increased productivity and time-savings.

Economic growth itself is not a guarantee for wider social progress. In most countries, there is a wide – and often widening – gap between rich and poor, and between those who can and cannot exploit new opportunities. Access to safe drinking water and sanitation is a human right, yet its limited realization throughout the world often has disproportionate impacts on the poor and on women and children in particular.

Economic development

Water is an essential resource in the production of most types of goods and services including food, energy and manufacturing. Water supply (quantity and quality) at the place where the user needs it must be reliable and predictable to support financially sustainable investments in economic activities. Wise investment in both hard and soft infrastructure that is adequately financed, operated and maintained facilitates the structural changes necessary to foster advances in many productive areas of the economy. This often means more income opportunities to enhance expenditure in health and education, reinforcing a self-sustained dynamic of economic development.

Many benefits may be gained by promoting and facilitating use of the best available technologies and management systems in water provision, productivity and efficiency, and by improving water allocation mechanisms. These types of interventions and investments reconcile the continuous increase in water use with the need to preserve the critical environmental assets on which the provision of water and the economy depends.

Environmental protection and ecosystem services

Most economic models do not value the essential services provided by freshwater ecosystems, often leading to unsustainable use of water resources and ecosystem degradation. Pollution from untreated residential and industrial wastewater and agricultural run-off also weakens the capacity of ecosystem to provide water-related services.

Ecosystems across the world, particularly wetlands, are in decline. Ecosystem services remain under-valued, under-recognized and under-utilized within most current economic and resource management approaches. A more holistic focus on ecosystems for water and development that maintains a beneficial mix between built and natural infrastructure can ensure that benefits are maximized.

Economic arguments can make the preservation of ecosystems relevant to decision-makers and planners. Ecosystem valuation demonstrates that benefits far exceed costs of water-related investments in ecosystem conservation. Valuation is also important in assessing trade-offs in ecosystem conservation, and can be used to better inform development plans. Adoption of 'ecosystem-based management' is key to ensuring water long-term sustainability.

Water's role in addressing critical developmental challenges

Interlinkages between water and sustainable development reach far beyond its social, economic and environmental dimensions. Human health, food and energy security, urbanization and industrial growth, as well as climate change are critical challenge areas where policies and actions at the core of sustainable development can be strengthened (or weakened) through water.

Lack of **water supply, sanitation and hygiene** (WASH) takes a huge toll on health and well-being and comes at a large financial cost, including a sizable loss of economic activity. In order to achieve universal access, there is a need for accelerated progress in disadvantaged groups and to ensure non-discrimination in WASH service provision. Investments in water and sanitation services result in substantial economic gains; in developing regions the return on investment has been estimated at US$5 to US$28 per dollar. An estimated US$53 billion a year over a five-year period would be needed to achieve universal coverage – a small sum given this represented less than 0.1% of the 2010 global GDP.

The increase in the number of people without access to water and sanitation in **urban areas** is directly related to the rapid growth of slum populations in the developing world and the inability (or unwillingness) of local and national governments to provide adequate water and sanitation facilities in these communities. The world's slum population, which is expected to reach nearly 900 million by 2020, is also more vulnerable to the impacts of extreme weather events. It is however possible to improve performance of urban water supply systems while continuing to expand the system and addressing the needs of the poor.

By 2050, **agriculture** will need to produce 60% more food globally, and 100% more in developing countries. As the

Haitian students breathe new life into depleted pine forest
Photo: UN Photo/Logan Abassi

current growth rates of global agricultural water demand are unsustainable, the sector will need to increase its water use efficiency by reducing water losses and, most importantly, increase crop productivity with respect to water. Agricultural water pollution, which may worsen with increased intensive agriculture, can be reduced through a combination of instruments, including more stringent regulation, enforcement and well-targeted subsidies.

Energy production is generally water-intensive. Meeting ever-growing demands for energy will generate increasing stress on freshwater resources with repercussions on other users, such as agriculture and industry. Since these sectors also require energy, there is room to create synergies as they develop together. Maximizing the water efficiency of power plant cooling systems and increasing the capacity of wind, solar PV and geothermal energy will be a key determinant in achieving a sustainable water future.

Global water demand for the **manufacturing industry** is expected to increase by 400% from 2000 to 2050, leading all other sectors, with the bulk of this increase occurring in emerging economies and developing countries. Many large corporations have made considerable progress in evaluating and reducing their water use and that of their supply chains. Small and medium-sized enterprises are faced with similar water challenges on a smaller scale, but have fewer means and less ability to meet them.

The negative impacts of **climate change** on freshwater systems will most likely outweigh its benefits. Current projections show that crucial changes in the temporal and spatial distributing of water resources and the frequency and intensity of water-related disasters rise significantly with increasing greenhouse gas emissions. Exploitation of new data sources, better models and more powerful data analysis methods, as well as the design of adaptive management strategies can help respond effectively to changing and uncertain conditions.

Regional perspectives

The challenges at the interface of water and sustainable development vary from one region to another.

Increasing resource use efficiency, reducing waste and pollution, influencing consumption patterns and choosing appropriate technologies are the main challenges facing **Europe and North America**. Reconciling different water uses at the basin level and improving policy coherence nationally and across borders will be priorities for many years to come.

Sustainability in the **Asia and the Pacific** region is intimately linked with progress in access to safe water and sanitation; meeting water demands across multiple uses and mitigating the concurrent pollution loads; improving groundwater management; and increasing resilience to water-related disasters.

Water scarcity stands at the forefront when considering water-related challenges that impede progress towards sustainable development in the **Arab** region, where unsustainable consumption and over-abstraction of surface and groundwater resources contribute to water shortages and threaten long-term sustainable development. Options being adopted to enhance water supplies include water harvesting, wastewater reuse and solar energy desalination.

A major priority for the **Latin America and the Caribbean** region is to build the formal institutional capacity to manage water resources and bring sustainable integration of water resources management and use into socio-economic development and poverty reduction. Another priority is to ensure the full realization of the human right to water and sanitation in the context of the post-2015 development agenda.

The fundamental aim for **Africa** is to achieve durable and vibrant participation in the global economy while developing its natural and human resources without repeating the negatives experienced on the development paths of some other regions. Currently only 5% of the Africa's potential water resources are developed and average per capita storage is 200 m^3 (compared to 6,000 m^3 in North America). Only 5%

of Africa's cultivated land is irrigated and less than 10% of hydropower potential is utilized for electricity generation.

Responses and means of implementation

The post-2015 development agenda

The Millennium Development Goals (MDGs) were successful in rallying public, private and political support for global poverty reduction. With regard to water, the MDGs helped to foster greater efforts towards improving access to drinking water supply and sanitation. However, the experience of the MDGs shows that a thematically broader, more detailed and context-specific framework for water, beyond the issues of water supply and sanitation, is called for in the post-2015 development agenda.

In 2014, UN-Water recommended a dedicated Sustainable Development Goal for water comprised of five target areas: (i) WASH; (ii) water resources; (iii) water governance; (iv) water quality and wastewater management; and (v) water-related disasters. Such a focused water goal would create social, economic, financial and other benefits that greatly outweigh its costs. Benefits would extend to the development of health, education, agriculture and food production, energy, industry and other social and economic activities.

Achieving 'The Future We Want'

The outcome document of the 2012 UN Conference on Sustainable Development (Rio+20), *The Future We Want*, recognized that 'water is at the core of sustainable development', but at the same time development and economic growth creates pressure on the resource and challenges water security for humans and nature. There also remain major uncertainties about the amount of water required to meet the demand for food, energy and other human uses, and to sustain ecosystems. These uncertainties are exacerbated by the impact of climate change.

Water management is the responsibility of many different decision-makers in public and private sectors. The issue is how such shared responsibility can be turned into something constructive and elevated to a rallying point around which different stakeholders can gather and participate collectively to make informed decisions.

A stakeholder meeting in Punjab, India
Photo: India Water Portal

A Somali woman drawing water from one of the many man-made ponds dug through a UNDP-supported initiative to bring water to drought affected communities.
Photo: UNDP Somalia, Jalam, Garowe, Somalia

Governance
Progress in water-related governance calls for engaging a broad range of societal actors, through inclusive governance structures that recognize the dispersion of decision-making across various levels and entities. It is, for example, imperative to acknowledge women's contributions to local water management and role in decision-making related to water.

While many countries face stalled water reform, others have made great strides in implementing various aspects of integrated water resources management (IWRM), including decentralized management and the creation of river basin organizations. As IWRM implementation has too often been geared towards economic efficiency, there is a need to put more emphasis on issues of equity and environmental sustainability and adopt measures to strengthen social, administrative and political accountability.

Minimizing risks and maximizing benefits
Investing in all aspects of water resources management, services provision and infrastructure (development, operation and maintenance) can generate significant social and economic benefits. Spending on drinking water supply and sanitation is highly cost-effective on health grounds alone. Investments in disaster preparedness, improved water quality and wastewater management are also highly cost-effective. Distribution of costs and benefits among stakeholders is crucial for financial feasibility.

Water-related disasters, the most economically and socially destructive of all natural hazards, are likely to increase with climate change. Planning, preparedness and coordinated responses – including floodplain management, early warning systems and increased public awareness of risk – greatly improve the resilience of communities. Blending structural and non-structural flood management approaches is particularly cost-effective.

Risks and various water-related security issues can also be reduced by technical and social approaches. There are a growing number of examples of reclaimed wastewater being used in agriculture, for irrigating municipal parks and fields, in industrial cooling systems, and in some cases safely mixed in with drinking water.

Existing assessments of water resources are often inadequate for addressing modern water demands. Assessments are necessary to make informed investment and management decisions, facilitate cross-sector decision-making, and address compromises and trade-offs between stakeholder groups.

Equity
Social equity is one of the dimensions of sustainable development that has been insufficiently addressed in development and water policies. Sustainable development and human rights perspectives both call for reductions in inequities and tackling disparities in access to WASH services.

This calls for a reorientation of investment priorities and operational procedures to provide services and allocate water more equitably in society. A pro-poor pricing policy keeps costs as low as possible, while ensuring that water is paid for at a level that supports maintenance and potential expansion of the system.

Water pricing also provides signals for how to allocate scarce water resources to the highest-value uses – in financial terms or other types of benefits. Equitable pricing and water permits need to adequately assure that abstraction as well as releases of used water support efficient operations and environmental sustainability in ways that are adapted to the abilities and needs of industry and larger-scale irrigation as well as small-scale and subsistence farming activities.

The principle of equity, perhaps more than any technical recommendation, carries with it the promise of a more water-secure world for all.

Prologue
The future of water – A vision for 2050

WWAP | Richard Connor, Joana Talafré, Karine Peloffy, Erum Hasan and Marie-Claire Dumont

Over the past several decades, ever-growing demands for – and misuse of – water resources have increased the risks of pollution and severe water stress in many parts of the world. The frequency and intensity of local water crises have been increasing, with serious implications for public health, environmental sustainability, food and energy security, and economic development.

Although the central and irreplaceable roles that water occupies in all dimensions of sustainable development have become progressively recognized, the management of water resources and the provision of water-related services remains far too low on the scales of public perception and of governmental priorities. As a result, water often becomes a limiting factor, rather than an enabler, to social welfare, economic development and healthy ecosystems.

The fact is there is enough water available to meet the world's growing needs, but not without dramatically changing the way water is used, managed and shared. The global water crisis is one of governance, much more than of resource availability, and this is where the bulk of the action is required in order to achieve a water secure world.

Evoluzione
Photo: Rhae

A vision for 2050

By 2050, humanity has achieved a water secure world,[1] where every person has access to adequate quantities of water of an acceptable quality and from sustainable sources, to meet their basic needs and sustain their well-being and development. The human population is protected from waterborne pollution and diseases and water-related disasters. Accessing water is no longer a gendered burden, and equitable access to water resources and services for both women and men has fostered greater social inclusion. Ecosystems are protected in a climate of peace and stability. Local and national economies are more robust, as the risks and uncertainties related to the availability of water resources have been taken into account in the long-term planning for poverty reduction and economic development. Norms and attitudes have changed as a result of educational interventions, institutional changes, improved scientific and technical knowledge, sharing of lessons learned and best practices, and proactive policy and legislative developments.

Access to water, sanitation and hygiene (WASH) has been made universal through the massive deployment of urban water infrastructure as well as through decentralized small-scale water purification technology in remote areas, leading to widely improved health conditions and allowing a life of human dignity for all persons. Technological innovation allows for reduced water consumption, such as through waterless sanitation infrastructure that provides energy and products from human excreta and eliminates pollution to precious freshwater resources.

There is a balance between extracted water and water returned to aquatic ecosystems and aquifers, ensuring their long-term sustainability. Wastewater from all major human uses is collected and treated to the most appropriate level for reuse or release back to the environment, and maximized reuse is a major contributor to the achievement of universal access to water.

Water demand per capita and per unit of productivity is significantly lower than it was in 2015 in the agricultural, industrial and energy sectors, allowing for the resource to be shared more equitably. Reduced competition among the major water users has also helped increase their long-term economic performance. Water productivity (e.g. 'crop per drop') in both rainfed and irrigated agriculture has increased dramatically, and water use efficiency in agriculture is widespread.

Agriculture as a whole is less vulnerable to rainfall variability due to the widespread adoption of advanced agro-technology, highly efficient irrigation techniques, reliable wastewater reuse and state-of-the-art water and soil conservation techniques. Water demand for everyday domestic uses is met through the use of efficient technologies and effective, equitable tariffs are in place. Power generation has increasingly adopted water efficient techniques (e.g. dry cooling), the proportion of less water intensive renewable energy (e.g. wind, solar PV and geothermal) has increased dramatically, and the development of sustainable hydropower installations in sub-Saharan Africa and South-East Asia has helped provide electricity to hundreds of millions of people who were previously unserved. Implementation and enforcement of water use regulation, in combination with development and adoption of water-efficient manufacturing processes, has limited the water demand for industry, prompting economic development.

Ecosystem-based management and other environmental interventions that build resilience have been widely adopted; these interventions also support protection of water sources, catchments and riverbanks and promote conservation and efficient use of water in agriculture and other economic activities.

Sustainable production and consumption patterns related to water are achieved based on consistent and transparent water accounting systems that quantify water flows in the economy and the environment, providing clear and relevant information about related impacts. In this context, effective decoupling of economic growth from water resource use and negative environmental impacts has been accomplished.

Water is a key consideration for all sectors that use it as a resource through production chains, resulting in better supply and demand management. Efficiency measures such as rainwater harvesting and wastewater reuse are mainstreamed. Global markets and trade flows are monitored through a global water sensitivity certification scheme that ensures water-intensive products are exported from areas with comparatively little or no water stress. The economic value of water has been recognized and all forms of economic enterprise take consideration of the water implications of their actions. Explicit, transparent and equitable regulation mechanisms are in place to address water allocation, distribution, access and management, without risk of corruption.

1 Based on the definition of 'water security' by the UN-Water Task Force on Water Security: "Water security is defined as the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability."

The world's major transboundary basins and aquifers are managed in a collaborative manner among the multiple states involved, leading to improvements in quality and ecological conditions as well as improved relations, capacity and benefit-sharing among neighbouring countries. Flexible multi-stakeholder water governance frameworks are commonplace, as are examples of cooperation, knowledge and technology transfers, and on-going participatory dialogue at all levels: local, national, regional and global.

At the national level, governments rely on an integrated water resources management (IWRM) approach. IWRM is based on a sound and systematic knowledge of the resource, both surface and groundwater, and of its current state. It supports effective and adaptive decision-making across a broad policy spectrum, including agriculture and food security, energy, industry, financing, environmental protection, public health and public security.

Financing for a wide range of water-related infrastructure and services, including operation and maintenance, has become a central element of government expenditure. A flexible approach has been adopted to achieve financial sustainability with on-going exploration of alternative financing options. Financing from non-governmental sources (including self-financing) and equitable tariffs support the public sector in achieving complete coverage of water management costs. This in turn has created an environment that encourages private sector involvement because of the lower risks to investment. Improved guidelines, legislation, licensing agreements and contracts also support sustainable financing for water-related infrastructure and services. Life-cycle planning approaches have improved understanding of the short-term, mid-term and long-term costs associated with development, maintenance and replacement of water systems. Mid-course corrections are also possible due to a flexible approach to financing for water. In using such an approach, investment plans are transparent and accessible, thus promoting accountability and participation from stakeholders. The principle that sustainable financing is necessary for ensuring universal access to water services underpins this integrated approach.

Technology, better management approaches and effective early warning systems enable rapid adaptive responses to variations in water availability and extreme water-related events. Despite massive reductions in greenhouse gas emissions GHG emissions worldwide, impacts from such extreme events are still increasing as a result of decades of human-induced climate change. Surface and groundwater, conjunctively managed, are at the centre of climate adaptation strategies, and improved and expanded water storage capacities create buffers for periods of water shortages.

The importance and value of ecosystems, and the services they deliver through water, are widely recognized. Appropriate steps to protect key aquatic systems have been taken through basin-wide cooperation to ensure that water abstraction remains compatible with hydrological and environmental sustainability, pollution is eliminated, and ecosystems are restored to provide climate-resilient sources of freshwater. Human and natural infrastructures are mutually reinforcing, and their coordinated management increases benefits while reducing costs. Cities are redesigned to give public access to natural watershed community parks that, in addition to providing direct benefits in terms of overall living standards, foster broad-based citizen stewardship over water.

Equity, non-discrimination, participation and accountability have become key principles in water governance. National laws support the mainstreaming of the human rights-based approach to water, which helps correct potential imbalances and avoid social exclusion. Over the period 2015-2030, the greenhouse gas emissions SDGs and targets, including an SDG specifically dedicated to water, helped muster political will, trigger public support and mobilize investments between. Although these alone were not enough to secure sustainable water for all, they led to new efforts and international conventions that take full account of the opportunities and limitations imposed by water on various other development goals, leading to cross-cutting synergies among sectors and actors. Policymakers, politicians, regulators, the judiciary, educators, allocators of resources, academics and members of civil society organizations are able to work together within their own areas of expertise to advance shared norms, protocols and understanding of water as a resource and how best to consume and protect it.

Water's role in underpinning all aspects of sustainable development has become widely recognized. It is now universally accepted that water is an essential primary natural resource upon which nearly *all* social and economic activities and ecosystem functions depend.

Getting there was not easy.

1 Unsustainable growth

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Unsustainable development pathways and governance failures have generated immense pressures on water resources, affecting its quality and availability, and in turn compromising its ability to generate social and economic benefits. The planet's capacity to sustain the growing demands for freshwater is being challenged, and there can be no sustainable development unless the balance between demand and supply is restored.

Global gross domestic product (GDP) rose at an average of 3.5% per year from 1960 to 2012 (World Economics, 2014), and much of this economic growth has come at a significant social and environmental cost. During this same period, population growth, urbanization, migration and industrialization, along with increases in production and consumption, have generated ever-increasing demands for freshwater resources. These same processes have also contributed to the polluting of water resources, further reducing their immediate accessibility and thus compromising the capacity of ecosystems and the natural water cycle to satisfy the world's growing demand for water (MEA, 2005a).

1.1 Increasing global water demand

Global water demand is largely influenced by population growth, urbanization, food and energy security policies, and macro-economic processes such as trade globalization and changing consumption patterns.

Over the past century, the development of water resources has been largely driven by the demands of expanding populations for food, fibre and energy. Strong income growth and rising living standards of a growing middle class have led to sharp increases in water use, which can be unsustainable, especially where supplies are vulnerable or scarce and where its use, distribution, price, consumption

Traffic in Beijing
Photo: Li Lou/World Bank

and management are poorly managed or regulated. Changing consumption patterns, such as increasing meat consumption, building larger homes, and using more motor vehicles, appliances and other energy-consuming devices, typically involves increased water consumption for both production and use.

Demand for water is expected to increase in all sectors of production (WWAP, 2012). By 2030, the world is projected to face a 40% global water deficit under the business-as-usual (BAU) scenario (2030 WRG, 2009).

Population growth is another factor, but the relationship is not linear: over the last decades, the rate of demand for water has doubled the rate of population growth (Shiklomanov, 1999; USCB, 2012). The world's population is growing by about 80 million people per year (USCB, 2012). It is predicted to reach 9.1 billion by 2050, with 2.4 billion people living in Sub-Saharan Africa, the region with the most heterogeneously distributed water resources (UNDESA, 2013a).

Increasing urbanization (see Chapter 6) is causing specific and often highly localized pressures on freshwater resource availability, especially in drought-prone areas. More than 50% of people on the planet now live in cities, with 30% of all city dwellers residing in slums. Urban populations are projected to increase to a total of 6.3 billion by 2050 (WWAP, 2012). Developing countries account for 93% of urbanization globally, 40% of which is the expansion of slums. By 2030, the urban population in Africa and Asia will double (UN-Habitat, 2010).

Excessive water withdrawals for agriculture and energy (see Chapters 7 and 8) can further exacerbate water scarcity. Freshwater withdrawals for energy production, which currently account for 15% of the world's total (WWAP, 2014), are expected to increase by 20% through 2035 (IEA, 2012). The agricultural sector is already the largest user of water resources, accounting for roughly 70% of all freshwater withdrawals globally, and over 90% in most of the world's least-developed countries (WWAP, 2014). Practices like efficient irrigation techniques can have a dramatic impact on reducing water demand, especially in rural areas.

Many of the pressures that impact water sustainability occur at local and national levels, and are influenced by rules and processes established at those levels. Increasingly, however, the rules and processes that govern global economics – investment of capital, trade, financial markets, as well as international aid and development assistance – influence local and national economies, which in turn dictate local water demand and the sustainability of water resources at the basin level (UNDESA, 2012).

1.2 Potential impacts of increasing demand

Competing demands will lead to increasingly difficult allocation decisions and limit the expansion of sectors critical to sustainable development, in particular food production and energy. Inter-sectoral competition and the delicate trade-offs between energy and agricultural production can already be seen in the debate about biofuels. Production of biofuel from food crops, such as corn, wheat and palm oil, has induced additional competition for land and water even within the agricultural sector, especially in regions already under water stress (HLPE, 2013), and has also been associated with increased food prices. Growing food crops for biofuel has spurred debate over ethical considerations regarding future food security as well as existing efforts to combat malnutrition (Pimentel et al., 2008).

> ***Population growth,*** *urbanization, migration and industrialization, along with increases in production and consumption, have generated ever-increasing demands for freshwater resources*

Increasing industrial production (see Chapter 9) will also lead to increased water use, with potential impacts on water quality. In certain areas where water use for industrial production is not well-regulated or enforced, pollution could increase dramatically, closely linking increasing economic activity with the degradation of environmental services.

Competition for water between water 'uses' and water 'users' increases the risk of localized conflicts and continued inequities in access to services. In this competition, the need to maintain water and ecosystem integrity in order to sustain life and economic development is often ignored (see Chapter 4). Frequently, the environment, as well as marginalized and vulnerable people, are the biggest losers in the competition for water.

Inter-state and regional conflicts may also emerge due to water scarcity and poor management structures. It is noteworthy that 158 of the world's 263 transboundary water basins lack any type of cooperative management framework. Of the 105 water basins with water institutions, approximately two-thirds include three or more riparian states (adjacent to rivers and streams); yet, less than 20% of the accompanying agreements are multilateral (UNEP, 2002). This indicates that the mechanisms, political will and/or resources to manage shared water resources bilaterally or multilaterally and share potential benefits efficiently and effectively are missing.

Competition over water highlights the difficult policy choices that are posed by the water-food-energy-nexus and the trade-offs involved in managing each sector, either separately or together. These three pillars of any functioning society are closely interlinked, and choices made in one area will inevitably impact the choices and hence resources available in the others (WWAP, 2014).

Over-abstraction is often the result of out-dated models of natural resource use and governance, where the use of resources for economic growth is under-regulated and undertaken without appropriate controls. Unsustainable withdrawals of surface and groundwater can severely affect water availability for ecosystems and the services they provide, with significant impacts on local economies and human well-being. Inadequate assessment of water resources, especially groundwater (Section 1.4), and in some cases a disregard of information when it is available, have contributed to water resources management failures in many parts of the world.

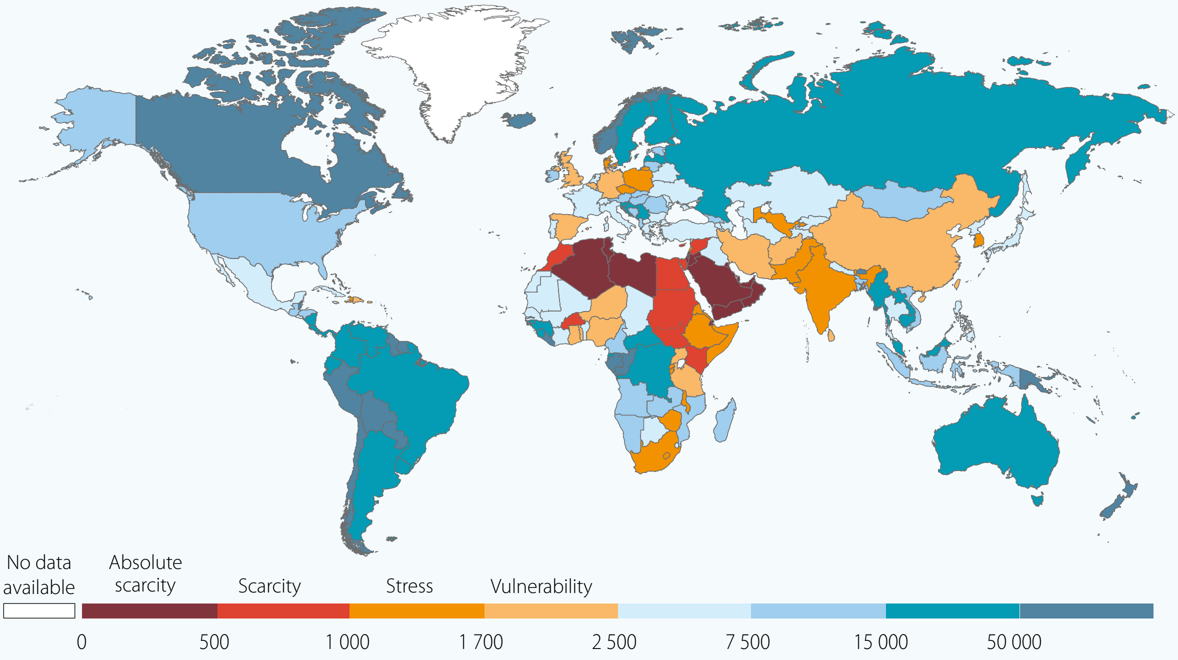
If institutional mechanisms within governments and other governance structures continue to follow narrow objectives along sector-specific mandates, fundamental disconnects will continue to occur. This situation has already led to negative impacts for the most vulnerable and marginalized people; accelerated ecosystem degradation; depleted natural resources; and slowed progress towards development goals, poverty reduction and conflict mitigation (Bonn2011 Nexus Conference, 2012).

1.3 Water resources: Status and availability

The distribution and availability of freshwater resources, through precipitation and runoff, can be erratic, with different areas of the globe receiving different quantities of water over any given year. There can be considerable variability between arid and humid climates and over wet and dry seasons. However, compounded yearly averages show significant variations in per capita water availability between countries (Figure 1.1).

Climate change will exacerbate the risks associated with variations in the distribution and availability of water resources (see Chapter 10). Increasing variability in

FIGURE 1.1 **Total renewable water resources per capita (2013)**



Note: The figures indicate total renewable water resources per capita in m³.
Source: WWAP, with data from the FAO AQUASTAT database. (http://www.fao.org/nr/water/aquastat/main/index.stm) (aggregate data for all countries except Andorra and Serbia, external data), and using UN-Water category thresholds.

precipitation patterns, which many countries have already begun to experience, are leading to direct and indirect effects on the whole of the hydrological cycle, with changes in runoff and aquifer recharge, and in water quality (Alavian et al., 2009). In addition, higher water temperatures due both to warmer climates and increasing discharges of waste heat, are expected to exacerbate many forms of pollution. These include sediments, nutrients, dissolved organic carbon, pathogens, pesticides and salt, as well as thermal pollution, with possible negative impacts on ecosystems, human health, and water system reliability and operating costs (Bates et al., 2008).

Groundwater plays a substantial role in water supply, in ecosystem functioning and human well-being. Worldwide, 2.5 billion people depend solely on groundwater resources to satisfy their basic daily water needs, and hundreds of millions of farmers rely on groundwater to sustain their livelihoods and contribute to the food security of so many others (UNESCO, 2012). Groundwater reportedly provides drinking water to at least 50% of the global population and accounts for 43% of all water used for irrigation (Groundwater Governance, n.d.). Groundwater also sustains the baseflows of rivers and important aquatic ecosystems. Uncertainty over the availability of groundwater resources and their replenishment rates pose a serious challenge to their management and in particular to their ability to serve as a buffer to offset periods of surface water scarcity (van der Gun, 2012).

Groundwater supplies are diminishing, with an estimated 20% of the world's aquifers being over-exploited (Gleeson et al., 2012), leading to serious consequences such as land subsidence and saltwater intrusion in coastal areas (USGS, 2013). Groundwater levels are declining in several of the world's intensely used agricultural areas and around numerous mega-cities (Groundwater Governance, n.d.). In the Arabian Peninsula, freshwater withdrawal, as a percentage of internal renewable water resources, was estimated at 505% in 2011 (FAO AQUASTAT), with significant volumes of groundwater reserves being transboundary in nature (UNESCWA/BGR, 2013).

Water availability is also affected by pollution. Most problems related to water quality are caused by intensive agriculture, industrial production, mining and untreated urban runoff and wastewater. Expansion of industrial agriculture has led to increases in fertilizer applications. These and other industrial water pollutants create environmental and health risks. Excessive loads of nitrogen and phosphate, the most common chemical contaminants in the world's freshwater resources (WWAP, 2009), contribute to the eutrophication of freshwater and coastal marine ecosystems, creating 'dead zones' and erosion of natural habitats (UN-Water, 2013).

The human interference with phosphorus and nitrogen cycles is well beyond safe thresholds. Eutrophication of surface water and coastal zones is expected to increase almost everywhere until 2030 (UNDESA, 2012). Thereafter, it may stabilize in developed countries, but is likely to continue to worsen in developing countries. Globally, the number of lakes with harmful algal blooms will increase by at least 20% until 2050. Phosphorus discharges will increase more rapidly than those of nitrogen and silicon, exacerbated by the rapid growth in the number of dams (UNDESA, 2012).

The disruption of ecosystems through unabated urbanization, inappropriate agricultural practices, deforestation and pollution is undermining the environment's capacity to provide basic water-related services (e.g. purification, storage). Degraded ecosystems can no longer regulate and restore themselves; they lose their resilience, further accelerating the decline in water quality and availability (see Chapter 4).

Global environmental degradation, including climate change, has reached a critical level with major ecosystems approaching thresholds that could trigger their massive collapse (UNDESA, 2012). This is a result of past failures to design decision-making mechanisms that would appropriately govern the global and national commons and the earth's shared natural resources. Despite efforts to create cooperation around environmental treaties and agreements, decisions directly affecting environmental issues are often taken outside of environmental policy circles. Any predominance of economic logic without the integration of social and environmental considerations, as it currently exists in many development approaches, means that long-term environmental objectives may be set aside in favour of short-term economic goals.

1.4 Constraints on water resources management

The previous sections of this chapter have provided a summary view of the processes that drive increasing demands for water, their potential consequences and what these could mean for water resources. However, there are additional constraints that pose significant challenges to improving water resources management. These transcend any type of pressure-state-response analysis, yet they are tangible and merit a critical level of consideration when addressing water-related issues in the context of sustainable development.

1.4.1 Persistent poverty

Persistent poverty is usually the result of a vicious cycle in which limited income converges with limited access to resources. Safe water and sanitation are precursors to health care, education and jobs (see Chapter 2). For the last 15 years, eradication of extreme poverty and hunger has been the number one priority under the MDGs. Nevertheless, as of 2012, 1.2 billon people still lived in extreme poverty (Lockhart and Vincent, 2013), the majority located in slums, often lacking adequate drinking water and sanitation services (UN-Habitat, 2011). The global limit of ecological sustainability of water available for abstraction is reported to have been reached (Barker et al., 2000). Regionally, this limit has already been exceeded for about one-third of the human population and it will rise to about half by 2030 (WWAP, 2012). Apart from access to sanitation and clean drinking water, the world's 850 million rural poor also lack access to water for agricultural production, which is usually their primary source of income (Soussan and Arriens, 2004). Without access to improved agricultural water management, poverty in these regions will persist (Namara et al., 2010).

Women and youth are disproportionately impacted both by water scarcity and the lack of safe drinking water, increasing the vulnerability associated with persistent poverty. Water policies are often based on generalized perspectives that lack gender perspectives and local knowledge (WWAP, 2012). By failing to integrate gender considerations in water resources management and also in sectors such as agriculture, urban water supply, energy and industry, gender inequities will persist, preventing the adoption of innovative solutions that may be put forth by women (WWAP, 2012).

In most countries (...) funding for water infrastructure is neither adequate, nor sustainable

1.4.2 Discrimination and inequalities in access to drinking water and sanitation services

Socio-economic inequalities, and the lack of policies to effectively address them, were among the main obstacles to the achievement of MDGs in general and improved access to sanitation and safe drinking water in particular (Donat Castelló et al., 2010). Many people around the globe including women, children, the elderly, indigenous peoples and people with disabilities have lower levels of access to safe drinking water, hygiene or sanitation facilities than other groups (see Chapter 5). While access to safe drinking water and sanitation is recognized as a basic human right, discrimination based on ethnicity, religion, economic class, social status, gender, age or physical abilities often restricts people from accessing land and water resources and related services. Such exclusion has long-term social and economic effects, as the disadvantaged are more likely to remain poor, lacking opportunities for education, employment and social engagement.

Population dynamics also affect access. High urbanization rates in many countries have not been matched by governments' ability to provide adequate drinking water and sanitation infrastructure and improved service delivery (UN-Habitat, 2011). Human migration from rural to urban areas is posing a continuous challenge to the provision of basic drinking water and sanitation services, especially in poor peri-urban and slum areas, as well as to public health, in particular to prevent outbreaks of cholera and other water-related diseases (WHO and UNICEF, 2014a).

In the rural context, which require different systems to those generally found in urban settings, providing adequate drinking water and sanitation is also challenging. The lack of infrastructure and services means that many people do not have access to adequate sanitation and must rely on unsafe water supplies. The lack of access to safe drinking water coupled with other shortages of basic services, scarce resources and limited income-generating possibilities, can further entrench vulnerability.

1.4.3 Insufficient and unsustainable financing for water resources management and services

Water services remain rather low on the scale of policy priorities, despite well-documented contributions to human and economic development. When compared with other development sectors, particularly education and health, sanitation and drinking water services receive a relatively low priority for both official development assistance (ODA) and national expenditure (UNDESA, 2013a). This under-prioritization of water directly contravenes a State's obligation to expend maximum available resources to promote the progressive realization of the human right to water and sanitation for all persons, without discrimination. Financing for water resources management is also usually a low priority, in spite of it being a cornerstone of economic growth (see Chapter 3) (SIWI, 2005).

In most countries, funding for water infrastructure comes from government allocations, although many developing countries still depend on external assistance to fund water resources management and utilities. This is neither adequate, nor sustainable. Most countries report that information required for adequate financial planning in the water

BOX 1.1

The terms 'safe' and 'improved' in the MDG context

When it was first devised, the objective of the water target in the Millennium Development Goals was to ensure access to '**safe**' drinking water. The precise wording is as follows:

Goal 7: *Ensure environmental sustainability*
Target 7.C: *Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation.*

There were no practical means, however, to measure the '**safety**' of the water sources people use. The WHO AND UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation started using the proxy indicator of an 'improved' water source for monitoring Target 7.C:

Indicator: *Proportion of population using an* ***improved*** *drinking water source*

All 'improved' water sources are not necessarily 'safe'. An **improved water source** is one where human use is kept separate from use by animals and faecal contamination. In many cases the water from such sources is **not of good enough quality to be safe** for human consumption (Bain et al, 2014).

Various estimations of the number of people who use 'improved' sources that are not 'safe' now exist and these indicate that billions of people do not have access to water that is truly safe. See, for example, the UN Report of the High-Level Panel of Eminent Persons on the Post-2015 Development Agenda (UN, 2013a). The number of people without 'safe' water could be as large as those who do not have access to basic sanitation (about 2.5 billion), for which progress is unsatisfactory by nearly all accounts. In its latest report, the WHO/UNICEF JMP recognizes and explains the inadequacy of the improved water proxy indicator and outlines plans for strengthening monitoring and encouraging safe management of water sources and sanitation services. Its commissioned studies have found that, at any given time, 1.8 billion people are using a source of drinking water that is faecally (TBC)-contaminated (Bain et al., 2014).

The unintended consequence of using the proxy indicator 'improved water source' for the 'safe' drinking water target is that **the indicator has redefined the target** by default; therefore, the original ambition of MDG 7.C has been downgraded. The claim that the original target has been reached is misleading, because what has really been met is a new and unintended MDG target for '**improved**' water. This redefinition of the original target can send decision-makers in the wrong direction, leading them to believe that target 7.C has been met and a problem solved, when in reality much still remains to be done.

Contributed by AquaFed (www.aquafed.org/).

services sector, such as information on users and their potential contributions, is insufficient. Costs of infrastructure operation and maintenance are often neglected or not well factored into water mobilization projects. As a result, many water systems are inadequately maintained, leading to damages, losses, unreliability, and decreasing quality and quantity of service to users. Financing is reported to be particularly inadequate for sanitation, with drinking water absorbing the majority of funding available particularly in developing countries (WHO, 2012a). Financing for wastewater treatment is chronically neglected.

Despite persistent management obstacles relating to financing in the water sector, over 50% of countries low in the Human Development Index (HDI) have reported that financing for water resources development and management from government budgets and official development assistance have been increasing over the last 20 years (UN-Water, 2012).

1.4.4 Data and information

Monitoring water availability, use and the related impacts, represents a massive and persistent challenge. Reliable and objective information about the state of water resources, their use and management is often poor, lacking or otherwise unavailable. Worldwide, water observation networks provide incomplete and incompatible data on surface and groundwater quality and quantity, and no comprehensive information exists on wastewater generation and treatment (WWAP, 2009). Various studies and assessments provide a snapshot of the state and use of water resources at a given time and place, but generally

do not provide a broader, more complete picture of how different dimensions of water are changing over time in different parts of the world.
In the context of sustainable development, where water is often a key driver – and a potential limiting factor – for economic growth, human well-being and environmental health, this lack of information and knowledge creates barriers to cohesive policy formulation and sound decision-making on developmental objectives. For example, there are often too few reliable metrics on which to track the outcomes of water productivity improvement measures (WWAP, 2014).

From an economic perspective, there is a need to couple data and information on water resources and their use with indicators of growth in various economic sectors in order to assess its role and contribution in terms of economic development, and to garner a better understanding of its consequences on the resource and different users. Similarly, quantifying water's role in maintaining healthy ecosystems is often limited to the determination of 'environmental flows' (i.e. the quantity and timing of water flows required to sustain freshwater ecosystems). Although an important and useful tool for managing freshwater ecosystems, environmental flows are often based on the requirements of certain indicator species and may not take full account of the interconnections between ecological systems and their impacts on economic and social development.

In terms of human well-being, much of the focus has been on monitoring access to safe water supply and sanitation services, which has in large part been driven by MDG target 7.C. Here too, data and information challenges persist, including the difficulty in translating the term 'safe' into a measurable metric (see Box 1.1). Water quality testing is still not available in most countries, making it difficult to determine if improved sources actually deliver 'safe' water to the user or whether the risks of contracting water-related diseases remain. Furthermore, most countries do not report on other aspects of access to 'safe' water such as the quantity available, possible security threats including as risks on the journey to fetch water, frequency and duration of access or supply, and water's potentially prohibitive cost (Dar and Khan, 2011).

Although real progress has been made, full compliance with the human right to access safe drinking water clearly requires something that is significantly better than many of the improved sources that people have to use. This situation also highlights the need to select target indicators based on good (and readily available) data, and to craft and implement good monitoring mechanisms. The MDG indicators focused on aggregate outcomes, which masked the fact that access improvements often did not reach the most vulnerable groups such as the elderly poor, people with disabilities, women and children. Indicators that disaggregate data by gender, age and social group pose both a challenge and an opportunity for the SDGs in the post-2015 development agenda (UN-Water, 2013).

While data availability and quality remain a concern, a limited number of core indicators pertaining to various aspects of water resources, services, uses and management in the context of sustainable development are available. Several of these indicators are used in this Report. They are compiled and presented in *Case studies and Indicators report* (WWAP, 2015).

PART 1

WATER AND THE THREE DIMENSIONS OF SUSTAINABLE DEVELOPMENT

CHAPTERS

2. Poverty and social equity – 3. Economic development – 4. Ecosystems

Water consumption of ricefields (Viet Nam)
Global Water Consumption
Photo: UN Photo/Kibae Park

The Prologue presents an ideal future where water resources are developed and used sustainably for the benefit of all. Although this vision for water is fully attainable by 2050, a number of obstacles related to unsustainable growth, as well as other challenges described in Chapter 1, will first need to be overcome.

A water-secure world is more than a goal unto itself. It is a critical and necessary step towards a sustainable future. Progress in each of the three dimensions of sustainable development – social, economic and environmental – is bound by the limits imposed by finite and often vulnerable water resources and the way these resources are managed to provide services and benefits. It is therefore imperative that the role of water is taken into account, when seeking to address all major sustainable development objectives.

Part 1 of this Report, presented in three chapters, explores the complex linkages between water and the three dimensions of sustainable development. Chapter 2 examines water and the social dimension of sustainable development with a focus on poverty. Chapter 3 presents a series of sound arguments that show how water is a central pillar of sustainable economic growth. Chapter 4 describes the fundamental and irreplaceable role of ecosystems and the services they provide in the context of water and sustainable development.

Poverty and social equity

2

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2.1 The water and poverty relationship

A daily struggle for water is one of the terrible burdens of poverty, especially for women and girls who spend endless hours fetching water over long distances. Sources of water are often unclean or unaffordable, or groups are simply cut off from using a particular water source. Many poor urban dwellers have to pay very high water prices to informal water vendors or do without water. Not having sufficient and safe water means constant weakness and pain through recurrent diarrhoea and other debilitating or fatal water-related diseases. It leads to loss of time, educational and employment opportunities. Low incomes and limited access to water also means choosing between paying for water, food, school fees or medicines. Around the world, 748 million people lack access to an improved drinking water source, while billions more lack drinking water that is really safe. In 2012, 2.5 billion people did not have access to an improved sanitation facility (WHO and UNICEF, 2014a).

Access to water for household uses is critical for a family's health and social dignity. Access to water for productive uses such as agriculture and family-run businesses is vital to realize livelihood opportunities, generate income and contribute to economic productivity. Almost one-fifth of the world's population – about 1.2 billion people – live in areas where water is physically scarce (UN-Water/FAO, 2007). One quarter of the global population also live in developing countries that face water shortages due to weak governance and human capacities, and a lack of infrastructure to transport water from rivers and aquifers (Comprehensive Assessment of Water Management in Agriculture, 2007). In practice, this means fewer opportunities to make use of water resources to grow food and for other productive purposes.

Access to water is linked to poverty. Reducing poverty through water management is a useful pro-poor framework for action, allowing for the introduction of inter-related issues of governance, water quality, access, livelihood opportunities, capacity-building and empowerment, water-related disaster prevention and management, and ecosystem management.

Access to water is also about access to land. In most cases, access to and ownership of land implies access to the water that passes through, lies beneath the surface or comes from the sky. The land-water interdependency is often overlooked and handled under separate governance structures.

BOX 2.1

Water supply investments: The importance of governance and financing for reducing poverty

Weak governance, in combination with low incomes and costs of services, make it much harder for poor people to acquire sustainable access to water. Even in situations where investments are made, sustainability remains a serious challenge. As much as 30% to 50% of water supply projects fail after two to five years. Though figures differ between countries, about 30% or more of water supply points are non-functioning, with another 10% to 20% being only partially functional. "Figures collated by the Rural Water Supply Network indicate an average rate of 36% non-functionality for hand pumps across 21 countries in sub-Saharan Africa." This level of failure represents a total investment of between US$1.2 billion and US$1.5 billion in the last 20 years. A European Union evaluation report of 23 water supply and sanitation projects in sub-Saharan Africa found that equipment was generally installed as planned, but fewer than half of the projects' results meet the needs of beneficiaries. A majority of the projects were potentially sustainable in the sense of using standard technologies and local materials. However, their results and benefits will not continue to flow in the medium and long term unless non-tariff revenue is ensured; or because of institutional ineffectiveness to regulate, monitor, collect service fees, manage procurement processes, and collect and disseminate information, or deficiencies in the capacities of operators to run the equipment installed.

Sources: ECA (2012); IRC (2009) and RWSN (2010).

Note: The evidence on unsustainable water, sanitation and hygiene (WASH) investments is mounting; see, for example, Ministry of Foreign Affairs of the Netherlands (2012).

The relation between water and poverty is a two-way street. Poverty itself can have negative effects on the management of water resources and services. The desperation and limitations arising from poverty can be a driver of pollution and unsustainable use of water resources. Poverty can also render existing investments in water less efficient, since households and communities often find it difficult to finance, operate and maintain infrastructure such as rural water pumps. This poses a serious threat to long-term development and poverty reduction (Box 2.1).

2.2 The equity challenge

Great strides have been made in many countries – such as Brazil, China and India – to reduce poverty. The *Human Development Report (HDR) 2013* suggests that by 2020 the combined economic output of these countries alone will surpass the aggregate production of Canada, France, Germany, Italy, the United Kingdom and the United States (UNDP, 2013). Much of this expansion is being driven by new trade and technology partnerships within the South. However, economic growth itself is not a guarantee for wider social progress. Poverty still remains at unacceptable levels even in these three countries, as elsewhere. In many developing countries, there is a wide – and often widening – gap between rich and poor, and between those who can and cannot exploit new opportunities arising from economic growth. This means that access to good schools, health care, electricity, safe water and other critical services still remains elusive for many people who live in economies on the rise. Other challenges, such as economic shocks, food shortages and climate change, threaten to undercut economic and social progress made in recent years.

BOX 2.2

Safeguarding the interests of poor people: Global trends with local effects

According to the Water Governance Facility (WGF, 2012), "Most vulnerable in a world of greater water insecurity are poor people living in informal urban settlements and those in rural areas whose livelihoods are dependent upon rainfed agriculture or the availability of grasslands and water for grazing animals. Protecting the rights of such people and avoiding elite capture of the resource and the benefits derived from it require tools that foster a more equitable allocation of scarce water resources."

Two global trends are converging: climate change, and growing economic development in least developed countries (LDCs) and emerging economies. This convergence is certain to intensify the water insecurity of poor and marginalized people in low income countries and add to the urgency for new approaches to the allocation of water resources for development. The *OECD Environmental Outlook to 2050* (OECD, 2012a) estimates that by 2050 water demands from manufacturing industries and thermal power generation will increase dramatically, especially in developing countries and the BRICS (the five major emerging national economies of Brazil, Russia, India, China and South Africa). In the manufacturing industry alone, the share of total water demand by 2050 is expected to increase from 7% to 22%. The water demand increase in BRICS will be sevenfold, while in developing countries it will come close to increasing by 400%. In OECD countries, an increase is expected of some 65%. While such increased demand for water can indicate positive economic growth ahead it also implies the huge challenge of how to allocate scarce water between and within different sectors such as industry, energy, agriculture and domestic use. There is also the huge challenge of how different groups, such as poor people, will be affected.

"To allocate water in ways that are efficient, equitable and sustainable in a world of increasing demand and more variable water supplies, the following issues could be considered:

- Market mechanisms (trading systems and full-cost pricing through valuation) excel in the efficiency arena, but can fall short when the goal is to realize the right to water and sanitation or when externalities that impact environmental sustainability are not taken into account.
- From an efficiency perspective, when markets do not fully capture the total value of water, other mechanisms have to be engaged to allocate water to the highest value uses and users. Yet what constitutes 'efficiency' and 'highest value uses and users' is often subjective. People living at the margins seldom qualify as high value users, yet good development practice demands that their needs be given priority.
- Conflict resolution mechanisms and rubrics for managing trade-offs are often needed to facilitate water sharing among competing users such as upstream and downstream stakeholders. Ensuring that powerful interests do not dominate or entirely capture the process requires robust safeguards to ensure that poor people can participate meaningfully, hold officials to account and access information." (WGF, 2012)

The *Global Risks 2014* report finds that income disparity is the risk most likely to cause an impact on the global scale in the next decade (WEF, 2014a). More than 80% of the world's population live in countries where income differentials are widening (UNDP, 2007). The HDR 2013 identified four key areas to keep the momentum of economic growth: (a) enhancing equity, including the gender dimension; (b) enabling greater voice and participation of citizens, including youth; (c) confronting environmental pressures; and (d) managing demographic change (UNDP, 2013).

Development is about improving people's well-being, giving them a say in the decisions that affect their lives, and expanding their freedoms, choices and opportunities. From this perspective, the way in which water resources are allocated in countries around the world is deeply problematic. Water resource allocation for a range of productive purposes, from agriculture to industry to ecosystem services, is typically inequitable. Generally speaking, comparatively powerless groups tend to be shut out of access to water, as well as the processes whereby allocation decisions are made. Although integrated water resources management (IWRM) approaches are guided by a balanced concern for economic efficiency, environmental sustainability and social equity, in practice, the social equity goal is often given less priority when water allocation decisions are made (WGF, 2012).

Non-inclusive growth coupled with inappropriate allocation of water resources and services and increasing demand for water by industry, agriculture and households run the risk of making societies more unstable and prone to tensions and conflicts. While demand is expected to continue to grow as a result of economic growth and changing consumer preferences, much can be done in the ways water is allocated and used. There is a need for more effective allocation mechanisms that also take into account the interests of poor people, and that can mediate grievances between different users (Box 2.2).

2.3 Key dimensions of poverty reduction

Water and economic development are closely associated, and poverty-oriented water interventions can have direct, immediate and long-term social, economic and environmental results, making a difference to billions of people. Investing in improved water management and services is a prerequisite to reducing poverty and achieving sustainable economic growth. Poor people receive very direct benefits from improved water and sanitation services through better health, reduced health costs, increased productivity and time-savings. Improved management of water resources management can provide fewer risks and increased productivity gains across and within sectors – such as land, energy, food, and mining – and upkeep of ecosystem services.

Water management contributes to four key dimensions of poverty reduction (UNDP/SEI, 2006):

Enhanced livelihoods security relates to incentives provided to poor people to develop abilities and make use of their assets to earn an acceptable living. Access to water is key to realizing livelihood opportunities and continuity of water flows determine the status and integrity of ecosystem services on which poor people are directly dependent, such as fishing or grazing of cattle. Reliable water supplies are critical for a range of food production activities including irrigation, rearing of livestock, aquaculture, horticulture and other types of production in rural and certain urban areas. It is therefore critical that water interventions support diversified domestic livelihood opportunities such as vegetable production, pottery or laundering.

> ***Comparatively powerless groups*** *tend to be shut out of not just access to water but also the processes whereby allocation decisions are made*

Reduced health risks relates to mitigating the social and environmental factors that put poor and vulnerable groups – especially women and children – at high risk from diseases

"One usual working day in Europe"
Photo: Svetlana Punte/European Commission DG EMPL

and poor nutrition leading to premature death. Water-borne diseases, such as diarrhoea and water-related vector-borne diseases like malaria are among the leading causes of death, especially affecting children and other vulnerable groups. Increased access to safe water, basic sanitation and better hygiene is one of the most effective ways to improve health and reduce poverty. From an economic perspective it is a highly attractive investment since the rate of return is in excess of those found in many so-called productive uses. Another effective strategy to alleviate poverty is to enhance the design of water infrastructure and water management in, for example reservoirs and irrigation structures, to reduce vector-borne disease transmission.

Reduced vulnerability implies reducing the risks and impacts of hazards related to volatile politics and economics as well as unsustainable environmental trends and shocks from water-related natural disasters. For example, floods and droughts undercut development and can lock people in to poverty and desperation. Long-term trends of degrading ecosystems, increased rainfall variability, water pollution and land degradation place additional strains on poor people and long-term development. Investment in improved water storage to 'even out' water access in and between rainy seasons and support preparedness for flood management is also an imperative part of any poverty reduction strategy.

Economic growth for poverty reduction is also critical. However, what matters is the quality of growth and how new wealth in a society is distributed. Water management and services provision are catalysts for such growth, which must create new livelihood opportunities for poor people. Water provides livelihood and entrepreneurial opportunities in various productive areas at many levels to develop supplying technologies, services and constructions. The untapped potential of local entrepreneurs needs to be realized since it can generate high returns for local economies in terms of jobs and multiplier effects (see Chapter 3). Major water infrastructure developments can generate significant national as well as regional economic benefits, and lessen vulnerabilities related to food and energy security. Such investments need to be done with proper impact assessments and in collaboration with other countries whenever relevant. These investments are not a panacea, however, and need to be accompanied by smaller-scale investments in relation to irrigation, power generation, crop diversification, institutional development, better access to markets by farmers and rural artisans, and capacity development. A diversified investment strategy is required to make good progress in reducing poverty.

2.4 Targeting gender equality

Improved gender equality is a key to boosting water management and access. The past two decades have seen a significant increase in gender awareness and the role women play to promote improved access to and management of water. However, in spite of a big push to mainstream gender in national development plans and policies, results on the ground remain rather limited. Women have considerable knowledge about the location and quality of local water resources and how to store water, but this knowledge is seldom tapped, and inclusion of women in decision-making on water development and management at all levels is still lagging. A study in South Asia, for example, attributed the workforce gender disparity to women's broader challenges of participating in the labour market (e.g. lack of access to childcare or work-schedule flexibility) and to their educational opportunities, which do not necessarily favour engineering education currently demanded by many parts of the water sector (UN-Women, 2012).
The current limited water access by the poor can result not only from economic pressures, but also from socio-political and environmental pressures, such as armed conflicts and droughts. Thus, women and children may have to walk even longer distances to access water, which can result in an increased exposure to violence in politically volatile areas.

Access to safe drinking water and sanitation is a human right, yet its limited realization throughout the world often has disproportionate impacts on women. The fact that many women and children are carrying water as a daily chore has a number of social and economic implications. A 2012 estimate suggests that cutting just 15 minutes off the walking time to a water source could reduce under-five child mortality by 11% and the prevalence of nutrition-depleting diarrhoea by 41%. In Ghana, a 15-minute reduction in water collection time increased girls' school attendance from 8% to 12%. A Bangladesh school sanitation project that provided separate facilities for boys and girls boosted girls' school attendance by an annual average of 11% (UN-Women, 2012; Nauges and Strand, 2011).

Economic development

3

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3.1 Expanding economic opportunities through water infrastructure

Developed and developing economies require water resources and water infrastructure to support activities and services needed for all three dimensions of sustainable development. Economic development and water are intimately connected in many ways. Water is an essential resource for economic production and an 'enabler' of trade for most types of goods and services. Water is as an essential input for the production of food and electricity, as well as for many manufactured products. Investments in water infrastructure are therefore fundamental to unlocking the full potential of economic growth (Box 3.1).

Water supply (quantity and quality) at the place where the user needs it must be reliable and predictable to support financially sustainable investments in economic activities. This requires both hard and soft infrastructure that is financed, operated and reliably maintained. In addition, infrastructure to reduce risk of water scarcity and to manage water-related disasters such as floods and droughts can make a country's development efforts more sustainable by reducing the vulnerability and/or increasing the resilience of economies to extreme events (Box 3.2).

3.2 Facilitating structural change

Over the long term, water development benefits spill over into the entire economy. Wise investment in water infrastructure and sound water management are both essential to facilitate the structural changes that are necessary in many developing and intermediate economies. In rural areas, irrigation can be a pre-condition for modernized agriculture, paving the way for industry by facilitating the accumulation of capital that allows surplus investments (Box 3.3).

Water development benefits spill over into the entire economy over the long term

When favoured by enabling social and political conditions, better living conditions can translate into new and heightened income opportunities. These in turn generate the savings required to foster capital accumulation with further improvements in infrastructure health and education

BOX 3.1

Opportunities for water investments to facilitate economic growth

The expansion of irrigated agriculture in the 1950s and 1960s in Asia saw a doubling of cereal production and a 30% increase in calories available per person. Investment in water supply and irrigation can produce high economic rates of return, as measured by benefit-cost ratios, and compare well with those in other sectors of infrastructure. Groundwater development has brought major socio-economic benefits to rural communities and in many countries has helped to alleviate agrarian poverty through increasing food security. According to the GWP (2012), "In South Asia, the groundwater boom has also largely been pro-poor, with marginal farmers of holdings smaller than two hectares increasing their groundwater-irrigated area by three times more proportionally than farmers with more than ten hectares of land."

Smallholder farmers in sub-Saharan Africa and South Asia are increasingly using small-scale irrigation to cultivate their land and examples show it is leading to improved yields and reduced risks from climate variability (Giordano et al., 2012).

Irrigated systems will increasingly require greater storage capacity to respond to variability in rainfall and more frequent and intense droughts. Quick and Winpenny (2014) have found that, "In Madhya Pradesh, incomes of farmers who constructed on-farm ponds to irrigate pulses and wheat have risen by over 70%; as a result, they have also been able to improve and expand their livestock herds. In Tanzania, half of the dry-season cash incomes of smallholders come from growing irrigated vegetables."

that widen the potential opportunities for production and reinforce the gains of progress.

Basic provision of water and sanitation services is required to unlock the potential of economic growth, particularly to break the vicious cycle of low productivity linked to poor health and lack of educational opportunities that maintains poverty and economic stagnation. Gains in terms of time-saving, improved health and more effective learning demonstrate that improve access to water and sanitation is one of the more labour-saving solutions. It has the twin effect of (a) freeing resources for the production of food and other goods and services; and (b) expanding the productive potential of the economy by indirectly enhancing human capital. Not surprisingly, the demonstrated economic benefits of investing in basic water services have a direct correlation with poverty alleviation (see Chapters 2 and 5).

Using Albert Hirschman's (1958) terms, one can say that the backward linkages of increased water supplies at affordable prices serve to foster further economic advances in many productive areas of the economy. In turn, higher production, means more income opportunities that enhance expenditure in health and education and many other goods and services reinforcing a self-sustained dynamic of economic development.

3.3 Investment challenges

Success of water investments can be measured by the sustainable economic progress and development to which it

BOX 3.2

Investing in water infrastructure: When damages avoided become main benefits

In Kenya, the 1997-98 floods cost the country at least US$870 million (11% of GDP) and the 1999-2000 drought cost at least US$1.4 billion a year (16% of GDP). On average, the country experiences a flood that costs about 5.5% of GDP every seven years and a drought that costs it about 8% of GDP every five years. This translates to a direct long-term fiscal liability of about 2.4% GDP per annum. This means that Kenya's GDP annually should grow at a rate of at least 5% to 6% in order to start reducing poverty. In 1996, a good year in Kenya, real GDP growth was 4.1% (SIWI, 2005).

In Pakistan, three years of repeated floods in 2010, 2011 and 2012 inflicted serious damage on the national economy, halving its potential economic growth. The economy grew on average at a rate of 2.9% per year during this period. That is less than half the rate of 6.5% that Pakistan could potentially have achieved if it had not faced economic and human losses associated with flooding.

Pakistan lost a total of 3,072 lives and US$16 billion to the 2010-2012 floods. An initial estimate made by the National Disaster Management Authority of the floods' impact shows agriculture sector losses at US$2 billion due to damages to 1.05 million acres of standing crops.

Consecutive years of flooding have also pushed up the country's inflation and unemployment rate because the flooding has disrupted supply chains, damaged major crops like sugarcane, rice and cotton, and hampered industrial production (Government of Pakistan, 2012).

BOX 3.3

Investing in water: A wise policy option that's good for business

Analysis of Africa's irrigation needs demonstrates an attractive internal rate of return, ranging from 12% in central Africa for large-scale irrigation to 33% for small-scale irrigation in the Sahel. The average economic rates of return for both water supply and irrigation projects compare well with those in infrastructure investments in other sectors, according to Foster and Briceño-Garmendia (2010), who present this table showing economic **rates of return for infrastructure projects** in sub-Saharan Africa (percentages):

Railway rehabilitation	Irrigation	Road rehabilitation	Road upgrades	Road maintenance	Power generation	Water supply
5.1	22.2	24.2	17	138.8	18.9	23.3

Source: Table extracted from Foster and Briceño-Garmendia (2010, Table 2.5, p. 71), © World Bank. https://openknowledge.worldbank.org/handle/10986/2692 License: CC BY 3.0 IGO.

Dhay, the first recipient of an urban micro credit scheme (PPAF) for women in Pakistan
Photo: Caroline Suzman/World Bank

contributes overall, but water challenges are context-specific. Some countries may give priority to investments in infrastructure for hydropower and irrigation for economic growth. However, poor attention to water availability and protection of critical water sources may mean that these investments perform below expectations. In other cases, technologies and financial resources to invest in water infrastructure might be available while the institutional capability is lacking, leading to poor or non-existent service provision. In other instances, the social benefits of water infrastructure might be self-evident, but the

BOX 3.4

Still many opportunities to do more with less

Agriculture, which accounts for 70% of global freshwater withdrawals, offers some of the best opportunities to take advantage of enhanced water efficiency to improve productivity and reduce poverty.

"On-farm water balance analysis indicates that, in savannah farming systems in sub-Saharan Africa, less than 30% of rainfall is used as productive transpiration by crops. Thus, crop failures commonly blamed on 'drought' might be prevented in many cases through better farm-level water management (Rockström et al., 2010)".

In sub-Saharan Africa, agricultural productivity can improve with little impact on water resources (FAO, 2012a) through a combination of sound agricultural practices and links to inputs, credit and markets combined with weather insurance schemes. These measures are ways of producing more with less. They offer outstanding opportunities to reconcile economic growth with the recovery and adequate protection of water resources (Quick and Winpenny, 2014).

More radical improvements in 'crop per drop' can be realized by the adoption of aerobic rice production in place of paddy field rice and the use of System of Rice Intensification cultivation and other agro-ecological methods not only for rice but also for other crops (Africare, Oxfam America and WWF-ICRISAT, 2010).

potential beneficiaries of these services might not have the ability to pay for their provision, or policymakers may not be willing to charge for them.

Water management can be highly capital intensive. Capital intensity results in economies of scale and low running costs. Many countries face very practical problems with the lack of availability of capital and the cost of capital. That availability is in turn dependent upon the ability to recover that capital. Scarcity of capital, in some contexts, forces reliance on low capital cost. On the other hand, high running cost solutions might make water unaffordable for the poor.

3.4 Economic opportunities from improved water efficiency

Water challenges and water development priorities change over time. The outstanding benefits of water as a means to pave the way out of poverty suggest placing

BOX 3.5

Trade-offs in water and production

To avoid solving one problem by worsening another, it is essential to understand how different areas of the economy are linked through water.

In spite of outstanding advances in water provision in the last decades, over 80% of wastewater worldwide (and 90% or more in developing countries) is not collected or treated, and urban settlements are the main source of pollution (WWAP, 2012). Effluent from industry is causing pollution to downstream surface-waters and aquifers and major health threats to people (Bahri, 2009). Small-scale industries, such as agro-processors, textile dyeing and tanneries, can release toxic pollutants into local waters (WWAP, 2012).

Land use change from urban and rural development can exacerbate soil erosion, reduce soil water-holding capacity, and decrease the recharge of groundwater and existing surface-water storage capacity. It does so through siltation and sedimentation of rivers and reservoirs that subsequently results in water scarcity over time. Land use change may involve the loss of wetlands, yet the importance of wetlands in regulating flood and drought risk is well understood (WWAP, 2012). There is also a link between deforestation and increasing flood risk, which has been observed at the micro level and over particular catchments. Deforestation results in degradation and desertification of watersheds and catchment areas, and reduces the amount of usable safe water available downstream (FAO, 2007).

Water development might come along with other costs, too. It may increase the exposure of economic assets to drought events and may lower reserves in rivers and aquifers to compensate for rainfall deficits. This exposure has been recognized in recent reports in the United States, where drought in 2012 had an impact on 80% of farms and ranches, resulting in crop losses in excess of US$20 billion and a wide range of ripple effects. According to the National Drought Forum (2012), "Corn crops were greatly reduced due to a lack of rainfall, affecting food and livestock feed supplies and prices, as well as corn ethanol production. Power plants had to scale back operations or even shut down because the water temperatures of many rivers, lakes and estuaries had increased to the point where they could not be used for cooling. Household, municipal and farm wells in the Midwest had to be extended deeper into aquifers to make up for the lack of rainfall, draining groundwater supplies and demanding more electricity to run the pumps." The full costs are estimated to be as high as US$50 billion.

BOX 3.6

Investing in protecting water resources

Measures of improved water resource management have shown considerable economic gains. A US$15 to US$30 billion investment in improved water resources management in developing countries can have direct annual income returns in the range of US$60 billion. Every US$1 invested in watershed protection can save anywhere from US$7.5 to nearly US$200 in costs for new water treatment and filtration facility (SIWI, 2005).

A global economic assessment of 63 million hectares of wetlands estimated their value at US$3.4 billion per year (Brander and Schuyt, 2010).

In eastern Uganda, more than one-third of the District of Pallisa is occupied by wetlands. The annual value of their goods and services has been estimated to be US$34 million for the local economy, which is equivalent to US$500 per hectare (Emerton and Bos, 2004).

an emphasis on infrastructure to unlock the economic growth potential of water in the early stages of a country's economic development. Once the marginal benefits of further development decrease, emphasis must gradually shift towards building human and institutional capabilities to enhance water efficiency and sustainability and secure economic and social development gains. Many benefits may be gained through promotion and application of best available technologies, management systems in water provision, use and allocation (Box 3.4).

Fortunately, wider adoption of best practices offers substantial efficiency gains, particularly in industry where greater efficiency in water use often results in increased profitability. This emphasizes the need to increase learning as well as improve the rate of adoption and diffusion of appropriate technologies. Capacity for rapid learning and innovation is now a key requirement for water management organizations.

3.5 Intersectoral trade-offs

Water is an essential input to production activities, and availability must be taken into account by decision-makers in sectors such as energy and industry; if not, their investments (by both private and public sector) will be put at risk. Projects in hydropower, irrigation, energy or urban development that are carried out simultaneously and in isolation from each other can lead to water scarcity, unsustainable use of resources, and conflicts between users and local communities. For example, energy options such as biofuels and hydraulic fracturing, and agricultural options such as crop choice or irrigation, impact directly on water scarcity and/or water pollution. This is one reason that an integrated approach to managing water resources has been adopted by the United Nations and governments in many countries. That approach will need to be extended (Box 3.5).

3.6 Protecting water resources

Water investments are crucial in emergent economies to ensure abundant and affordable water supplies to the economic system. There is a need, however, to increasingly shift the focus of such investments towards changing the way in which water, and the environment more generally, are valued, managed and used. Water investments can help to reconcile the continuous increase in water use with the need to preserve the critical environmental assets on which the provision of water and the economy depend. Any possibility of sustaining the gains of economic progress relies on investing in the protection of water-related ecosystems (see Chapter 4) for maintaining the essential and varied environmental services they provide, and upon which the economy depends (Box 3.6).

4 Ecosystems

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4.1 Context

Aquatic ecosystems are at the centre of all life and all forms of development. However, while economic and population growth are set to increase strain on existing water resources, most economic models are yet to value the essential services provided by freshwater ecosystems, a mistake that often leads to unsustainable use of water resources and degradation of aquatic ecosystems. There is a need to shift towards environmentally sustainable economic policies where ecosystem-based management (EBM) takes into consideration the interconnection of ecological systems to address human impacts and meet the needs for healthy productive ecosystems. EBM needs to be part of the solution to ensure a 'green economy'[2] and sustainable development.

2 UNEP has developed a working definition of a green economy as one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. In its simplest expression, a green economy can be thought of as one which is low carbon, resource efficient and socially inclusive.

Healthy ecosystems are required for continuous supply of water and other services vital for human well-being and development. According to the Millennium Ecosystem Assessment (MEA, 2005b), ecosystem services comprise four main categories:

- provisioning (e.g. clean water);
- regulating (e.g. flow regulation and flood control);
- cultural (e.g. recreation); and
- supporting (e.g. habitat for aquatic species).

Different ecosystems provide different services. Wetlands, for instance, attenuate floods, store water and provide other direct economic benefits such as fisheries and tourism. As Box 4.1 illustrates, a healthy ecosystem provides key services to maintain environmental, economic and social well-being. Another example is forested highlands, which have a key role in recharging aquifers and ensuring clean water flows for agriculture, hydropower and other uses. They are also critical for conserving biological diversity, water and soil, and providing major habitats for wildlife. (see also Box 6.2).

BOX 4.1

Reconnecting lakes in the Central Yangtze River Basin

In the last 50 years, Hubei Province's wetland ecosystem, with its 1,066 lakes, has played a major role in summer flood attenuation along the Yangtze River basin, home to 400 million people. However, 757 of the lakes were converted to polders and disconnected from each other, which resulted in massive flood damage from 1991 to 1998 causing hundreds of deaths, costing billions of dollars, and resulting in pollution from aquaculture fertilizer.

In 2002, a WWF sustainable lake programme demonstrated a good example of the role of natural infrastructure by re-establishing the natural flood protection provided by the river basin. Sluice gates were seasonally opened around three lakes (Hong, Tian-e-Zhou and Zhangdu) and illegal, uneconomic aquaculture facilities and other infrastructure were removed, reducing pollution.

This resulted in an increase in fish and wildlife and return of species. Before the programme, Lake Hong supported only 100 herons and egrets; since its restoration, 45,000 wintering water birds and 20,000 breeding birds are now found. To strengthen the effectiveness of wetland conservation efforts, a Nature Reserve Network was established linking 17 reserves. In 2006, the Hubei provincial government adopted a wetlands conservation master plan and allocated resources to protect 4,500 km^2 by 2010.

The local population benefited from cleaner water supplies and a 17% increase in fish catches within six months of reconnection of Lake Zhangdu. The development of certified eco-fish farming adopted by 412 households increased income of fisheries dependent households by 20% to 30%.

Sources: WWF (2008); Pittock and Xu (2011); ICPDR (1999) and Scholz et al. (2012).

Tourism and ecosystems conservation, Napo Wildlife Center, Yasuni National Park (Ecuador)
Photo: Peter Prokosch, http://grida.no/photolib/detail/napo-wildlife-center-yasuni-national-park-ecuador_d911

4.1.1 Ecosystem-based management

Ecosystem-based management is described by the United Nations Convention on Biological Diversity (CBD) as a "strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way" (CBD, 2014). The interconnected network of ecosystems can be seen in the quantity of water required to maintain water-related ecosystem services, and the ecosystems that serve to maintain this quantity, such as wetlands and forests (WWAP, 2012). Such ecosystem inter-relationship is often referred to as 'natural infrastructure' (NI). It is nature's equivalent to human-built infrastructure, providing for the maintenance of healthy ecosystems, and many of the same services.

Natural infrastructure uses the natural environment and natural processes to create healthier environments and may present economic benefits, since the destruction of NI requires investment in built infrastructure to perform some of the same services. EBM demonstrates that opportunities can be missed when the interlinkages between ecosystems and their collective provision of services are not taken into account.

Ecosystem services remain under-valued, under-recognized and under-utilized within economic and resource management approaches. The MDG framework did not fully recognize water's interlinkages with other areas, and an emphasis on 'sustainability' was not included (UN-Water, 2014).

A more holistic focus on ecosystems for water and development can ensure that benefits are maintained. As noted in the UN-Water (2014) report on a global goal for water, the difficulty of balancing water supply between multiple users and uses will become worse, unless attention is paid to the sustainable use and development of water resources and the ecosystems that provide them. The EBM approach addresses these shortfalls. Incorporating ecosystem-based thinking into water management will play important roles in addressing the proposed target areas for the post-2015 Sustainable Development Goals, which include WASH, water quality, water efficiency, integrated water resources management and water-related ecosystems.

4.2 Challenges

Ecosystems across the world, particularly wetlands, are in decline in terms of the services they provide. Increasing population and economic growth are accelerating strain on the natural world. Direct drivers of ecosystem degradation include infrastructure development, land conversion, water withdrawal, eutrophication and pollution, overharvesting and overexploitation, and the introduction of invasive alien species (MEA, 2005b).

4.2.1 Environmental challenges

The WWF Living Planet Index 2012 shows a 30% decline in biodiversity health since 1970 (WWF, 2012). Poor water management approaches can be a driver of this decline, for example, through poorly designed or operated dams disrupting water flows or degradation of soil water retention. Pollution from untreated residential and industrial wastewater and agricultural run-off also weakens ecosystem capacity to provide services such as water.

Ecosystems across the world, particularly wetlands, are in decline in terms of the services they provide

Climate change also has a significant impact on ecosystems. The effect on wetlands and their multiple ecosystem services is expected to be severe. Rising sea levels will threaten biodiversity, while increased frequency and strength of storms and tidal surges will increase damage and variation of sediment transfer in river flows (Boelee, 2011).

While these environmental challenges steadily degrade the health of ecosystems and thus the quality of their services, short-term economic and social decisions further threaten sustainability. Over-exploiting forests for timber or firewood, for example, compromises ecosystem health, including its capacity to regulate the level of the water table.

4.2.2 Social challenges

Degraded ecosystems strain the most vulnerable populations, particularly the poorest, leading to food and water insecurity. As populations increase and ecosystem services decline, the risk of resource conflicts rises especially where tensions already exist along ethnic or socio-economic lines. According to UN peacekeepers, since 1990, at least 18 violent conflicts have been fuelled by the exploitation of natural resources, whether 'high-value' resources like timber, diamonds, gold, minerals and oil, or scarce ones like fertile land and water (UNEP, 2009). Ecosystem degradation and climate change have significant potential to increase these tensions.

4.2.3 Economic challenges

While economic development may lead to ecosystem decline, ecosystem services underpin economic development, so the real challenge is in building awareness of the economic value of healthy ecosystems.

In some cases, human-built infrastructure can cause biodiversity loss and degradation of ecosystem services, yet it often directly depends on ecosystem services to maintain performance. Dams, for example, are constructed to ensure water availability, flood protection, hydropower and other services. However, dams can prevent nutrients and sediments from reaching oceans and alter the water cycle by increasing water 'residence time', altering the flow of matter and energy in rivers which changes the conditions of these ecosystems entirely (Vörösmarty et al., 2010). This can have a direct and negative impact on other sectors such as downstream fisheries and agriculture. At the same time, dams only work effectively when supported by healthy ecosystems. Unhealthy ecosystems cause dams to become clogged by siltation, damaged by flood waters or degraded with pollution. Dams also need proper watershed management. The challenge, therefore, is to manage water resources to maintain a beneficial mix between built and natural infrastructure and provision of their respective services.

Current food production practices are likewise responsible for nitrogen, phosphorous and pesticide loading and fisheries depletion (Vörösmarty et al., 2010). It is estimated that between US$4.3 and US$20.2 trillion per year worth of ecosystem services were lost between 1997 and 2011 due to land use change (Costanza et al., 2014).

Water is a key resource for industrial and manufacturing processes (e.g. heating, cooling, cleaning, rinsing, etc.), but generated wastewater can cause environmental damage when discharged untreated. The industrial and manufacturing sector has a corporate social responsibility to take action to ensure acceptable quality of discharged water and cover the costs related to any corrective clean-up action. At the same time, manufacturing processes can also benefit from cleaner water influent by saving costs on treating potential impurities (Corcoran et al., 2010).

4.2.4 Management challenges

Current water management practices are often fragmented, leading to lost synergies, poor trade-offs and sub-optimal solutions. This phenomenon pervades across sectors such as health, leaving missed opportunities for broader strategies (Boelee, 2011). It fails to capitalize on synergies in basin-wide and cross-sectoral approaches to water management to protect ecosystem services, such as the flow of water needed to maintain biodiversity.

Poor water management (especially wastewater management) leads to the degradation of ecosystems through pollution and contamination, resulting in social and economic costs: it is more expensive to rehabilitate an ecosystem than to preserve it. In short, there is a basic failure to recognize the economic and social value of healthy ecosystems.

The water management sphere is beset by a lack of ecosystem knowledge among decision-makers, and lack of resources and technical know-how to empower communities to take the lead in EBM. Lack of resources, skills and capacity affects related approaches such as watershed management or other conservation programmes. Management practices have emphasized water quantity requirements for human and environmental needs at the expense of water quality. Moreover, they prioritize human uses over environmental needs and fail to recognize the symbiotic relationship between the two.

4.3 Responses

Responses that mitigate, reverse and, most of all, prevent ecosystem degradation are required to address threats to ecosystems. The nature of these responses has implications for the quality and quantity of water supply, especially since restored ecosystems do not always perform the same range of ecosystem services as the original sites (Boelee, 2011). The adoption of EBM is essential to ensure water sustainability.

4.3.1 Ecosystems valuation

Using economic arguments for preserving ecosystems can make them relevant to decision-makers and planners. An economic perspective is also important in assessing trade-offs in the conservation of ecosystems and can be used to better inform development plans (Farber et al., 2002).

Ecosystem valuation can be broadly described as what users would be willing to pay directly for the services, or what it would cost to replace the same services with built infrastructure (Boelee, 2011). Such valuations can be incorporated into national income accounts, or used to clarify comparative options in land use planning, payment for ecosystem services (PES) and common asset trusts (Costanza et al., 2014). Valuations help in building the case for a green economy in the post-2015 development agenda.

> ***Ecosystem valuation** has demonstrated that benefits far exceed costs of water-related investments in ecosystem conservation*

Ecosystem valuation has demonstrated that benefits far exceed costs of water-related investments in ecosystem conservation. According to the study 'Changes in the Global Value of Ecosystem Services', the 2011 economic value of ecosystems has been globally estimated at US$124.8 trillion. Global GDP was estimated at US$75.2 trillion in the same year (Costanza et al., 2014). Box 4.2 illustrates the application of this approach at the micro-level.

BOX 4.2

Wastewater treatment in the Fynbos Ecosystem, South Africa

The Fynbos Ecosystem of Western Cape, South Africa, contains numerous wetlands whose function and value until recently were unknown. Many of these wetlands have been degraded or lost due to farming practices and other land use changes. Both wetlands and land use play a role in determining water quality emanating from sub-catchments in the biome. Water-quality amelioration by wetlands benefits both ecology and humans downstream. For example, preventing contamination protects downstream fisheries from pollutants and reduces the impact on human health, such as from extensive growth of algae or aquatic macrophytes due to nutrient loading.

The economic benefits of the water treatment capacity of wetlands in the Fynbos Biome were estimated "on the basis of the cost of performing the same service, i.e. removal of nitrogen, with man-made water treatment plants. The study calculated the value of the wetlands' service as US$12,385 per hectare per year, high enough to compete with alternative land uses."

Highlighting the economic value of critical wetlands builds a case for investing in natural infrastructure. While policy changes have not directly been impacted by this study, an increased number of these studies globally show growing demand for improved understanding of the value of nature.

Source: Turpie (2010).

4.3 BOX

Transboundary collaboration for healthy ecosystems and community engagement

The International Joint Commission (IJC) was established by the Boundary Waters Treaty of 1909 between the USA and Canada and serves to resolve and prevent transboundary water disputes between the two countries.

The Commission adopted the Lake Erie Ecosystem Priority (LEEP) for 2012-2015. In August 2013 it released a collaborative report between scientists of both countries entitled 'Lake Erie Ecosystem Priority: Scientific Findings and Policy Recommendations to Reduce Nutrient Loadings and Harmful Algal Blooms'. The study focused on lake-wide changes resulting from phosphorus enrichment, climate change and invasive species.

The report contained policy proposals to reduce phosphorus inputs to the lake, for implementation by federal, state and provincial governments, including setting phosphorus load targets 40% below average loads of the past five years.

The report was then opened up to the public for comment through the internet and open house events held in Michigan, Ohio and Ontario and a scientific panel discussion at the Great Lakes Week held in Milwaukee, Wisconsin. Public engagement helped in shaping the outcomes of the report.

Source: IJC (2013).

4.3.2 Natural infrastructure solutions

In order to effectively address the myriad environmental challenges, water managers need to recognize and incorporate NI into their planning and implementation activities (Dini, 2013). For example, the creation of 'green corridors' along rivers, floodplains and streams can link ecosystems, thus absorbing nutrients and reducing water pollution.

Conservation programmes are often reactive and fail to fully consider the interconnected nature of ecosystem processes for sustainability. The NI perspective places emphasis on connectivity (EPA, 2014), creating a sustainability framework for environmental decisions. NI solutions should be seen as cost-effective, long-term infrastructure solutions that utilize water-related ecosystem services to augment, replace and/or strengthen performance of built infrastructure to provide a wide array of benefits that support livelihoods. It has higher capacity to adapt to climate change impacts. Hence investments yield benefits across a number of policy areas, as illustrated in Table 4.1. For example, in the table, the rows which refer to "Water purification and biological control", "Reconnecting rivers to floodplains" and "Wetland restoration/conservation" are shown as NI alternatives for "Water treatment plant", as illustrated in the Yangtze example in Box 4.1.

4.3.3 Policy responses

The major decisions in EBM over the next decades must address trade-offs between "agricultural production and water quality, land use and biodiversity, water use and aquatic biodiversity" (MEA, 2005c).

The emphasis on access to water and sanitation in the MDGs has focused policy priorities on urgent human needs, but addressing broader sustainability issues that underpin access to water resources must move to the forefront. The post-2015 development agenda focuses on higher attention to ecosystems, water quality and disaster management and needs to be supported by further evidence of the necessity of an integrated ecosystem-based management of water resources.

Coordination and collaboration between natural resource managers and sectors such as health, agriculture and industry are needed to foster synergy and integrate responses to environmental, economic and social challenges and eliminate compartmentalization. Collaboration is vital for policy formulation and compliance and for stakeholder engagement in planning and monitoring, as in the example in Box 4.3. Policies should provide incentives and reduce operational bottlenecks for the implementation of EBM tools, such as PES, in combination with Reducing Emissions from Deforestation and Forest Degradation (REDD), and landscape planning, among others.

Coordination among international environmental bodies can reduce compartmentalization and create a conducive framework for enforcement. The Ramsar Convention, for instance, is already working with the World Heritage Convention, Convention on the Conservation of Migratory Species of Wild Animals and the CBD in developing 'wise use' concepts for an integrated approach to wetland conservation (Boelee, 2011).

Policies should seek to increase participation of all stakeholders (local, regional and national) including rural women in developing countries, who already act as grassroots ecosystem managers. Involving them more substantively in decision-making would benefit all, integrate indigenous knowledge in the process and help capitalize on the increasing global concern for international environmental issues.

Sustainable wastewater treatment is also key to maintaining sustainable ecosystem services, particularly water provision and purification. Protected areas can be utilized to preserve

TABLE 4.1 **Overview of natural infrastructure solutions for water resources management**

Water management issue (Primary service to be provide)		Natural infrastructure solution	Location: Watershed	Location: Floodplain	Location: Urban	Location: Coastal	Corresponding built infrastructure solution (at the primary service level)
Water supply regulation (including drought mitigation)		Re/afforestation and forest conservation	■				Dams and groundwater pumping Water distribution systems
		Reconnecting rivers to floodplains		■			
		Wetland restoration/conservation	■	■	■		
		Constructing wetlands	■	■	■		
		Water harvesting*	■	■	■		
		Green spaces (bio-retention & infiltration)			■		
		Permeable pavements*			■		
Water quality regulation	Water purification and biological control	Re/afforestation and forest conservation	■				Water treatment plant
		Riparian buffers		■			
		Reconnecting rivers to floodplains		■			
		Wetland restoration/conservation	■	■	■		
		Constructing wetland	■	■	■		
		Green spaces (bio-retention & infiltration)			■		
	Erosion control	Re/afforestation and forest conservation	■				Reinforcement of slopes
		Riparian buffers		■			
		Reconnecting rivers to floodplains		■			
Moderation of extreme events (floods)	Riverine flood control	Re/afforestation and forest conservation	■				Dams and levees
		Riparian buffers		■			
		Reconnecting rivers to floodplains		■			
		Wetland restoration/conservation	■	■	■		
		Constructing wetland	■	■	■		
		Establishing flood bypasses		■			
	Coastal flood (storm) control	Protecting/restoring mangroves, coastal marshes and dunes				■	Sea walls
		Protecting/restoring reefs (coral/oyster)				■	

** Built elements that interact with natural features to enhance water-related ecosystem services.*

Source: Extracted from UNEP/UNEP-DHI/IUCN/TNC (2014, Table 1, p. 6).

specific ecosystems that provide services vital to the health of much larger landscapes that may shelter specific endangered species. This requires collaboration with local populations and balancing trade-offs between conservation and economic activities.

The drivers of ecosystem and biodiversity degradation must be addressed through policies with actionable goals:

- Elimination of perverse subsidies that deplete ecosystem services and the reallocation of funds towards their preservation;
- Promotion of water efficiency technologies and increased water productivity in agriculture;
- Reduction of nutrient loading through wiser fertilizer use;
- Improved mitigation of destructive environmental impacts in extractive industries;
- Correction of market failures that cause environmental degradation; and
- Greater involvement and capacity building of stakeholders and greater accountability and transparency in decision-making regarding ecosystem conservation (Boelee, 2011).

Ecosystem-based management must be adaptive and incremental, beginning with a specific objective focused on a few issues; later, these issues can be increased in number and scope.

PART 2

ADDRESSING CRITICAL DEVELOPMENTAL CHALLENGES

Uzbek women, Khiva (Uzbekistan)
Photo: Global Water Partnership

The interlinkages between water and sustainable development reach far beyond its social, economic and environmental dimensions. Water plays a vital role in various aspects and challenges related to sustainable development, including human health, food and energy security, urbanization, industrial growth and climate change. Part 2 of this Report defines critical ‘challenge areas’ where policies and actions at the core of sustainable development can be strengthened or weakened through water.

Chapter 5 reflects on the role of water, sanitation and hygiene (WASH) in achieving sustainable development and outlines key challenges to achieving sustained universal coverage. Chapter 6 covers the challenges associated with rapid urbanization, describing how cities provide opportunities for more sustainable use of water. Chapter 7 focuses on what is required to achieve a world free from hunger and malnutrition in a sustainable manner. Chapter 8 addresses the challenges of meeting rising energy demands without compromising the sustainability of freshwater resources. Chapter 9 examines water’s role in the pursuit of sustainable industrial development. Finally, Chapter 10 describes how sustainable freshwater resources management is affected by climate variability and change.

Water, sanitation and hygiene

5

UNICEF and WHO | Robert Bain, Richard Johnston,* Cecilia Scharp, Rifat Hossain,* Bruce Gordon* and Sanjay Wijesekera

This chapter reflects on the role of water, sanitation and hygiene (WASH) in achieving sustainable development, and outlines key challenges that need to be addressed in order to achieve and sustain universal coverage.

WASH is fundamentally important to lives and livelihoods, and underpins poverty alleviation and sustainable development (Figure 5.1). At a basic level, everyone needs access to safe water in adequate quantities for drinking, cooking and personal hygiene, and sanitation facilities that do not compromise health or dignity. Lack of WASH takes a huge toll on health and well-being and comes at a large financial cost, including a sizeable loss of economic activity in many countries, not just least developed countries. While the impacts are most pronounced in lower income countries, challenges remain in wealthier nations where concerns regarding water safety and environmental sustainability persist alongside inequalities. Many of the broader implications of inadequate WASH – for education, cognitive development and nutrition – are not fully documented, and inadequate WASH is one of many deprivations suffered by the world's poorest and most marginalized populations.

Access to water and sanitation is recognized as a human right and has long been a central aim of international development policies and targets (UNCESCR, 2003; UNGA, 2010). The MDGs sought to "halve the proportion of the population without access to safe drinking water and basic sanitation" between 1990 and 2015 (UNGA, 2001). The

* The author is a staff member of the World Health Organization. The author alone is responsible for the views expressed in this publication and they do not necessarily represent the views, decisions or policies of the World Health Organization. Nothing contained herein shall be construed as a waiver of any of the privileges and immunities enjoyed by WHO under national or international law, and/or as submitting WHO to any national court jurisdiction.

FIGURE 5.1

Schematic of criteria for sustainable water, sanitation and hygiene services and their key impacts on sustainable development

Sustainable Development

Economy

Direct
- Reduced burden of collecting water when on premises
- Lower medical expenses
- Affordability including for the poor

Indirect
- Educated and healthy workforce
- Industry and commerce

Environment

Direct
- Reduced water wastage and avoiding overexploitation
- Adequate treatment of excreta and wastewater to protect the natural environment

Indirect
- Sustainable environmental services

Equity

Direct
- Disease prevention
- Dignity
- School attendance, especially for adolescent girls

Indirect
- Full participation in society
- Reduced poverty
- Gender equality

Underpinning Human Rights WASH criteria:
Normative: Availability, safety, acceptability, accessibility and affordability
Cross-cutting: Non-discrimination, participation, accountability, impact and sustainability

Source: Authors and UNGA (2010).

WHO and UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP) reports impressive gains made over the last two decades with 2.3 billion people gaining access to an improved drinking water source and 1.9 billion to an improved sanitation facility (WHO and UNICEF, 2014a). Of those gaining access to drinking water, 1.6 billion now use a higher level of service: a piped water supply on premises. However, much still needs to be done – 748 million do not use an improved source of drinking water and 2.5 billion do not use an improved sanitation facility. Moreover, not all of those using improved facilities have fulfilled their rights; for example, an estimated 1.8 billion people drink water contaminated with *Escherichia coli*, an indicator of faecal contamination (Bain et al., 2014).

Hand washing with soap is one of the important elements of hygiene in WASH, although it did not form part of MDG monitoring. Globally, the prevalence of hand washing with soap is very low with some estimates suggesting four out of five people do not wash their hands after contact with excreta (Freeman et al., 2014). Moreover, many challenges remain in addressing concerns about the adequacy of WASH services and ensuring their sustainability (Box 5.1).

5.1 Return on WASH investments

Investments in water and sanitation services result in substantial economic gains. In developing regions, the return on investment has been estimated at US$5 to US$28 per dollar invested (WHO, 2012b). Overall, US$53 billion a year over a five-year period would be needed to achieve universal coverage (Hutton, 2013) – a small sum given this represented less than 0.1% of global world product in 2010 and since the return on investment is many times higher.

Despite the potential for sizeable returns on investment, sustainable financing has not yet been attained in many settings, raising questions about who should pay and what the barriers to investment are. In many cases, capital investments are made without adequate financial planning or investment in maintenance, operations and monitoring (AMCOW, 2011; WaterAid India, 2008; Barnard et al., 2013). This leads to poor levels of service (e.g. quality, reliability, acceptability), lower usage and, in some cases, permanent failure. Such unsustainable financing not only reduces the benefits but also wastes available capital, resulting in lower coverage per dollar spent.

From the user's perspective, the affordability of WASH services is of utmost importance and may influence access, especially for the poor. The financing of water and sanitation, including the proportion contributed by households, varies greatly (WHO, 2014) as does willingness to pay for water and sanitation services. Data on household contributions are few and generally available at the national level, preventing assessments of affordability for the poorest. In most countries, regressive cost structures predominate whereby low volume consumers pay a premium on a per volume basis. There are some notable exceptions, such as South Africa (Box 5.2), where a basic level of service is free to the end user.

In order to reap the full benefits of these services, greater emphasis is needed on ensuring that services last. In many settings, services are not living up to their potential, with intermittency a daily problem for piped supplies even in

BOX 5.1

Examples of unsustainable WASH

- Persistently non-functioning community supplies
- Failure to treat wastewater or safely handle excreta
- Leakage and intermittency of utility piped water
- Increasing water scarcity and low priority given to domestic water use
- Inadequate investment in maintenance and operations

Source: UNGA (2013).

BOX 5.2

A focus on providing for the poorest leads to more equitable WASH outcomes in South Africa

"With the ending of apartheid the Government of South Africa prioritized the provision of basic services including, water supply, sanitation and energy services. Ambitious targets were set within a policy framework that included 'free basic water' and 'free basic sanitation' for households with resources below the social grant amount (approximately US$1 per day). In 2012, 3.47 million and 1.84 million people benefitted from free services for water and sanitation respectively."

"Resources were provided to decentralized organizations charged with providing basic WASH services. Strong monitoring frameworks were put in place to track progress against the targets. Although the time frame for reaching the targets of universal coverage have not been met, major gains in access have been achieved, especially for the poor and those living in rural areas. There remains, however, a major challenge in attracting and retaining professional staff to manage, operate and maintain WASH infrastructure."

Source: WHO (2014, p. 4).

major cities, and functionality of community sources and hygienic sanitation facilities not always assured. The problem of non-functioning supplies and unused sanitation facilities is symptomatic of unsustainable or misdirected financing and a mismatch between supply and demand. This points to the need for greater accountability, enhanced monitoring as well as adequate financing for continued operations and maintenance. This is not restricted to lower income countries. The investment 'deficit' for ageing infrastructure in the United States has been estimated at US$84 billion by 2020 (ASCE, 2011). Water services should also be located close to or ideally within the home in order to ensure that time can be used more productively since opportunity costs are an important contributor to the overall return on investment (WHO, 2012b) and to support good hygiene.

5.2 Environmental implications

The quantities of water required for domestic uses, and especially ingestion, are generally very small compared to those for agriculture and industry: 20 litres per person per day for drinking and personal hygiene is considered to be 'basic' access (WHO, 2011). Domestic water accounts for at most 11% of freshwater withdrawals (FAO, 2011a). Yet the availability of water and sanitation services is intimately linked to the wider policies and practices in water management. Unregulated abstraction can influence local availability of water and its quality with negative repercussions for water services. Changing climate is also expected to influence water resource availability, putting more pressure on already stretched resources and increasing the risk of contamination due, in part, to more frequent and intense flooding (WHO/DFID, 2009).

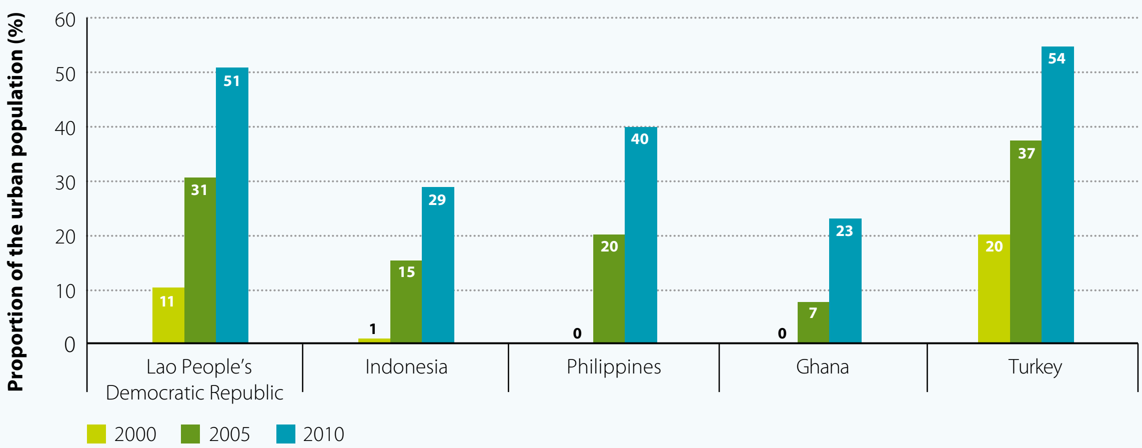
Pollution of the environment in other spheres can also influence the ability to provide adequate quantities of high-quality drinking water or the costs and energy required to do so. Ensuring water safety requires a focus on source protection, rational use of fertilizer and pesticides, and reducing industrial pollution as integral elements of comprehensive water safety planning.

In many lower-income countries *bottled water is a privilege of the wealthy who may resort to it due to lack of trust in the safety of municipal supplies, exacerbating inequalities*

As societies develop, their water usage patterns change. Global trends in the use of different water sources demonstrate a shift towards piped water on premises, especially in urban areas. Use of piped water can be highly beneficial for societal well-being; however, it also generates a tendency to raise the quantity of water used per capita, increasing stress on local water resources and wastewater

FIGURE 5.2

Strong growth of bottled and sachet water as a main drinking water source in urban settings, 2000-2012



Source: Authors' analysis based on data compiled by the WHO and UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP).

treatment facilities. In addition, household surveys show a marked increase in the use of packaged waters – bottles and sachets – in several countries (Figure 5.2). Although globally this is a small proportion of people, with an estimated 6% of people primarily relying on bottled water in 2010 (WHO and UNICEF, 2012), there are concerns about the environmental sustainability of packaging water (especially the plastic waste) and affordability of this trend. In many lower-income countries, bottled water is a privilege of the wealthy who may resort to it due to lack of trust in the safety of municipal supplies.

Lack of sanitation and poor management of excreta has a detrimental impact on the environment. In many countries, the demand for sewer-connected sanitation coverage has meant increases in connections without due attention to treatment and disposal of wastewater. Although data are few, estimates suggest that even in upper-middle income countries wastewater from 75% of households with sewer connections may not receive adequate treatment (Baum et al., 2013).The impact of releasing untreated human excreta to the environment is substantial, with negative impacts on rivers, lakes and coastal waters. Furthermore, the WHO and UNICEF JMP finds that one billion people do not use a sanitation facility and instead defecate in the open (WHO and UNICEF, 2014a). In addition to the clear risk to the health of communities, where open defecation takes place, the consequences for water and the environment are severe. The ideal solution from a sustainability perspective is to find productive uses for wastewater, especially in agriculture, thus relieving stress on water resources and treatment facilities as well as avoiding loss of nutrients. Where wastewater is to be treated, minimizing the amount of wastewater generated improves the potential for adequate and efficient treatment. In countries where robust regulations and wastewater treatment exist, reducing energy use is a key challenge requiring innovative approaches.

5.3 Reducing disparities and enhancing services

Sustainable development and human rights perspectives both call for reductions in inequalities and tackling disparities in access to services (UNGA, 2013). The human right to water and sanitation sets normative and cross-cutting criteria against which the adequacy of WASH services is to be judged (Figure 5.1). For WASH services to meet individual's needs, they must be aesthetically and culturally acceptable so that people are willing to and continue to use them, reliable, functional and physically accessible for all, including the elderly and disabled. Services must be appropriate for a given population and setting, and therefore must be selected and managed in such a way as

Public toilet in the shanty town of Ciudad Pachacutec, Ventanilla District, El Callao Province (Peru)
Photo: Monica Tijero/World Bank

to enable participation from a wide range of stakeholders, including the customers.

Pronounced disparities in access to WASH services, for example between regions, rural and urban areas, and socio-economic groups, are well-documented (WHO and UNICEF, 2014a). In order to achieve universal access, there is a need for accelerated progress in disadvantaged groups and to ensure non-discrimination in WASH service provision. Whereas some countries have made remarkable progress in reducing inequalities, in others these gains have largely bypassed the poor and marginalized. Ethiopia provides an example of a country that has made great progress during the period of working towards the MDGs – substantially increasing sanitation coverage and doing so equitably across wealth quintiles and regions (Figure 5.3). In 22 years, Ethiopia reduced open defecation from 92% to 37% (WHO and UNICEF, 2014a).

Coverage alone does not fully reflect inequalities; disparities are evident in the levels of service related to the safety, accessibility and reliability of water services (WHO and UNICEF, 2011). Even in countries where the majority of the population uses piped water on premises, certain minority groups may be neglected. For example, an analysis of data from Bosnia and Herzegovina found only 32% of the poorest Roma use an improved source of drinking water compared with 94% of the general population (WHO and UNICEF, 2014a). In order to ensure sustainability, the type of service needs to be appropriate to the context and carefully chosen based on the available infrastructure, human and financial resources. For example, the suggestion that everyone should aspire to a sewer-connected sanitation facility (a flush toilet) can create great difficulties for achieving sustainable systems with adequate financing and especially suitable management of wastewater. Similarly, in remote rural areas community sources such as boreholes can be more affordable than a piped system and easier to maintain. In these settings, safe household storage is essential to avoid contamination and creating potential breeding grounds for disease vectors.

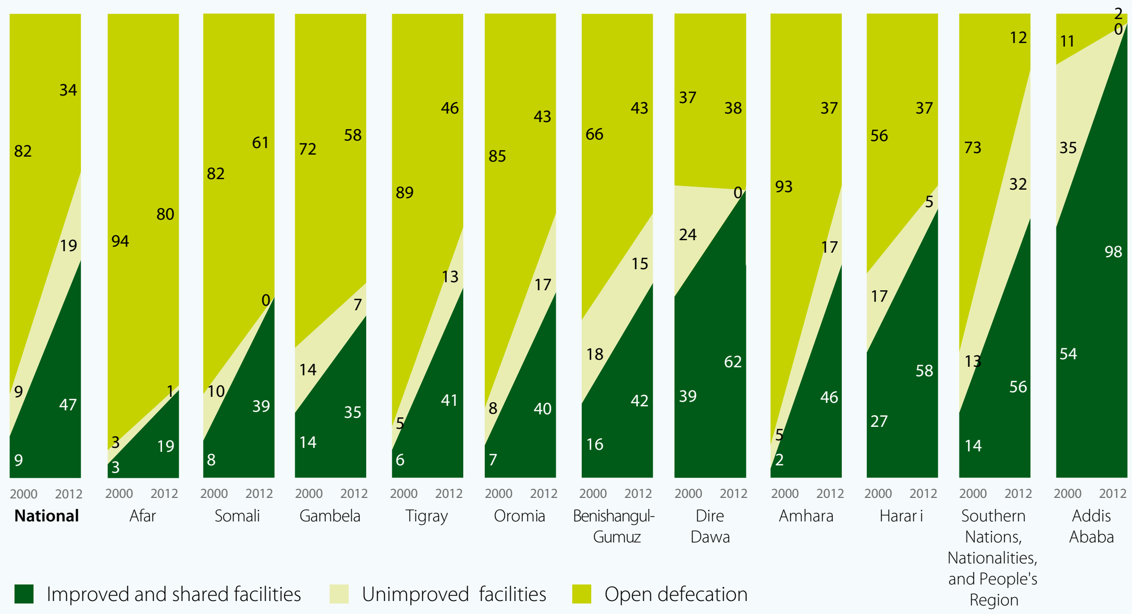
Household surveys and national censuses also indicate that there are disparities within households, including gender. Women and girls are often responsible for collecting water, especially in rural sub-Saharan Africa where many must spend at least half an hour to do so (WHO and UNICEF, 2012), and some make multiple trips taking up two to four hours a day (Pickering and Davis, 2012). At school, lack of sanitation is more likely to hinder a girl's educational attainment than a boy's. Women's involvement in local management of water supplies improves the chances of successful outcomes (UNEP, 2004), illustrating the importance of inclusive and participatory approaches in sustainable water resource management.

5.4 Towards sustainable WASH services

Many challenges remain in securing sustainable WASH services for present and future generations and ensuring that these services are within environmental limits. The types of challenges vary considerably between countries, with attaining basic access the priority in some and enhancing services and meeting environmental targets in others. As coverage continues to increase globally, the emphasis will shift towards attaining the additional benefits of higher levels of service as well as achieving environmental sustainability.

Globally, key targets for sustainable WASH identified by a wide stakeholder consultation include: universal access to basic water, sanitation and hygiene; elimination of open defecation; reduction of inequalities; progressive improvement of service levels; and safe management of water and excreta (WHO and UNICEF, 2013). In order to achieve these goals, there is a need to focus on service delivery and not solely on capital costs, ensure that services are financially viable, enhance accountability and transparency in financing, strengthen independent regulatory agencies, and build capacity to monitor progress and assess inequalities in service. Creation of new infrastructure, while essential, will not suffice to increase sanitation and hygiene coverage. A renewed focus on changing social norms is paramount.

FIGURE 5.3 **Sanitation coverage (%) in Ethiopia, by province (2000-2012)**



Source: WHO and UNICEF (2014a, Fig. 19, p. 15). Reproduced with the permission of the publisher.

6 Urbanization

UN-Habitat | Bhushan Tuladhar, Andre Dzikus and Robert Goodwin

6.1 Water in a rapidly urbanizing world

Cities have become the place where development challenges and opportunities increasingly come face to face. In 2014, 3.9 billion people, or 54% of the global population, lived in cities, and by 2050, two-thirds of the global population will be living in cities (UNDESA, 2014). Furthermore, most of this growth is happening in developing countries, which have limited capacity to deal with this rapid change.

Cities impact the hydrological cycle in several ways by: extracting significant amounts of water from surface and groundwater sources; extending impervious surfaces thus preventing recharge of groundwater and exacerbating flood risks; and polluting water bodies through the discharge of untreated wastewater. Since much of the water consumed by cities generally comes from outside the city limits, and the pollution they generate also tends to flow downstream, the impact of cities on water resources goes beyond their boundaries. Cities also import significant amounts of food, consumer goods and energy from outside the city, which requires large amounts of water at the point of production, transportation and sale. This virtual demand of cities greatly exceeds direct water use (Hoekstra and Chapagain, 2006).

At the same time, as centres for innovation, cities provide opportunities for more sustainable use of water, including treating used water to standards that enable it to be used again. They are well positioned to rapidly adopt conservation measures, and the concentration of people in compact settlements can reduce the cost of providing services such as water supply and sanitation. Furthermore, cities can connect with their hinterlands and support the protection of water resources in their surrounding areas by actively engaging in watershed management or providing PES.

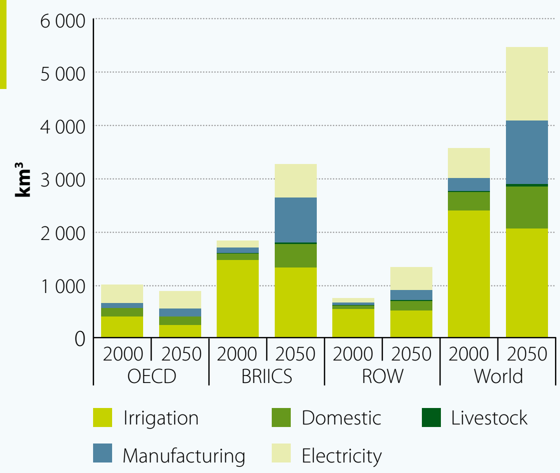
6.2 Challenges

6.2.1 Access to water supply and sanitation

Rapid urbanization, increased industrialization, and improving living standards generally combine to increase the overall demand for water in cities. As shown in Figure 6.1, by 2050, global water demand is projected to increase by 55%, mainly due to growing demand from manufacturing, thermal electricity generation and domestic use, all of which mainly results from growing urbanization in developing countries (OECD, 2012a). As easily available surface water and groundwater sources have been depleted in many urbanized areas, cities will have to go further or dig deeper to access water, or will have to depend on innovative solutions or more advanced technologies such as reverse osmosis for desalination, or reclaimed water to meet their water demands (see WWAP, 2015, Chapter 1, Case study "Towards sustainable groundwater management in Asian cities".)

Although the MDG target on access to safe drinking water – as measured by the proportion of population using an improved drinking water source (see Box 1.1) – was met in 2010, the progress in urban areas has not been able to keep up with the rapid pace of urbanization (Figure 6.2). Between 1990 and 2012, the number of urban residents who did not have access to an improved drinking water source decreased by 1 percentage point. However, in absolute terms, the number of people in urban areas without access to an improved drinking water source increased from 111 million to 149 million (WHO and UNICEF, 2014a), indicating that

FIGURE 6.1 **Global water demand in 2000 and 2050**



Note: BRIICS (Brazil, Russia, India, Indonesia, China, South Africa); OECD (Organisation for Economic Co-operation and Development); ROW (rest of the world). This graph only measures 'blue water' demand and does not consider rainfed agriculture.
Source: OECD (2012a, Fig. 5.4, p. 217, output from IMAGE). OECD Environmental Outlook to 2050 © OECD.

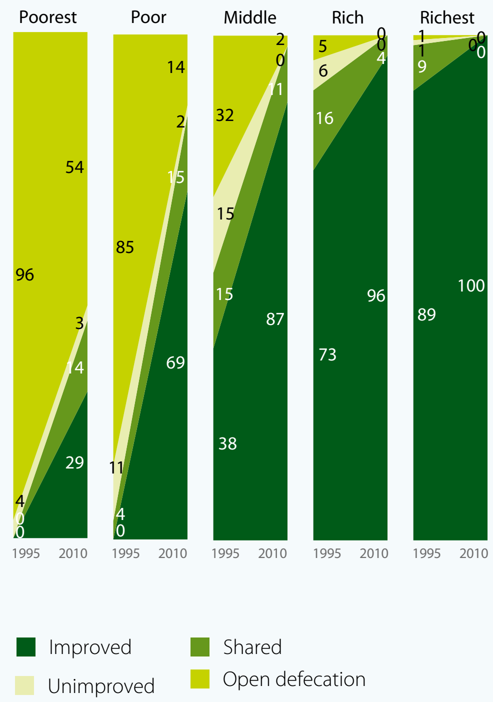
access to drinking water is actually deteriorating where the most rapid urbanization is outpacing public services (see Section 6.3.1). The situation is worse in sub-Saharan Africa, where urbanization is happening most rapidly. In this region, the percentage of people who enjoyed piped water on their premises, which is the preferred option for urban areas, actually decreased from 42% to 34% (WHO and UNICEF, 2014a). This clearly indicates that access to 'safe' drinking water sources continues to be a major problem in cities in the developing world.

Similar to trends in drinking water, the number of urban residents without access to improved sanitation increased by 40%, from 541 to 754 million, between 1990 and 2012 (WHO and UNICEF, 2014a). Therefore, although sanitation coverage is generally higher in urban areas, because of rapid urbanization, increasing numbers of urban residents, particularly the poor, are unable to access improved sanitation. Also, due to higher population densities in urban areas, the health consequences of poor sanitation can be pervasive. In urban Cambodia, for example, 54% of the people in the poorest quintile still defecate in the open, while among the richest 40% of the population, this has gone down to zero (Figure 6.3).

The increase in the number of people without access to water and sanitation in urban areas is directly related to the rapid

FIGURE 6.3

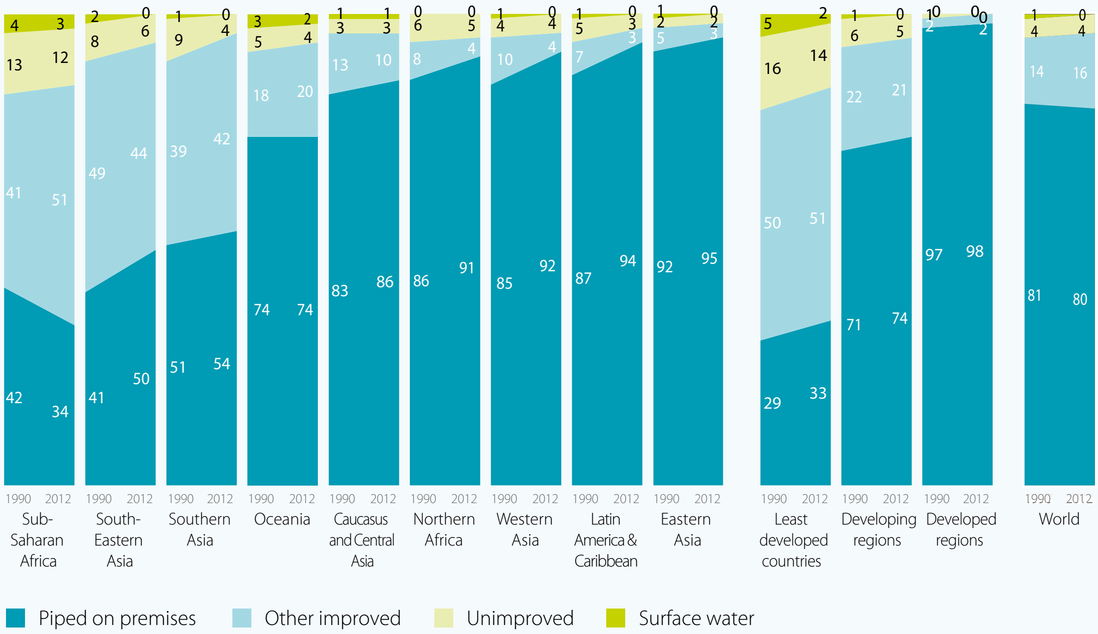
Access to sanitation in urban Cambodia in different wealth quintiles



Source: Extracted from WHO and UNICEF (2014a, Fig. 29, p. 24). Reproduced with the permission of the publisher.

FIGURE 6.2

Trends in urban water supply coverage (1990-2012)



Source: WHO and UNICEF (2014a, Fig. A4-1, p. 66), reproduced with the permission of the publisher.

growth of slum populations in the developing world and the inability or unwillingness of local and national governments to provide adequate water and sanitation facilities in these communities. While there has been some progress in moving people out of slum conditions, it has not been enough to counter population growth in informal settlements. The world's slum population is expected to reach 889 million by 2020 (UN-Habitat, 2010). As slum dwellers are generally more likely to suffer inadequate access to safe water and sanitation and are also more vulnerable to the impacts of extreme weather events, water management in cities, particularly slum settlements, will be a major challenge in the future. In some informal settlements, however, local communities and the private sector have come up with innovative solutions. In Mombasa, for example, where only about 15% of the people have access to piped water supply, more than 80% have access to an improved water source because they receive water from kiosks (Figure 6.4).

6.2.2 Pollution and wastewater management

Many cities in developing countries do not have the necessary infrastructure to collect and treat wastewater. In the absence of proper drainage systems, sewage mixes with stormwater causing further pollution. It is estimated that up to 90% of all wastewater in developing countries is discharged untreated directly into rivers, lakes or the oceans, causing major environmental and health risks (Corcoran et al., 2010). This has huge social and economic impacts due to increased health care costs and lower labour productivity. Wastewater also has impacts on the global environment as wastewater-related emissions of methane, a powerful global warming gas, and nitrous oxide could rise by 50% and 25%, respectively, between 1990 and 2020 (Corcoran et al., 2010).

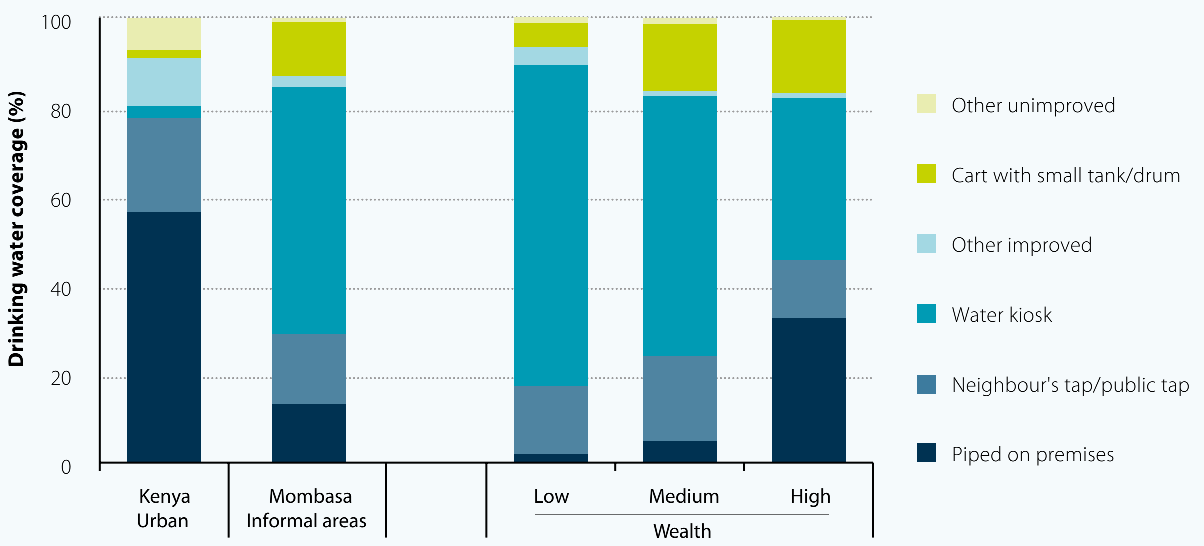
There is clearly a need to expand wastewater treatment systems and improve efficiency of existing treatment plants. While some developing countries such as Chile have been successful in treating almost all their wastewater (Bartone, 2011), experience from most developing countries indicates that wastewater management can be expensive and most cities do not have or allocate the necessary resources for this. Moreover, the cost of the wastewater collection is often underestimated. There is a need for more innovative options for such as decentralized wastewater treatment solutions and biogas production for reusing and recycling wastewater and reducing the cost of wastewater management (Lüthi et al., 2011).

6.2.3 Institutional capacity and water governance

Given the rapid pace of urbanization, the institutional capacity of local and national governments and water utilities to increase investments and manage the delivery of services is becoming critical, especially in cities with old and poorly maintained water and sanitation infrastructure and cities in the developing world. High rates of unaccounted-for water (mainly due to leakages), unsustainable tariffs and weak systems of governance are typical manifestations of the growing capacity gaps in many urban areas. Leakage results in loss of revenue, higher chances of drinking water

FIGURE 6.4

Access to water in Mombasa's informal settlements



Source: WHO and UNICEF (2014a, Fig. 24, p. 20). Reproduced with the permission of the publisher.

contamination and outbreaks of waterborne diseases, which will further reduce water service quality and the consumers' willingness to pay.

6.2.4 Climate change and water-related disasters

Because the impacts of climate change are complex and unpredictable (see Chapter 10), the availability of and demand for water are highly likely to be affected. Water and sanitation infrastructure may be at risk because of extreme events and sea level rise. With increased urbanization encroaching upon natural drainage paths and changed land use caused by urbanization resulting in increased runoff, there is also an urgent need for more sustainable urban drainage systems to address the issues of inundation and water contamination. As the urban poor tend to live in concentrated and highly vulnerable areas such as river banks, they are more vulnerable to the impacts of climate change. Coping with the effects of climate change will therefore require cities to strengthen planning and management capacities related to water and integrate water management with overall urban development.

6.3 Responses

The dedicated goal for water and its five targets proposed by UN-Water (2014) as part of the post-2015 agenda for sustainable development (see Chapter 16) are very relevant for the sustainable use of water in the urban context. The targets provide an appropriate framework for responding to the challenges of managing water in cities.

6.3.1 Pro-poor policies for safe water supply and sanitation

Rapid urbanization is outpacing public service provisions in the developing world and the overall number of people without access to safe water and sanitation in urban areas is increasing. The proposed target on universal access to safe water, sanitation and hygiene should stimulate action to address this critical issue. Furthermore, as the target also includes an element of progressively eliminating inequalities in access, it would encourage policy-makers to address the needs of the urban poor. In doing so, governments and service providers can learn from experiences of successful and innovative initiatives that focus on the needs of urban poor and create an enabling environment for service delivery (Box 6.1).

__Many cities__ in developing countries do not have the necessary infrastructure to collect and treat wastewater

6.3.2 Integrated urban water management

The proposed target on sustainable use and development of water resources can benefit from experiences of

BOX 6.1

Pro-poor policies in Kampala

In 2004, the Government of Uganda set a target of 100% coverage of water supply and sanitation services in urban areas by 2015. In response, the National Water and Sewerage Corporation (NWSC), which is responsible for water and sanitation services in Kampala, introduced a series of measures such as affordable connection, a pro-poor tariff, and special projects targeted at the poor. It set up an urban pro-poor branch in 2007 and provided a variety of service options including household connections, prepaid public water points/kiosks, and shared yard taps. As a result, NWSC was able to significantly expand its services to the urban poor while increasing its revenue. The pro-poor branch was also able to reduce the proportion of inactive public water points and yard taps from 40% in 2007 to less than 10% in 2009.

Source: Kariuki et al. (2014).

BOX 6.2

Forest conservation by a water utility in Costa Rica

Since 2000, the local water supply company (Empresa de Servicios Públicos de Heredia) in the province of Heredia in Costa Rica has invested in protecting strategic forest areas in the Virilla River Watershed, allowing for the recharge of surface and groundwater sources. Enforcement of approved regulation against changes in land use patterns ensures the protection of the province's main sources of water supply. The company charges an additional 3% of the monthly water bill to its users and collected funds are used to compensate land owners for control of changes in land use. Over the last ten years, the programme has protected more than 1,100 ha of forest within the catchment. As a result, the province is able to provide clean water to all its 200,000 residents while minimizing the need to invest in water treatment infrastructure.

Source: Barrantes and Gámez (2007).

Rocinha Favela, the largest in Brazil
Photo: Ahln

6.3 BOX

Phnom Penh water supply: An example of good governance

The Phnom Penh Water Supply Authority (PPWSA), which has transformed itself from a near-bankrupt, demoralized and corrupt institution into one of the best water utilities in the world, can provide valuable experiences for other cities. Under the dynamic leadership of Ek Sonn Chan, PPWSA was able to turn around the performance of the utility within a decade to provide all people with continuous, good quality and affordable water supply, while consistently increasing its net profit. Due to its pro-poor policies, it has also increased its connections to poor households from 101 household connections in 1999 to 17,657 in 2008. The fact that Phnom Penh has been able to reduce its unaccounted-for water from over 60% in 1998 to just 6% by 2008, which is comparable to Singapore, demonstrates that state managed utilities in developing countries can be efficient, if they have good leadership and governance.

Source: Biswas and Tortajada (2010).

6.4 BOX

DEWATS in Indonesia

The government of Indonesia is promoting community-managed decentralized wastewater treatment systems (DEWATS) and aims to reach 5% of the total urban population through DEWATS by the end of 2014. A review of almost 400 DEWATS units installed in different Indonesian cities between 2003 and 2007 found that over 80% of them were functioning well and complying with effluent discharge standards. The study found, however, that sustained use of the infrastructure over the long term requires some external monitoring and support, as community groups often lose enthusiasm and are reluctant to fund major repairs on their own. It concluded that "community managed DEWATS can be effective for serving poor communities where the appropriate type of system is built well in the right location, the number of users is optimized and sustained and there is shared responsibility with government for operation and maintenance" (WSP, 2013).

Source: WSP (2013).

integrated urban water management (IUWM) systems in various countries. IUWM calls for the alignment of urban development and basin management and brings together water supply, sanitation, and stormwater and wastewater management, and integrates these with land use planning and economic development. Implementation of IUWM will require appropriate institutional structures, policies, careful planning, capacity-building and investment in systems such as protection of upstream catchment areas, rainwater harvesting and recharge, water demand management and water reuse (Box 6.2).

6.3.3 Urban water governance

The target on equitable, participatory and accountable water governance will require strong political commitment, appropriate policy and legal frameworks, effective institutional structures, efficient administrative systems and capable human resources. It will also require investments in water infrastructure, renewal, operations and maintenance. A study estimates that one dollar of water and sewer infrastructure investment increases private output (gross domestic product) in the long-term by US$6.35 and yields a further US$2.62 output in other industries. These benefits accrue in terms of jobs created, final output and private sector investment (Krop et al., 2008). Experiences from cities around the world have shown that it is possible to improve the performance of urban water supply systems and increase revenue and profits, while continuing to expand the system and addressing the needs of the poor, provided that there is strong leadership and good governance (Box 6.3).

6.3.4 Sustainable sanitation

Effective management of water resources and reduction of water pollution will require investment in sustainable sanitation systems which are technically appropriate, economically viable, socially acceptable and environmentally sound. These may include promotion of reuse, treatment of wastewater to an appropriate level for the intended reuse option, and integration of sanitation systems with overall water resource and urban planning and design (Lüthi et al., 2011). Since transportation accounts for much of the cost of wastewater management, decentralized systems that treat wastewater close to the source, using simple technologies that maximize recycling of water and nutrients, can be more effective, particularly in poor and peri-urban settlements (Box 6.4). Wastewater systems can also generate energy; treated wastewater can be reused, thus contributing to water, energy and food security and therefore health and economy. In Accra, urban vegetable gardens irrigated by treated wastewater provide up to 90% of the vegetable needs of the city (Tettey-Lowor, 2009).

On-site sanitation, which is still the main approach used in most urban areas in Africa and Asia, is a challenge as well as an opportunity. If faecal sludge is not managed properly, it can cause major health risks and pollution, but avoiding extensive sewer systems leads to investment savings and allows for more innovative decentralized options that are less water- and energy-intensive can be explored.

6.3.5 Adaptation to climate change and water-related disasters

The World Bank estimates that the global costs of adaptation from 2010 to 2050 will be US$70 billion to 100 billion a year (World Bank, 2010a). The sectors requiring the main bulk of this investment will be water supply and flood protection, infrastructure and coastal zones, with urban areas requiring an estimated 80% of the total funding required for adaptation (World Bank, 2010b). As most of this investment will be needed in developing countries, where the infrastructure and systems are yet to be built, there are possibilities for making future cities climate smart, thus reducing climate risks and maximizing environmental and economic benefits. For example, cost-benefit assessments of early warning systems for storms, floods, and droughts undertaken throughout Asia indicate potential returns of up to US$559 for each US$1 invested (Subbiah et al., 2008).

Some cities like Singapore have taken adaptive measures to increase the resilience of urban water supply and sanitation systems. To avoid seawater intrusion into reservoirs, most reservoir dams are much higher than the predicted sea level rise, and if needed the gates can be further raised. By diversifying its water sources to include rainwater harvesting, reclaimed water and desalinization, the city has reduced its vulnerability to prolonged dry periods (Chiplunkar et al., 2012).

7 Food and agriculture

FAO | Edited by: Jippe Hoogeveen

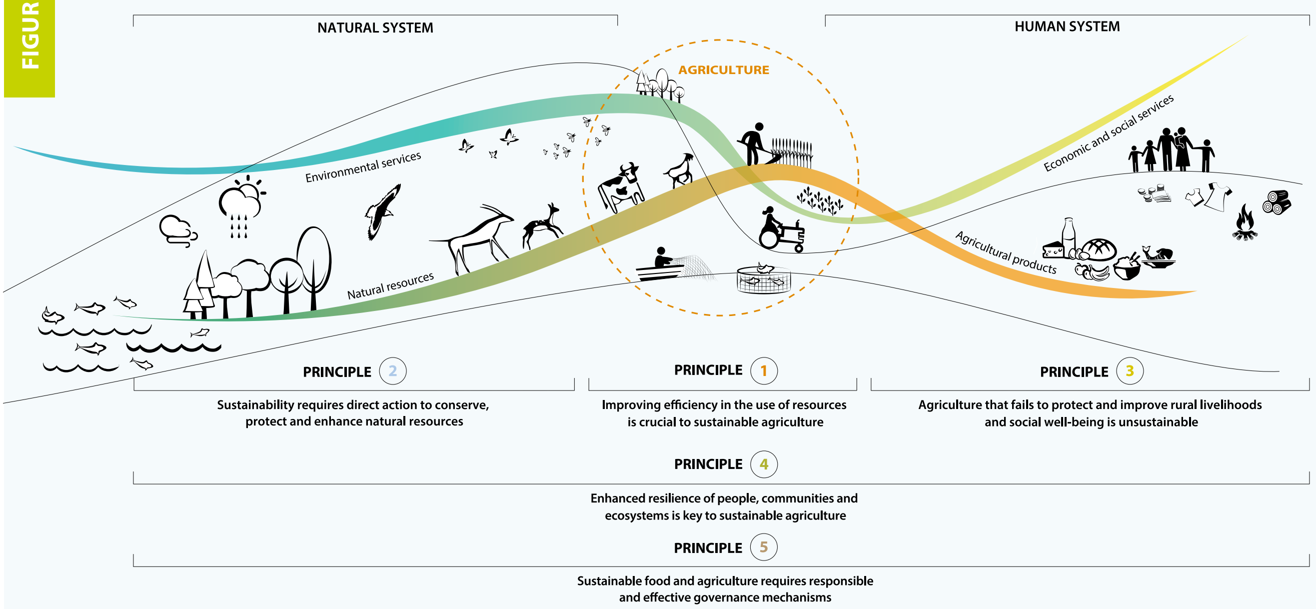
By 2050, agriculture will need to produce 60% more food globally, and 100% more in developing countries (Alexandratos and Bruinsma, 2012). However, current growth rates of agricultural demands on the world's freshwater resources are unsustainable. Inefficient use of water for crop production depletes aquifers, reduces river flows, degrades wildlife habitats, and has caused salinization of 20% of the global irrigated land area (FAO, 2011a). The bulk of capture fisheries production comes from coastal waters, where both the productivity and the quality of fish stocks are severely affected by pollution, much of which comes from agriculture. Although reservoirs can create opportunities for aquaculture, capture fisheries and aquaculture can also be threatened by competing demands from hydropower development and water diversion for industrial uses.

To achieve "a world free from hunger and malnutrition, where food and agriculture contribute to improving the living standards of all, especially the poorest, in an economically, socially and environmentally sustainable manner" (FAO, 2013a), FAO has proposed the following five principles (FAO, 2014a):

1. Improving efficiency in the use of resources is crucial to sustainable agriculture.
2. Sustainability requires direct action to conserve, protect and enhance natural resources.
3. Agriculture that fails to protect and improve rural livelihoods and social well-being is unsustainable.
4. Enhanced resilience of people, communities and ecosystems is key to sustainable agriculture.
5. Sustainable food and agriculture requires responsible and effective governance mechanisms.

The principles are interconnected and complementary and should often be considered simultaneously (Figure 7.1). They support the three dimensions of sustainable development. The first two principles directly refer to the environment, while the third refers to social and economic development. The fourth and the fifth underpin all three dimensions of sustainable development. For the application of all five

FIGURE 7.1 **The five principles of sustainable agriculture**



Source: FAO (2014a, Fig. 3, pp. 18-19).

principles, a range of actions can be taken to enhance agricultural productivity and sustainability.

7.1 Improving resource use efficiency

In broad terms, agriculture has two options to increase water use efficiency: reduce water losses and increase water productivity.

The first option seeks to increase the efficiency of water use by reducing water losses in the process of production. Technically, 'water use efficiency' is a dimensionless ratio that can be calculated at any scale, from irrigation system to the point of consumption in the field. It is generally applied to any management approach that reduces the non-beneficial use of water (i.e. reducing leakage or evaporative losses in water conveyance and application). The second option focuses on increasing crop productivity. This involves producing more crop or value per volume of water applied.

Clearly, there is scope for managing the demand for water in agriculture in time and in space. However, excessive emphasis is often placed on the first option, with efforts aimed at reducing water 'losses' within irrigation distribution systems. Two factors limit the scope for and impact of water loss reduction. First, only part of the water 'lost'(defined as water that is diverted for purposes that have clear and tangible benefits, such as for household purposes, irrigation, industrial processing and cooling), while withdrawn for beneficial use, can be recovered effectively at a reasonable cost. Second, part of the water 'lost' between the source and final users return to the hydrological system, either through percolation into aquifers or as return flow into river systems. The share of water lost through non-beneficial consumption, either through evaporation or through drainage into low quality water bodies or to the sea, varies according to local conditions. A clear understanding of the real potential for reducing water losses is needed to avoid designing costly and ineffective demand management strategies (2030 WRG, 2013).

The single most important avenue for managing water demand in agriculture is through increasing agricultural productivity

In most cases, the single most important avenue for managing water demand in agriculture is through increasing agricultural productivity. Increased crop yields are made possible through a combination of improved water control, improved land management and agronomic practices. The latter include the choice of genetic material, and

BOX 7.1

Deficit irrigation for high yield and maximum net profits

Maximum crop productivity is achieved using high-yielding varieties with optimal water supply, soil fertility and crop protection. However, crops can also produce well with sub-optimal water supply. In deficit irrigation, water supply is less than the crop's full requirement, and mild stress is allowed during growth stages that are less sensitive to moisture deficiency. The expectation is that any yield reduction will be limited, and additional benefits are gained by diverting the saved water to irrigate other crops or for other beneficial uses.

A six-year study of winter wheat production on the North China Plain showed water savings of 25% or more through the application of deficit irrigation at various growth stages. In normal years, two irrigations (instead of the usual four) of 60 mm were enough to achieve acceptably high yields and maximize net profits. In Punjab, Pakistan, a study of the long-term impacts of deficit irrigation on wheat and cotton reported yield reductions of up to 15% when irrigation was applied to satisfy only 60% of total crop evapotranspiration. The study highlighted the importance of maintaining leaching practices in order to avoid the long-term risk of soil salinization.

In studies carried out in India on irrigated groundnuts, production and water productivity were increased by imposing transient soil moisture-deficit stress during the vegetative phase, 20 to 45 days after sowing. Water stress applied during the vegetative growth phase may have had a favourable effect on root growth, contributing to more effective water use from deeper soil horizons. Higher water savings are possible in fruit trees, compared to herbaceous crops. In Australia, regulated deficit irrigation of fruit trees increased water productivity by approximately 60%, with a gain in fruit quality and no loss in yield.

It should be noted, however, that deficit irrigation can only obtain good results if the irrigation systems provide very reliable water services that are also quite flexible.

Source: FAO (2011b).

Planting rice in Viet Nam
Photo: UN Photo/Kibae Park

improved soil fertility management and plant protection. It is important to note that plant breeding and biotechnology can help by increasing the harvestable parts of the biomass, reducing biomass losses through increased resistance to pests and diseases, reducing soil evaporation through vigorous early growth for fast ground cover, and reduced susceptibility to drought. Therefore, managing overall demand through a focus on water productivity rather than concentrating on the technical efficiency of water use alone is an important consideration (Box 7.1).

7.2 Conserving, protecting and enhancing natural resources

It is crucial to protect and restore natural ecosystems like wetlands, forests, rivers and lakes that provide important ecosystem services with regard to the quality and quantity of water (see Chapter 4). However, while preserving the environmental function of water systems is a priority, its execution will involve careful negotiation on required environmental flows. Since agricultural landscapes also perform environmental functions, the boundary between environmental water requirements and agricultural water demand is often not clear-cut (see WWAP, 2015, Chapter 7, Case study "Progress on sustainable development objectives in the Mekong Delta, Viet Nam.")

BOX 7.2

Rio Rural: Payments for environmental services in a watershed management programme

In the northern parts of the State of Rio de Janeiro, Brazil, past rural policies gave priority to mono-cropping of coffee and sugar cane, as well as extensive cattle raising. The associated deforestation and unsustainable production systems lead to soil degradation and depletion of water resources.

Since 2006, the Rio Rural Programme has been working to reverse this pattern by providing long term support to small family farmers, to transition to eco-friendly productive systems. Since most of the more sustainable technologies have higher costs of implementation and low impacts on rural income, it is crucial to establish a financial incentive system to support their adoption.

With financing from GEF (2006-2011), the World Bank (2010-2018), federal and state programmes and the private sector, Rio Rural will invest US$200 million on 180,000 ha and benefiting 78,000 farmers, of which 47,000 receive direct financial incentives and technical assistance to improve productivity. In return, farmers agree to conserve remnant forest areas.

The Rio Rural strategy for long-term sustainability of farmers´ agro-ecosystems is to ensure that every farming technology upgrade is jointly adopted with a conservation practice, so farmers are able to raise productivity while improving environment quality. Farmers who adopt rotational grazing systems with Rio Rural support also agree to release part of their lands to forest restoration, to protect springs and riparian strips.

Activities directly related to water protection are partly funded by water supply authorities, at local, state and federal levels. Rio Rural offers technical support and financial incentives to income generation activities and watershed management committees invest earmarked shares of water fees directly in the conservation practices.

Contributed by the Rio Rural project team, Sustainable Development Department (SEAPEC), Rio de Janeiro State Secretariat of Agriculture, Brazil (http://www.microbacias.rj.gov.br/index.jsp).

With increased intensive agriculture, water pollution from both point and non-point sources may worsen. Technologies exist to limit agricultural water pollution, in particular through integrated pest and plant nutrition management. Experience from high income countries shows that a combination of incentives, including more stringent regulation, enforcement and well-targeted subsidies, can help reduce water pollution (FAO, 2012b). In addition, the PES approach (see Section 4.3.1), often in combination with the above-mentioned incentives, can lead to a noticeable reduction in agricultural pollution and savings in water treatment costs downstream of agricultural land (Box 7.2).

7.3 Rural livelihoods and social well-being

Agricultural development aims to benefit those whose livelihoods depend on it by increasing their access to resources and assets, their participation in markets and their job opportunities. If it fails to do so, it is unsustainable. Since 75% of the world's poor live in rural areas, broad-based rural development and the wide sharing of its benefits are the most effective means of reducing poverty and food insecurity (World Bank, 2007a). The status of women, who make up the majority of the world's hungry and have disproportionately low levels of resource ownership, requires special attention. With equal access to resources and knowledge, female farmers, who account for the majority of all subsistence farmers, could produce enough additional food to reduce the number of the world's hungry by 150 million (FAO, 2011c).

Water scarcity can impose a major constraint on agricultural productivity and rural poverty reduction. The vulnerability of rural people remains considerable due to a combination of highly variable and erratic precipitation; poor development of hydraulic infrastructure, management and markets; non-conducive land and water governance; and a lack of access to water for domestic and productive uses. For millions of smallholder farmers, fishers and herders, water is one of the most important production assets. Securing access to and control and management of water is key to enhancing their livelihoods, especially in Africa (see Chapter 15). Approaches exist for well-targeted local interventions in water that contribute to rapid improvement in the livelihoods of the rural poor (Box 7.3). However, investments in water infrastructure alone cannot suffice to improve agricultural productivity. Farmers need access to inputs like fertilizer and seed material and, like fishers, need access to water, and all users need access to credit. In addition, they need better education and information regarding the use of inputs and latest techniques.

> ***The social impacts** of rapid food price inflation have hit the poorest hardest*

In South-East Asia, under the influence of fast but uneven economic growth, the agricultural sector faces two complex trends: (a) an increasing income gap between agriculture and other sectors and (b) the need to reverse the unsustainable use and degradation of the region's limited natural resources base. A key challenge for decision-makers is to adopt policies and strategies to help bridge a widening gap between urban affluence and rural poverty, while also encompassing 'green' measures necessary to enhance ecological well-being. For many farmers and fishers, solutions need to be found outside of the agricultural sector.

BOX 7.3

The Keita Project: Exploring the range of water conservation options in western Niger

The Keita Project, funded by Italy and the World Food Programme at more than US$80 million, started its activities in the Ader-Doutchi-Majiya, an arid region of Niger, in 1984. It is a project of unusual scale and duration and, by 1991, it covered an area of 13,000 km^2, with about 300,000 people in 400 villages. The project provided services and infrastructure on a grand scale. By the end of 1999, it had created 50 artificial lakes, 42 dams and 20 anti-erosion dykes, and 65 village wells. It had applied soil and water conservation techniques to about 10,000 ha of land, and had planted 16 million reforestation seedlings. In addition, the project provided a variety of infrastructure, including schools, maternity centres, veterinary facilities, shops and storehouses, and it included women's empowerment programmes, microcredit and adult literacy courses.

The aspects of the project that were most appreciated by the local population were the increased availability of water and fodder, together with the distribution of 'food for work' in an area with few work opportunities (Rossi, 2006). Ten years after project completion, most of the hydraulic infrastructure was still in place and functioning for the benefit of local populations.

Source: FAO (2002 and 2008, Box 6, p. 51) and Italian Development Cooperation (2009).

There is general recognition that the current performance of the irrigation sector is often environmentally unsustainable, and that the level of service delivery is, on the whole, inadequate to meet the poorest farmers' needs to generate sufficient income for a dignified livelihood, let alone their future requirements. Modernizing large scale irrigation systems should allow for farm size consolidation, rendering them highly reliable, flexible and service oriented. This would also create room for acknowledging the multiple users of water so that their planning can be compatible with long-term urban, energy and transport infrastructure perspectives.

Female farmers, *who account for the majority of all subsistence farmers, could produce enough additional food to reduce the number of the world's hungry by 150 million*

7.4 Improving resilience

In the context of sustainable food and agriculture, resilience is the capacity of farming, fishing and herding communities, households or individuals to maintain or enhance system productivity by preventing, mitigating or coping with risks, adapting to change and recovering from shocks. Phenomena such as extreme weather events and market volatility, as well as civil strife and political instability, impair the productivity and stability of agriculture, which in turn increases uncertainty and risks for producers. The social impacts of rapid food price inflation have hit the poorest hardest. Improving the resilience of water users to shocks and extreme events is a vital part of an effective coping strategy (Box 7.4). The buffering capacity of global agricultural markets to absorb supply shocks and stabilize agricultural commodity prices is tied to the continued functioning of land and water systems. At the same time, climate change brings additional risks and further unpredictability of harvests for farmers, fishers and herders due to warming and related aridity, shifts in rainfall patterns, and the frequency and duration of extreme events.

7.5 Effective governance

The key principles for enhancing effective governance include: participation, accountability, transparency, equality and fairness, efficiency and effectiveness, and rule of law (FAO, 2013b). Following these key principles helps ensure social justice, equity and a long-term perspective on the protection of natural resources. When sustainability processes are dominated by abstract environmental concerns, without adequate attention to social and economic dimensions, they are unlikely to be implemented. A transition to sustainable agriculture requires enabling

BOX 7.4

Strengthening adaptive capacity of smallholder farmers through land and water management

The pilot project 'Strengthening capacity for climate change adaptation in land and water management' carried out from 2011 to 2014 by FAO and funded by the Swedish International Development Cooperation Agency (Sida), aimed to identify appropriate technologies that decrease crop and livestock production risk in East Africa.

In sub-Saharan Africa, 'no regret options' for climate change adaptation (i.e. options that increase the resilience of communities, not only to climate change but to any type of shock) have the highest probability of success both in the short and in the long term. In the Wurba watershed, Shoa Robit Woreda Ethiopia, measures were implemented to retain the surface runoff in the uplands and improve water-holding capacity of the soil. These measures increase groundwater recharge and also protect the top soil. The measures consisted of hillside terraces with trenches, stone check dams on hillsides, cut-off drains, trenches and micro-basins.

In addition, water harvesting methods were undertaken in an attempt to reduce the impact of periods of droughts and to diversify sources of income. These methods included excavation of ponds on homesteads and farmland, lined with geo-membrane, in which water was stored and used for domestic purposes, to water animals, and for horticulture. The project also provided cisterns for rooftop water harvesting, as no source of water is available locally during the dry season. The interventions have decreased the time and labour required to fetch water, while also increasing household incomes through the availability of high value horticultural products.

Source: FAO (2014b).

BOX 7.5

Groundwater governance in Andhra Pradesh, India

The Netherlands-funded 'Andhra Pradesh Farmer Managed Groundwater Systems (APFAMGS) Project' was implemented by FAO in the southern part of the Republic of India. It covered about 638 villages in seven drought-prone districts of Andhra Pradesh. In the project area, the natural groundwater recharge rates are estimated to be about 70–100 mm/year.

By the late 1990s, groundwater abstraction rates had grown to an equivalent of 120–150 mm/year, and an increasingly large portion of existing dug wells fell dry or became seasonal. In response, a rapid growth of bore wells was observed with steadily increasing depths (related to the flat-rate rural electricity tariff). The expansion of groundwater use resulted in serious dewatering of the main water bearing horizons of the shallow aquifer system.

In order to reverse the problem, the project developed a participatory hydrological monitoring programme to provide farmers with the necessary knowledge, data and skills to understand the hydrology of groundwater resources. Due to significant variations in local hydrogeology, the calculations are specific for each aquifer and follow the standard methodology developed and used by India's Central Ground Water Board.

Groundwater management committees in each aquifer or hydrological unit estimated the total groundwater resource available and worked out the appropriate cropping systems to match. The committees then disseminated the information to the entire farming community and acted as pressure groups encouraging appropriate water saving and harvesting projects, promoting low investment organic agriculture and helping formulate rules that would ensure inter-annual sustainability of limited groundwater resources.

In the majority of the pilot project area, the results have been very positive, as witnessed by a substantial reduction in groundwater use through crop diversification and irrigation water-saving techniques and improving profitability despite less water use.

Source: Govardhan Das and Burke (2013).

policy, legal and institutional environments that strike the right balance between private and public sector initiatives, and ensures accountability, equity, transparency and appropriate legislation (Box 7.5).

Agriculture and food security are intimately linked to water, and therefore policies in these domains must be consistent. In times of crises, and with volatile markets, ensuring a country's food security (or that a country's population is fed) becomes a primary concern for national decision-makers. Water authorities should cease to regard water as a sector 'compartment' and engage more proactively with other economic sectors to make their strategies for coping with water scarcity coherent with key decisions being taken elsewhere (WWAP, 2009). Such intersectoral dialogue is essential for 'operationalizing' the concept of integrated water resources management.

Policies, legislation and fiscal measures have profound effects on what happens at district and local levels, most importantly in setting boundaries for stakeholder involvement in decision-making, and in clearly articulating their roles and responsibilities (Moriarty et al., 2007). It is crucially important that there is good alignment among the many policies, items of legislation and fiscal measures that influence water management, service delivery and level of demand. Decisions outside the water domain, such as those concerning energy prices, trade agreements, agricultural subsidies and poverty reduction strategies, often have a major impact on water supply and demand, and hence on water scarcity.

8 Energy

WWAP | Richard Connor

8.1 Thirsty energy

A necessity for meeting basic human needs like cooking and heating, access to a secure source of energy is a core component of sustainable development. Energy is tightly interlinked with water. Nearly all forms of energy require some amount of water as part of their production process. Thermal power generation and hydropower, which respectively account for 80% and 15% of global electricity production, generally require large quantities of water. Conversely, energy is required for the collection, treatment and delivery of water. It has been estimated that electricity accounts for 5% to 30% of the total operating cost of water and wastewater utilities (World Bank, 2012), but in some countries such as India and Bangladesh, it can be as high as 40% (van den Berg and Danilenko, 2011).

Water and energy also provide complementary services at the household level, where energy is needed for pumping water from wells (for domestic or agricultural use), and to produce hot water for cooking, cleaning and hygiene.

8.1.1 Access to water and energy services

Access to water and energy services is necessary to meet sustainable development goals. The same people who lack access to improved water and sanitation are also likely to lack access to electricity and to rely on solid fuel for cooking (WWAP, 2014). Some 748 million people lack access to an improved source of drinking water (WHO and UNICEF, 2014a), although the number of people whose right to water is not satisfied could be as high as 3 billion (Onda et al., 2012); 2.5 billion people remain without access to improved sanitation. Over 1.3 billion people lack access to electricity, and roughly 2.6 billion use solid fuels (mainly biomass) for cooking (IEA, 2012). Another estimated 400 million people rely on coal for cooking and heating purposes, which, like wood, charcoal, peat or other biomass, causes air pollution and has potentially serious health implications when used in traditional stoves. The close association between waterborne diseases like diarrhoea caused by lack of safe drinking water and sanitation and respiratory diseases caused by indoor air pollution is a point of evidence that it is the same people that are underserved by water services and electricity. These two combined courses are also one of the most important causes of premature death and loss of disability-adjusted life years (DALYs) [3].

Meeting any sustainable development goal related to health, and by association to poverty, education, and overall equity, is therefore contingent on providing access to safe water and energy services to all, including women and children who represent a disproportional share of the underserved.

8.1.2 Global energy demand

At the global level, energy demand is projected to increase by one third by 2035, with demand for electricity expected to grow by 70% over the same period (IEA, 2013). In terms of primary energy, the transition away from fossil fuels is likely to take considerable time to achieve. Demand is expected to grow for all forms of energy: oil by 13%, coal by 17% (mainly before 2020), natural gas by 48%, nuclear by 66% and renewables by 77%. Global power generation will continue to be dominated by thermal electricity production from coal, natural gas and nuclear – with coal remaining the largest source. The share of renewables, including hydropower (the largest source), is expected to double, accounting for 30% of all electricity production by 2035 (IEA, 2013).

Because 90% of thermal power is water intensive, the estimated 70% increase in electricity production by 2035 would translate into a 20% increase in freshwater withdrawals. Water consumption would increase by 85%, driven by a shift towards higher efficiency power plants with more advanced cooling systems (that reduce withdrawals but increase consumption), and increased production of biofuel (IEA, 2012).

With the exception of evaporative losses, hydropower is generally non-consumptive but can require the storage of large amounts of water in reservoirs, which may or may not be available for other uses at certain times. The quantity of water required for thermal power is dependent on the type

3 One DALY can be thought of as one lost year of "healthy" life. The sum of these DALYs across the population, or the burden of disease, can be thought of as a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability.

of cooling system. Open-loop cooling requires more water withdrawals but is less consumptive, whereas closed-loop systems require less water to operate but nearly all of this water is consumed.

In terms of water impacts, wind and solar PV are clearly the most sustainable forms of power generation. However, in most cases, the intermittent service provided by wind and solar PV needs to be compensated for by other sources of power that do require large quantities of water to maintain load balances.

Although increasing in proportion to conventional energy, renewables remain underdeveloped and under subsidized in comparison to fossil fuels (WWAP, 2014). Wind and solar PV account for only 3% of the global power mix. Although they are expected to grow rapidly over the next few decades, they are not likely to represent much more than 10% of global electricity generation by 2035 (IEA, 2012). Geothermal energy for direct thermal uses (district heating and others) and for power generation is underdeveloped and its potential is greatly underappreciated. It is climate independent, produces minimal to near-zero GHG emissions, consumes minimal to near-zero water (depending on the system configuration), and its availability is infinite at human time scales (WWAP, 2014; Williams and Simmons, 2013).

__In terms of water impacts,__ wind and solar PV are the most sustainable forms of power generation

8.2 Challenges: Meeting ever growing demands

Meeting ever-growing demands for energy will generate increasing stress on freshwater resources with repercussions on other users, such as agriculture and industry. Since these sectors also require energy, there is room to create synergies as they develop together.

Agriculture accounts for 70% of water withdrawals worldwide and the food production and supply chain

Geothermal plant in Wairakai (New Zealand)
Photo: Geothermal Resources Council

accounts for about 30% of total global energy consumption (WWAP, 2014). The industrial sector accounts for about 37% of primary global energy use and proportionately uses significantly less water (UNIDO, 2008). Increasing both water and energy efficiency in these sectors alone would generate substantial savings and have positive repercussions, especially in areas where resources are most scarce. However, the greatest challenge lies in decreasing the water intensity of fuel and power generation.

Power generation is dominated by thermal electricity, which accounts for over 80% of global electricity production. Maximizing the water use efficiency of power plants will be a key determinant in achieving a sustainable water future. This will require limiting the construction and use of the least efficient coal-fired power plants and widely adopting dry-cooling or highly efficient closed-loop cooling technologies.

***Although increasing** in proportion to conventional energy, renewables remain underdeveloped and undersubsidized in comparison to fossil fuels*

Although using alternative water sources, such as sea or wastewater, can be challenging, they offer a great potential for reducing demands for freshwater (WWAP, 2014).

Climate change increases the risks and adds to the pressures. Over the past decade, the increased intensity of droughts, heatwaves and local water scarcities has interrupted electricity generation, with serious economic consequences. At the same time, limitations on energy availability have constrained the delivery of water services.

There is much room for development of hydropower installations, particularly in sub-Saharan Africa and South-East Asia where access to modern energy services is lowest and undeveloped technical potential is greatest. Beyond electricity generation, hydropower reservoirs may also provide storage for dry spells and support flood management, irrigation, navigation and recreation. Problems can arise when releases of water are required for different purposes at different times throughout the year. Large-scale hydroelectric plants around the world have been criticized for a number of reasons, including damage to the environment and biodiversity, loss of cultural and historical sites, and social disruption (Glassman et al., 2011).

Although increasingly competitive, wind and solar PV remain expensive and therefore require policy support to foster their deployment in most countries. Hydropower and geothermal energy have long been economically competitive. In addition to displacing water intensive thermal power, renewables offer additional benefits, including enhancing energy security and diversity, reducing GHG emissions and local air pollution, contributing to 'green growth', and mini-grid or off-grid solutions which are often less costly than grid extension to rural areas (IEA, 2013). Support for the development of renewable energy, which remains far below that for fossil fuels, will need to increase dramatically before it makes a significant change in the global energy mix, and by association, in water demand. Renewables, such as wind, solar PV and geothermal energy, can make a substantial contribution to energy supply and freshwater demand at local or national scales, even if they do remain marginal at the global scale.

Biofuels offer an alternative energy source to fossil fuels. Their water-related impacts mainly depend on whether they are produced from rainfed or irrigated feedstock crops. The water requirements of biofuels produced from irrigated crops can be much larger than for fossil fuel resources and can therefore have important implications for local water availability, whereas rainfed production does not substantially alter the water cycle. Bioenergy production involving smallholders can help create jobs, improve livelihoods and reduce poverty in rural areas. Optimism over biofuels is tempered by concerns over their economic viability and their implications for socio-economic development, food security and environmental sustainability (WWAP, 2014).The outlook for biofuels remains uncertain as they are highly sensitive to possible changes in oil and gas prices, as well as government subsidies and blending mandates, which remain the main stimulus for biofuels use (IEA, 2013).

Withdrawals and consumption are not the only aspects that deserve attention in the context of water and environmental sustainability. Thermal power plants using open-loop cooling release large volumes of heated water into natural watercourses, affecting fish and other wildlife. Biofuel production, like agriculture, can lead to nutrient loading, affecting the quality of surface water and groundwater. Coal mining requires large amounts of water, and discharges to surface water bodies and aquifers may be contaminated. Oil and gas extraction yields high volumes of water that comes out of a well along with the oil and gas. This 'produced water', which usually has very high salinity and is difficult to treat, is often re-injected subsurface.

Uncertainties persist over potential human health and the long-term environment impacts from the development

Geothermal cooling towers at Larderello, Tuscany (Italy)
Photo: Simon

of unconventional sources of gas ('fracking') and oil (oil/tar sands), both of which require disproportionally large quantities of water and pose significant risks to water quality.

8.3 Responses: A water perspective on energy

In terms of technology, the energy sector is evolving rapidly. Unconventional oil and gas supplies are being unlocked, liquefied natural gas is enhancing supply flexibility, larger shares of variable renewable supply are being integrated into the power sector and overall energy efficiency is increasing (IEA, 2013). The drivers of this evolution are mainly economic (market supply/demand), political (energy security) and social (providing safe energy to the unserved).

The quest to reduce GHG emissions is leading the deployment of renewable energy technologies. Wind, solar PV and geothermal energy have the added benefit of consuming negligible quantities of water. However, as renewables become increasingly competitive on their own merits, carefully designed subsidy schemes will be required to allow for the multiple benefits of low-carbon energy sources without placing excessive burdens on those that cover the additional costs associated with low-carbon energy production (IEA, 2013).

With the possible exception of the most water scarce areas, availability of (and impacts on) water for various energy production processes is far too rarely taken into account in energy policy-making. The two domains have historically been regulated and managed separately (World Bank, 2013). This has led to the adoption of unsustainable practices that jeopardize the availability of water resources and creates risks to other users and the environment (WWAP, 2014, Box 3.3).

Yet there are pragmatic measures that can be taken to co-produce energy and water services and to exploit the benefits of synergies. These include combined power and desalination plants, combined heat and power plants, using alternative water sources for thermal power plant cooling, and even energy recovery from sewerage water (WWAP, 2014).

Unfortunately, not every situation offers such opportunities for synergies. There are situations in which competition for resources can arise between water and energy objectives, meaning some degree of trade-off will be necessary. These trade-offs will need to be managed and contained, preferably through collaboration and in a coordinated manner, which in turn requires adequate and compatible data and information.

Improved cooperation between regional electrical grids and transboundary basin organizations operating in the same region, in conjunction with the respective national governments, could potentially help to better coordinate water management and the energy sector via hydropower development. Such cooperation can also support the sustainable allocation of water to other forms of energy producers and other water use sectors in the region.

Finally, from a global sustainable development perspective, the availability (and limitations) of water for energy production will be a necessary and critical factor in achieving the SDG on energy, and in meeting its related targets. Even if electricity production from renewables like wind and solar PV were to double, there would still be a need to rely on water-intensive sources of energy to achieve universal access to affordable, sustainable and reliable energy services and to support global economic and industrial growth.

9 Industry

UNIDO | UNIDO Water Management Unit and John Payne, John G. Payne and Associates Ltd

Since the Dublin Statement on Water and Sustainable Development in 1992, several notable pronouncements regarding water and sustainability have been issued, including the MDGs and the Rio+20 Outcome Document, *The Future We Want*. But until the 2013 Lima Declaration (UNIDO, 2013), none had specifically addressed inclusive and sustainable industrial development.

The Lima Declaration focuses on poverty eradication through sustainable industrial growth supported by the 'three dimensions of sustainable development': economic growth, social equity and environmental sustainability. The underlying principle is that 'industrialization is a driver of development' by increasing productivity, jobs and income towards the eradication of poverty and providing opportunities such as gender equality and youth employment (UNIDO, 2013, Clause 2). The Declaration builds on the MDGs and Rio+20 and moves towards the post-2015 development agenda. Promoting the sustainable use of natural resources and reducing environmental impact are included in the measures. These two measures have a direct bearing on industrial water use, which is a very obvious way industry can demonstrate its commitment to the environment through 'sustainable production and industrial resource efficiency' (UNIDO, 2013, Clause 21).

9.1 Context

Industry is a widely-based sector. This chapter concerns manufacturing and extractive industry, whereas agriculture and power generation, themselves large industrial water users, are discussed separately in Chapters 7 and 8. Key elements of the water services industry are covered in Chapters 5 and 6 on WASH and urbanization.

The scope of water-related challenges across the industrial spectrum is a function of scale. The *OECD Environmental Outlook to 2050* (OECD, 2012b) predicts that global water demand for manufacturing will increase by 400% from 2000 to 2050 which is much larger than any other sector. Most of this increase will be in emerging economies and developing countries, with implications on water supply, allocation and quality. Large corporations, often multinational or global, have made considerable progress in evaluating and reducing their water use (Box 9.1) and that of their supply chains. Small and medium-sized enterprises (SMEs) are faced with similar water challenges on a smaller scale, but have fewer means and less ability to meet them.

New construction in Astana (Kazakhstan)
Photo: Shynar Jetpissova/World Bank

BOX 9.1

Mining and water sustainability: Minera Esperanza, Chile

Minera Esperanza's operation is located 180 km from Antofagasta in the Atacama Desert, one of the driest places in the world, and requires approximately 20 million m^3 of water a year to operate. Securing a long-term supply of useable water and optimizing its use in the processes were important for mining development. As a result the plant was designed to use untreated seawater. Studies in laboratory conditions and carried out by a pilot project determined optimum operating conditions for the primary flotation process using seawater. A supply pipe network was constructed to transport seawater 145 km from the Pacific coast to the mine site. Minera Esperanza recruited a significant part of its staff from neighbouring communities. A major feature of the community plan was a programme to enhance the job skills (both for construction and mine workers) of the local residents. To provide equal opportunities, Minera Esperanza focused on attracting women to participate in the scheme and in 2010 had 12% women workers, compared with a country average for the mining industry of 6%.

Source: Adapted from ICMM (2012).

Moreover large companies and SME's are faced with different water sustainability issues depending on whether they operate in developed or developing countries.

In developed countries, the emphasis is mainly on efficiency measures to conserve water resources that already exist. For developing countries, however, the priority for industry is to gain and secure access to water supplies that are reliable, which is often a challenge in water stressed areas.

Various possibilities for water efficiency are available for each of these situations depending on the progress of industrial development and the business climate. Sustainable industry may be achieved by retrofitting old facilities and plants, or building new ones specifically designed for efficiency and, in some locations, interlinked in eco-industrial parks (Box 9.2).

The shape and form of industry's plans and actions and the degree to which they are executed are conditioned by prevailing national and local regulatory regimes as well as by certain trade- and investment-protection agreements. Collisions of policy with regard to water in different sectors, for example the water-energy nexus, lead to functional trade-offs in water use.

9.2 Challenges

Balancing the requirements of sustainability against the conventional view of industrial mass production creates a number of conundrums for industry. This stand-off can only be resolved by effecting trade-offs and changing paradigms. Water use is central to these dilemmas.

On the largest scale, the challenge of globalization is how to spread the benefits of worldwide industrialization

BOX 9.2

Water and wastewater in eco-industrial parks

Industrial parks have existed for some time in both developing and developed countries. Most are created by formal planning processes, but some have grown organically. They provide competitive advantages for the businesses within them and also social, economic and environmental benefits beyond the confines. Usually, industrial parks separate a collection of factory premises from domestic habitation and other activities. However, this does not apply universally. For example, the China-Singapore Suzhou Industrial Park in China combines over 60 Fortune 500 companies with a current residential population of 600,000 people.

Eco-industrial parks ensure effective management of water and effluents together with liquid and solid materials recovery. They:

- permit 'tailored' water supply, effluent collection and treatment that maximizes the use and reuse of available water and other materials;
- aid the optimization of processes to reduce carbon footprints and ensure compliance with regulations: and
- enable the whole water cycle to be linked with successive steps in the value chain of the processes and products of the industries in the park.

A good example is the Shanghai Chemical Industrial Park, which groups chemical companies working in chlorine chemistry and has an integrated water and wastewater and solid waste services operator, Sinofrench.

At the conception stage, industrial parks bring the full benefits of specialized design, pooling best available technology, risk reduction and risk sharing in ways that optimise future technical performance and provide security for investors. At the operational stage, they provide the benefits of a committed and specialized operator with high levels of operation and management skills, rigorous quality control procedures backed by on-site laboratories and often with an additional R&D facility.

In some cases, the provision of specialized effluent treatment to preserve a country's specialized industry has been the reason for creating a park. The Tuzla Organized Leather Industrial Zone Project in Istanbul is an example. In other cases, by integrating water and wastewater challenges it has been possible to ensure continuity of historic industry groupings threatened with closure on environmental protection grounds such as Bran Sands on Teesside in the U.K. and Villers-Saint-Paul in France.

Contributed by AquaFed. For more information about the parks, see the online sources for SIPAC (www.sipac.gov.cn/english/), SCIP (www.scip.com.cn/en/), Tuzla (www.ideriosb.org.tr/hizmetler/aritma), Bran Sands (nwl.co.uk/business/water-and-waste-water-management.aspx) and Villers-Saint-Paul (www.suezenvironnement-media.com/wp-content/uploads/2014/02/12.-Villers.pdf) equitably and without unsustainable impacts on water and other natural resources. While UN-Water has proposed a 'dedicated global goal for water' with targets designed to be tailored to the contexts and priorities of each country, the reality of national and local politics in regulating water, as well as geography, will involve compromises (WWAP, 2014).

Industry's priority is to maximize production rather than water efficiency and conservation. Even in the case of improved water efficiency there may be a rebound effect (Ercin and Hoekstra, 2012) where the water savings obtained are reinvested to increase production. Therefore, though the process may be more efficient, total water use may not decrease. In parallel, industry seeks to be either self-supplied or to obtain water from public supplies at the lowest price possible, neither of which encourages water efficiency, though the value of water to industry may be high. Moreover, cost–benefit drives water efficiency as it relates to maximizing company profit rather than optimizing water use. Within industries, water hotspots can be identified that present the highest risks and highest opportunities (Figure 9.1).

The business case for water efficiency frequently requires a financial trade-off. The common problem is the internal rate of return. Investment in efficient water treatment technology or cooling processes may have longer payback periods than the immediate returns of alternative short-term investment in production. Moreover, low (or non-existent) water prices do not encourage investment in water efficiency, which may have other drivers such as water allocation or permitting. On the upside, in the long term, investment in sustainable technology provides extended savings. Conversely, it may be less expensive to pay the fine for pollution than to pay for better water treatment. Managers have to see and make the business case to offset shareholder and stakeholder pressure. However, it is incumbent upon the political and legal authorities to develop appropriate incentives for industries (standards, permissions, prohibitions, fines, charges, etc.) with objectives to align business decisions with the public interest.

Directly related to the debate over water efficiency are predicaments arising from the introduction of new water technology. There are many good ideas and innovative

FIGURE 9.1

Examples of water hotspots in selected industries

	Exploration	Development	Operations	Distribution (Export)
Upstream oil & gas	• Groundwater environmental safety	• Water efficiency and environmental safety in asset design and construction • Groundwater environmental safety	• Reduction or better management of produced water • Groundwater environmental safety	• Safety of the "water we cross" (river crossing, internal water lanes, sealanes and their fragile environments)

	Supply chain	Operations	Products	Distribution
Assembled products	• Raw materials environmental records and availability • Supply chain resilience to future reduced water availability	• Improvement in water efficiency of manufacturing plants	• Sell water management benefits of products – understand where this is a buying factor	• Safety of the "water we cross" (internal water lanes, sea-lanes and their fragile environments)
Pharmaceuticals	• "License to operate" through engagement with communities and government: - in the vicinity of manufacturing operations - where key raw materials originate • Disposal of COD-rich waters and connections with other industries			

Source: Place et al. (2012, Table 4, p. 64). Reproduced with the permission of Arthur D. Little.

approaches. There are even technological solutions developed for niche applications, such as removal of specific contaminants, which may struggle for acceptance outside the mainstream issues of more effective and efficient overall water treatment. But it can be difficult bringing new technology from concept to laboratory to pilot scale and to full commercial implementation. Investors with venture capital are looking for the best bets and industrial managers are looking for reliability and track record; neither of these views is conducive to moving innovation forward quickly.

Thoughtful policy and regulation combining compliance and incentives may provide a balance between supporting the needs of industry versus overall economic results, social benefits and the environment (see WWAP, 2015, Chapter 6, Case study "Water recycling in Singapore"). Additionally, the application of sustainable measures requires assistance, education and finance. In this respect, agencies such as UNIDO, can act as intermediaries and provide a necessary stimulus, particularly in transitional and developing economies.

9.3 Responses

Actions to improve water sustainability in industry commonly originate from one of two directions. First, top-down approaches are those initiated by government at various levels. They include command-and-control (carrot and stick) methods of policy, regulation, enforcement and incentives. Manufacturing as a point source of pollution is a good target. In the past, these methods focused on technology and performance ignoring preventive approaches and resource efficiency (UNEP, 2011). Second, bottom-up approaches come from industry as it reacts to government approaches, a company's own internal policies, customer demand and public pressure. The industry approach is more hands-on and applied, and often dependent on technology and engineering to deliver results and meet needs. Corporate and managerial buy-in is necessary to enable industry to produce the deliverables.

It may be less expensive to pay the fine for pollution than to pay for better treatment

Intersecting these top-down and bottom-up actions are initiatives from intergovernmental agencies which, acting as intermediaries, provide guidance, targets and expert advice (Box 9.3). Other players include nongovernmental organizations and academia that contribute certain specialties at various levels.

9.3.1 Governance directions

Policy for sustainable industry has four main instruments (UNEP, 2011), which are closely paralleled in the Lima Declaration:

Regulatory and control mechanisms usually target water abstractions and effluent discharges, and include legislation, standards and licensing. On the upside, they can promote

BOX 9.3

United Nations post-2015 global goal for water and what it means for industry

The United Nations has proposed a set of potential targets and indicators for a global goal for water sustainability (Chapter 16) which filter down to national levels. As these targets dovetail with the intent of the Lima Declaration, it can be foreseen that they may lead to general guidelines for industry. In particular, two of the targets have direct relevance to industry as they relate to quantity and quality of water addressing complexities in the SDGs of the post-2015 development agenda.

Target B deals with improving the sustainable use and development of water resources. Actions are called for to increase water productivity and reduce waste from inefficient industrial processes. A core indicator is the change in industrial GDP per industrial withdrawals. The aim is the sustainable management of the resource to balance social, economic and environmental needs.

Target D concerns wastewater and pollution. Protection of water quality is seen as a pre-condition to sustainable development. With regard to industry, the main elements within the target are reductions in untreated industrial wastewater and increases in safe reuse of wastewater. The focus is on both point sources and diffuse (non-point) sources of pollution. One indicator references the proportion of industrial wastewater not collected in public systems that is treated to national standards; another the proportion of flows discharged by industrial wastewater treatment plants that is safely reused.

Source: UN-Water (2014).

best available techniques/technology (BAT) and the polluter-pays principle (PPP), which encourages manufacturers to recycle. On the downside, the standards may not keep up with technological progress, yet industry requires predictable regulation to enable long-term planning and investment in order to accommodate change.

Economic or market-based instruments can include monetary penalties for non-compliance and charges for water withdrawals and wastewater discharge. To promote integrated water resources management (IWRM), prices can be influenced through taxes and royalties and quantity may be regulated through tradable permit systems for water which currently exist in only a handful of countries. Credit and trading schemes can be introduced in developing countries through industry initiatives and projects (UNEP, 2011). In such countries, it may be possible to apply water sustainability approaches to specific industry sectors in a similar way to those proposed for climate action. Similarly, such sector approaches would run the risk of targeting high polluters, as opposed to the full value chains of supply and demand involving these and other industries.

Fiscal instruments and incentives are comprised of public expenditure, subsidies and taxation that can affect cost–benefit analyses in industry and change the BAU status. Taxation can drive technology change and conversely tax exemptions can apply to specific products that are more water efficient and tax revenues directed to the same end. There is an increasing trend, particularly in developed countries, to abolish subsidies that distort the price of water below its full cost. It is recognized that inefficiencies in water use are the result of users, including industry, who do not pay the full cost (WBCSD, 2012). Funds of various sorts are available to support sustainable manufacturing and environmental subsidies can encourage innovative water technology. SMEs with limited access to commercial financing could receive preferential loans funded by environmental taxes.

Voluntary action, information and capacity-building based on information instruments, such as product data and labelling reporting, which could have a water efficiency or pollution component. Eco-labelling and consumer awareness can reflect water use and pollution. Support programmes aimed at SMEs could improve resource efficiency and recycling.

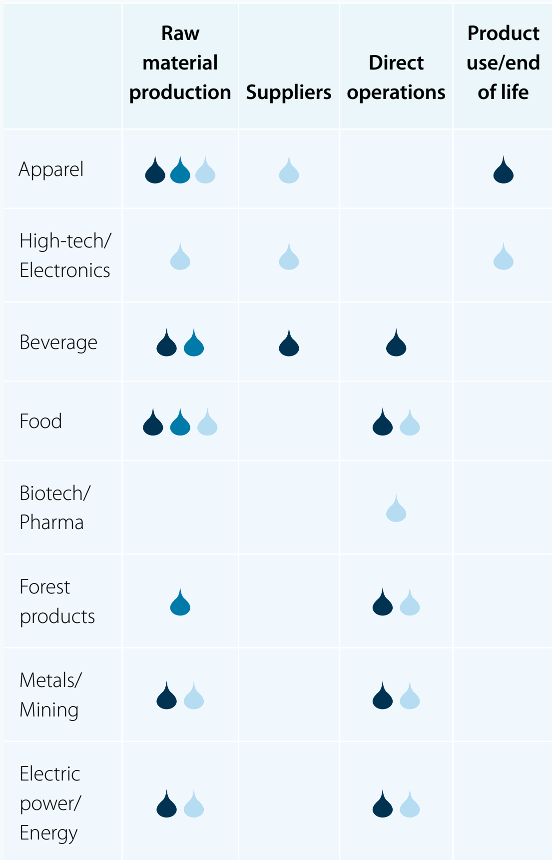
9.3.2 Industry reaction

The efforts of government need a corresponding response reaction from industry to effect improvements in water use and efficiency (UNEP, 2011).

For the application and success of sustainable water initiatives they must be referenced to baseline evaluations. A Water Footprint Assessment (WFA) accounts for the direct and indirect use of freshwater in industry (UNEP, 2012). WFAs apply to the supply chain as well as to the production process (Figure 10.2). Most companies have a supply chain water footprint much larger than their operational one, and it may be more cost-effective to shift investment in sustainability in that direction (Hoekstra et al., 2011). More than 80% to 90% of a company's footprint, and most of its water risks, may be beyond its direct operations (Place et al., 2012). The analysis may also include water use downstream from where the product was produced then purchased or used to the point of its disposal. Water footprinting

FIGURE 9.2

Relative water footprints of various industry sectors



Note: Water drops indicate the value chain segments that have relatively high blue, green and grey water footprint intensities. The water footprint is an indicator of water use that looks at both direct and indirect water use of a consumer or producer. The water footprint of an individual, community or business is defined as the total volume of freshwater that is used to produce the goods and services consumed by the individual or community or produced by the business.

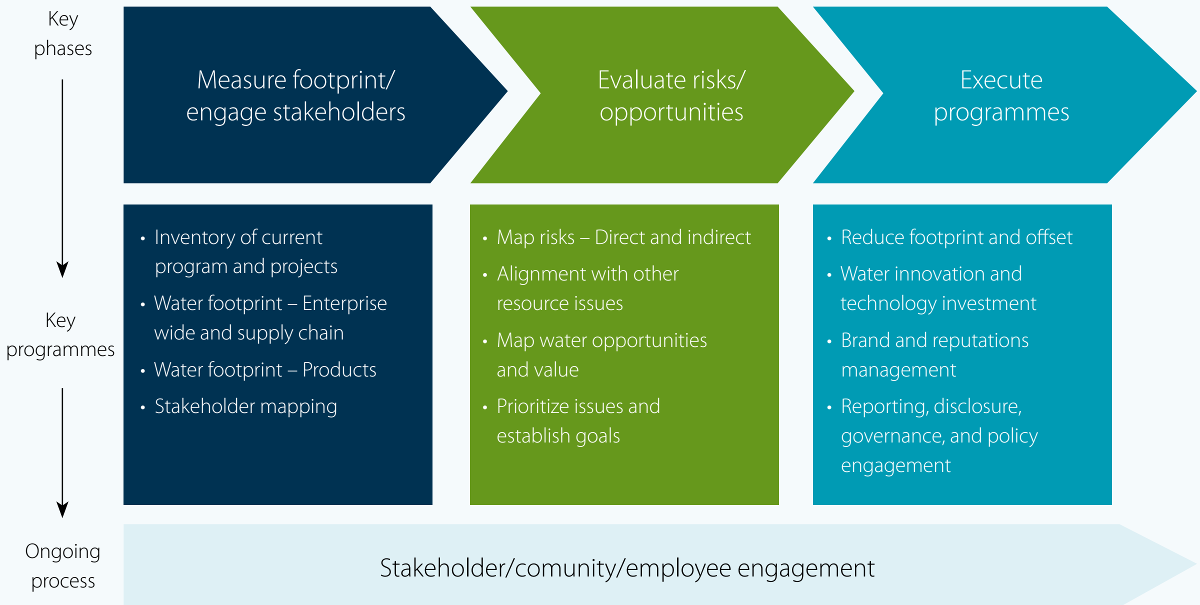
Source: Morrison et al. (2009, Table 3, p. 20).

also changes the concept of water use to incorporate consumptive water use with withdrawals, and the focus from complying with discharge standards to managing the grey water footprint from an ecosystem perspective (UNEP, 2012). Notwithstanding, the WFA methodology has shortcomings and its relevance is being questioned in different situations.

Water stewardship concerns how a company performs and behaves in terms of its operations and supply chains (WWF/DEG KFW Bankengruppe, 2011). Stewardship means being proactive in conservation, restoration and management at the watershed level and balancing internal and external action. Communication with other stakeholders in the same watershed and engagement in forums is essential. A three-phase water stewardship strategy is shown in Figure 9.3. At the plant level, approaches include cleaner production and zero discharge and associated technologies, life-cycle management and eco-design. At the industry level, there are sustainability initiatives for supply chains and industrial

FIGURE 9.3

Water stewardship strategy for industry



An effective water stewardship strategy has three key phases and programmes to support the actions of each phase. It is essential to keep stakeholders, local communities, and employees engaged in the stewardship activities across all phases.

Source: Deloitte (2012, Fig. 1) and Sarni (2011).

TABLE 9.1

UNIDO's Green Industry Initiative

Greening of industries Helping enterprises improve resource productivity and environmental performance	**Creating new green industries** Establishing new operations delivering environmental goods and services
• Efficient use of materials, energy and water • Reduction of wastes and emissions • Safe and responsible management of chemicals, renewable raw materials • Phasing out toxic substances • Substituting fossil fuels with renewable energy sources • Product and process redesign, Green Chemistry	• Reduce, reuse and recycle (3R) industries • Pollution control technology and equipment • Renewable and energy-efficient technologies • Waste management and resource recovery • Environmental advisory and analytical services

Source: UNIDO (2014).

clusters in economic zones to maximize the use of available water resources and reuse of wastewater. These are moves towards closed-cycle manufacturing.

9.3.3 UNIDO as a catalyst: the Green Industry Initiative

In concert with government and industry initiatives, UNIDO has a green industry policy in line with the Lima Declaration (UNIDO, 2011a). In addition, UNIDO is actively promoting a Green Industry initiative (Table 9.1) that is directly applicable to water efficiency (UNIDO, 2011b).

.Business partnerships are key to the development of green industry, and include social investments, philanthropic, multi-stakeholder and transformational partnerships (UNIDO, 2014). The purpose is to capture the core strengths of the private sector and to change business operations in line with sustainability goals. In putting this policy into action, UNIDO has set up National Cleaner Production Centres in a number of countries. It uses its TEST methodology (Transfer of Environmentally Sound Technology) to demonstrate that economic benefits can accrue from sustainable and cleaner production (UNIDO, 2014).

Adapting to climate variability and change

10

UNESCO-IHP and WMO | Contributors: Wouter Buytaert, Anil Mishra, Siegfried Demuth, Blanca Jiménez Cisneros, Bruce Stewart and Claudio Caponi

10.1 Context

The essence of sustainable freshwater resources management is balancing freshwater supplies with demands and uses in a manner that ensures water availability (quantity and quality) for the present and the future. Climate variability and change may affect both sides of the balance, and thus add to the challenges (IPCC, 2014).

Climate change will affect the natural water balance and water availability in several ways: changes in spatiotemporal patterns and variability of precipitation affect the replenishment of water resources. Increases in temperature cause higher evaporation from open surfaces and soils, and increased transpiration by vegetation, potentially reducing water availability. Water quality will be affected (Hipsey and Arheimer, 2013), for instance as a result of seawater intrusion in coastal aquifers, faster dissolved oxygen depletion because of higher water temperatures, or higher content of pollutants that flow into water bodies following extreme rain events (IPCC, 2014). Each of these impacts has implications for ecosystems, including biodiversity and ecosystem services.

Although the fundamental physics behind these processes are rather straightforward, the specific impacts of climate change on local water resources are difficult to determine. One reason is that of scale. Water resources within a river basin are determined by local and regional weather patterns and water uses, which are often poorly resolved by global climate models, if at all considered (Todd et al., 2011).

The other factor concerns weather and climate patterns, and anthropogenic and non-anthropogenic changes therein, affecting hydrological processes in complex ways, which include secondary effects, interactions and feedbacks (Milly et al., 2010). For example, changes in precipitation and temperature may induce shifts in natural vegetation patterns, which will not only affect transpiration, but also interception of precipitation and soil moisture. Many other human activities, such as deforestation and other land-use changes, soil degradation, withdrawals for agricultural and industrial use, and water contamination have a profound and often negative impact on the availability and quality of water resources.

Lastly, the spatial patterns of water demand are highly variable and changing. Population growth and elevated living standards are creating a continuous increase in demand for water in many developing countries. The worldwide trend of urbanization increases the related water demand of cities (see Chapter 6), which may increase pressure on nearby water sources, as well as the need for costly water transport.

Many tools exist to deal with these issues. Statistical and dynamic methods can be used to downscale climate model outputs to the river basin scale. Computer-based simulation models are available also for water quantity and quality modelling. Nonetheless, the complex relations between climate change, ecosystem response, water quality, water consumption patterns and policy actions are not always fully understood, and models that do take account of several of these aspects cannot be easily coupled. The resulting uncertainties are often so high that the outputs from models using downscaling methods for water resources availability have little, if any, value for decision-making necessary for sustainable development, such as where to locate or re-locate new agricultural, residential or industrial development in areas safely out of flood zones yet with adequate water supplies to meet anticipated near- and long-term future needs.

10.2 Challenges

Some climate-induced changes may lead to positive outcomes for local and regional water resources. A temperature increase may make water-rich high-latitude regions and mountain areas potentially more liveable. Increases in precipitation may alleviate water scarcity in some arid and semi-arid regions. Putting proper infrastructure in place, for instance to store or reclaim water, may help translate these changes to actual positive local impacts. However, the negative impacts of climate change on freshwater systems will most likely outweigh its benefits.

Current projections show that freshwater-related risks increase significantly with increasing GHG emissions. The latter are leading to an exacerbated competition for water among all uses and users, affecting regional water, energy and food securities (IPCC, 2014). Combined with an increasing water demand, this will create huge challenges for water resources management.

There is a wide spectrum of threats to sustainable water resources management related to climate change. In coastal regions, including parts of Bangladesh and much of South-East Asia, sea level rise threatens salinization of

***Climate change** will affect the natural water balance and water availability in several ways: changes in spatiotemporal patterns and variability of precipitation affect the replenishment of water resources*

coastal aquifers, with potential effects on drinking water sources and coastal ecosystems (see WWAP, 2015, Chapter 5, Case study "Challenges to freshwater security in the Pacific SIDS: focus on saltwater intrusion in Samoa"). Many of the biggest and fastest growing megacities are located in coastal areas, and are facing a combination of threats emerging from increasing flood risk and degradation of essential ecosystem services (World Bank, 2010c; Hallegatte et al., 2013). On the other side of the topographical spectrum, tropical and subtropical mountain regions are

Emigrant Lake during the 2014 drought in Oregon (United States)
Photo: Al Case

traditionally poverty pockets because of their physically harsh environmental conditions. Melting glaciers, drying wetlands, deforestation and soil erosion may disrupt mountain ecosystem services hence threatening socio-economic development and widening the development gap with the surrounding lowlands (Viviroli et al., 2011). The cryosphere, where water is frozen, provides us with direct, visual evidence of temperature changes and is an important contributor to water supplies in many countries. Within populations, vulnerability is highly variable. But it is clear that climate change will tend to exacerbate existing equality patterns, including gender inequality. Women are often disproportionately affected by climate-change related natural disasters such as floods and droughts.

In addition to the impacts of climate change, there are often universal constraints to the development of adaptation actions due to data scarcity, poor predictive capacity of socio-economic and climate models, inadequate decision support mechanisms and limited institutional capacity.

Regarding data, the lack of availability and access is well known (see Section 1.4.4). The global *in situ* hydrometeorological network has been in decline since the 1980s, and large regions, mainly in the tropics and subtropics, currently have insufficient rain gauge density and in some instances do not provide good quality data (WMO, 2009). Hydrometeorological monitoring also tends to be concentrated in highly populated regions and economic backbones. While this makes sense from an operational perspective, it limits the monitoring and development of untapped resources and contributes to widening the poverty gap. New data sources, especially satellite observations, hold great promise to alleviate the problem of data scarcity for certain hydrological processes such as precipitation and evapotranspiration. The best results are often obtained by merging in-situ data with remotely sensed data sources. However, in some cases, the collection of *in situ* data is costly and requires highly- trained personnel to collect and verify data, especially for groundwater assessment and water quality measurement (Hipsey and Arheimer, 2013).

This scarcity of good quality and relevant data impacts the performance of socio-economic, hydrological and climate models, and thus limits their usefulness and credibility in supporting decision-making and policy formulation. From predicting the impact of localized land-use changes to global climate projections, models provide quantitative estimates of the potential impact of different scenarios, using tools such as sensitivity analyses. As such, they can help weigh the benefits and costs of different policy options and adaptation or adaptation/mitigation scenarios. But models of the water cycle are still plagued by large uncertainties if not properly calibrated with field data, especially in non-stationary conditions such as those produced by climate change (Beven, 2008). There is a need to quantify these uncertainties, and interpret them in a context of managing future risks as well as benefits, to support the policy-making process (Brugnach et al., 2008).

Current institutional aspects of water resources management also often form bottlenecks for effective climate adaptation. For instance, inadequately described or enforced water rights may hinder improved access to water for poor and other vulnerable communities in many developing regions. Also, despite the increasing adoption of integrated water resources management (IWRM) concepts, political levels of decision-making are still often misaligned with the natural boundaries of water resources. This is particularly the case for transboundary river basins and groundwater aquifers.

Lastly, current disaster response and prevention management strategies are often still insufficiently integrated, and focus on individual disasters (e.g. floods or droughts) rather than pursuing a holistic, sustainable development and resilience-based approach.

10.3 Responses and opportunities

10.3.1 Adaptive management

Adaptation decisions need to be taken now. An adaptive approach focusing on robust strategies and low regret or no-regret solutions[4] is a way to deal with the current uncertainties in climate impact projections (Heltberg et al., 2009).

Adaptive water management aims to move away from a 'predict-and-control' paradigm, to one of building resilient communities. Strategies under this outdated paradigm include irreversible decisions, costly long-term infrastructure developments, and fixed management strategies. They do not allow for adjustment and learning. Instead, adaptive management accepts that irreducible uncertainties exist about future climate change, and therefore champions an approach based upon flexibility, robustness and resilience, and continuous learning. It aims at creating capacity to respond effectively to changing and uncertain conditions, using solutions that are robust under the full range of possible future climate scenarios (Pahl-Wostl, 2007).

This approach is particularly useful in areas most vulnerable to climate change, such as low-lying deltas and other coastal areas, fragile mountainous areas and arid and semi-arid regions. For instance, the Himalayas and the Andes have a history of intensive land use, with cultivation and grazing on steep slopes, large-scale deforestation and soil degradation. These processes affect water resources negatively in terms of both quantity and quality. Soil compaction favours surface runoff, decreasing the recharge of groundwater aquifers and accelerating the hydrological response and increasing the risk for both floods and droughts. When these impacts are combined with increasing populations in mountainous areas, the limits of sustainability may be exceeded in the near future. The interactions between climate change and these issues (e.g. soil compaction through intensive land use) may affect the speed and magnitude, but not the fundamental trend of the impacts. Hence, low-regret strategies (Jiménez Cisneros et al., 2014), such as protecting ecosystems that provide clear benefits to water supply, enhancing supplies via retention and recharge dams in small water catchments, and reducing distribution losses and water requirements, are obvious pathways towards increased sustainability and resilient communities.

10.3.2 Knowledge generation for policy formulation

Amid the variety of water resources adaptation issues, enhanced monitoring and evaluation of weather and climate are clearly priorities. There is often a clear inverse relation between data availability and water resources vulnerability, highlighting the need for identifying focus areas that combine a high fragility with a high complexity of the natural environment and low data availability. Examples of such regions are mountains and arid and semi-arid regions in low-income countries, as well as river and groundwater systems that provide ecosystem services to fast-growing megacities. Investments should focus on strengthening traditional monitoring networks (i.e. *in situ*, based on robust, low cost, easy to maintain technology) because of their proven track record of generating data and information to support scientific knowledge generation.

At the same time, exploration and support for new forms of data collection would help build the knowledge base and broaden the understanding of trends. Remote sensing technologies have a high initial cost but can provide observational data in traditionally data-scarce areas. The advent of cheap electronics, networking technology and personal devices including widespread access to mobile phone services, and cloud-computing based data analytics, also enable the installation of distributed sensor networks, often in a way that involves local actors in the data collection and knowledge generation process. Such

4 No-regret interventions are defined as strategies that yield benefits regardless of future trends in climate scenarios.

citizen science (Gura, 2013) has the added benefit of bringing generators and users of knowledge closer together. Nonetheless, the validation and tailoring of the data for water management decision-making systems is still an outstanding challenge to be met.

There is also a challenge to collect data and improve understanding of interactions and feedbacks between the water cycle and other natural and human processes, such as the carbon cycle, population growth, food production, energy consumption and ecosystem services. Data analysis and simulation methods still have a long way to go to enable the formulation and evaluation of adaptation practices. Translating policy options into model parameterizations is in itself a very uncertain and difficult process, which may be complicated further by model uncertainties and deficiencies.

Capacity-building of technicians, water managers and policy makers is another priority to optimize the creation of actionable knowledge. The exploitation of new data sources, better models and more powerful data analysis methods, as well as the design of adaptive management strategies, will require new skills and continuous education. Again, focused attention on data-sparse and vulnerable and deprived areas would greatly help to bridge the traditional knowledge divide.

Communication of available environmental and socio-economic observations, insights and predictions, with their uncertainties, is critical to the implementation of successful policies. Integrating environmental and socio-economic knowledge and its limits into policy formulation is a challenge, in which improved communication and interaction between actors is crucial. New technologies for visualization and communication of data and simulations (infographics) are emerging (Spiegelhalter et al., 2011), which allow for two-way interaction and interactive scenario analysis. Climate information and services, including data, diagnostics, assessments, monitoring, predictions and projections that users need for a broad range of climate-sensitive decisions at different levels are required at national and local scales. There is a need for the implementation of a process of knowledge co-generation, in which science listens and reacts to the needs of decision-makers, who in turn try to understand the limits of science and accept to integrate its outcomes in the decision-making process (e.g. Buytaert et al., 2012). This will provide a much better support for adaptive governance of water resources, in addition to information from continuous monitoring and the build-in ability to flexibly change the course of adaptation.

Lastly, institutional development holds promise for improving climate change adaptation. In particular, the strong interaction of climate change with other natural and socio-economic change highlights the need for a more integrated approach, for instance by merging sustainable development with disaster response and humanitarian aid. Creating forums of water users, public authorities and other relevant stakeholders at the basin scale could achieve a more inclusive approach to consultation, coordination and efficient decision-making. Together with transparent criteria and priorities for water allocation and planning, especially under conditions of scarcity, these are potential short-term solutions to increase environmental sustainability and societal resilience, complementing enhanced monitoring and scientific knowledge generation as longer-term objectives.

PART 3
REGIONS

CHAPTERS

Walking through the Potato Park in Pisaq, Cusco (Peru)
Photo: Manon Koningstein (CIAT)

The challenges, interlinkages and opportunities described throughout the previous chapters of this report are presented from a global perspective. However, the challenges at the interface of water and sustainable development can vary considerably from one region to another. Part 3 of the report examines the challenges and opportunities most relevant to specific regions of the world.

The five regional chapters cover Europe and North America, Asia and the Pacific, the Arab region, Latin America and the Caribbean, and Africa. The delineation of the five regions follows the regional division of the United Nations regional economic commissions (UNECE, UNESCAP, UNESCWA, UNECLAC and UNECA) maps of the Member States can be found in the fourth edition of the WWDR (WWAP, 2012). For the Arab region and Africa chapters, it was decided that all the Arab countries would be reported on in the Arab region chapter rather than having some of them included in the Africa chapter.

Europe and North America

11

UNECE | Annukka Lipponen and Nicholas Bonvoisin

Many countries in the UNECE region have high levels of economic development and per capita resource use, which exert increasing pressure on natural resources. At the same time, poverty is widespread in the eastern part of the pan-European region (South-Eastern Europe, Eastern Europe, the Caucasus and Central Asia), where economic development is a priority. In both cases, the main challenges are increasing resource use efficiency, reducing waste, influencing consumption patterns and choosing appropriate technologies. There is friction between water use sectors in many basins in the region (UNECE, 2011). The challenge is to look beyond water to other sectors and address the need for more integration and coherence of sectoral policies. Reconciling different water uses at the basin level and improving policy coherence nationally and across borders will be priorities for many years to come.

Management of the nitrogen cycle has been identified as a major challenge across most of the region, and improving the handling of nutrients in agriculture plays a key role in addressing the related problems. Diffuse agricultural pollution poses significant pressure on 38% of the European Union's (EU) water bodies. The EU water blueprint also identifies the need to tackle diffuse pollution using different approaches to accommodate the wide range of agricultural systems. The 'greening' of agriculture, which also includes improving water use efficiency in agriculture (especially in South-Eastern Europe, Eastern Europe, the Caucasus and Central Asia) while taking account of the potential impacts of climate change is therefore the second key priority for the region's sustainability.

11.1 Coordination between users

Well-functioning coordination at different levels – from national to river basin and sub-basin – and joint planning involving different interests are important for sustainable management of water resources. In Eastern Europe, the Caucasus and Central Asia (EECCA), intersectoral coordination mechanisms for water resource use have been established in Armenia, Kyrgyzstan, Tajikistan and Ukraine, and are being established in Azerbaijan and Kazakhstan (UNECE/OECD, 2014). In this sub-region, regular national

Windmill farm in Mid-Michigan (United States)
Photo: Mike Boening Photography

meetings under the European Union Water Initiative National Policy Dialogues provide for intersectoral exchange on major water policy developments (UNECE, 2013). A number of policy packages have been adopted as a result of such intersectoral consultation. In Turkmenistan, for example, an inter-ministerial expert group drafted a new National Water Code in line with the UNECE Water Convention[5] and principles of IWRM (EU, OECD and UNECE, 2014).

***Well-functioning coordination** at different levels – from national to river basin and sub-basin – and joint planning involving different interests are important for sustainable management of water resources*

Incompatible sectoral objectives, unintended consequences of resource management and trade-offs between sectors may result in friction and possibly conflict. This is especially the case in transboundary settings, where intersectoral coordination and steps to address negative intersectoral impacts or capitalize on potential synergies between sectors are even more challenging. An assessment of the water-food-energy-ecosystems nexus is being carried out in selected transboundary river basins under the UNECE Water Convention, in close cooperation with national administrations, to strengthen the basis for decision-making through knowledge, dialogue and joint identification of solutions. Solutions might include adjustments to policies, management and coordination measures, and operation of infrastructure. In the Alazani/Ganikh River basin, shared by Azerbaijan and Georgia, deforestation caused by extraction of biomass for fuel results in the degradation of ecosystems and their services, as well as aggravation of sedimentation. Energy policy and notably gasification and electrification of rural areas were identified in a nexus assessment as potential tools in mitigating the situation (UNECE, 2014).

An institutional and legal framework is needed to provide a basis for addressing intersectoral issues (Beisheim, 2013). Transboundary cooperation in the Sava River basin, underpinned by the basin's framework agreement[6] and the International Sava River Basin Commission, covers navigation, sustainable water management, river tourism and hazards. This permanent mechanism provides a platform for transboundary coordination of developing joint/integrated plans for the basin. The International Commission for the Protection of the Danube River, in cooperation with the Sava River Basin Commission and the Danube Navigation Commission, coordinated a process of intensive, cross-sectoral consensus-building between stakeholders, which led to the adoption of the *Joint Statement on Guiding Principles for the Development of Inland Navigation and Environmental Protection in the Danube River Basin* (ICPDR/SRBC, 2007).

Formalized cooperation involving different users of water resources can help to better inform decisions and reduce friction between different sectoral objectives. However, reaching effective and balanced intersectoral governance is complex, and solutions have a high degree of context specificity. The case of the Rhone River demonstrates that even in the context of increased cooperation between actors, the consideration of governance at the river basin scale and the inclusion of a growing number of water users, the governance challenge is such that agreements adopted in a sectoral perspective do not guarantee more integrated and coherent management of a river (Bréthaut and Pflieger, 2013).

11.2 'Greening' agricultural practices

Many governments in the UNECE region have started to reorient their policies to take into account the environmental consequences of food and agriculture production and consumption. In the pursuit of green growth strategies, the OECD (2011) has compiled examples of green growth policies for agriculture, including:

- Environmental regulations and standards, e.g. for controlling agro-chemical use;
- Support measures targeting environmental outcomes or environment-friendly production practices and public investments in green technologies; and
- Application of economic instruments such as charges on use of environmentally-damaging inputs.

Pressures are also mounting to modernize agriculture in Central Asia, where some gradual crop diversification is observed and efforts are being made to reduce water losses in the extensive and ageing infrastructure. In Kazakhstan,

5 Convention on the Protection and Use of Transboundary Watercourses and International Lakes (1992). The amendments to Articles 25 and 26 entered into force on 6 February 2013, turning the Convention into a legal framework for transboundary water cooperation open for accession by countries outside the UNECE region.

6 Framework Agreement on the Sava River Basin (2002), Protocol on Navigation Regime (2002) Protocol on the Prevention of Water Pollution caused by Navigation (2009), Protocol on Flood Protection (2010).

the *Presidential Decree on Transition to Green Economy* (Government of Kazakhstan, 2014a) sets ambitious targets for improving water efficiency in different uses, including agriculture, and these are echoed in the new *State Programme on the Management of Water Resources* (Government of Kazakhstan, 2014b).

The reform of the EU Common Agricultural Policy (CAP) for the post-2013 period may significantly alter water use in agriculture in the EU. Albeit heavily debated, the introduction of a 'greening payment' – where 30% of the available national agricultural subsidy is linked to the provision of certain sustainable farming practices, such as permanent grassland and crop diversification – would mean that a significant share of the subsidy would be linked to rewarding farmers for the provision of environmental public goods. Other EU instruments such as cross-compliance (which links certain CAP payments with specific environmental requirements) and rural development funding have had a positive impact in supporting policy objectives to improve water quantity and quality. However, these instruments were considered by EU auditors to be limited with regard to CAP's policy objectives (ECA, 2014).

The EU Roadmap to a Resource Efficient Europe requires that by 2020 water abstraction should stay below 20% of available renewable water resources. In the face of predicted scarcity increases, the EU water blueprint (EC, 2011) refers to a number of measures and tools to increase water efficiency, including volumetric water pricing, innovation, water efficiency targets and leakage reduction. The EU Water Framework Directive (EU, 2000) provides criteria for establishing water pricing schemes, and introduces the concepts of cost recovery, the 'polluter pays' principle and incentive pricing. Charging for agricultural water use can have a significant impact on reducing water use, but implementation faces constraints including a lack of appropriate tariff structures, societal resistance and concerns about impacts on food prices (ARCADIS et al., 2012).

The Mediterranean region is among the most water-scarce areas in pan-Europe. In Cyprus, the government has encouraged farmers to switch to high-efficiency irrigation systems by providing subsidies and long-term, low-interest loans. This policy has resulted in a major change in irrigation behaviour and irrigation efficiency (EEA, 2009). However, improved irrigation efficiency may lead to the expansion of irrigated area instead of increased flows in rivers.[7]

Wastewater reuse is recognized to have considerable potential in many EU Member States, but is constrained by a lack of standards and concerns about its safety and its possible effect on the sale of crops.

In the United States, despite gradual improvement of water use efficiency in irrigation in the past few decades with the adoption of gravity and pressure/sprinkler-based systems, at least half of irrigated cropland is still irrigated traditionally. Also, more than 90% of irrigators do not evaluate crop irrigation requirements using more efficient on-farm water management practices such as moisture-sensing devices and commercial irrigation-scheduling services (Schaible and Marcel, 2012). After a long debate to address different concerns around agricultural interests, government spending and support for provision of water for the poor, the country passed a Farm Bill in February 2014 (known officially as the Agricultural Act of 2014). The bill expanded crop insurance for farmers, eliminated a crop subsidy that had been paid whether or not crops were grown, cut the food stamp budget (Supplemental Nutritional Assistance Program) by US$8.5 billion over a ten year period, and introduced new soil conservation measures.[8]

7 Under EU rural development regulation, an investment resulting in an increase of the irrigated area is only eligible in situations where the river basin management plan did not identify undue water quantity pressures. The Presidency revised consolidated text of the proposed EAFRD Regulation COM (2011) 627/3 (EC, 2012).

8 The Agricultural Act of 2014 of the United States Congress. See, for example, http://www.nytimes.com/2014/02/05/us/politics/senate-passes-long-stalled-farm-bill.html?_r=0 and http://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2014/02/04/congress-oks-food-stamp-cuts-in-farm-bill

12 Asia and the Pacific

UNESCAP | Kelly Anne Hayden, Donovan Storey, Jeremy Tormos-Espinoza and Salmah Zakaria

The heavily populated Asia-Pacific region faces challenges associated with water-related disaster risk reduction in the context of climate change, accelerated urbanization, and the quality and quantity of available water supplies. These three issues are examined detail in the sections below. The region's challenges concerning water and sustainable development, however, are by no means limited to those covered in this report. For example, intensified industrial development and growing energy demand will add to already existing pressure on water resources in the region. Individually and together, these challenges create significant obstacles to sustainable development

Although some progress has been made in terms of access to improved drinking water (people using improved water supplies increased by 19% Southern Asia and 23% in Eastern Asia between 1990 and 2012), nearly 1.7 billion people in the region (with more than half of these living in rural areas) still did not have access to improved sanitation in 2012 (WHO and UNICEF, 2014a).

12.1 Water-related disasters

Asia and the Pacific is one of the most disaster-prone regions in the world. In 2013, over 17,000 people died from water-related disasters in the region, accounting for 90% of all water-related disaster deaths globally. Economic losses totalled more than US$51.5 billion (CRED, 2014). Exposure of people and assets to hydrometeorological hazards has been growing over the past few decades. With urbanization, people and increasingly valuable economic assets are located in hazard-prone areas such as floodplains (UNESCAP/UNISDR, 2012).

Climate change (see Chapter 10) is likely to increase the incidence and severity of extreme events, with some projections including an increase in the frequency of years

The Mekong Delta is set to face more extreme weather conditions
Photo: G. Smith/CIAT

with above normal monsoon rainfall or extremely low rainfall (IPCC, 2014). Melting glaciers will affect water supplies, creating risks of glacial lake outburst floods and downstream flooding for some regions, and in the long term leading to an overall reduction in water supplies from snow cover and glacial runoff (World Bank, 2013). Over the long term, drought will become an even more serious concern, particularly given the already strained water access issues (IPCC, 2013).

Governments have been working towards making their countries and societies more resilient, but much more work is needed. In many countries, national policies are not well implemented, measures to protect the most vulnerable are often lacking, and institutional capacity to handle disasters are at times weak (UNESCAP/UNISDR, 2012). Some governments have been working towards better integrating disaster risk reduction into development strategies through their development plans. The governments of Bangladesh, China and Indonesia have been consistently investing in disaster risk reduction as they recognize that disasters can undo hard-earned development gains and cause long-term economic and social damage (UNESCAP, 2013).

12.2 Urban water

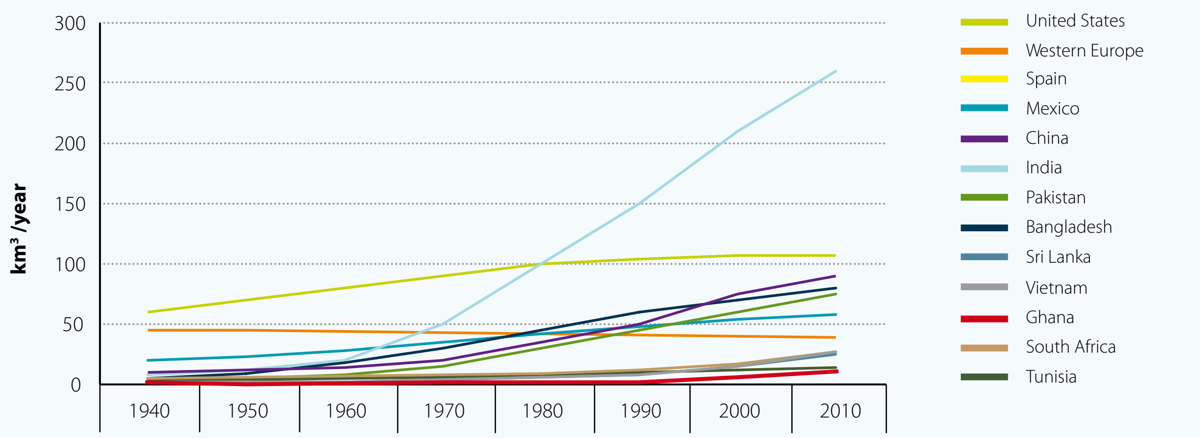
Asia and the Pacific is one of the most rapidly urbanizing regions in the world, with 2.4% annual growth of the urban population (see Chapter 6). In 2012, 47.5% of the total population (over 2 billion) lived in urban areas (UNDESA, 2014), with 30% of the region's urban population living in slums (UN-Habitat, 2013). By 2015, it is estimated that 2.7 billion people will be living in urban areas (UNDESA, 2014), placing considerable stress on the resource base of the region's cities, including water, and undermining the sustainable development efforts of these cities and their respective national governments.

The Asia-Pacific region faces a myriad of urban water challenges. These include drinking water supply (compounded by a high proportion of water loss in distribution), water quality control, limited coverage of sewerage networks and (often non-existing) wastewater treatment systems, pollution control, and ecosystem degradation, especially in peri-urban areas and in surrounding river basins. Sustainability of cities in the region is intimately linked to the key water-related challenges: lack of access to safe water and sanitation; increasing water demand for multiple uses and the concurrent pollution loads; and increasing resilience to disaster events such as floods and droughts.

India, China, Nepal, Bangladesh and Pakistan alone account for nearly half the world's total groundwater use

Urban water needs and challenges require multi-sectoral, inclusive and comprehensive strategies. Several strategies are notable in the region, including efforts towards urban nexus (water-energy-food) planning; integrated stormwater management and green buildings (stormwater management and road tunnels in Malaysia); water sensitive urban design

FIGURE 12.1 **Growth in agricultural groundwater use in selected countries, 1940–2010**



Source: Shah (2005). Reproduced from Figure 1 "Growth in groundwater use in selected countries: 1940-2010". Groundwater and Human Development: Challenges and Opportunities in Livelihoods and Environment. Water, Science & Technology 51 (8): 27-37 with permission from the copyright holders, IWA Publishing.

(Australia); eco-efficient water infrastructure development (Indonesia and the Philippines); and urban wetlands (Kolkata, India). Efforts to rehabilitate urban water resources include the increasing use of wastewater for peri-urban agriculture and for energy production. An increasing number of initiatives are now looking at opportunities to integrate water management with urban needs in energy, green spaces and food security.

Provision of safe water has been primarily under the aegis of governmental bodies, but public–private partnerships are also well established in the region, including with the Manila Water Company in the Philippines, SYABAS in Malaysia and Shenzhen Water Group in China. Financing and managing the future needs of urban water infrastructure will be a considerable challenge, particularly for the region's rapidly growing small- and medium-sized cities where resources and capacity are limited.

There are a number of lessons to be learned from recent typhoons and the success stories of cyclone shelters and early warning systems in Bangladesh, India and the Philippines, and from the development of strategic frameworks and revitalized institutional arrangements in river management (Citarum River rehabilitation project in Indonesia). Many of these strategies require not only urban but also regional and national support and commitment, signifying that urban water management and meeting future water needs is a challenge that involves coordination of stakeholders both within and beyond the urban boundary.

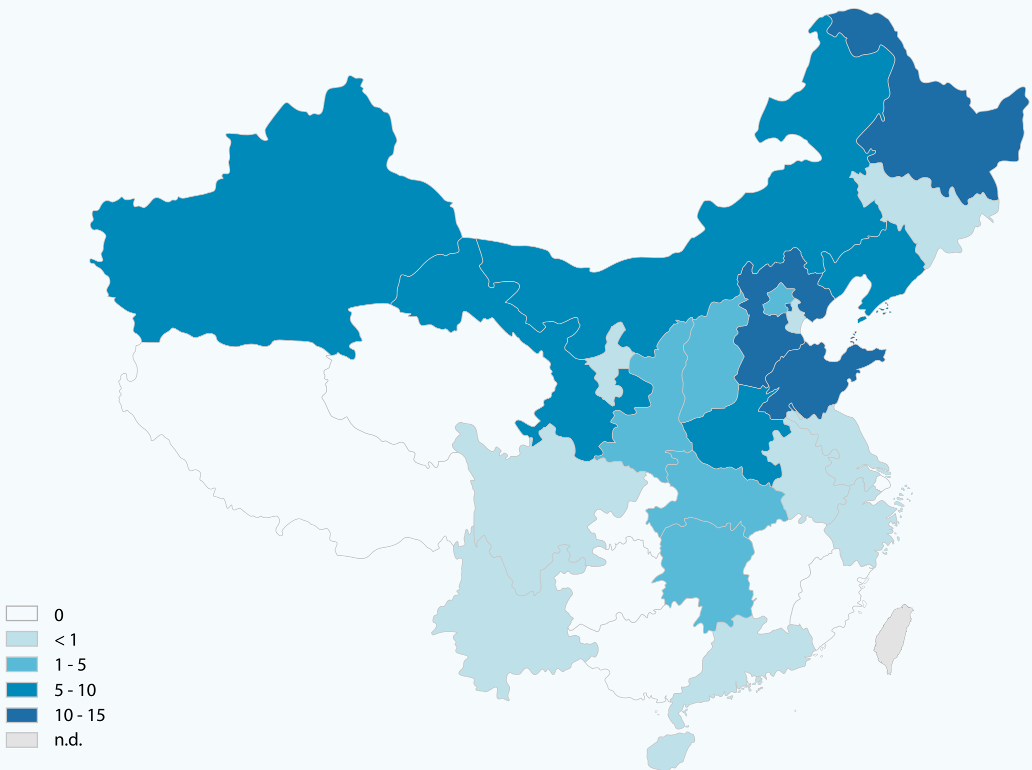
12.3 Groundwater

Any consideration of the quality and quantity of available water supplies in the region must examine groundwater, which is critical to several economic sectors. Experts estimate that groundwater irrigation contributes US$10 to US$12 billion per year to the Asian economy. When also including earnings from groundwater sales for irrigation, that estimate increases to US$25 to US$30 billion (Shah et al., 2003). Bangladesh, China, India, Nepal and Pakistan together account for nearly half the world's total groundwater use (IGRAC, 2010).

Smallholder irrigation projects can provide households easy access to groundwater at relatively low costs and is particularly effective in areas with plentiful groundwater resources. In India, the groundwater or tube well revolution has largely contributed to relieving poverty, but the increase in demand for irrigation has also caused severe groundwater stress in areas such as southern and eastern Maharashtra,

FIGURE 12.2

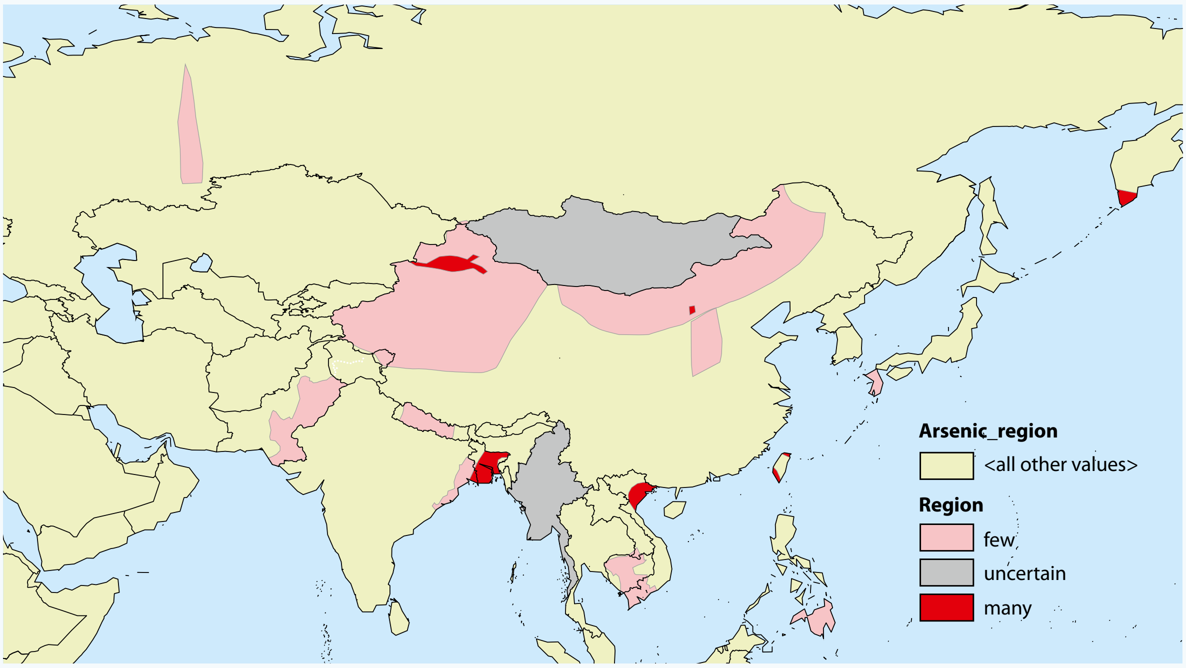
Agricultural groundwater use in China (km³ per year)



Source: Adapted from Wang et al. (2012, Fig. 3-a, p. 6).

FIGURE 12.3

Map of arsenic traces in groundwater in Asia



Source: IGRAC (n.d.), http://www.un-igrac.org/publications/148

and Rajasthan. Figure 12.1 shows the rapid growth in groundwater use in India, where the increase in the total number of mechanized wells and tube wells rose from less than 1 million in 1960 to 19 million in 2000.

China extensively uses groundwater for agriculture (Figure 12.2). Intensive irrigation over the North China Plain aquifer system has significantly lowered the water table by more than 40 metres in parts of the shallow aquifer and much of the deep aquifer since 1960 (Foster and Garduño, 2004). Investigations by the Chinese Ministry of Water Resources in 118 cities revealed that 97% of groundwater sources are polluted, with 64% of cities having seriously polluted drinking water from groundwater sources (World Bank, 2007b).

Coastal cities such as Calcutta, Dhaka, Jakarta and Shanghai are experiencing saltwater intrusion in groundwater supplies due to uncontrolled groundwater abstraction as a result of the inadequacy of public water supply systems. Saltwater intrusion will be exacerbated by the rise in sea-level resulting from climate change (IPCC, 2014). Land subsidence as a result of groundwater abstraction is seen in a number of coastal Asian cities including Bangkok.

Groundwater quality is affected by both anthropogenic and natural contaminants. Natural groundwater contaminants found in the region's aquifers include arsenic (Figure 12.3), fluoride and iron. Anthropogenic contaminants come from fertilizers and pesticides used in agriculture; mining, tanneries and other industries; landfill and garbage dumps; and inadequate sanitation and wastewater disposal. Water shortages during the dry season are leading to over-exploitation of groundwater, a situation seen in China (World Bank, 2007b), Thailand (World Bank, 2011) and elsewhere. The Pacific is also facing freshwater stress (see WWAP, 2015, Chapter 5, Case study "Challenges to freshwater security in the Pacific SIDS: Focus on saltwater intrusion in Samoa"). For example, people in Tuvalu and Samoa increasingly rely on bottled water because of lower than average rainfall in recent years and saltwater intrusion of underground reserves from rising sea levels.

If managed in a sustainable manner, the region's groundwater can serve as a buffer in times of surface water scarcity, hence contributing positively to nearly all sustainable development objectives. However, if groundwater resources continue to be used beyond sustainable limits, agricultural production, which is the main source of income for the majority of the population in the region, will be threatened.

13 The Arab Region

UNESCWA | Carol Chouchani Cherfane

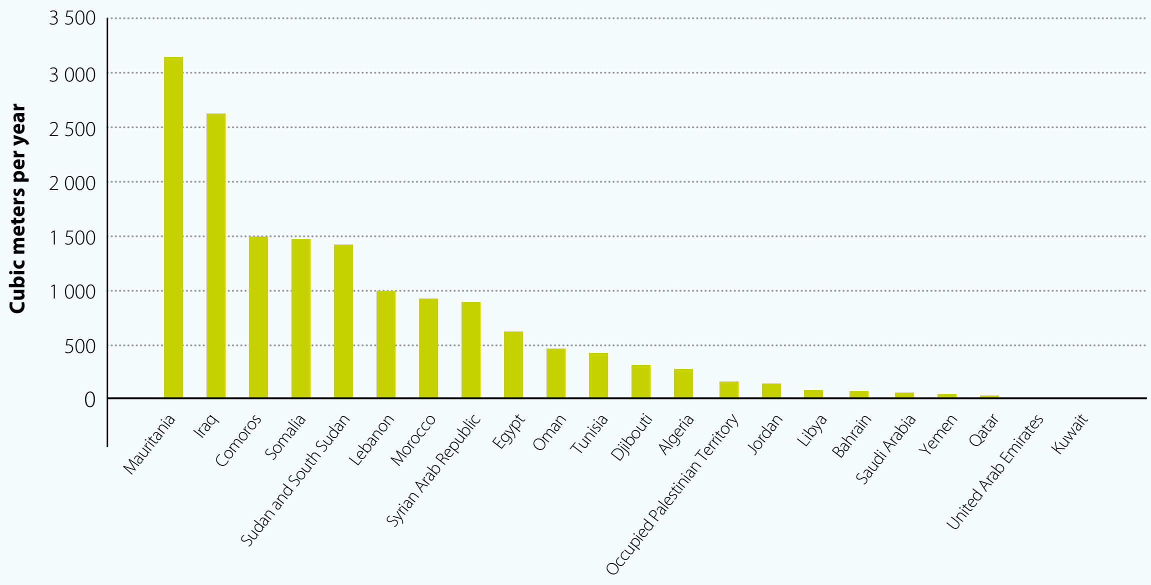
Water scarcity stands at the forefront when considering the water-related challenges that impede progress towards sustainable development in the Arab region. Other important challenges include the need for more sustainable water use, access to more reliable water services (particularly in least developed countries and countries suffering directly and indirectly from conflict), and improved water governance for national and transboundary surface water and groundwater resources.

13.1 Water scarcity

Population growth and increasing socio-economic pressures have reduced the availability of freshwater resources in the Arab region. Availability dropped from 921 m^3 per capita per year in 2002 to 727 m^3 per capita per year a decade later, with 16 of 22 Arab countries falling below the water scarcity level of 1,000 m^3 per capita per year and able to withdraw on average only 292 m^3 per capita per year in 2011 (Figure 13.1). Almost 75% of the Arab population live under the water scarcity level, and nearly half lives under extreme water scarcity level of 500 m^3 per capita per year.

Climate change and climate variability are making the situation even worse. A comparison of climate indices based on historical observations conclusively finds that there has been a consistent warming trend across the Arab region since the mid-twentieth century (Donat et al., 2014). Drought now affects over two-thirds of the land area of UNESCWA member countries (UNESCWA, 2013a), and an ensemble of regional climate change models for the Arab region projects an increase of temperature of at least 2°C by the year 2040 (Nikulin, 2013). Meanwhile, infrequent yet intensive flash floods damaged and destroyed infrastructure in the Comoros, Gaza Strip, Oman, Saudi Arabia and Tunisia during 2012 and 2013. Climate change adaptation measures, drought preparedness strategies, and flash flood risk maps are in turn being prepared and updated in Egypt, Jordan, Lebanon, Morocco, Palestine, Sudan and Tunisia

FIGURE 13.1 **Per capita share of renewable water resources in selected Arab region countries (2011)**



Note: The statistics for the year 2011 cover Sudan and South Sudan, as South Sudan did not become a country since July 2011.
Source: UNESCWA, prepared with data from FAO AQUASTAT.

In the Berkani neighborhood near Meknès (Morocco), 10,504 households are now connected to piped water services
Photo: Arne Hoel/World Bank

(UNDESA/UNESCWA, 2013). Artificial groundwater recharge is being pursued in the Persian Gulf sub-region as a means to harvest water from flash floods to increase water storage capacity and freshwater availability in face of increasing scarcity.

13.2 Threats to sustainability

Unsustainable consumption and over-extraction of freshwater resources also contribute to water shortages and threaten long-term sustainable development. On average, the agricultural sector continues to be the greatest consumer of water in the Arab region, although consumption levels vary significantly between countries. These represent only 16% of freshwater withdrawals in Djibouti, but 99% of total freshwater withdrawals in Somalia over the last decade (FAO AQUASTAT). The urgent social and political need to ensure food security while avoiding negative impact on rural livelihoods has led Arab governments with agriculture-dependent segments of society to pursue irrigation efficiency programmes, wastewater reuse and water harvesting schemes as ways to conserve water resources.

Such measures were chosen over water pricing schemes that may generate socio-economic repercussions for vulnerable communities. Egypt, Jordan, Lebanon, Morocco, Oman and Tunisia have also sought to rehabilitate irrigation canals, terraces and traditional water networks to improve agricultural water use efficiency, although flood irrigation remains dominant in many countries (ICARDA/GEF/IFAD, 2013). Meanwhile, most Arab countries remain dependent upon food imports to offset national food deficits.

Although several countries in the region are rich in oil and gas reserves, desalination cannot be a sustainable option unless alternative energy sources are considered. Apart from a handful of pilot solar energy desalination facilities being piloted in the region (see Box 12.2, WWAP, 2014), investments in nuclear energy are being pursued to diversify the region's water-energy mix. Dozens of nuclear-powered desalination plants are expected to go online in Arab countries over the next 20 years, with Saudi Arabia alone expected to build up to 16 nuclear desalination facilities by 2030 (WNA, 2013).

Water utilities face increasing freshwater shortages due to drought, water distribution losses, damage to water infrastructure and networks due to armed conflicts, and increasing energy costs associated with pumping water from more distant or deeper sources. These factors reduce their ability to provide regular and reliable quality services to domestic consumers in a sustainable manner. Meanwhile, water rationing and groundwater pumping to offset water shortages have become commonplace in Egypt, Jordan, Lebanon, Palestine and Syria. Countries of the Gulf Cooperation Council are in turn looking at ways

***The Arab region** is pursuing efforts to respond to increased water scarcity, drought, climate variability and service deficiencies under changing and uncertain conditions*

to increase water storage in aquifers as a means to increase reserves and offset risks (see WWAP, 2015, Chapter 3, Case study "Sustainable water resources management in the Gulf Cooperation Council countries").

Threats to sustainability are further exacerbated by regional conflicts. By October 2013, access to water supply services in Syria had decreased by 70% on average since the beginning of the conflict and has continued to decline due to a breakdown in services, This has resulted in a massive undertaking among WASH sector partners to distribute chlorine, hygiene kits and generators throughout the country (UNICEF, 2013). The situation has become precarious along the Euphrates River, where water levels have dropped and destroyed pipes have forced residents of Aleppo, Syria, to use jerrycans to collect water from untreated surface water sources. Over 1.53 million Syrian refugees have also been registered in Jordan and Lebanon, where water services are already stressed by scarcity and drought[9]. Water infrastructure destroyed during the Arab-Israeli conflict has forced Palestinians to spend a significant share of their income on water from tankers and to rely on unclean sources of water in the Gaza Strip, which have increased the prevalence of water-related diseases (UN, 2013b).

In addition to the impacts of civil and military conflict, the dependency of Arab countries on transboundary water resources further complicates matters. Over 66% of freshwater resources in Arab countries originate outside national borders (Arab Water Council, 2012), which leaves downstream Arab countries vulnerable to upstream developments, such as the construction of the Renaissance Dam on the Blue Nile in Ethiopia and Turkish dams along the Tigris and Euphrates rivers. Groundwater reserves in large aquifer systems in the Western Asia part of the Arab region extending from Iraq to Yemen far exceed the discharge volume of all rivers combined in that area (UNESCWA/ BGR, 2013). However, the number of surface water or groundwater agreements involving Arab countries is very limited, and the few that exist are bilateral in nature rather than at the basin level.

13.3 Progress and perspectives

In the face of these challenges, Arab countries are focusing on water and sustainable development in legal and policy frameworks. For example, the Arab Ministerial Water Council adopted a regional water security strategy for sustainable development in 2012 and an associated action plan in May 2014. At the national level, the new constitution of Tunisia (adopted in January 2014) established the human right to water and the preservation of water and its rational use as an obligation of the state and society (National Constituent Assembly of Tunisia, 2014). Morocco and Algeria also have legal provisions related to access to water and sanitation (OHCHR, 2010).

According to the WHO and UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation, out of the total Arab population estimated at 355 million people in 2011, approximately 17% (60 million people) do not have access to improved drinking water sources, while 20% (71 million people) do not have access to improved sanitation facilities (UNESCWA, 2013b; WHO and UNICEF, 2013). This means that 83% of the population in the Arab region has access to improved water sources. However, this does not mean that consumers have regular or reliable access to water supplies, or that the quality of water supplied is safe for drinking (see Box 1.1). The Arab regional MDG+ Initiative is improving monitoring and reporting on the quality and quantity of access to water supply and sanitation services under the auspices of the Arab Ministerial Water Council.

Water harvesting and reuse are expanding throughout the region, with best practices being exchanged between

9 Calculated based on UNHCR figures as of 6 March 2014, as presented in Majdalani (2014).

Tunisia and Palestine,[10] irrigation with treated wastewater expanding in Jordan, and treated wastewater being injected on a daily basis into coastal aquifers to ward off saltwater intrusion and bolster water reserves in Oman (Zekri et al., 2014). Egypt has used water from flash floods to recharge groundwater along the Red Sea. Artificial groundwater recharge through the construction of dams and other infrastructure is also common in the Persian Gulf and Mashreq sub-regions. Improved water use efficiency is being promoted through Green Help Desks and Clean Production Centres instituted in most Arab countries. Collaborative mechanisms for transboundary groundwater also continue among Algeria, Libya and Tunisia on the North-Western Sahara Aquifer System[11] and shared rivers such as the Senegal. Nevertheless, there is a need for cooperation and improved water governance and the management of transboundary surface water and groundwater resources. Improved databases, monitoring systems and assessment tools are also under development by international and regional organizations and national ministries to inform planning and decision-making.

The Arab region is thus pursuing efforts to respond to increased water scarcity, drought, climate variability and service deficiencies under changing and uncertain conditions. A more integrated and inclusive approach to water resources management is needed. Ensuring water security under conditions of increased water scarcity will require coordinated responses across sectors, and the recognition of water supply and sanitation as a human right as central to the achievement of sustainable development in the Arab region.

10 Memorandum of Understanding between Tunisia and Palestine, 2012.

11 Technically supported by the Sahara and Sahel Observatory (OSS).

14 Latin America and the Caribbean

UNECLAC | Author: Andrei Jouravlev

With the cooperation of Caridad Canales, and comments and contribution of Terence Lee, Miguel Solanes and Juan Pablo Bohoslavsky

Latin America and the Caribbean is a hydrologically and economically heterogeneous region, which in the last decade has seen significant reductions in poverty, high economic growth and greater macroeconomic stability, as well as the emergence of a middle class (UNECLAC, 2013a and 2013b). However, the region remains the most unequal in the world. It has been unable to converge per capita GDP with developed countries, and over 160 million people (about 28% of its population) still live in poverty.

The focus of national policies is primarily on economic development and poverty reduction. The basis of most economies remains the export of natural resources, which use large quantities of water in production. This situation generates tensions in water management for two main reasons. First, economic activities and population tend to be concentrated in dry and sub-humid areas. This leads to increasing competition in terms of quantity, but also more recently in terms of quality and opportunity of use for scarce water resources. This situation is expected to be aggravated in the future through the joint negative effect of higher water demands due to population growth and economic development coupled with drier conditions and increased hydrological variability in many river basins as a result of climate change (IPCC, 2008). Second, economic growth and rising income levels generate increased demand for public services and environmental amenities. Unfortunately, recent decades have seen a reduction in investments in economic infrastructure. With rising incomes and democratization, people are demanding more emphasis to be given to

Isla del Sol (Sun Island), Lake Titicaca (Bolivia)
Photo: Benjamin Dumas

environmental conservation, citizen participation in decision-making, and protection of the rights of indigenous communities. These tensions highlight two water-related priorities that countries will have to address in the coming decades: (i) strengthening water governance and (ii) improving provision of drinking water supply and sanitation services.

14.1 Water governance

The first priority for Latin America and the Caribbean is to improve and consolidate water governance, with a paradigm shift to the sustainable integration of water resources management and use into socio-economic development and poverty reduction. Given the relative abundance of water in the region, any 'water crisis' is more institutional than related to physical availability (UNECLAC, 2001). Most countries have an extremely limited formal institutional capacity to manage water resources, and effective implementation of existing management instruments is not very high on political agendas. Common problems include inefficient public administration; widespread informality; weak regulatory institutions; low levels of participation, coordination, transparency, credibility and accountability; unstable and insufficient financing; corruption and capture; fragmented and outdated water legislation; lack of technical capacity; implementation agencies and service providers with politicized and weak governance; and insufficient information. The widespread inability to establish effective formal and stable institutions to deal with water allocation (and increasingly reallocation) and pollution control issues is evidenced in many examples of poor management, informality and lack of coordination (WWAP, 2012).

These deficiencies in governance manifest themselves in unsustainable and informal practices of water use, water pollution, particularly in and downstream from densely populated urban areas, and especially in the proliferation of conflicts in relation to most large infrastructure and natural resources development projects (Martín and Justo, 2014). These conflicts arise particularly between large commercial interests such as mining and hydroelectric power on the one hand, and the interests of environmental protection, in-stream water users, and small local, traditional and indigenous users (often without duly formalized water rights) on the other. Many of these conflicts relate to projects with foreign participation, which are usually covered by international investment agreements. Various cases in the region, as well as in other parts of the world (Solanes and Jouravlev, 2007; Bohoslavsky, 2010; UNCTAD, 2014) indicate that, particularly in countries with weak governance, international investor protection can limit public policy space to adequately manage water and other natural resources and regulate public utility services. Ultimately, there is a need for strong governance to ensure an adequate balance between the efforts to attract foreign investment and ensure stable business environment, on the one hand and the objective to achieve socio-economic development, poverty reduction, environmental sustainability and protection of vital public interests, on the other.

Given the relative abundance of water in the region, any 'water crisis' is more institutional than one in terms of physical availability

To overcome this situation, governments will have to put in place and make fully operational: (i) water management institutions that adequately respond to the nature of the problems involved in utilising the resource, and that are in tune with the conceptions and practices of society; (ii) water management instruments (water use rights and discharge permits, assessment, planning, water quality norms, demand management, conflict resolution, regulation, etc.), which increasingly use economic means such as charges, efficient costs, markets and social evaluation; (iii) independent water authorities, with powers and resources commensurate with their responsibilities, supported by river basin organizations; (iv) water allocation (and especially reallocation) systems that promote investment in water development and conservation, ensure efficient and orderly water use, avoid monopolies and facilitate control in the public interest; and (v) water pollution control systems able to mobilize the necessary technological and financial resources (Solanes and Jouravlev, 2006).

14.2 Drinking water supply and sanitation

The second priority for Latin America and the Caribbean is to consolidate the progress achieved in providing drinking water and sanitation services, ensuring the full realization of the human right to water and sanitation (Justo, 2013) and considering the post-2015 development agenda. The levels of provision of water and sanitation, with the possible exception of wastewater treatment, achieved in the region compare favourably to those in other developing nations (Jouravlev, 2004; Sato et al., 2013; WHO and UNICEF, 2014b). However, such overall estimates tend to exaggerate real levels of access to services and do not take into consideration the preferences of the population for piped access and especially the serious deficiencies in service quality (intermittence, water losses, water quality control, etc.) which disproportionally affect rural areas and the poor (Jouravlev, 2011). Many cities still suffer from episodic flooding because of inadequate stormwater drainage infrastructure and deficiencies in urban planning (WWAP, 2012).

Governments will have to concentrate efforts to achieve universal service coverage – with emphasis on household connections, improvement in service quality and sustainability – which could take 10 to 20 years in many countries, while the expansion of wastewater treatment and stormwater drainage systems is likely to require similar time. With the expansion of wastewater treatment (and reuse), attention will have to centre on more advanced treatment technologies (tertiary with nutrient removal) and sludge disposal as well as solid waste management and industrial and non-point source pollution control, particularly in agriculture.

To advance in the realization of these goals, governments will have to focus public policies on (Hantke-Domas and Jouravlev, 2011): (i) assigning high political priority to these services both in terms of budgetary allocations and development of stable and efficient institutions; (ii) a gradual transition to self-financing with tariff design that encourages resource use efficiency, accompanied by the creation of effective subsidy systems for low income groups; (iii) a more consolidated or aggregated industrial structure, to take advantage of economies of scale and ensure technical and financial viability of service providers; (iv) effective economic regulation, with emphasis on access to information, uniform accounting, benchmarking and consumer participation; (v) adjusting regulatory practices and utilities' governance to their property structure, so as to make them more transparent and responsive to regulatory incentives; and (vi) closer integration of economic regulation and water and land management policies so as to ensure environmental sustainability of service provision.

Africa

15

WWAP | Stephen Maxwell Kwame Donkor

15.1 Overview

Building on the economic recovery of the past decade, improvements in governance, and the gradual emergence of capable states beginning in the mid-1990s, Africa's key policy goal is a transition and transformation from political to economic independence. The fundamental aim is to achieve durable and vibrant participation in the global economy while ensuring that the abundant natural resources are managed sustainably and equitably to serve the needs of present and future generations of Africans.

For Africa, perhaps more than any other region of the world, the challenge of sustainable development lies in developing Africa's natural and human resources without repeating the negatives that have appeared on the development paths of others. Rather, the region can learn from the negative experiences to engender sustainability, such as supporting policy choices for 'clean' industrial processes that reduce waste and pollution of water sources.

Many African economies are now growing faster than they have in 40 years. Six of the world's 10 fastest growing countries (on the basis of GDP) in the 2000s were in sub-Saharan Africa: Angola at 11.1% a year; Nigeria 8.9%; Ethiopia 8.4%; Chad 7.9%; Mozambique 7.9%; and Rwanda 7.6%. And several others were above or near the 7% growth needed to double their economies in 10 years. In 2012 Sierra Leone led the way with a 17.2% rise in GDP (ACET, 2014).

These figures must, however, be taken with some caution in terms of sustainable development because it has not been accompanied by an effective transformation of the basic economic structures of many of these states. These are based on exporting raw agricultural and mineral products without much processing and have led to a rise in social and economic inequity.

The backbone of many African economies is agriculture (Box 15.1), which is dependent on highly variable and unpredictable rainfall patterns. Assured and timely water availability is a major constraint in sustainable agricultural production. As other regions around the globe gentrify and reach fertility rates below those needed to replace current populations and thus a productive work force, Africa has a different problem – that of rapid population growth, which can be seen as an opportunity to transform African economies to sustainable and inclusive growth for the next half century. This population must be fed, educated, and kept healthy and productive. It is in this context that water for food, water for health and water for energy is critical to the continent's sustained development. Important progress has been made towards attaining the MDG target for access to improved drinking water (except for the most fragile states), especially for urban populations, but much less progress has been made with respect to sanitation.

__The concept__ of sustainable development is perhaps more important for Africa than other regions of the world

BOX 15.1

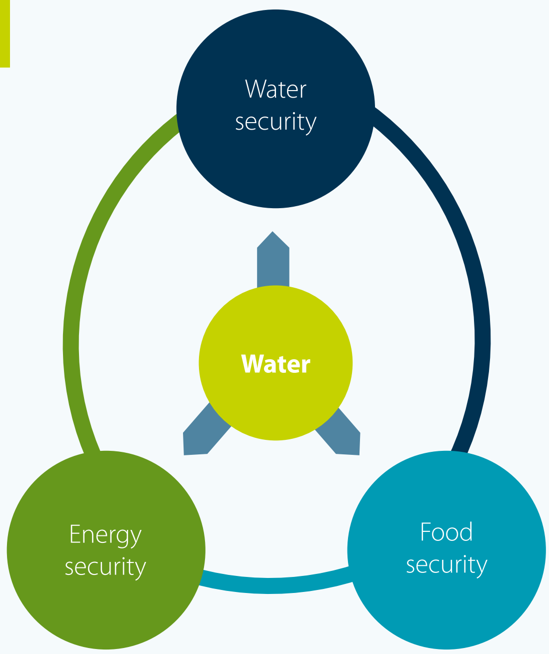
Kofi Annan on Africa's green and blue revolutions

"If we want to accelerate Africa's transformation, then we have to significantly boost our agriculture and fisheries, which together provide livelihoods for roughly two-thirds of all Africans. […] The time has come to unleash Africa's green and blue revolutions. These revolutions will transform the face of our continent for the better. Beyond the valuable jobs and opportunities they will provide, such revolutions will generate a much-needed improvement to Africa's food and nutrition security."

Source: Africa Progress Panel (2014, p. 11).

At the highest policymaking level, the African Union (AU) has recognized the critical role of water in various Summit Declarations (AU, 2004 and 2008; AMCOW, 2008) and has adopted the African Water Vision 2025 as the fundamental policy instrument for the management of Africa's water resources for sustainable development. The shared vision is for: "An Africa where there is an equitable and sustainable use and management of water resources for poverty alleviation, socio-economic development, regional cooperation, and the environment" (UNECA, 2000). As a policy instrument, the African Water Vision 2025 identifies the key challenges for water resources development in Africa.

FIGURE 15.1 **The water-food-energy nexus in Africa**



Water security: The availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environment and economies (Grey and Sadoff, 2007).

Food Security: When all people at all times have access to sufficient , safe, nutritious food to maintain a healthy and active life (WHO, n.d.).

Energy Security: The uninterrupted physical availability (of energy) at a price which is affordable, while respecting environment concerns (IEA, 2011).

Source: Wouters (2011).

15.2 Key water challenges related to sustainable development in Africa

The Sharm el-Sheikh Commitments by the AU identify key water challenges related to sustainable development in Africa (AU, 2014):

1. Water infrastructure for economic growth;
2. Managing and protecting water resources;
3. Achieving water supply and sanitation MDGs;
4. Global changes and risk management in Africa;
5. Water governance and management;
6. Financing water and sanitation sector; and
7. Education, knowledge, capacity development and water information.

Of particular importance for Africa is the critical nexus between water, food and energy (Figure 15.1). Water availability, access and optimal use are essential for transforming the vicious cycle of insecurities to a virtuous upward spiral towards inclusive green (and blue) growth. Currently, only 5% of the Africa's potential water resources are developed and average per capita storage is 200 m^3 compared to 6,000 m^3 in North America. Only 5% of Africa's cultivated land is irrigated and less than 10% of hydropower potential is utilized for electricity generation (Sperling and Bahri, 2014). This occurs in a situation where only 57% of the population has access to modern energy services (mainly electricity), which are becoming less reliable with the accelerating rate of urbanization in most of the region's major cities (IEA, 2013). In 2012, three years before the end of MDGs, on average about 36% of the population did not have access to improved water resources and 70% still did not have access to improved sanitation. (WHO and UNICEF, 2014b).

In addition to these statistics, climate variability and change is likely to restrain progress in managing Africa water resources. Regional cooperation is especially needed due to the multiplicity of transboundary water resources (more than 80 international river basins and aquifers) which must be managed coherently and equitably to meet regional and national goals and evolving sectoral needs.

Agriculture remains the Achilles' heel of Africa's development. Low productivity levels trap millions of farmers in poverty, act as a brake on growth and weaken links between the farm and non-farm economies. Africa's farmers could potentially feed rapidly growing urban populations and generate exports to meet demand in global markets. However, the region is increasingly dependent on imports. African countries spent US$35 billion on food imports (excluding fish) in 2011 and the share accounted for by intra-African trade is less than 5% (Africa Progress Panel, 2014). If Africa's farmers increased productivity and substituted their own produce for these imports, this would provide a powerful impetus to reduce poverty, enhance food and nutrition security, and support a more inclusive pattern of economic growth. This potential is dependent on developing the infrastructure and expertise for harnessing the abundant water resources for irrigation, power generation, domestic use and value adding industries to traditional export commodities. Such water infrastructure development is dependent on a deeper level of regional integration and cooperation due to the transboundary nature of most of Africa's water resources. A paradigm shift from a focus on trade only between African nations to joint planning and resource development (including water) is needed in future discourse on African regional integration.

15.3 The way forward

Despite these challenges, significant progress has been made by many African countries in the utilization of water resources for socio-economic development. Looking forward, the key will be not only achieving economic growth but also sustainable and inclusive growth. The Africa Progress Report addresses the importance of achieving economic growth, as well as sustainable and inclusive growth (Africa Progress Panel, 2014, p. 14):

> *Africa stands at a crossroads. Economic growth has taken root across much of the region. Exports are booming, foreign investment is on the rise and dependence on aid is declining. Governance reforms are transforming the political landscape. Democracy, transparency and accountability have given Africa's citizens a greater voice in decisions that affect their lives. These are encouraging developments. Yet the progress in reducing poverty, improving people's lives and putting in place the foundations for more inclusive and sustainable growth has been less impressive. Governments have failed to convert the wealth created by economic growth into the opportunities that all Africans can exploit to build a better future. The time has come to set a course towards more inclusive growth and fairer societies.*

Fisher on the White Nile (Morada), Khartoum (Sudan)
Photo: Arne Hoel/World Bank

15.2 BOX

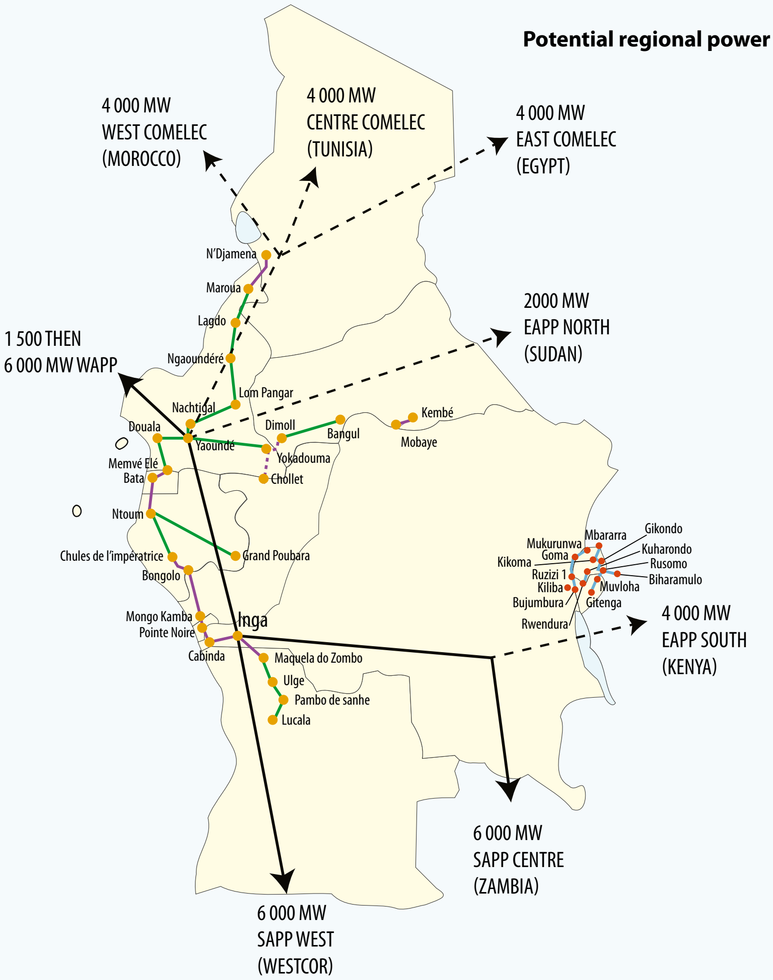
The Grand Inga project

Offering 40,000 MW of potential hydropower, the Grand Inga hydroelectric project on Africa's largest river, the Congo River, may provide a potential answer to meeting Africa's regional energy needs. The table shows current potential hydropower, actual electricity production, consumption per capita and 2005 demand estimates. The map shows one of the options for distribution of the power generated if the Grand Inga project is executed and shows how the enormous power generated by the massive dam can be distributed through the Power Pools to meet demand in all regions of Africa. This makes the Grand Inga hydropower project a truly regional project and could help improve regional integration using a renewable energy source, water, as the prime instrument.

Energy situation in Africa

Sub-region	Hydroelectricity potential (GWh)	%	Electricity production (GWh)	%	Consumption per capita (kWh/hab/ monthly)	Estimate of demand in 2015	%
North Africa	41 000	3.7	133 830	33.2	740	209 296	36.8
West Africa	100 970	9.2	38 033	9.4	143	50 546	8.9
Central Africa	653 361	57.7	10 537	2.6	148	13 052	2.3
Southern Africa	151 535	13.8	208 458	51.7	1617	279 409	49
East Africa	171 500	15.6	12 281	3.1	68	12 281	3
Total	**1 118 366**	**100**	**403 139**	**100**			

Potential regional power distribution from Grand Inga



Target networks 2020-2030
Option 1A – Direct current 500 kV with backbone North-South coast in 400 kV AC

- Multiregional projects 500 kV CC
- Multiregional projects 500 kV CC (2030)
- Regional projects 220/400 kV AC
- Regional projects 400 kV AC (post-2025)
- RDC-Rwanda-Burundi-Tanzania projects 110/220 kV AC
- National projects 220/400 kV AC

Acronyms:
COMELEC – Comité Maghrébin de l'Électricité
EAPP – Eastern Africa Power Pool
kV – Kilovolt
SAPP – Southern African Power Pool
WAPP – Western Africa Power Pool
WESCOR – Western Power Corridor

Source: ECCAS (2010).

BOX 15.3

Large-scale agricultural lease investments

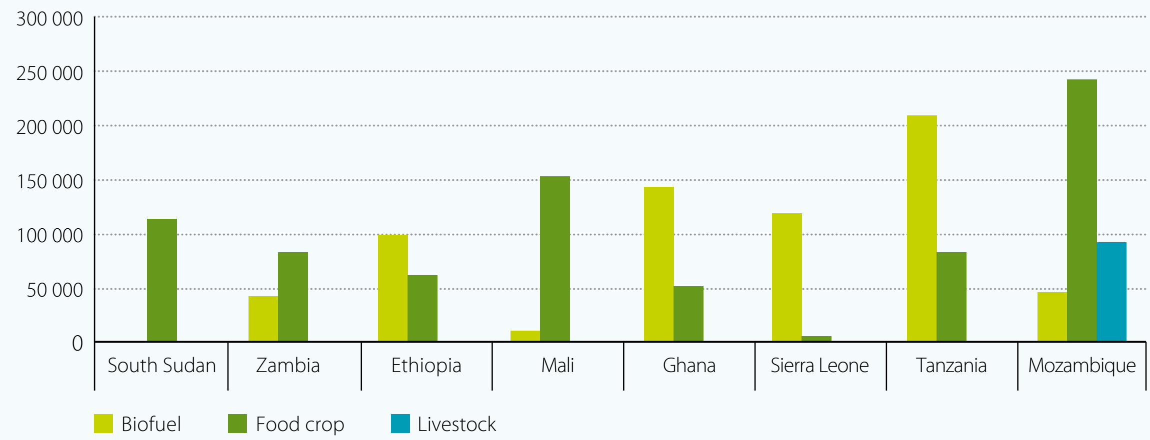
A study commissioned by the African Ministers' Council on Water (AMCOW) and executed by the International Water Management Institute (IWMI) assessed the extent and prevalence of large-scale agricultural lease investments (LSALI) in many countries in Africa (IWMI, 2014). Proponents of LSALI contend that after 50 years of difficulty in transforming low productivity traditional agricultural practices, large-scale private-sector investments – mainly as part of the overall efforts at attracting foreign direct investments (FDI) – may provide an alternative means of acquiring the technologies needed in improving overall productivity in African agriculture.

Sub-Saharan African countries with total large-scale investment in agricultural land greater than 100,000 hectares, 2000-2012.

These large-scale investments are widespread across the continent and many are based on irrigated farming for both local consumption and exports of food crops, livestock and biofuels.

Source: IWMI (2014). IWMI acknowledges support from FAO, GRID-Arendal and UNEP in the conduct of the study that produced this map and graph.

Production activities on large-scale investment schemes in selected Sub-Saharan African countries (2000-2012)



In terms of agriculture, Africa's response, led by the African Development Bank (AfDB), is to promote interventions which focus on water storage and management to overcome the low, unreliable rainfall during the cropping season, *in situ* rainwater management, water harvesting or runoff harvesting, and water management for crop growth in wetlands. Additional interventions will also focus on infrastructure for livestock, fisheries and rural energy (AfDB, 2010).

To achieve this, regional – and especially transboundary – cooperation in the development of Africa's water resources will be critical in the coming decades. Transformation in agricultural production based on more acreage under irrigation, transboundary hydropower generation and distribution through regional power pools and a redoubled effort to meet the goals and targets of the African Water Vision 2025 will be essential.

Emerging approaches for meeting Africa's energy and food security needs for sustainable development include inter-regional generation and use of hydropower such as the Inga Power Project and Large Scale Agricultural Lease Investments. Boxes 15.2 and 15.3 provide an introduction to these emerging approaches for promoting a virtuous upward spiral in the water-food-energy nexus for sustainable development in Africa. They may stimulate some 'leapfrogging' in the use of modern agricultural technologies and increase productivity. These approaches have been proposed as essential to meeting the growing food and energy needs of an urbanizing and industrializing Africa.

PART 4
RESPONSES AND IMPLEMENTATION

CHAPTER

16. Framework for implementing *The Future We Want*

Consolation Prize "Clean India Photo Contest" 2008
Photo: Dinesh Chandra

Recognizing the critical role of water across the different developmental challenges described throughout this report is merely the first step towards achieving sustainable development. True progress requires immediate and decisive action.

This part of the report presents a roadmap of potential responses, solution options and means of implementation that can be adopted to foster progress. Since the challenges vary across the planet in both nature and scope, it is incumbent upon stakeholders and decision-makers in each region, country, basin and community to identify the most appropriate mix of options for their particular situation. Implementing such action is necessary to ensure sustainable water management and a mandatory path on the route towards sustainable development.

Framework for implementing *The Future We Want*

16

UNDP | Joakim Harlin, Marianne Kjellén and Håkan Tropp

WWAP | Richard Connor, Joana Talafré, Karine Peloffy, Erum Hasan and Marie-Claire Dumont

16.1 Water and the three dimensions of sustainable development

The outcome document of the 2012 United Nations Conference on Sustainable Development (Rio+20), *The Future We Want*, recognized that 'water is at the core of sustainable development' and its social, economic and environmental dimensions (Assevero and Chitre, 2012). Water is the lifeblood of the planet and of critical importance for all socio-economic development.

From a social perspective, there are obvious connections between access to safe and adequate quantities of water and health, for drinking first, but also for hygiene and sanitation at the household, community and national levels (see Chapter 5). Access to safe and predictable sources of water is essential to addressing the multiple forms of deprivation related to poverty (see Chapter 2), directly through drinking water and its relation to human health, but also indirectly since water is required in most economic activity (see Chapter 3).

Economically, addressing lack of safe drinking water and sanitation will lead to long-lasting effects on human capital and growth. Recent estimates suggest that, globally, the benefits of achieving universal access to sanitation outweigh the costs by a factor of 5.5 to 1, whereas for universal access to drinking-water the ratio is estimated at 2 to 1 (WHO, 2012b).

Sustainable management of water resources and related infrastructure can greatly increase productivity in the agricultural and food sector (see Chapter 7). Achieving more efficient water use is crucial considering that production and consumption of agricultural products alone account for over 70% of water withdrawals in many developing countries (UNDESA, 2013b). Beyond the primary economic sectors, water is also crucial to all other economic activities, most notably through its role in energy production, mining and tourism. Water scarcity could be an important obstacle for the expansion of the power sector, especially in Asia, southern Africa and the Middle East, where the demand is set to grow rapidly (WWAP, 2014).

Water can also lead to economic losses due to water-related hazards, which have risen greatly in the last decade. Since the Rio Earth Summit in 1992, floods, droughts and storms have affected 4.2 billion people (95% of all people affected by all disasters) and caused US$1.3 trillion of damage (63% of all damage) (UNISDR, 2012).

The environmental dimension of water and sustainable development includes the role of healthy ecosystems, which provide water services that have enormous societal value through flood control, groundwater recharge, river-bank stabilization and erosion protection, water purification, biodiversity conservation, as well as transportation, recreation and tourism (MEA, 2005b) (see Chapter 4). Drivers that affect water quality and quantity, such as pollution, species introductions, changes in land use and climate change, can also affect the ability of ecosystems to appropriately regulate themselves, affecting other ecosystem services in turn. Removing or reducing these pressures is therefore a necessary aspect of maintaining ecosystem integrity.

16.2 The post-2015 development agenda

16.2.1 Stocktaking at the end of the MDGs: Achievements and lessons

In September 2000, 189 world leaders signed the United Nations Millennium Declaration from which emerged a set of eight MDGs. For the first time, there was an

BOX 16.1

Millennium Development Goal 7: Ensure environmental sustainability

- **Target 7.A:** Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources
  - Indicator 7.4 Proportion of total water resources used
- **Target 7.C:** Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation
  - **Indicator 7.7:** Proportion of population using an improved drinking water source
  - **Indicator 7.8:** Proportion of population using an improved sanitation facility

Source: UNGA (2001).

global agreement in which rich and developing countries recognized that they share the responsibility to end poverty and its root causes. Water underpins all the MDGs but is only explicitly included in Goal 7 targets 7A and 7C (Box 16.1).

The MDGs have been successful in rallying public, private and political support for global poverty reduction. A major strength of the MDG framework has been its focus on a limited set of concrete development goals and targets, which has supported priority-setting in national and international development policies. For water, the MDGs fostered greater coordination of international development efforts towards improving access to drinking water supply and sanitation.

However, as the MDGs did not derive from a consultative process with a wide range of national-level stakeholders, they have suffered from a perception of being donor-centric and being somewhat imbalanced regarding which topics were addressed. For example, no specific targets were included for sustainable water resources management (surface and groundwater), for water quality, pollution, wastewater treatment or for maintaining the roles of ecosystems. Water-related gender and hygiene dimensions were also lacking, as were water-related disasters.

The strength of being simple and relatively straightforward to measure also led to difficulties in accounting for the local context. The way that the MDGs achievements are accumulated can mask significant regional and in-country disparities. Inequities between urban-rural, rich- poor, men-women, large and small countries are lost in the aggregated data.

Another set of problems with the MDGs stem from the use of proxy indicators. The target for safe drinking water, for example, was captured by the proxy indicator for using an 'improved drinking water source' (Box 1.1) and important aspects such as the quality, availability and reliability of services were not included.

The limited scope of the MDGs has also not prompted developing countries – particularly those vulnerable to emerging challenges such as climate change, food crises and rapidly increasing urbanization – to fully address governance-related issues such as the development of robust government institutions, social welfare systems and an enabling environment for civil society participation (UN, 2012).

Despite some drawbacks, however, the MDGs created momentum and constituted a vital instrument in focusing global attention to the lack of access to safe drinking water and sanitation. Pioneering efforts also helped to highlight many institutional challenges such as lack of implementation capacity, weak stakeholder participation

Children learning the importance of proper hand washing and drinking safe water, Had Ane Primary School, Oudomxay Province (Laos)
Photo: Bart Verweij/World Bank

and unclear mandates within government structures (UN, 2013c). The achievement of the MDG drinking water target, albeit measured, through the proxy indicator of an 'improved' water source, demonstrates that setting international goals and targets can drive change through sustained commitment, dedication of resources and effective implementation approaches (UN, 2013c). As they come to an end, the experience of the MDGs shows that a thematically broader, more detailed and context- specific framework for water, beyond the issues of water supply and sanitation, is critical for the post-2015 development agenda.

16.2.2 The need for a dedicated post-2015 goal for water

Whereas the MDGs concentrated efforts on developing countries, the post-2015 SDGs will aim for a worldwide scope. This is especially important in the context of water services since the drinking water and wastewater infrastructure of developed nations has deteriorated in the last decades (ASCE, 2011) and vulnerable populations still lack access to WASH in rich countries (Government of Canada, 2014).

Water's fundamental importance for human development, the environment and the economy needs to feature prominently in the new post-2015 development agenda. In 2014, UN-Water recommended a dedicated SDG for water with five target areas: (i) WASH; (ii) water resources; (iii) water governance; (iv) water quality and wastewater management; and (v) water-related disasters. A dedicated water goal would create social, economic, financial and other benefits that greatly outweigh its costs (UN-Water, 2014) and extend well beyond the water domain (as it is normally understood) (Box 16.2). The development of health, education, agriculture and food production, energy, industry and other social and economic activities all depend on the effective management, protection and provision of water and the delivery of safe water supply and sanitation services. Communities also need protection from the dangers that water-related hazards can present.

Technical advice from UN-Water on a possible global SDG for water helped inform discussions of the UN General Assembly Open Working Group (OWG) on Sustainable Development Goals. In September 2014, the General Assembly adopted a resolution on the final report of the OWG on SDGs, containing 17 goals, one of which is a dedicated goal on water. The General Assembly decided that the proposal of the OWG on the SDGs "shall be the main basis for integrating sustainable development goals into the post-2015 development agenda, while recognizing that other inputs will also be considered in the intergovernmental negotiating process at the 69th session of the GA" (UNGA, 2014). All dimensions of water suggested by UN-Water were incorporated in the final report of the OWG (Box 16.3).

Water is much more than a cross-cutting issue. Unless the fundamental role of water is recognized, water resources and the impacts of its various uses are properly assessed, and the major water-related challenges are addressed, many other critical objectives of the new development agenda will be unachievable (UN-Water, 2014). Water and water

BOX 16.2

Outcomes of a dedicated SDG for water as suggested by UN-Water

Outcome		Means
Healthy people	through	Universal access to safe drinking water, sanitation and hygiene, improving water quality and raising service standards
Increased prosperity		The sustainable use and development of water resources, increasing and sharing the available benefits
Equitable societies		Robust and effective water governance with more effective institutions and administrative systems
Protected ecosystems		Improved water quality and wastewater management taking account of environmental limits
Resilient communities		Reduced risk of water-related disasters to protect vulnerable groups and minimize economic losses

Source: UN-Water (2014).

BOX 16.3

Text related to water and sanitation in the final report of the Open Working Group on SDGs

Introduction

Paragraph 7. Rio+20 outcome reaffirmed the need to be guided by the purposes and principles of the Charter of the United Nations, with full respect for international law and its principles. It reaffirmed the importance of freedom, peace and security, respect for all human rights, including the right to development and the right to an adequate standard of living, including the right to food and water, the rule of law, good governance, gender equality, women's empowerment and the overall commitment to just and democratic societies for development.

Proposed goal 1. End poverty in all its forms everywhere

1.5 by 2030 build the resilience of the poor and those in vulnerable situations, and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters

Proposed goal 3. Ensure healthy lives and promote well-being for all at all ages

3.3 by 2030 end the epidemics of AIDS, tuberculosis, malaria, and neglected tropical diseases and combat hepatitis, **water-borne diseases**, and other communicable diseases

3.9 by 2030 substantially reduce the number of deaths and illnesses from hazardous chemicals and air, **water**, and soil pollution and contamination

Proposed goal 6. Ensure availability and sustainable management of water and sanitation for all

6.1 by 2030, achieve universal and equitable access to safe and affordable drinking water for all

6.2 by 2030, achieve access to adequate and equitable sanitation and hygiene for all, and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations

6.3 by 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and increasing recycling and safe reuse by x% globally

6.4 by 2030, substantially increase water use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity, and substantially reduce the number of people suffering from water scarcity

6.5 by 2030 implement integrated water resources management at all levels, including through transboundary cooperation as appropriate

6.6 by 2020 protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

6.a by 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies

6.b support and strengthen the participation of local communities for improving water and sanitation management

Proposed goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable

11.5 by 2030 significantly reduce the number of deaths and the number of affected people and decrease by y% the economic losses relative to GDP caused by disasters, **including water-related disasters**, with the focus on protecting the poor and people in vulnerable situations

Proposed goal 12. Ensure sustainable consumption and production patterns

12.4 by 2020 achieve environmentally sound management of chemicals and all wastes throughout their life cycle in accordance with agreed international frameworks and significantly reduce their release to air, **water** and soil to minimize their adverse impacts on human health and the environment

Proposed goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and biodiversity loss

15.1 by 2020 ensure conservation, restoration and sustainable use of terrestrial and inland **freshwater ecosystems and their services**, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements

15.8 by 2020 introduce measures to prevent the introduction and significantly reduce the impact of **invasive alien species on land and water ecosystems**, and control or eradicate the priority species

Source: UNGA (2014).

infrastructure will be a vital part of the foundations for sustainable development, poverty alleviation and human well-being irrespective of the post-2015 development agenda outcome. Hence, water problems and water's inter-linkages to sustainable development will need to be addressed for generations to come – even in the absence of a dedicated water SDG in the post-2015 development agenda.

16.3 Achieving *The Future We Want*

Sustainable development is recognized as the way to collectively progress as a global society. But there are many questions: How does one achieve success on such an ambitious but somewhat ambiguous quest? How can a balance be reached between different societal interests? What and whose priorities should take precedence? What trade-offs need to be made? Ban Ki-moon, United Nations Secretary-General, speaks of the dilemma of sustainable development and water, stating: "There is still enough water for all of us – but only so long as we keep it clean, use it more wisely and share it fairly" (Planet Under Pressure, 2012).

Water management and decisions affecting water will play a key role in tackling the development challenges of the twenty-first century, including urbanization, sustainable industrial development and economic growth, eradicating persistent poverty, ensuring food security, responding to new patterns of consumption and conserving threatened ecosystems.

Demand for water is increasing from all sectors, particularly for energy, manufacturing industry and agriculture in developing countries and emerging economies (OECD, 2012a). The paradox is that water is essential for development but at the same time development and economic growth will put pressure on the resource and challenge water security for humans and nature. There are also major uncertainties about the precise amounts of water required to meet the demand for food, energy and other human uses, and to sustain ecosystems (see Section 1.4.4). These uncertainties are further exacerbated by the impact of climate change on available water resources (see Chapter 10).

Unfortunately, water management is far too often done in hindsight. The real drivers of water demand and use are mainly found in the need for more food, fodder and fibre, energy production, mining of minerals, industry and manufacturing, and for meeting increasing domestic needs, especially in rapidly growing cities. The fact that multi-uses of water are critical for development, combined with its dispersed decision-making character, makes water management the responsibility of many different decision makers in public and private sectors. How can such shared responsibility be turned into something constructive that different parties can rally around to collectively make informed decisions?

There are no quick fixes or silver bullets. It is equally apparent that different societal contexts need to find their own unique ways and apply their own measures to achieve *the future they want*. Like the MDGs, the SDGs will continue to provide government guidance and momentum for development priorities as well as better alignment between bilateral and multilateral donor organizations. Tensions between multiple water priorities and entitlements will need to be resolved contextually by water stakeholders on the ground (Tremblay, 2011).

Vulnerability to climate change and other hazards – including economic volatility – is highly inclined towards the poor. It is the 'bottom billion' that suffers from lack of access to services and from the most severe consequences of natural and human-made disasters. A new grip on poverty and a solid commitment to governance, risk and security issues, and equity is required in the coming decades. It must take into account investments needed in infrastructure, institutional development, human capacities and technological application and innovation.

16.3.1 Addressing the governance crisis: Reorienting policy frameworks

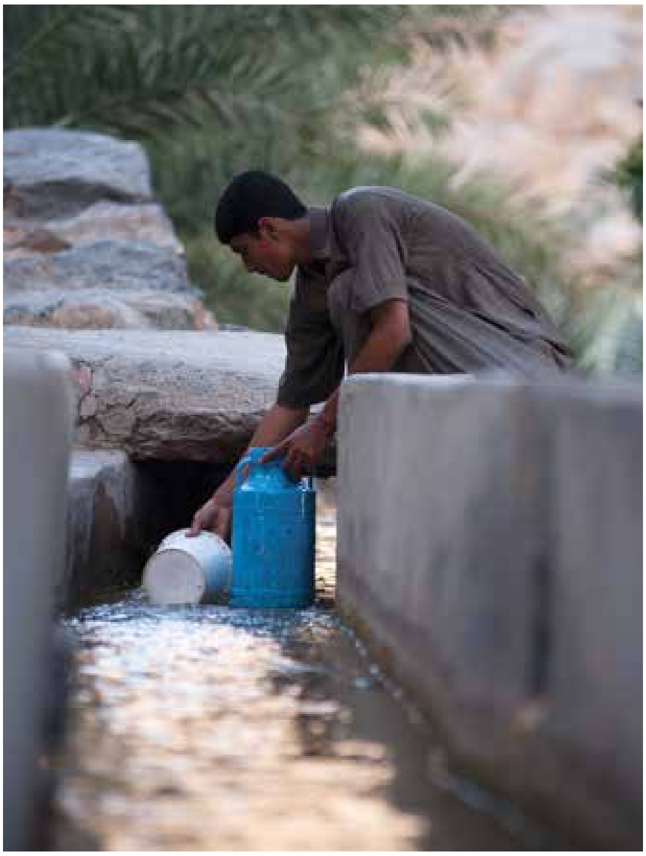
The global water crisis is mainly one of governance (WWAP, 2006). Addressing the challenges related to water requires changing the way we assess, manage and use our water resources. Progress calls for engaging a broad range of societal actors to take account of water in their decision-making processes and responses.

Research shows that essential governance features incorporate inclusive structures that can enable effective legal frameworks, reduction of inequality, open access to systematically updated data and information, and meaningful stakeholder participation (Planet Under Pressure, 2012). Inclusive governance structures recognize: the dispersion of decision-making across various levels and entities, from the local to the global level; gender and socio-economic stakeholder aspects; and interdependencies between public and private sectors. This is particularly true for water, where the agents of change are numerous and the drivers multiple. It is for example, imperative to recognize women's contributions to local water management and their role in decision-making related to water. Water aspects need to be clearly visible and accounted for in decisions to promote food and energy security.

Many paths to sustainable development are linked to water, but the decisions that determine how water resources are used or abused are largely driven by economic sectors. Achieving the vision for the future of water (see Prologue) will require reorienting policy frameworks significantly to strengthen public policies and institutions, including planning systems and decision-making processes.

During recent years many countries have re-oriented their water policies towards an IWRM approach. Fundamentally, the IWRM approach can be seen as a set of management methodologies to achieve coordinated development and management of water, land and related resources that aims to achieve sustainable water development. It provides a sound basis for countries to adopt more integrated decision-making that provides greater incentives for sustainable development, with water as the catalyst for progress (Planet Under Pressure, 2012). Yet, while some countries have made great strides to implement various aspects of IWRM, including, for example, decentralized management and the creation of river basin organizations, many others still face huge implementation problems and water reform is stalling (WWAP, 2006 and 2009). While the rationales for IWRM implementation have been too much geared towards economic efficiency, there is a need to put more emphasis on issues of equity and environmental sustainability (WGF, 2012). For example, the use of human rights-based approaches can sharpen the focus on equity through targeted work on social, political and administrative accountability, non-discrimination and rule of law (Tremblay, 2011).

***Many paths** to sustainable development are linked to water, but the decisions that determine how water resources are used or abused are largely driven by economic sectors*



Irrigation channels carry water from its source to the top of the village, Al Hamra', Ad Dakhiliyah (Oman)
Photo: Simon Monk

Different scales require different solutions. Growing demand for and use of water will have impacts beyond country borders and make water a primary strategic national resource. There are a number of transboundary river commissions that mediate different country interests and promote technical cooperation, such as the Mekong River Commission, Zambezi Watercourse Commission, Orange-Senqu River Commission, and many more. There are also many cases of bilateral and multilateral collaborations and agreements. For example, the Grand Ethiopian Renaissance Dam (GERD) for hydropower has created downstream concerns, particularly in Egypt. In August 2014, Egypt, Ethiopia and Sudan agreed to form a committee to serve as a joint negotiation platform and to perform independent studies on the impacts of the dam (FDRE, 2014). While all three countries have legitimate claims and concerns, the dam will produce energy that can benefit the entire region's energy security. A regional perspective that takes into account other ongoing economic collaborations and broader trade issues (e.g. food and energy) can open up space for more constructive negotiations and dialogues.

The need for taking broader political economy dynamics in society into account is also illustrated by gender issues and water. The advancement of gender equity would require that organizations and agencies review not only their own structures and practices, but also develop improved understanding of the underlying power dynamics and structural barriers that reinforce gender inequities in water access, use and management. This would imply strategies with greater focus on women's solidarity and collective action, and the inclusion of men and boys in the efforts towards changing values, attitudes and gender relations (WGF, 2014).

The benefits of strengthened inclusive governance are manifold, both in terms of providing enforcement tools and through its impacts on political processes of allocation and quality control. Inclusive governance helps: ensure coherence of the normative framework of the water sector; increases the accountability and transparency of its service providers; promotes a comprehensive set of minimum standards for water supply; prioritizes poor, marginalized and vulnerable groups and strengthens their claims for improved access to water; and provides effective monitoring, assessment and enforcement mechanisms (Tremblay, 2011).

To achieve effective governance of water resources and services, decision-makers and service providers need to take responsibility for their decisions and the quality of service. Accountability mechanisms can help to clarify the commitments of actors involved in water governance and lead to efficient management of fiscal resources. They can also help protect water resources and increase control over the actions of public and private stakeholders, while ensuring adequate quality standards. According to a World Bank study, unethical practices drain 30% of the budgets within the WASH sector in sub-Saharan Africa (Plummer and Cross, 2006). To be able to attract much of the funding required for sustainable infrastructure development and functional institutions, it will be increasingly important to institute anti-corruption measures across water and related economic sectors. Improving accountability will require all decision-makers in government, the private sector and civil society to recognize that being open and transparent, engaging stakeholders, evaluating and learning, and responding to complaints is crucial to their legitimacy and effectiveness and to achieve long-lasting benefits to the poor through sustainable water and sanitation interventions.

Accountability is at the heart of well-functioning regulatory systems. The regulator holds to account water service providers and industries, for example, by verifying compliance with rules and regulations. Regulatory measures can take the form of administrative and legal or economic incentives. A wide range of measures exists to strengthen social, administrative and political accountability, such as public expenditure tracking, auditing, public access to water utility budget and performance information, citizen report cards, consumer redress mechanisms, establishment of model contracts, and raising consumer awareness of their rights and obligations. In Albania, for example, the providers of water and sewerage services and their customers established a so-called 'model contract'. The contract integrates the provisions of the consumer protection law and those of the water and sewerage code. Developed by the stakeholders in the sector, the contract covers all standard elements such as terms of service, fees and payments, metering, service interruptions and complaints, handling them in a way that is fully compliant with all applicable legislation. By the end of 2011, over 35,000 contracts, based on the model had been signed (including new contracts and old ones replaced), representing around 16% of all serviced customers (WGF, 2013).

The above examples of policy reorientation are also important for the next sections of this Chapter, which look at reduced risks and increased security and how particular water measures can address inequity aspects to a greater extent.

> ***Investing in all aspects** of water resources management, services provision and infrastructure can be highly cost-effective*

16.3.2 Minimizing risk and maximizing water security
Water users face multiple risks, and securing access to water is a fundamental requirement for various livelihood purposes. Climate change and political and economic volatility create additional risks. Responses can include a range of measures to: expand, improve and reinforce infrastructure; develop water use efficiency technologies; employ adaptive management; and maintain ecosystem services and natural infrastructure.

Investing in all aspects of water resources management, services provision and infrastructure (development, operation and maintenance) is beneficial to social and economic development. The size of net benefits will be highly country-specific as a function of its particular situation. Nevertheless, current evidence suggests that even under the most conservative estimates, historical spending on drinking water supply and sanitation has been 'highly cost-effective' on health grounds alone (UNOSD/UNU, 2013). There is also much evidence to suggest that investment in disaster preparedness, improved water quality and wastewater management are very cost-effective (UN-Water, 2014). Distribution of costs and benefits among stakeholders is crucial for financial feasibility (FAO, 2010). Decision-makers can evaluate costs and benefits from a hydrological basin viewpoint and appraise economic justification by taking account of the benefits of multiple uses: domestic, industrial, power and energy, agricultural and environmental. Financing proposals can gauge various incentives or penalties in the forms of water taxes, charges, subsidies, environmental service payments, or soft loans, among others (FAO, 2010).

__The complexity__ of any pricing of water resources is compounded by the fact that different users and uses are very differently inserted into local and global economies

Projects can focus on developing innovative financing schemes, seek multiple financing partners among the expected beneficiaries of investments and consider re-paying contributors from the savings in public expenditures (2030 WRG, 2013).

For example, investing in ecosystem services can result in significant cost savings in drinking water supply, improved sanitation and wastewater management (see Chapter 4). It costs US$235,000 per year to optimize waste treatment to preserve the ecological integrity of the Nakivumbo swamp in Uganda that provides water purification services for the city of Kampala worth US$2 million annually (Russi et al., 2012). Watershed management saves US$300 million every year for New York City and avoided capital costs of US$5 billion (Perrot-Maître and Davis, 2001).

Investments can align with initiatives aimed at 'greening the economy' through enabling synergies with local job creation and national economic growth opportunities that focus on the poor. It has been advanced that every US$1 million invested in river restoration in the United States of America creates 15 jobs as well as obvious public benefits in terms of reduced pollution (Kantor, 2012). Pro-poor employment can be a key element of community endorsement of a water-related project (2030 WRG, 2013).

Water-related disasters are the most economically and socially destructive of all natural hazards. Economic losses due to natural and human-induced water-related hazards have increased greatly in the last decade, well beyond reported immediate losses. Single water-related disasters can even have repercussions on development on a multi-annual to decadal scale. This situation is likely to become exacerbated by climate change, which is anticipated to increase the frequency of heavy precipitation over many areas of the world, and to intensify droughts in some areas over certain seasons. Planning, preparedness and coordinated responses – including floodplain management, early warning systems and increased public awareness of risk – have been shown to greatly improve the resilience of communities to natural hazards. Blending structural and non-structural flood management approaches is particularly cost-effective (UN-Water, 2014).

Risks and various water-related security issues can also be reduced by technical and social approaches. One example is to treat wastewater as a resource. It is possible and potentially beneficial to move beyond treating wastewater as a costly by-product to be disposed of and explore paths to valuing this otherwise discarded resource (FAO, 2010). Not all water needs to be up to drinking quality standards; it is a matter of distinguishing the right kind of treatment for the right kind of use. There are a growing number of examples of reclaimed wastewater being used in agriculture, for irrigating municipal parks and fields, in industrial cooling systems, and even in some cases, mixed in with drinking water (2030 WRG, 2013). Biogas produced from wastewater sludge is being used to power water treatment plants, public transportation and city heating.

Young girl refills water pot, Korhogo, Savanes (Côte d´Ivoire)
Photo: UN Photo/Ky Chung

Increased water scarcity should lead to a questioning of the propriety of using precious freshwater as a waste disposal mechanism in flushing toilets. Focusing on access to WASH and providing infrastructure to the worlds' slums and informal settlements provides an opportunity for intensive innovation in moving away from the conventional flush-toilet/sewerage systems. The ever-increasing concentrations of people in urban spaces can enable the deployment of efficient, radically different technical solutions that may have been unaffordable or unthinkable elsewhere (Planet Under Pressure, 2012). The other challenge will be to educate and persuade urban populations who may be reluctant to adopt alternatives to conventional sewerage systems.

Existing global and national water resources assessments are often inadequate for addressing twenty-first century water demands and resolving increasing competition among users, especially under conditions of increased climatic variability. Thus, new approaches for comprehensive assessments of water resources are urgently needed to support complex decision-making. These assessments in turn will require viable financing and capacity building, and they will remain an essential tool for sustainable development and monitoring progress towards achieving the SDGs in particular.

Comprehensive water resources assessments require sound scientific data on the status of hydrological basins and groundwater resources, coupled with metrics concerning water demand, withdrawals, consumption and discharges by different users. Information regarding governance and regulatory mechanisms, as well as gender-disaggregated data on access to water resources and services also need to be significantly expanded and shared among stakeholders. Assessments are necessary in order to make informed investment and management decisions, facilitate cross-sector decision-making, and address compromises and trade-offs between stakeholder groups.

To better inform work at all levels, the capacities to measure, model and monitor relevant dimensions of use and the sustainability of supplies need to be strengthened. Transparent sharing of information enables participation and trust, and is key for the successful implementation of initiatives seeking behavioural change. For example, it has been shown that consumer engagement and education can lead to a greater public endorsement of demand-side improvement projects even when they result in increased water bills (2030 WRG, 2013).

Alongside GDP growth and other economy-wide indicators such as GHG emissions, water accounting at the river basin level has been proposed as a tool for the purpose of overall water management and the generation of economic assessments (UNDESA, 2012). There is also a need to consider ecosystem services within such resource accounting schemes, to establish the links between resource efficiency, biodiversity and ecosystem services and the connection to the social values of water (UNEP, 2012).

16.3.3 Equitable growth

The third group of issues that need to be addressed in order to achieve the *Future We Want* relates to equity. Indeed, social equity is one of the dimensions of sustainable development that has been insufficiently addressed in development and water policies (see Chapter 2). A fresh commitment and sustained action to reduce poverty and inequities is urgently needed in the post-2015 world.

In order to achieve universal access to water and sanitation, there is a need for accelerated progress in disadvantaged groups and to ensure non-discrimination in WASH service provision. Pronounced disparities between regions, rural and urban areas, and socio-economic groups are well-documented (WHO and UNICEF, 2014a). Even in countries where service coverage is near universal, certain minority groups may be neglected (see Section 5.3).

Whereas services at the general level are far less available in rural areas, there has been an increase in the number of people without access to water and sanitation in urban areas (see chapters 5 and 6). The situation relates to the rapid growth of slums and the inability or unwillingness of local and national governments to provide adequate facilities for impoverished urban communities. People living in the world's slums (estimated to reach nearly 900 million by 2020 (UN-Habitat, 2010) are more vulnerable to extreme weather events and more likely to suffer from the lack access to safe water and sanitation. However, as described in section 6.2.1, innovative solutions such as functioning water kiosks have been shown to significantly improve access to drinking water supplies in informal settlements.

Local and national authorities need to find ways to cross the institutional boundaries produced by policies or regulation that impede service provision to informal areas. Useful starting points for this can involve building on existing solutions and actor constellations to find ways to incrementally improve the situation – in dialogue with users and providers. Determination can also be highly beneficial to increasing coverage, as exemplified in the case of pro-poor policies in Uganda (see Box 6.1).

Sustainable development and human rights perspectives both call for reductions in inequities and tackling disparities in access to services (UNGA, 2013). This calls for a reorientation of investment priorities and operational procedures to provide services and allocate water more equitably in society. Greater equity is not only a moral imperative; it also stands to improve the economy (see Chapters 2 and 3) (WHO, 2012b). Yet, despite the potential for sizeable returns on investment, adequate financing has not yet been attained in many settings.

Prioritizing investments in the provision of basic services unlocks the potential for economic growth and breaks the vicious cycle of low productivity linked to poor health and lack of education opportunities that preserves poverty. Where benefits such as reduced disease prevalence accrue to society rather than to the investor, regulatory measures may be needed to guide investments towards the greatest return for society.

Regulators ensure that service providers act in coherence with water sector policies. This is important for accountability. Social objectives may be high on the political agenda of most developing countries, yet they tend to be poorly followed up in regulatory practices. This may be a consequence of importing regulatory frameworks from economies where services are already provided to all citizens, and where coverage is consequently not an issue (Gerlach and Franceys, 2010). Equity needs to be kept as a priority at several policy levels and, in particular, followed through by regulatory measures.

In order to maximize the benefits, services should be provided close to or ideally within the home, not only to conveniently support good hygiene and health, but in order to ensure that time can be used more productively. Opportunity costs are an important contributor to the overall return on these investments (WHO, 2012b). Further, having facilities in or nearer to the home is also important from a safety perspective, as women and girls in particular may face harassment and violence when collecting water, when using communal toilet facilities or when undertaking open defecation in the evenings.

Beyond water, access to electricity can have tremendous positive effects on education achievement as it provides the opportunity for studies after dark. Moving up the energy ladder and the use of cleaner fuels for cooking and heating also has very positive effects in reducing respiratory disease, particularly for women who tend to be those responsible for cooking, and for the children who tend to be present in smoky environments with their mothers. The same people who lack access to improved water and sanitation are likely to lack access to electricity and to rely on solid fuel for cooking (WWAP, 2014). The demonstrated economic benefits of investing in basic services have a direct correlation with the alleviation of poverty.

The economic benefits of prioritizing equity and poverty eradication can also be discerned in the adequate prioritizing of investments in the area of agriculture. As presented in Chapter 3, the internal rate of return on investing in large-scale irrigation in central Africa was calculated at 12%, while the figure for investing in small-scale irrigation in the Sahel stood at 33%. Policies to support income generation for small-scale producers are not only fair; they also stimulate economic growth in rural areas. As suggested in the previous section, to ensure that equitable water allocation is followed through, greater accountability, transparency and not least participation is required to avoid resources being captured by powerful minorities.

The allocation of water between users and between different types of uses, like agriculture, industry or municipal demands, is usually managed through systems of administrative permits. Water pricing also provides signals on how to allocate scarce water resources to the highest-value uses – in financial terms or other types of benefits. Still, the complexity of any pricing of water resources is compounded by the fact that different users and uses are very differently inserted into local and global economies. Indeed, the contribution to the economy and benefits created by subsistence farming or commercial agriculture is difficult to compare with any simple parameters. Equitable pricing and water permits would need to adequately assure that abstraction as well as releases of used water support efficient operations and environmental sustainability. This can be done in ways that are adapted to the abilities and needs of industry and larger-scale irrigation as well as the small-scale and subsistence farming activities.

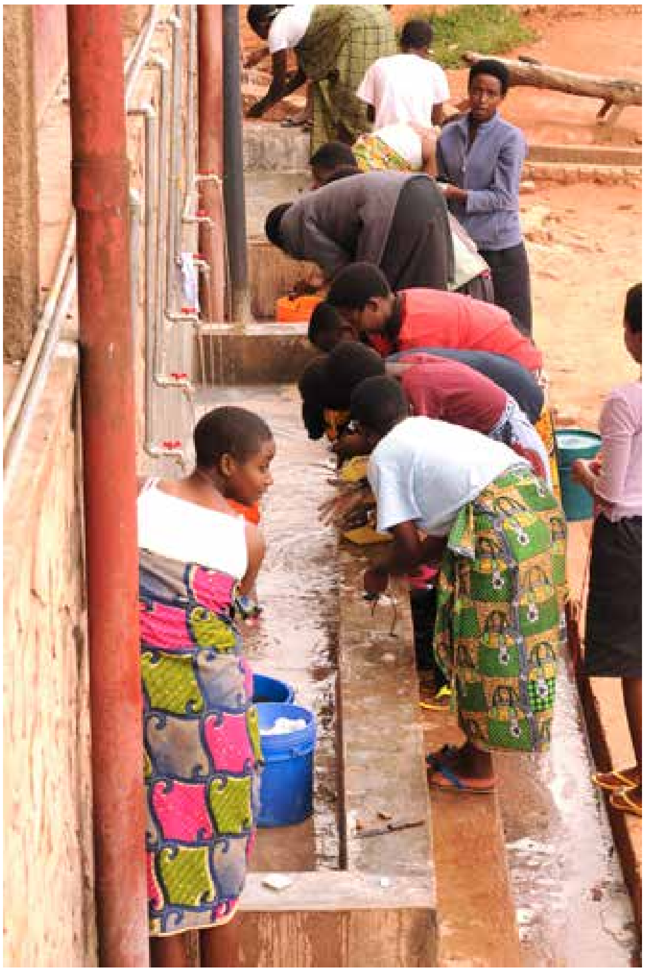
The human right to water and sanitation requires that all persons have sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses without discrimination (UN, 2002). Discrimination over access takes place whenever lower priority in investment or service delivery is provided to residents lacking social, economic or cultural clout over those with power to decide. Affordability can be determined in several ways, e.g. as a proportion of a household's income, though there is no generalized agreement on the appropriate proportion (Dar and Khan, 2011).

In the area of service delivery, prices or tariffs are usually linked to volumetric measures of water. Yet, prices in this area do not represent the scarcity value of the water as such but the cost of its delivery in a clean state. In many places, water services are under-priced, resulting in poor service delivery, low maintenance of existing infrastructure and the lack of extension to new service areas, as service providers are not fully compensated for the cost of service delivery.

Low tariffs are at times justified by poor people's inability to pay. Low tariffs may have the effect of limiting the scope of services, however, and tend to exclude low-income populations from public water services. This contradiction is partly due to under-pricing which precludes network extension and hence permeates historic inequalities of public water systems catering to powerful minorities rather than the public at large and more recent settlers. The other part of this contradiction relates to the fact that many poor households still pay significant amounts of money to receive water. Since the public system is not responding to this demand, independent or informal providers tend to be the main suppliers of water in informal, low-income or peri-urban areas. In these situations, the poorest pay more for water, sometimes of a lower quality, than the rich.

In a piped water system, it is the access to a connection which determines who has access or not to a service. In order to provide access for the poor, it is more important to subsidize, or amortize over time, the cost of the connection rather than the cost of water as such. As suggested above, the tariff price for piped water may be magnitudes lower than that from other supply sources. As a result, people excluded from piped water services may be purchasing water from mobile vendors or even paying for water they have to collect themselves at kiosks. This speaks for a pro-poor pricing policy to keep effective connection costs as low as possible, while ensuring that water use is paid for at a level that supports maintenance and potentially even expansion of the system. Where affordability is still an issue, it is preferable to support those who are unable to pay rather than to lower the price of water to everyone, particularly as it may only be the wealthiest that benefit from such a policy.

Serious concern about the increasingly inequitable division of resources and income in the world has been voiced by economic leaders and development agencies. The World Economic Forum identified 'widening income disparities' as an important trend and major global risk (WEF, 2014a and 2014b). Oxfam finds these extreme levels of wealth concentration to be damaging and worrying, not least because "when wealth captures government policymaking, the rules bend to favour the rich, often to the detriment of everyone else" (Fuentes-Nieva and Galasso, 2014). Wealth concentration can also skew water policies and supply priorities, as shown in a mapping research project in Nairobi, Kenya. Here, the water provider pumps more water to the



Girls washing and cleaning at the Lycée Regina Pacis (Burundi)
Photo: SuSanA Secretariat

never-rationed upper and high-consuming areas, testifying that "despite recent apparent concerns for the poor, servicing the wealthy high consumers who consume and pay more and are more politically influential is still prioritized" (Ledant et al., 2013).

Present water tariffs are commonly far too low to actually limit excessive water use by wealthy households or industry. While it is important that pricing policies reward users for saving water, responsible use may at times be more effectively fostered through awareness- raising and appealing to the common good. Pricing signals need to be supported by awareness-raising and information in order to work towards a cohesive society that collaborates around the wisest possible use of water – cherished and shared equitably within the present and towards future generations. Again, sustainable development needs to work with the economic, social and environmental dimensions coherently to ensure the mutual reinforcement of social equity, economic growth and sustainability.

Epilogue
Water for a sustainable world

WWAP | Richard Connor

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In the *sustainable world of 2050* envisioned in the Prologue of this Report, water resources are managed and water-related services provided in support of human wellbeing and ecosystem integrity in a robust and equitable global economy. This vision is attainable, but only if the required efforts are deployed, supported by a number of concrete actions, all of which are interrelated and mutually reinforcing.

First, appropriate legal and institutional frameworks are required in order to guarantee that water resources are managed and used sustainably. These include laws and regulations whose enforcement ensure a secure balance between water availability and use, and protect the resource against pollution and over-abstraction for the security of future generations.

> ***Decisions** that determine how water resources are used (or abused) are not made by water managers alone, but driven by various socio-economic development objectives and the operational decisions to achieve them*

Second, there is an urgent need to increase access to WASH services, and improve existing service levels. Reflecting the established principles of the human right to water and sanitation, as recognized in Resolution 64/292 of the UN General Assembly in July 2010, governments need to adopt ambitious targets for improving WASH service levels in order to reduce the global burden of WASH-related diseases, to improve productivity and economic growth, and to reduce inequalities between population groups.

Third, increased investment and financial support for water development is essential. When efficiently and transparently managed, investments in water generate social, economic, financial and other benefits that greatly outweigh its costs. In addition to adequately financing the development, operation and maintenance of infrastructure, increased funding is also needed in order to develop institutional capacity and ensure well-functioning governance structures. Greater financial support is equally essential to enhance the knowledge base and provide reliable and objective information about the state of water resources, their use and management, to enable water managers and administrators to inform decision-makers about policy options and their potential impacts.

Fourth, managing and allocating water across competing developmental sectors to meet multiple challenges is required to ensure that benefits created for one group of stakeholders do not disadvantage others. Water needs to be at the centre of a multisectorial dialogue, which includes decision-making processes and mechanisms for conflict resolution within the context of national inter-ministerial bodies and multilateral agencies, and in the case of transboundary waters. Decisions that determine how water resources are used (or abused) are not made by water managers alone, but driven by various socio-economic development objectives and the operational decisions to achieve them. Progress towards sustainable development requires engaging a broad range of actors in government, civil society and business to assure that water is taken into account in their decision-making and to promote cooperation across disciplines, sectors and borders.

The development of the post-2015 SDGs provides a critical opportunity to generate progress. Achieving the SDGs by 2030 will require a concerted effort across multiple domains and sectors, and water will need to be recognized as the nexus through which various SDGs and other development objectives are linked. Water efficiency gains in one domain can help relieve constraints in others, and contribute to the realization and sharing of greater benefits to society. For example, the health and livelihood benefits of access to safe water supplies and improved sanitation services is incontrovertible. Water management responses that maximize co-benefits can reduce risks, but these require coordinated approaches. Taking full account of the opportunities and limitations imposed by water on various other development goals would lead to cross-cutting synergies among sectors and actors, allowing progress to continue beyond the 2030 milestone.

Whereas poverty eradication and the reduction of inequities remain at the core of the concerns of the UN system, governments have obligations towards the of their citizens. To contribute towards a water-secure, fair and sustainable world, the UN system will need to continue to provide and promote leadership addressing the full range of goals and targets in the post-2015 world. Particular emphasis is needed on: universal access to water, sanitation and hygiene; the sustainable use and development of water resources; equitable, participatory and accountable water governance; increased reuse and reduced pollution from wastewater; maintaining ecosystem services; and reduced human and economic losses from water-related disasters.

Specifically addressing these critical issues through a dedicated global SDG for water with specific and measurable targets will trigger national governments and the global community to take action and track progress over a much broader set of water-related challenges than was considered under the MDGs. Each of these challenges is fundamental to sustainable development, just as most other sustainable development goals are in some way water dependent. Addressing these water-related challenges within the SDG process represents an inescapable intermediate step towards achieving the 2050 vision for water in a sustainable world.

Students at public school in Taliko neighbourhood, Bamako (Mali)
Photo: UN Photo/Marco Dormino

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ABBREVIATIONS AND ACRONYMS

2030 WRG	2030 Water Resources Group
ACET	African Centre for Economic Transformation
AfDB	African Development Bank Group
AMCOW	African Ministers' Council on Water
ASCE	American Society of Civil Engineers
AU	African Union
BAT	Best Available Techniques/Technology
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe
BRICS	Brazil, Russia, India, China and South Africa
BRIICS	Brazil, Russia, India, Indonesia, China and South Africa
CAP	European Union Common Agricultural Policy
CBD	Convention on Biological Diversity
CRED	Centre for Research on the Epidemiology of Disasters
DALYs	Disability-adjusted life years
DEWATS	Decentralized wastewater treatment systems
DFID	Department for Internal Development (United Kingdom)
EAFRD	European Agricultural Fund for Rural Development
EBM	Ecosystem-based management
EC	European Commission
ECA	European Court of Auditors
ECCAS	Economic Community of Central African States
EEA	European Environment Agency
EECCA	Eastern Europe, the Caucasus and Central Asia
EPA	Environmental Protection Agency
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse gas
GWP	Global Water Partnership
HDI	Human Development Index
HDR	Human Development Report
HLPE	High Level Panel of Experts on Food Security and Nutrition
ICARDA	International Center for Agricultural Research in the Dry Areas
ICMM	International Council on Mining and Metals
ICPDR	International Commission for the Protection of the Danube River
ICRISAT	International Crops Research Institute for the Semi-Arid-Tropics
IEA	International Energy Agency
IFAD	International Fund for Agricultural Development
IGRAC	International Groundwater Resources Assessment Centre
IJC	International Joint Commission (Canada and United States)
IPCC	Intergovernmental Panel on Climate Change
IRC	International Water and Sanitation Centre
IUCN	International Union for Conservation of Nature
IUWM	Integrated urban water management
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management

JMP	WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation
LSALI	Large-scale agricultural lease investments
MDGs	Millennium Development Goals
MEA	Millennium Ecosystem Assessment
NI	Natural Infrastructure
OECD	Organisation for Economic Co-operation and Development
OHCHR	Office of the High Commissioner for Human Rights
OWG	Open Working Group
PES	Payment for ecosystem/environmental services
PV	Solar photovoltaic
RWSN	Rural Water Supply Network
SDGs	Sustainable Development Goals
SEI	Stockholm Environmental Institute
SIDS	Small Island Developing States
SIWI	Stockholm International Water Institute
SMEs	Small and medium-sized enterprises
SRBC	International Sava River Basin Commission
TNC	The Nature Conservancy
UN	United Nations
UNCESCR	United Nations Committee on Economic, Social and Cultural Rights
UNCTAD	United Nations Conference on Trade and Development
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UN-DPAC	United Nations Decade Programme on Advocacy and Communication
UNECA	United Nations Economic Commission for Africa
UNECE	United Nations Economic Commission for Europe
UNECLAC	United Nations Economic Commission for Latin America and the Caribbean
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCWA	United Nations Economic and Social Commission for Western Asia
UNGA	United Nations General Assembly
UN-Habitat	United Nations Human Settlements Programme
UNIDO	United Nations Industrial Development Organization
UNISDR	United Nations Office for Disaster Risk Reduction
UNOSD	United Nations Office for Sustainable Development
UNU	United Nations University
USCB	United States Census Bureau
USGS	United States Geological Survey
WASH	Water, Sanitation and Hygiene
WBCSD	World Business Council for Sustainable Development
WEF	World Economic Forum
WFA	Water Footprint Assessment
WGF	Water Governance Facility
WHO	World Health Organization
WMO	World Meteorological Organization
WNA	World Nuclear Association
WRI	World Resources Institute
WSP	Water and Sanitation Program
WWAP	World Water Assessment Programme
WWF	World Wide Fund For Nature/World Wildlife Fund

BOXES, TABLES AND FIGURES

BOXES

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The United Nations World Water Development Report

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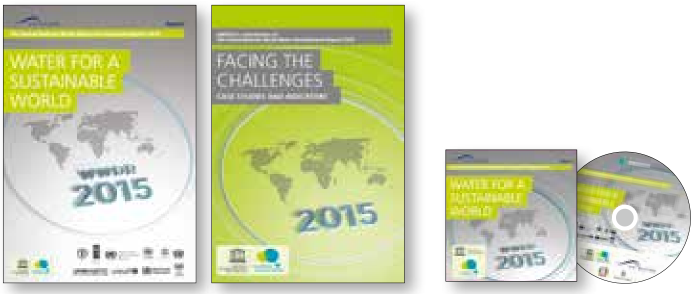

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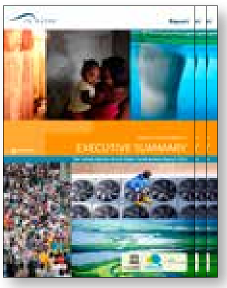

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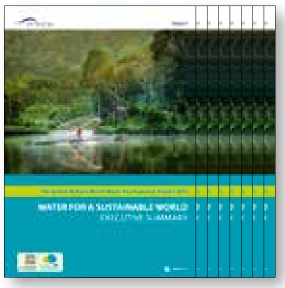

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United Nations Educational, Scientific and Cultural Organization
World Water Assessment Programme

WWDR 2015

UN-WATER REPORTS

UN WATER

UN-Water is the United Nations (UN) inter-agency coordination mechanism for freshwater related issues, including sanitation. It was formally established in 2003 building on a long history of collaboration in the UN family. UN-Water is comprised of UN entities with a focus on, or interest in, water related issues as Members and other non-UN international organizations as Partners.

The work of UN-Water is organized around Thematic Priority Areas and Task Forces as well as awareness-raising campaigns such as World Water Day (22 March) and World Toilet Day (19 November).

The main purpose of UN-Water is to complement and add value to existing programmes and projects by facilitating synergies and joint efforts, so as to maximize system-wide coordinated action and coherence. By doing so, UN-Water seeks to increase the effectiveness of the support provided to Member States in their efforts towards achieving international agreements on water.

PERIODIC REPORTS

World Water Development Report (WWDR)

is the reference publication of the UN system on the status of the freshwater resource. The Report is the result of the strong collaboration among UN-Water Members and Partners and it represents the coherent and integrated response of the UN system to freshwater-related issues and emerging challenges. The report production coordinated by the World Water Assessment Programme and the theme is harmonized with the theme of World Water Day (22 March). From 2003 to 2012, the WWDR was released every three years and from 2014 the Report is released annually to provide the most up to date and factual information of how water-related challenges are addressed around the world.

- ✓ Strategic outlook
- ✓ State, uses and management of water resources
- ✓ Global
- ✓ Regional assessments
- ✓ Triennial (2003-2012)
- ✓ Annual (from 2014)
- ✓ Links to the theme of World Water Day (22 March)

UN-Water Global Analysis and Assessment of Sanitation and Drinking-Water (GLAAS)

is produced by the World Health Organization (WHO) on behalf of UN-Water. It provides a global update on the policy frameworks, institutional arrangements, human resource base, and international and national finance streams in support of sanitation and drinking water. It is a substantive input into the activities of Sanitation and Water for All (SWA).

- ✓ Strategic outlook
- ✓ Water supply and sanitation
- ✓ Global
- ✓ Regional assessments
- ✓ Biennial (since 2008)

The progress report of the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP)

is affiliated with UN-Water and presents the results of the global monitoring of progress towards MDG 7 target C: to halve, by 2015, the proportion of the population without sustainable access to safe drinking-water and basic sanitation. Monitoring draws on the findings of household surveys and censuses usually supported by national statistics bureaus in accordance with international criteria.

- ✓ Status and trends
- ✓ Water supply and sanitation
- ✓ Global
- ✓ Regional and national assessments
- ✓ Biennial (1990-2012)
- ✓ Annual updates (since 2013)

UN-WATER PLANNED PUBLICATIONS 2015

- UN-Water Analytical Brief on Wastewater Management
- UN-Water Analytical Brief on Water Efficiency
- UN-Water Analytical Brief on Water Quality Monitoring
- UN-Water Country Briefs
- UN-Water Policy Brief on Discrimination and the Right to Water and Sanitation
- UN-Water Report on the International Decade for Action 'Water for Life' 2005-2015

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WWDR 2015

The United Nations World Water Assessment Programme (WWAP) is hosted and led by UNESCO. WWAP brings together the work of 31 UN-Water Members as well as 37 Partners to publish the United Nations World Water Development Report (WWDR) series.

Under the theme Water for Sustainable Development, the WWDR 2015 has been prepared as a contribution from UN-Water to the discussions surrounding the post-2015 framework for global sustainable development. Highlighting water's unique and often complex role in achieving various sustainable development objectives, the WWDR 2015 is addressed to policy- and decision-makers inside and outside the water community, as well as to anyone with an interest in freshwater and its many life-giving benefits.

The report sets an aspirational yet achievable vision for the future of water towards 2050 by describing how water supports healthy and prosperous human communities, maintains well functioning ecosystems and ecological services, and provides a cornerstone for short and long-term economic development. It provides an overview of the challenges, issues and trends in terms of water resources, their use and water-related services like water supply and sanitation. The report also offers, in a rigorous yet accessible manner, guidance about how to address these challenges and to seize the opportunities that sound water management provides in order to achieve and maintain economic, social and environmental sustainability.

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Regione Umbria

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The United Nations World Water Development Report 2015

FACING THE CHALLENGES

CASE STUDIES AND INDICATORS

United Nations
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Assessment Programme

UNESCO's contribution to
The United Nations World Water Development Report 2015

FACING THE CHALLENGES

CASE STUDIES AND INDICATORS

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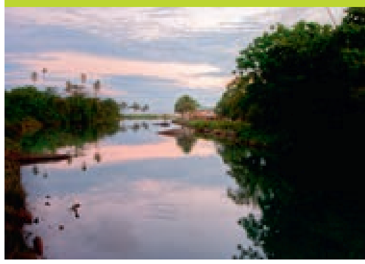

DATA AND INDICATORS

PART 2

Human well-being

Electricity

Impact of hazards

Progress towards Millennium Development Goals

PREFACE

By Michela Miletto, WWAP Coordinator a.i.
and Engin Koncagül, Author

This publication, which brings together a number of case studies and a wealth of data underpinning selected indicators, is UNESCO's contribution to the 2015 edition of the United Nations *World Water Development Report* (WWDR 2015). The material found herein complements the theme of the WWDR 2015, 'Water for a Sustainable World'.

The sixth edition of the WWDR is launched at a critical juncture. By adopting the Millennium Declaration in 2000, world leaders resolved 'to stop the unsustainable exploitation of water resources'. The time frame for achieving the Millennium Development Goals (MDGs) that evolved from such determination will draw to a close at the end of 2015. The international community has been elaborating the United Nations post-2015 development agenda. In 2014, a milestone was reached when the United Nations General Assembly adopted a resolution on the final report of the Open Work Group on Sustainable Development Goals. The Group's proposal contains 17 goals, the sixth of which focuses on water: 'Ensure availability and sustainable management of water and sanitation for all'. Overall, the Sustainable Development Goals (SDGs), which will be adopted by the United Nations General Assembly in September 2015, will set international objectives for a wide range of issues from poverty reduction and social development to environmental protection and disaster risk reduction.

In his foreword to the first edition of the WWDR in 2003, the former Secretary-General of the United Nations Kofi Annan highlighted that 'the centrality of freshwater in our lives cannot be overestimated … and its quality reveals everything, right or wrong, that we do in safeguarding the global environment'. His thoughts are as valid and important today as when he expressed them.

Through the five editions of the WWDR since it was first published, the series has reported on the progress made towards sustainable use of water resources. While the international community has undoubtedly made progress in rising to meet this challenge, there is 'unfinished business' that requires attention and common efforts. The WWDR 2015, prepared in collaboration with many United Nations agencies and other entities concerned with freshwater issues, continues in this endeavour reporting on the state, uses and users of this valuable resource.

The WWDR series, in addition to providing the latest statistics to show trends and challenges in a business-as-usual-scenario, have also always showcased a number of case studies to capture snapshots of real-life conditions on the ground in various regions of the world. In 2015, this tradition continues with UNESCO's contribution to the WWDR: seven case studies from the Arab States, Asia and the Pacific, Europe and Latin America.

The WWDR 2015 underlines that 'groundwater supplies are diminishing, with an estimated 20% of the world's aquifers currently over-exploited. Worldwide, 2.5 billion people depend solely on groundwater resources to satisfy their daily needs for water and hundreds of millions of farmers rely on groundwater to sustain their livelihoods and contribute to the food security of so many others.' Given the importance of this fragile resource, a number of case studies focus on its sustainable use, among other issues. From Pacific Small Island Developing States with limited economic means to wealthy Gulf Cooperation Council countries and major metropolises in Asia, the challenges facing governments in managing this largely not well studied resource are broad.

The case studies point to the fact that for both surface and groundwater resources, political willingness will be required to address the urgent need to reconsider supply-side management in all sectors and improve water efficiency to achieve maximum productivity per cubic meter consumed.

This publication also features a rich compilation of more than 30 indicators that shed light on a number of globally important trends related to the theme of the WWDR 2015 such as water demand, population growth, expansion of slums, access to electricity, improved water supply and sanitation, prevalence of undernourishment, human displacement due to hazards, and global progress towards achieving the MDGs. The World Water Assessment Programme Secretariat (WWAP) will continue to refine and develop robust indicators as an inseparable part of its work in global reporting.

This action-oriented and people-centred publication is made possible thanks to the voluntary contributions of UNESCO Member States and other partners. We would like to express our gratitude to them for their support to WWAP, and invite others to join us in future editions of this Case Studies and Indicators Report to share their unique and practical experience with the international community.

Michela Miletto **Engin Koncagül**

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CONTRIBUTORS

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The difference between what we do and what we are capable of doing would suffice to solve most of the world's problems.

Mahatma Gandhi

PART 1

CASE STUDIES

CHAPTERS

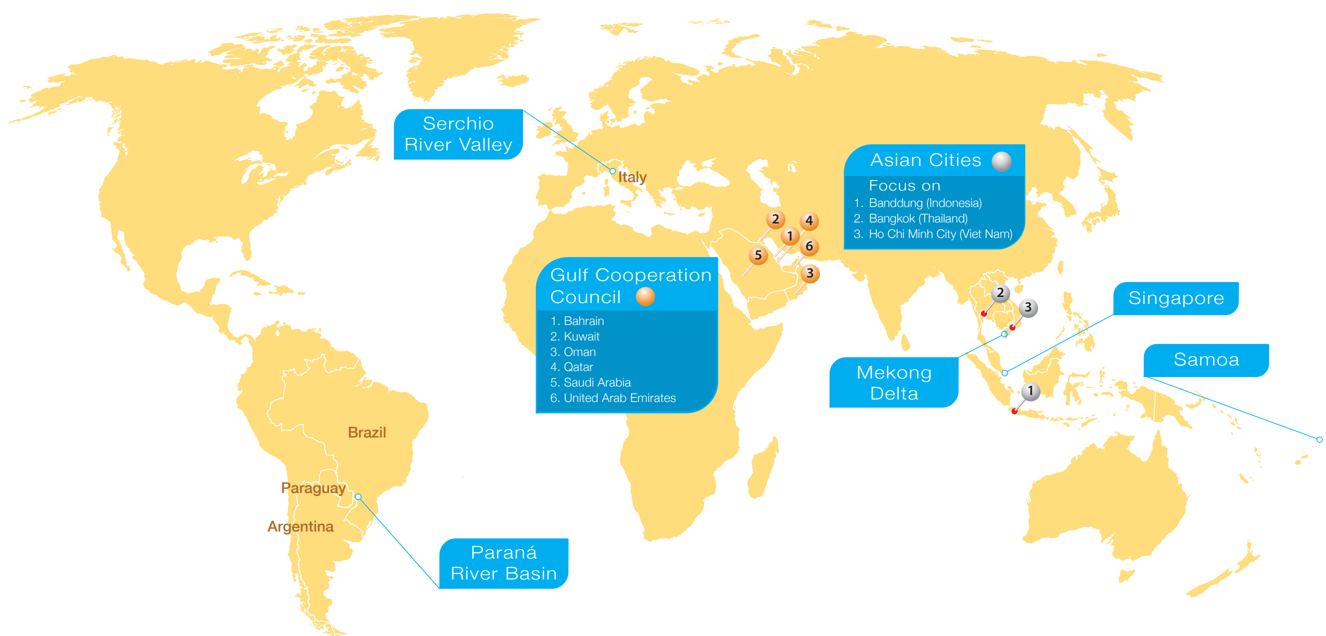
Highlights of the findings

The 2015 edition of the United Nations *World Water Development Report* (WWDR 2015), the sixth in the series since 2003, emphasizes how water resources and the range of services they provide underpin socio-economic development. Without a doubt, since the introduction of the Millennium Development Goals in 2000 considerable progress has been made in terms of improvements in health, food security and protection of the environment – all of which combined has helped lift hundreds of millions of people out of poverty. Unfortunately, this progress has not been evenly distributed around the world, and much still needs to be done in many places.

This report, which is UNESCO's contribution to the WWDR 2015, brings together selected examples of country perspectives and experiences. The seven case studies featured (see map below) highlight not only good practices, innovative approaches and promising commitments but also the negative consequences of one-sided sectoral approaches and unsustainable responses to water demand.

As the case studies from Asian cities, Gulf Cooperation Council (GCC) countries and Pacific Small Island Developing States (SIDS) highlight, aquifers contribute significantly to water provision to meet the increasing demands. However, rather than strategic development of this resource with a mid- to long-term vision, emphasis has been placed on increasing groundwater abstraction, in some cases through incentives, at the expense of degradation and depletion of aquifers and serious land subsidence. In Pacific SIDS, climate change, climatic variation and, notably, a lack of data on the availability of water resources exacerbate the groundwater condition. Regulations are being developed in the Asia-Pacific region and GCC countries to curb and reverse the worsening trend of unsustainable groundwater use. There have been positive developments; for example, fair pricing of groundwater has allowed a continuous recovery of water table levels in Bangkok (Thailand) and the land subsidence rate has stabilized. In response to escalating unsustainable groundwater use, a number of GCC countries have been promoting modern irrigation techniques in agriculture. GCC members have also

Distribution of the case studies



turned their attention to the high losses in the municipal distribution network and have made progress in bringing these down to the level of international norms.

In Samoa, authorities have made major efforts in improving their water governance framework and institutional arrangements. However, changing the business-as-usual approach of water development over water management as well as tackling fragmented water governance remains a challenge that is not specific to the case study countries from Asia-Pacific region and GCC but is global in nature.

As the WWDR 2015 highlights, the decisions that determine how water resources are used should not be made by water managers alone. Progress towards sustainable development requires a broad range of actors – in government, civil society and business – to take account of water in their decision-making. The case studies from Brazil and Italy show that stakeholder participation and community involvement in project planning and implementation promotes ownership and boosts the chances of successful outcomes.

The Cultivating Good Water programme, initiated in 2003 on the Brazilian side of the Paraná River basin, aims to curb environmental degradation and introduce climate change adaptation and water conservation efforts. The steering committees that are established at the municipal level bring together a wide variety of stakeholders. Thanks to this collective approach, environmental recovery efforts have been completed or have reached an advanced stage in approximately 30% of the basin area.

In Italy, river contracts are becoming more common as a participatory management tool for the protection of rivers, restoration of the environment and better planning of land use. The strength of river contracts lies in their prioritization of direct consultation with a broad stakeholder group. The Serchio River contract, an example from the Tuscany region, involved more than 270 stakeholders in its planning phase. The river contract has so far led to an updated territorial plan for urban development in harmony with nature, structural measures to reduce flood risk, and the involvement of farmers in protection of the environment.

The case study from Singapore illustrates the importance of political will and continuous investment in research and development to achieve long-term water sustainability in water scarce areas. To reduce its dependency on external freshwater, the Water Master Plan of the country outlined plans for a diversified water supply, including recycled water. Investment in membrane technology allowed the purification of wastewater to levels that meet stringent requirements of industry for process water and international quality standards for drinking water. Following a public education campaign directed towards a wide range of stakeholders, the recycled water, introduced under the name NEWater, has achieved a 98% acceptance rate. Transboundary river basins cover around 45% of the globe's surface. As national and international competition for limited water resources escalates, water managers, politicians and engineers need to work together to ensure that water is managed in an integrated manner across boundaries. The Basin Development Strategy, approved in 2011 by the members of the Mekong River Commission, constitutes an example of such an approach.

The case study from Viet Nam shows that accelerated economic growth, as a result of economic reforms collectively known as Đổi Mới, are combating poverty in the country. However, growing problems in the Mekong Delta, such as water pollution, destruction of mangrove forests and climate change, challenge the success of development scenarios based on agriculture and industry. The country has a high stake in the effective implementation of integrated water and land-use policies in the national context.

Case studies illustrate that there is increasing momentum to curb unsustainable business-as-usual approaches. However, in spite of the growing recognition of environmental degradation and diminishing water resources, global efforts have clearly not been sufficient to couple sustainable socio-economic development with sustainable use of freshwater resources, and this is leading to a growing water crisis and human sufferance. The post-2015 development agenda may help the international community to tackle this problem for the most part by 2030.

1 Towards sustainable groundwater management in Asian cities

Abstract

In several Asian cities, groundwater has been instrumental for socio-economic development by meeting the water demand of various sectors. Under growing pressures such as increasing populations, higher living standards and industrialization, signs of unsustainable groundwater use have emerged: a decline in the groundwater level, land subsidence and the deterioration of water quality from contamination by both natural sources and human activities. Measures to limit withdrawal, such as licensing systems and charging schemes, have been implemented. The success of these initiatives should be looked at through a local rather than a regional lens because of varying levels of surface water and groundwater availability as well as different policy and agency coordination issues in specific contexts. Changing the business-as-usual emphasis on water development over water management will be important for Asian cities in the future, as it will be for other regions around the world.

Groundwater plays an important role in meeting the water demand of various sectors in Asia. For example, the drinking water supply in many urban settlements in the region comes mainly from aquifers, including capital cities Jakarta (Indonesia), Hanoi (Viet Nam) and Beijing (China). Groundwater is also the main source of supply for rural communities in Asia that are not connected to a drinking water network; for example, 60% of such a population in Cambodia and 76% in Bangladesh depend on tube wells. In large urban areas, the use of groundwater by industry is usually more prevalent than its use for human consumption.

In spite of groundwater's crucial value to Asian cities, emphasis has been placed on its development without a clear focus on its proper management, and this has resulted in depletion and degradation of the resource in many situations. This case study

TABLE 1.1 Reliance on groundwater in selected Asian cities

City (country)	Population (millions)	Groundwater (% of water supply)	Issues
Bandung (Indonesia)	2.4	75	Excessive abstraction, land subsidence
Bangkok (Thailand)	11.5	9	Excessive abstraction, land subsidence
Ho Chi Minh City (Viet Nam)	7.4	35	Decline in groundwater level, saline water intrusion, pollution
Hyderabad (India)	7.8	30	Decline in water levels in most wells, pollution
Kathmandu (Nepal)	2.5	55	Excessive abstraction, decline in groundwater level, pollution
Lahore (Pakistan)	8.0	100	Rapid aquifer decline, pollution
Tokyo (Japan)	13.3	30	Excessive abstraction, land subsidence
Vientiane (Lao People's Democratic Republic)	0.2	92	Pollution
Yangon (Myanmar)	4.7	50	Excessive abstraction

provides an overview of groundwater use in selected Asian cities (Table 1.1), highlighting Bangkok, the capital and most populous city of Thailand, and Bandung, the third largest city in Indonesia (by population). Current challenges, implementation of policy instruments, and management practices and their outcomes are discussed.

In the nine cities listed in Table 1.1, groundwater has long been used as a readily accessible and cheap source of water for various sectors, and this has helped boost the economies of these cities (Figure 1.1). A growing demand for groundwater is expected along with population increase and socio-economic development. However, major problems linked to over-extraction of groundwater are already obvious in some areas. These problems include land subsidence, lowering of the water table, contamination of groundwater and saline water intrusion into the aquifers.

Land subsidence resulting from groundwater exploitation has been observed in Bangkok, Bandung, Ho Chi Minh City and Tokyo. In some parts of these cities, land subsidence has been so severe that structural damage to buildings and infrastructure has occurred. In eastern Bangkok, land subsidence rates of 10 cm per year or higher have been measured, and in several locations in Bandung, they have reached as high as 24 cm per year (IGES, 2007).

In Lahore, the second largest city of Pakistan by population, the groundwater level was at a shallow depth (about 5 m below the surface) until 2003. According to the Water and Sanitation Agency in Lahore, the average decline in the city's groundwater level for the years between 2003 and 2011 ranged from 5 to 11 m. The elevation of water table had dropped as much as 45 m below the surface in some areas by 2011. Because of this drastic lowering of the water table, the installation and operating costs of water wells have increased substantially.

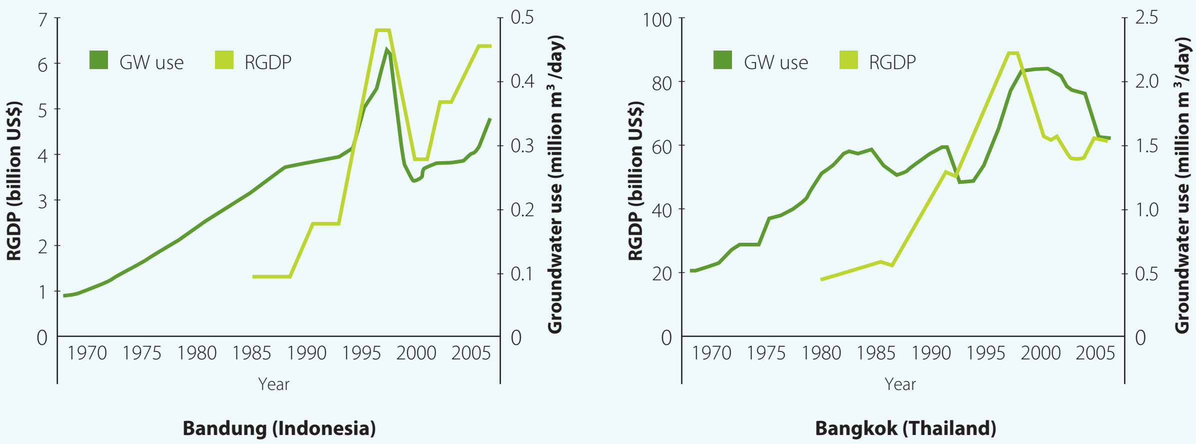
In many Asian cities, groundwater is contaminated by both natural sources (e.g. arsenic, fluoride) and human activities, posing serious health risks to millions of people. Anthropogenic pollutants include coliform bacteria, volatile organic compounds, nitrates and heavy metals such as cadmium. The main sources for these types of contaminants are industrial and agricultural activities, domestic wastewater, and inefficient solid waste management practices (e.g. leakages from landfills). For instance, in Bandung, shallow groundwater is not fit for direct consumption as it is contaminated by domestic and industrial wastewater, especially from the abundant textile factories in the city. Furthermore, elevated concentrations of halogenated hydrocarbons and trace elements occur locally downstream of waste disposal and industrial compounds. The groundwater of Hyderabad has high concentrations of sulphates (>400 mg per litre) due to industrial activities, and the concentration of fluoride in deeper groundwater at certain locations is beyond permissible limits.

Excessive groundwater abstraction may also result in aquifer salinization that limits its use. In Ho Chi Minh City, all aquifers are affected by salinity to some extent. In Bangkok, the increased concentration of chloride and total dissolved solids in groundwater is a serious concern.

To curb and reverse the spiralling trend in degradation of groundwater resources, regulations are being developed in

FIGURE 1.1

The correlation between groundwater (GW) use and real gross domestic product (RGDP) (inflation-adjusted GDP)



Note: A significant amount of groundwater use in these cities is for industry: 80% in Bandung and 60% in Bangkok.
Source: IGES (2007, Fig. 6, p. 8). © IGES. Reprinted with permission.

the region. Specific national laws in Japan and Thailand now control groundwater use, particularly in certain critical areas, in order to mitigate problems such as land subsidence. In some Asian cities, regulations aiming to control abstraction to fit local conditions, with or without national laws on groundwater, have been put in place (Table 1.2). Local regulations are generally more useful because they reflect local conditions of groundwater and actual water use.

An example of groundwater regulation is charging for its use. This is a departure from the common practice of the user paying for the installation of the well but not for the resource itself. In Bangkok and Bandung, and recently in Ho Chi Minh City, a user charge or a tax has been levied as a tool to disincentivize unsustainable abstraction of groundwater. While this is a positive step, its effectiveness in reducing demand remains limited in some locations because of policy issues. In the case of Bandung, the municipality introduced a zoning and permit system in 1995 followed by a groundwater charge for abstraction in 1998. However, inefficiencies in implementation have resulted in an increase of illegal groundwater abstractions within the Bandung basin. Overall, from 1995 to 2004, the rate of groundwater depletion in Bandung's deep aquifers reached as high as 12 m per year. All sectors (notably industry, which is the largest water user in the city) still tap into groundwater resources as their unit cost is cheaper than that of the public water supply. Over-extraction has also been a common problem in Bangkok. However, a groundwater pricing scheme along with the improvement of water availability through surface water resources development helped ameliorate the situation (Box 1.1). Limited availability of surface water in Bandung is among the major reasons why similar approaches did not work equally well in that city.

BOX 1.1

Regulating groundwater use in Bangkok

By combining a strict pricing system with expansion of the public water supply system, abstraction of groundwater has decreased and land subsidence has been mitigated in Bangkok. A charge for groundwater was introduced in 1985 in the Bangkok metropolitan region. However, this had little effect on reducing groundwater abstraction, mainly because the charge was lower than what the piped water supply cost. The groundwater charge was therefore increased gradually until 2003, and an additional charge for groundwater preservation was introduced in 2004. Groundwater users now pay more for groundwater than for water from the piped public water supply system. As a result, a continuous recovery of the groundwater level has been observed in central Bangkok and its eastern suburbs. At present, the land subsidence rate has stabilized, and in some areas there has been recovery as well.

TABLE 1.2

Local regulations for the control of groundwater abstraction and use in selected Asian cities

City (country)	Regulations and laws	Background and purpose
Bandung (Indonesia)	Government Regulation 43/2008 on Groundwater Management	Regulation for the well licensing system, registration of wells and water pricing
Bangkok (Thailand)	Groundwater Act (1977, 1992, 2003)	Regulations on groundwater abstraction to mitigate decline of groundwater levels associated with land subsidence; namely, permission for drilling, designation of no-pumping areas and set-up of the Groundwater Development Fund
Ho Chi Minh City (Viet Nam)	National Technical Regulation on Underground Water Quality (QCVN 09:2008/BTNMT) and several decisions issued by the Ministry of Natural Resources and the Environment (such as 05/2003/QD-BTNMT, 02/2004/CTBTNMT, 17/2006/QD-BTNMT, 13/2007/QD-BTNMT, 15/2008/QD-BTNMT	Regulations on drilling and licensing of exploration and exploitation of groundwater
Hyderabad (India)	Andhra Pradesh Water, Land and Trees Act (2002)	Registration and licensing of groundwater extraction wells used for industrial purposes, registration of rigs, classification of groundwater basins, etc.
Tokyo (Japan)	Industrial Water Law; Law Concerning the Regulation of Groundwater Abstraction for Use in Buildings	Regulation of industrial uses of groundwater; regulation of groundwater use in both residential and commercial buildings

In terms of institutional arrangements, in several of the countries in this study, two or more agencies or ministries exist at the national level for the management of surface water and groundwater resources, while local authorities are responsible for the implementation of relevant laws. However, coordination between these agencies as well as across national and local governments is not always sufficient for satisfactory implementation of control measures. For example, in Viet Nam, four ministries (Natural Resources and Environment; Industry; Agriculture and Rural Development; Transportation and Public Works) have activities related to groundwater management, but weak coordination among them remains a barrier for effective implementation of laws and for data collection in Ho Chi Minh City (see Viet Nam case study, Chapter 7, page 27.

In addition to the regulations highlighted above, several other approaches and measures are being considered to ensure the sustainable use and protection of groundwater resources. Among these are an improved definition of 'sustainable yield' that takes into account the contribution of groundwater to surface water flow and groundwater-dependent ecosystems; assignation of a value to groundwater itself, and pricing the other resources (including energy) needed to pump groundwater in a costing scheme (Kemper, 2007); assignation of groundwater use rights that are adapted to different conditions; promotion of local management of groundwater resources to best respond to local conditions and demands; and a deeper integration of groundwater management into national policy and planning for all sectors to incorporate groundwater conservation and protection measures into their actions and into sound water management.

Acknowledgement

Sangam Shrestha

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2 The Cultivating Good Water programme in the Paraná River basin, Brazil

Abstract

Itaipu Binacional introduced the Cultivating Good Water programme (or CAB) as a response to environmental degradation and as a blueprint for sustainable development in the region where the Paraná River borders Brazil and Paraguay. In 2003, the programme was initiated on the Brazilian side of the Paraná River basin 3, an area that was facing mounting challenges (pollution, deforestation, loss of biodiversity) under intense agricultural activity and from the increasing impacts of climate change. Sharing responsibilities with stakeholders at the basin level through decentralized, participatory management has been at the core of the programme and has paved the way to its success. Under the programme, 63 initiatives with a focused range of targets (e.g. ethical, cultural, social and those relating to the economy and resource efficiency) have been implemented. CAB steering committees have been established by law in all of the 29 municipalities of the programme area; they provide a discussion platform where problems are discussed openly and corrective actions for better water resources management and protection of the environment are agreed upon. Concrete integration of the social and educational dimension of the programme has allowed it to make a drastic change to the business-as-usual scenario that environmental degradation is an acceptable trade-off for economic development. The programme has been under way for 11 years, and it has become a development model that is being implemented in other parts of Brazil, in Latin America and in Africa.

Itaipu Dam is located on a stretch of the Paraná River that draws the south-eastern border of Paraguay with Brazil. These countries joined forces to construct the dam in the mid-1970s and to found and run the Itaipu Binacional. Itaipu Binacional manages the dam's hydropower plant, which commenced operations in the mid-1980s and is the largest in the world in terms of electricity production: in 2013, it produced 98.6 TWh. The plant supplies 17% and 75% of electricity demand in Brazil and Paraguay, respectively.

In 2003, with the change of presidency in Brazil and a new direction promoted for state-owned companies to expand their social and environmental activities within the communities in which they operate, Itaipu Binacional undertook an extensive review of its strategic plan. An understanding grew that Itaipu, because of its importance and influence in the region, could become an important promoter of public policies of the federal government on agriculture, poverty reduction and social inclusion of vulnerable segments of the population (such as small farmers and fishers) and on the adoption of measures to adapt to climate change. Itaipu Binacional therefore expanded its institutional mission and strategic objectives, which were previously restricted to energy production, to focus on finding solutions to environmental and social issues in the area where the Itaipu dam and its reservoir is located. The Cultivating Good Water programme (*Cultivando Água Boa programa* in Portuguese, or CAB henceforth) was launched in the same year by Itaipu Binacional to implement this new mission.

CAB was introduced on the Brazilian side of the Paraná River basin 3 (Figure 2.1), which covers approximately 8,000 km^2 and comprises 29 municipalities with about one million inhabitants in total. Sub-basins form the basic planning units for the implementation of CAB. The agriculture sector is the predominant economic activity in the area: 35,000 small farms producing mainly soybeans and maize, animal farms with more than 1.5 million pigs and 30 million poultry, and agro-industries that are based on these plant and animal products have been established. The agricultural practices in the area have often been unsustainable and have also led to deforestation and pollution. Underlying these problems in the past was the remnant of the colonial view that environmental degradation was an acceptable trade-off for economic development. CAB was first and foremost a response to the looming environmental crisis, but climate change adaptation and water conservation were also proposed areas of emphasis.

For CAB to achieve its goals, a strong social component is necessary (Box 2.1). The overarching principle of innovative governance aims to involve basin communities in the decision-making process. Social inclusiveness is also at the core of the programme in order to improve the overall quality of life for the local people and to embed a culture of sustainability in the behavioural characteristics of the community through a broad process of educational and environmental communication.

The CAB actions undertaken so far target the conservation of water, protection of farmland and forests as well as the adoption of techniques to reduce air, water and land pollution derived from agriculture. These conservation and protection efforts also help mitigate the major impacts of climate change that are already present in the Paraná River basin such as longer periods of drought and a higher number of storm events leading to floods. The corrective actions to reduce pollution include improving rural sanitation and wastewater treatment, reducing pesticide use, planting trees, putting up fences to protect springs and forests, collecting recyclable waste and implementing soil conservation measures (e.g. no-till farming and terracing) (Box 2.2). Since the beginning of the programme, environmental recovery efforts have been completed or have reached an advanced stage in 206 sub-basins, a number corresponding to approximately 30% of the basin area.

FIGURE 2.1

Location of the programme area in the Paraná River basin 3

Environmental education is one of the main pillars of the CAB programme and it is put into practice via ongoing dialogue with all the stakeholders in education forums that are present in all 29 municipalities. Over the 11 years since the launch of CAB, more than 200,000 residents on the Brazilian side of the Paraná River basin 3 have been educated through lectures, conferences and meetings on issues related to water and climate change, environmental ethics and responsibilities, and sustainable development. The Environmental Education Network complements this by offering training courses for all levels of society including teachers and water managers in hundreds of establishments. More than 20,000 people are actively involved in this network, including, notably, numerous youth representatives.

As agriculture is the predominant sector in the Paraná River basin, switching to sustainable agricultural practices is among the main targets of CAB. Under the theme of sustainable rural development, approximately 1,500 family farms have made significant progress in the use of green farming techniques, which have led to reduced carbon dioxide emissions and pesticide use. In the process, 1,200 of these farms have started organic farming and organized themselves into 14 associations. A major result of the switch to green farming has been an increase in farmers' income through successful marketing of 'Organic Life' fairs that are held several times a year in various locations across the region. These fairs have been visited by more than 50,000 local customers. Among the principal consumers of organic food are public schools, where 70% of the meals served are prepared with local organic products. The cooks, mostly women, in these schools are taught about the benefits of organic food. A regional contest has been established with prizes awarded to the best recipes and cooks. This initiative also promotes gender equality by elevating the public recognition of work that is done mostly by women.

CAB also has a target to improve the lives and the income of fishers by reducing extractive fishing. Itaipu Binacional has been supporting fish farming research and development in the reservoir area, benefitting more than 700 small-scale fishers and their families. By adopting net tanks and fish farming techniques, these families have increased their income and enjoy guaranteed production.

The programme fosters improvement in the lives and livelihoods of indigenous Guaraní communities in the region by creating the opportunity for them to raise livestock, to farm corn, cassava and medicinal plants, to grow fruit trees, to build fish farms, and to make arts and crafts and undertake cultural activities.

BOX 2.1

Stakeholder participation in the design and implementation of the Cultivating Good Water programme

The sub-basins for implementation of the Cultivating Good Water programme (CAB) are identified with the community and its leaders and authorities. To engage all the social players in the area, a broad call was made to constitute a steering committee for CAB in each of the 29 municipalities. The steering committees, which are established by law, are like forums that bring together a wide variety of stakeholders such as farmers, teachers, politicians, community and religious leaders, and representatives of federal and state governments and municipal institutions. In committee meetings, the community discusses its priorities, sets the role of its partners, decides how actions will be carried out within its territory, and monitors and evaluates the results of individual projects. There are also management committees for all projects (e.g. environmental education, family farming, medicinal plants and sustainability of indigenous communities). Thanks to this collective and collaborative approach, CAB has more than 2,200 active partners – non-governmental organizations, federal, state and local governments, universities, farmers organizations, workers unions, trade associations, community representatives – involved in all its projects.

In setting out community goals, the Workshops for the Future scheme (*Oficinas do Futuro*) plays an important role in bringing all stakeholders together. An open discussion on the problem leads to a common vision that materializes as a 'water pact'. The pact concludes with a public commitment in which community leaders and the government seal a sustainability partnership and set corrective actions to take place in the watersheds. From 2003 to 2013, 59 such water pacts were established. Representatives of stakeholders from all 29 municipalities join the annual CAB meeting in Foz do Iguaçu, where they discuss strategies, evaluate results and plan activities for the following year.

During the workshops as well through the ensuing water pacts, the families of farmers, principally women, are engaged in the planning and decision-making process. This practice contributes to the empowerment of women and the presence of female leaders in CAB projects; for example, the association of environmental agents of Foz do Iguaçu (Coaafi), the association of farmers of medicinal plants (Gran Lago Cooperative) and the association of farmers of São Miguel do Iguaçu all have female presidents. Women also make up 90% of the managers of environmental education in the municipalities and 40% of the coordinators of the municipal steering committees.

BOX 2.2

Results of water, land and forest conservation actions in Cultivating Good Water programme area

- Five million seedlings of native species planted to recover forests and protect springs
- 1,400 km of fence constructed to prevent cattle from damaging riparian forests and polluting rivers
- 160 water supply facilities established at which to clean tractors and other farming machinery to protect rivers from pesticide run-off
- 189 units of liquid fertilizer (composed of wastewater from animal husbandry) aspersion equipment donated to communities (reducing the need for pesticides and avoiding contamination of water)
- 220 km^2 of terraces built to prevent soil erosion and reduce sediment load in rivers
- 800,000 tonnes of carbon dioxide sequestered through restored forests in the basin and the protected areas of Itaipu
- Geo-referencing of the environmental management of farms and sub-basins, based on agreements with 11 universities

'Biodiversity, our heritage' is a strong theme of CAB. The projects initiated under this broad component seek to conserve and improve the genetic diversity of local species (animals and plants) through research, development and reproduction. By planting more than 24 million trees and protecting species in natural sanctuaries, it has been possible to establish the Santa Maria Biodiversity Corridor, which connects two main sanctuaries of wildlife in Southern Brazil: the Iguaçu National Park (a UNESCO World Heritage Site) in the state of Paraná and the Ilha Grande biome in the state of Mato Grosso do Sul. Another noteworthy initiative is the Piracema Channel, which allows migratory fish species to travel in the Paraná River without the Itaipu Dam forming a barrier.

Overall, CAB now has 63 initiatives conducted under 20 broad themes ranging from environmental education to biodiversity and sustainable rural development to name a few. Thanks to its success, the programme has been widely disseminated and is being replicated in different parts of Brazil as well as in regions of Latin America and Africa.

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Fábio Mendes Marzano, Itaipu Binacional

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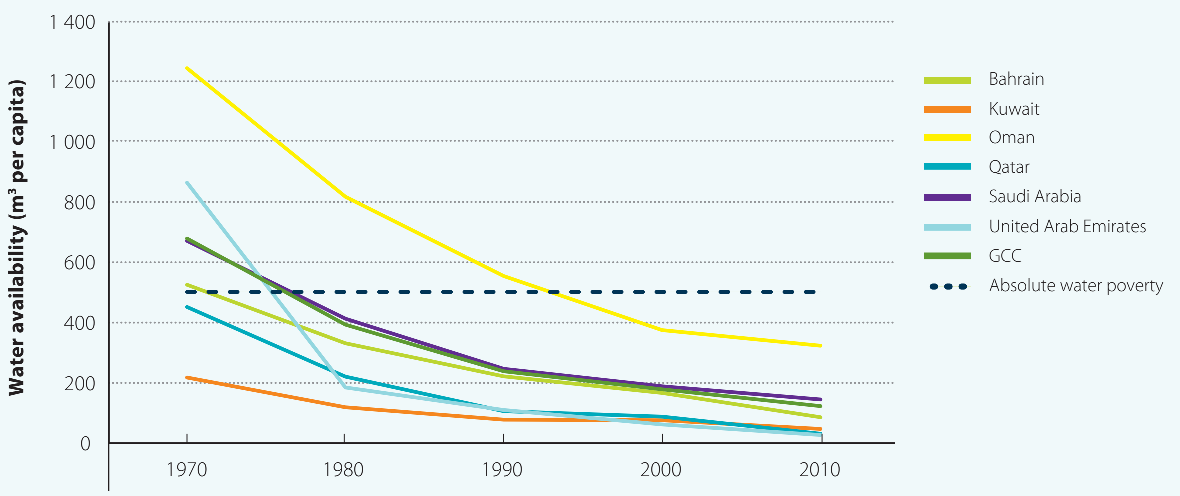
3 Sustainable water resources management in the Gulf Cooperation Council countries

Abstract

While the GCC countries have invested heavily in infrastructure (i.e. desalination plants, treatment facilities, dams and well fields) to increase the provision of water supply, inadequate attention has been given to how efficiently the water is being supplied, used, recycled and reused. To be able to move towards sustainable water use, there is an urgent need to reconsider the existing traditional supply-side management approach in all sectors and to raise awareness in society so as to reduce irrational water use. Furthermore, under the currently prevailing general subsidy system, it is becoming crucial for GCC countries to focus on improving water efficiency to achieve maximum productivity per cubic metre consumed. Some promising actions are being taken on the ground, but the enhancement of water efficiency is yet to become a major priority in the water management policies and agenda of the countries in the region.

The Gulf Cooperation Council (GCC) countries, Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates, are located in an arid region where sustainable water provision for all needs is a complex, challenging task. The complexity stems not only from limited water availability but mainly from escalating demand in every sector, resulting from fast-paced socio-economic development, efforts to increase food production, urbanization and rapid population growth - population has increased from about 14 million to 30 million over 20 years (1980 to 2010). As a result, the average per capita freshwater availability decreased from approximately 600 m^3 per year to 160 m^3 per year, which is well below the absolute water poverty line of 500 m^3 per year (Figure 3.1). The total water use for all sectors in the region increased from about 6 billion m^3 in 1980 to about 26 billion m^3 in 2010. Agriculture is the major component – with an average of 80% – of the total water demand in the GCC countries (Table 3.1). Consequently, the GCC countries are facing increasing water scarcity and water supply costs, which both pose real threats to their further development.

FIGURE 3.1 Per capita water availability trends in the Gulf Cooperation Council countries (1970-2010)



Source: Adapted from The World Bank (2005).

The challenge of providing water to meet all needs is expected to grow over time because of many pressing drivers, including climate change and the prevailing general subsidy system. In the majority of the GCC countries, the focus of water management has been supply-side measures through the development of new and costly resources, such as seawater desalination, to reduce the expanding gap between water availability and demand. Centralized water management at the national scale, fragmentation of institutions managing water resources and sectoral approaches in many countries have caused substantial financial, economic, environmental and social costs. Improvement of water efficiency in all sectors is critical to tackle the challenge and make progress towards sustainable use of scarce resources.

The challenge is compounded by the fact that in the GCC countries water efficiency is generally very low on both the supply and the demand sides. On the supply side, for example, the physical leakage component of the non-revenue water[1] in the municipal networks can be as high as 40%, which is at odds with the high cost (US$1-2 per m^3) incurred in producing desalinated water. Moreover, water recycling is limited: treated wastewater on average does not exceed 50% of total domestic water use, and the reuse rate is less than 40% of the treated volumes. On the demand side, per capita water consumption in the domestic sector in many GCC countries exceeds 500 litres per day, which ranks among the highest figures in the world. Furthermore, in the agriculture sector, the predominance of inefficient irrigation practices leads to the loss of more than 50% of irrigation water applied. Similarly, in the industrial sector, processes are not optimized to reduce water use and recycling efforts are negligible. Overall, recent efforts to enhance water efficiency have yet to become a priority in the political agenda of the GCC countries. However, some promising actions are being taken, as highlighted in the sections below.

1 Non-revenue water is the difference between the volume of water put into a water distribution system and the volume that is billed to customers. Non-revenue water comprises three components: real losses (through leaks, sometimes also referred to as physical losses), apparent losses (through theft, metering inaccuracies, data-handling errors, etc.) and unbilled authorized consumption.

3.1 Reduction of non-revenue water

While the water supply utilities in the GCC countries demonstrate high performance in providing reliable and uninterrupted service to their clients, the share of real losses (i.e. leakage) in non-revenue water is high in some of these countries. In Saudi Arabia, for example, it is estimated to be 20-40%, and in Bahrain, 30%. The situation has led to significant financial losses as well as problems associated with urban water logging.

However, all the GCC countries have now turned their attention to the losses in the municipal distribution network and have made progress in bringing these down to 10-15%, the level of acceptable international norms. In Qatar, the average non-revenue water level decreased from 59.1% in 2007 (real losses equal 33.6%) to 19.6% in 2012 (real losses equal 6.8%). Kuwait and the United Arab Emirates have reported reductions in non-revenue water of 5% and 7%, respectively.

3.2 Industrial water and wastewater management

In the GCC countries water consumption in the industrial sector has been increasing alongside product diversification policies to lower economic vulnerability to price fluctuations in oil and gas. The total water consumption in the sector increased from about 321 million m^3 in the mid-1990s (representing about 1.3% of the total water consumption) to more than 1.3 billion m^3

TABLE 3.1

Water consumption by sector in the Gulf Cooperation Council countries (2010)

Country	Municipal		Industrial		Agricultural		Total million m^3
	million m^3	%	million m^3	%	million m^3	%	
Bahrain	231	51.3	29	6.4	190	42.3	450
Kuwait	646	54.8	20	1.7	513	43.5	1 179
Oman	182	10.0	94	5.2	1 546	84.8	1 822
Qatar	370	56.7	22	3.4	261	39.9	653
Saudi Arabia	2 283	13.1	753	4.3	14 410	82.6	17 446
United Arab Emirates	983	21.4	477	10.4	3 140	68.2	4 600
Total	**4 695**	**18.0**	**1 395**	**5.3**	**20 060**	**76.7**	**26 150**

in 2012 (about 5.3% of the total water consumption). The water requirement of the industrial sector is mainly satisfied by groundwater (96%) and complemented by desalinated water.

Given the competing demands from other sectors, measures are being taken by many GCC countries to effectively manage industrial water consumption and to limit the impacts of industrial discharges. For example, in Bahrain, subsidies for industrial water use from the municipal water supply network have been set to be gradually lifted to represent the full cost of water provision by the year 2015. Similarly, in Oman, the tariff for industrial water consumption from the municipal network has been placed at approximately US$1.7 per m^3, which is higher than the tariff for domestic water use (about US$1 per m^3).

3.3 Water use and policy reform in the agriculture sector

The agricultural development policies aiming for food self-sufficiency without a corresponding clear priority on water use efficiency have led to excessive water use in the sector. In particular, the lack of water tariffs for groundwater has resulted in the predominance of traditional irrigation methods and the cultivation of water intensive crops, both of which are the culprit of high water consumption in agriculture. Flood irrigation is used on 72% of the agricultural lands in Bahrain, on 63% in Kuwait, 60% in Oman and 75% in Qatar. The use of such traditional methods with low irrigation efficiency leads to high water losses, reported at 25-40%. In Oman, it is estimated that losses from the distribution network and flood irrigation methods amount to 40%. The United Arab Emirates has expanded its use of modern techniques for irrigation by providing loans and technical support to farmers. Consequently, the proportion of irrigated land equipped with modern irrigation methods (e.g. drip, sprinkler) has reached about 90% (2,100 km^2) in the country. This has generally achieved 40-60% savings in water use (as high as 90% in the vicinity of the capital Abu Dhabi). Moreover, the use of greenhouses in the United Arab Emirates increased significantly, reaching a total area of 5 km^2.

The use of groundwater for agriculture is free of charge in GCC countries. Moreover, in most of the countries there are no flow meters installed in wells, which makes it difficult to monitor and control groundwater abstraction. Consequently, intensive and unsustainable water use for irrigation (94% on average of which is withdrawn from groundwater) has led to the fast depletion of some fossil (non-renewable) aquifers and damaged the others through increased salinity. To curb this negative trend, in Oman, authorities completed a national well inventory and collected data on technical specifications (i.e. well depth) and licence authorization. Wells that had been drilled after 1991 without a licence were closed at the cost of the owner, and a fine was levied.

To protect groundwater from further deterioration, some of the GCC countries, for example Bahrain, have been pursuing a policy of expansion in the use of treated wastewater for irrigation. Similarly, the use of treated wastewater in irrigation has been increasing progressively in Kuwait, Qatar and the United Arab Emirates as treated wastewater often has a lower salinity than groundwater. Saudi Arabia revised its agricultural policies after irrigation water demand increased from about 0.7 billion m^3 in 1975 to over 23 billion m^3 in the late 1990s, when wheat production reached 4 million tonnes per year. In 2000, the food self-sufficiency policy went through a major review in the country, encouraging the use of water efficient irrigation technologies such as drip irrigation and soil moisture sensing equipment. As a result, wheat production was phased out, land distribution ceased and subsidies (e.g. for gasoline and electricity prices; credits for buying water pumps and irrigation equipment; exemptions on tariffs on imported fertilizers and equipment; protection against foreign competition in the domestic markets) were reduced. These actions have resulted in a general decrease in irrigated areas and in groundwater abstraction (about 17.5 billion m^3 in 2012) in Saudi Arabia. This achievement will contribute to the sustainability of groundwater resources.

Acknowledgement

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River contracts for sustainable development in the Italian context: The Serchio River case study

4

Abstract

A river contract is a participatory management tool for the protection of rivers, restoration of the environment and better planning of land use. In Italy, river contracts are becoming more common, with the participation of basin, regional, provincial and municipal authorities as well as other stakeholders. The strength of river contracts lies in their prioritization of direct consultation with this broad stakeholder group. Projects under these contracts are carried out through public-private partnerships for better efficiency of implementation and to enable job creation. Collective governance is increasingly associated with successful efforts for sustainable development, and the Serchio River contract, which involved more than 270 stakeholders in its planning phase, is one such successful example from the Tuscany region. It has a number of notable achievements such as redefining rules for urban development in harmony with nature and the river and involving farmers in protection of the environment.

The European Union Water Framework Directive[2] (adopted in 2000) identifies the river basin as a natural geographical and hydrological unit for the implementation of integrated water resources management policies. The Directive also asserts consultation with and active participation by citizens at the relevant level in the choices to be made relating to issues such as agro-ecology balance, land use planning and water management. However, defining the hydrographical basin as the ideal spatial scale of management may not necessarily adapt well to the particularities of an area and above all may not be accepted by all the political and economic powers of the basin in question (Guerra, 2013). It has been suggested that rather than one formal agreement at the basin scale it may be more appropriate to identify the territories (e.g. sub-basin, or two or more basins together) most concerned by a specific problem and to create organizations or ad hoc agreements accordingly (Blomquist, 2008). This approach underlies the logic that enabled the creation of river contracts in search of effective solutions for the recovery of river basins.

In the Italian context, river contracts are progressively gaining more importance for the integrated management of water resources and for reversing the current planning model, which focuses on urban growth. In Italy over the past 40 years an area equal to the Lombardy, Liguria and Emilia-Romagna regions combined has been urbanized at a rate of 85 km^2 per year. Unless this trend is curbed, the land transformation rate is estimated to reach as high as 0.75 km^2 per day (approximately 300 km^2 per year) by 2020. This will lead not only to systematic destruction of the natural environment but also to increased risk of floods because of the exploitation of floodplains and other vulnerable areas. From 2000 to 2012, floods in the European Union caused an average annual loss of about US$5.7 billion*, an amount that could grow to US$27.3 billion* by 2050. In Italy, emergency interventions related to flooding equate to approximately 0.7% of the gross domestic product (GDP) (Bastiani, 2011). Climate change and increasing climatic variability are likely to worsen the situation. To curb high urbanization rate, flooding and related problems, the projects implemented under river contracts encourage the establishment of a better balance between the use of land and water resources by promoting urban policies that focus on water quality, hydrogeological risk prevention, containment of land exploitation, and overcoming sectoral visions and interests.

River contracts respond to the need for introducing new forms of governance that are sought by European directives and guidelines for the public administration to implement integrated management of water, land and landscape[3] in a shared and subsidiary manner. River contracts prioritize the participation of basin, regional, provincial and municipal authorities as well as other stakeholders. Collective governance

2 Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy.

3 The European Landscape Convention defines 'landscape' as "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors" (COE, 2014). Landscape, therefore, has diverse characteristics ranging from areas of ecological importance to dryland and urban areas to farmland.
* European Central Bank exchange rate: EUR 1 = US$1.16 -- (January 2015).

such as this is increasingly associated with successful efforts for sustainable development. Local communities lie at the centre of such governance; they are the main actors in protecting rivers as collective resources, stopping the degradation and disappearance of natural landscapes, maintaining biodiversity and the environment, and achieving more efficient use and sustainable management of these valuable resources (Martini and Soccodato, 2012).

Lombardy and Piedmont were pioneering regions, implementing a number of river contracts for the protection of spring systems, environmental rehabilitation of flood detention basins, enhancement of secondary hydrographic networks (e.g. channels, creeks) and improvement of agricultural systems.

In Piedmont, the river contracts introduced in 2007 through the regional Water Protection Plan now concern not only rivers but also some major regional lakes. Furthermore, the Region has introduced specific measures in its Rural Development Plan for an integrated river and agriculture management policy. In Italy, the creation of the National Table of River Contracts the same year (2007) provided crucial support for the development of other river contracts, as it became possible to coordinate efforts and compare experiences to build a culture of collective governance. The Italian Ministry for the Environment, Land and Sea and the Italian Institute for Environmental Protection and Research (ISPRA) jointly promoted the recognition of river contracts as a management tool for the protection of rivers within the national legislative framework.

FIGURE 4.1 **Serchio River basin and the project area of the Serchio River contract**

The initial river contracts have led to similar efforts in regions of central and northern Italy (Abruzzo, Emilia-Romagna, Umbria, Tuscany and Veneto) as well as in the south (Basilicata, Calabria, Campania, Puglia and Sicily). In the Veneto, contract projects are underway in the Marzenego, Piave and Meolo rivers, and an estuary contract has been initiated for the mouth of the Po, Brenta and Adige rivers focusing on the complex interaction of inner, transitional and marine-coastal waters. In the Abruzzo region, initial contracts cover the Tordino River and the gorges of the Sagittario River. The regional government has added river contracts to the mandate of the Regional Agriculture Councillor, thus confirming the Abruzzo authorities' intention to initiate other river contracts. Emilia-Romagna has a broader approach to river contracts. For example, the Panaro River is covered by a landscape contract,[4] and the river contract for the Marecchia River, by being included in the Strategic Plan for the Province of Rimini, has aspects of a development plan. River contracts in Umbria are oriented towards landscape recovery (Bastiani, 2014). For example, the Paglia River contract proved to be the main tool for the revival of the areas at Orvieto that were affected by severe floods in 2012. In Tuscany, river contracts are promoted by the Regional Government and local authorities and are linked to river basin management plans (as in the case of the Serchio Valley, elaborated in the following paragraph), but spontaneous contracts are also derived from citizen actions (e.g. the park built around Valdarno Empolese river to protect the environment and to harmonize aspects of the landscape).

4 A landscape contract aims to establish a balance among natural, urban and peri-urban areas to protect the environment, to create recreational areas rich with activities, and to establish a scenic landscape.

Serchio is the third longest river in Tuscany, flowing over a distance of 126 km mainly in the Province of Lucca. The project area of the Serchio River contract (Figure 4.1) is a 37.5 km length that is located in the middle reaches of the river between Ponte di Campia (Municipality of Barga) and the Sant'Ansano bridge in the Ponte a Moriano area (Municipality of Lucca). The residential areas along this stretch of the river are historically positioned along the ridges or halfway up the hills, but since the 1950s they have expanded to the bottom of the valley, leading to the saturation of significant parts of the flat terraces, in some cases including floodplains. The tendency of the settlements to concentrate at the bottom of the valley instead of exploiting other possibilities offered by the topography of the area has created congestion and infrastructure problems. Industry (particularly paper mills) is also localized along the river and has a tendency to extend to the riverbed. Residential zones and industrial areas occupy approximately 13% and 7%, respectively, of the basin (a total of 20%).

The river contract for the Serchio River aims to curb landscape and ecosystem degradation and to rehabilitate land in various sub-basins. The first pilot project focused on the mid-section of the Serchio Valley. In order to ensure a comprehensive participatory process, a large number of potential stakeholders were initially identified. The Territorial Planning Office of the Province of Lucca concluded that approximately 270 of these (including 12 national public institutions, 40 regional public institutions, 64 local public institutions, 30 media agencies, 11 university departments and 13 higher education institutes) were capable of effectively contributing to the process. The Territorial Planning office held a consultation meeting in February 2012 in which it presented to stakeholders and invited

BOX 4.1

Empowering farmers as guardians of the river

'Farmers: The Guardians of the River' is a pilot project designed to determine and implement best practices applicable to the specificities of the Serchio River contract project area to revive habitats that are no longer present because of excessive transformation of the environment by human activities (anthropization). The objectives are to increase the effectiveness of environmental reclamation while minimizing costs; manage environmental damage prevention and early intervention, even in areas where accessibility is low, through the involvement of local people; and encourage farmers to stay in the area by empowering them as the 'Guardians of the River'.

In spite of limited investment and financial resources, the project has had a number of successes, including:

- Contributions from European Union rural development funds for projects to clean streams (located at an altitude of 600 m and above) from excessive vegetation;
- Monitoring and reporting environmental issues at different scales;
- Planification of appropriate, timely and cost-efficient interventions; and
- Incentivization of agroforestry.

The project has strengthened the concept of multi-functionality in agriculture by building collaboration between farmers and relevant institutions for a mutually beneficial partnership: the farmers are financially rewarded for benefits generated by environmental protection while their involvement in data collection and information sharing helps timely measures to be taken to protect rivers and land resources in a cost-effective manner.

elaboration on targets related to river restoration, protection of water quality, flood control and prevention, and boosting tourism and the local economy sustainably. Two subsequent meetings were directed towards building a long-term sustainable development vision, designing plausible scenarios and identifying projects required to achieve the overarching targets. An action plan and a memorandum of understanding with the local community and stakeholders was presented in a final meeting in April 2012, where 44 projects (to be implemented through public-private partnerships) were each assigned a degree of priority. Some projects were structural measures (such as construction of retention basins for flood control), while others were 'soft' measures (such as education and training and information collection and sharing). The major results of the contract so far have been an updated Territorial Plan of Provincial Coordination for controlled urban development in harmony with nature and the river, structural measures to reduce flood risk, biking and walking trails on an interprovincial scale to boost tourism, and the involvement of farmers in protection of the environment (Box 4.1).

Acknowledgements

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Challenges to freshwater security in the Pacific Small Island Developing States: Focus on saltwater intrusion in Samoa

5

Abstract

Pacific Small Island Developing States (SIDS) are facing mounting challenges to protect and efficiently manage their limited freshwater resources. There are many facets to ensuring freshwater security in SIDS, which the Samoa case study illustrates. Among these, saltwater intrusion into aquifers stemming from climate change and human-related causes is emerging as a critical challenge. Although they are broadly acknowledged, gaps in data prevent a reliable and detailed assessment of the country's current vulnerability to this problem and its extent. In response, the integrated water management and governance frameworks have been significantly improved. However, the complex setting, where traditional and legal structures are intertwined, and fragmented water governance hinder the decision-making process. The scale of future water-related challenges will depend on how well the current commitments set in national strategy documents are translated into actions and on better enforcement of legislation. Investment and enhancement of human and technical capacity related to water science and resources assessment and sustaining national public awareness campaigns need to be considered key priorities in this process.

Despite their diversity in geography, geology and population density, Pacific Small Island Developing States (SIDS) face a range of common natural, financial and human capacity-related challenges in providing adequate water, in terms of both quantity and quality, to their populations. Saltwater intrusion, the penetration of seawater into coastal aquifers and bodies of surface freshwater, is one of these shared issues. It is particularly relevant and an increasing challenge for some island states; for example, Samoa, where 35% of the water supply is drawn from aquifers. Though it is widely acknowledged, saltwater intrusion remains a poorly researched and documented phenomenon in the Pacific region. Of perhaps even more serious concern in the Pacific SIDS are issues related to the reliable assessment and proper management of water resources, a situation that creates a hindrance to building resilience and alleviating poverty.

While contributing only marginally to greenhouse gas emissions, Pacific SIDS bear the effects of climate variability and change to a disproportionate degree through sea level rise, ocean acidification, intensification of water-related natural hazards, and altered temperature and precipitation patterns. These changes endanger freshwater supply and access on these island states, which have limited and vulnerable resources. Tropical cyclones and storm surges, which are expected to increase in intensity in the near future (IPCC, 2014*a*), destroy water storage and management facilities and provoke floods and saltwater intrusion, causing brutal water crises. An example of such a crisis is the state of emergency that was declared in the Federated States of Micronesia after it was hit by exceptionally high tides (augmented by local weather patterns and ocean conditions) in 2007. But slow-onset events also pose problems; for instance, sea level rise is expected to have significant impact on financial assets in SIDS like Samoa, where major infrastructure and 70% of the population is located in the low-lying areas that are highly exposed to water-related disasters such as tsunamis. Sea level rise will also intensify coastal erosion, flooding and saltwater intrusion in flat coastal areas on islands and atolls in the near future (IPCC, 2014*b*).

Weather patterns such as El Niño[5] and La Niña[6] periodically produce wet and dry climate cycles that can lead to, depending on the location of an island, extreme events such as abundant rainfall episodes or intense periods of drought, limiting safe drinking water availability. Drought is a particularly crucial issue for those Pacific SIDS that are strongly reliant on rainwater and have limited groundwater resources at their disposal. These include states located on atolls such as Kiribati, Nauru, the Marshall Islands and Tuvalu. In 2011, Tuvalu and Tokelau both declared a state of emergency due to drought.

5 El Niño is a warming of the sea temperature associated with changes in the atmospheric circulation in the tropical Pacific and worldwide. It usually occurs every two to seven years, causing drought in most Pacific SIDS (NOAA, n.d.).

6 La Niña is associated with cooler than normal sea water temperatures in the Equatorial Pacific Ocean and its impacts tend to be the opposite of El Niño (NOAA, n.d.).

Human induced dynamic pressures resulting from economic growth as well as increasing population introduce further complexity to safeguarding freshwater resources. The culmination of flooding, drought, sea level rise, growing consumption and other factors is an increased vulnerability to saltwater intrusion for the Pacific SIDS (Figure 5.1). Table 5.1 summarizes of observed and expected vulnerabilities and challenges for freshwater associated with saltwater intrusion in selected Pacific SIDS.

In the remainder of this case study, Samoa serves as an example of the Pacific SIDS in the context of freshwater security, with particular emphasis on saltwater intrusion.

5.1 Saltwater intrusion in Samoa

Samoa has two main islands (Upolu and Savai'i) (Figure 5.2), which together have about 180,000 inhabitants. As in other Pacific SIDS, sea level rise and recurrent droughts and floods are among the key triggers for the challenges of unreliable water supply and poor quality water through saltwater intrusion.

Samoa relies on both surface water, which meets about 65% of the demand, and groundwater, which meets about 35%. However, during the dry season, surface water reserves are gradually exhausted and become insufficient in some parts of the islands. To cope with the situation and to boost water availability, the Samoan Water Authority and the private sector have been increasing their groundwater abstraction (Samoa Ministry of Natural Resources and Environment, 2013*a*). Although there is a lack of data on (current and future) water demand and supply, surface water and groundwater use is generally forecasted to rise in response to population growth,[7] hydropower generation and demands of other sectors (mainly

7 The annual population growth was 0.64% between the two last censuses (2005 and 2011). The Samoan Bureau of Statistics has predicted the annual population growth rate to be between 0.7% and 1.5% between 2011 and 2021 (Samoa Ministry of Natural Resources and Environment, 2013a). These data should be interpreted with caution considering the uncertain and varying influence of emigration in the country.

FIGURE 5.1

Possible causes of saltwater intrusion

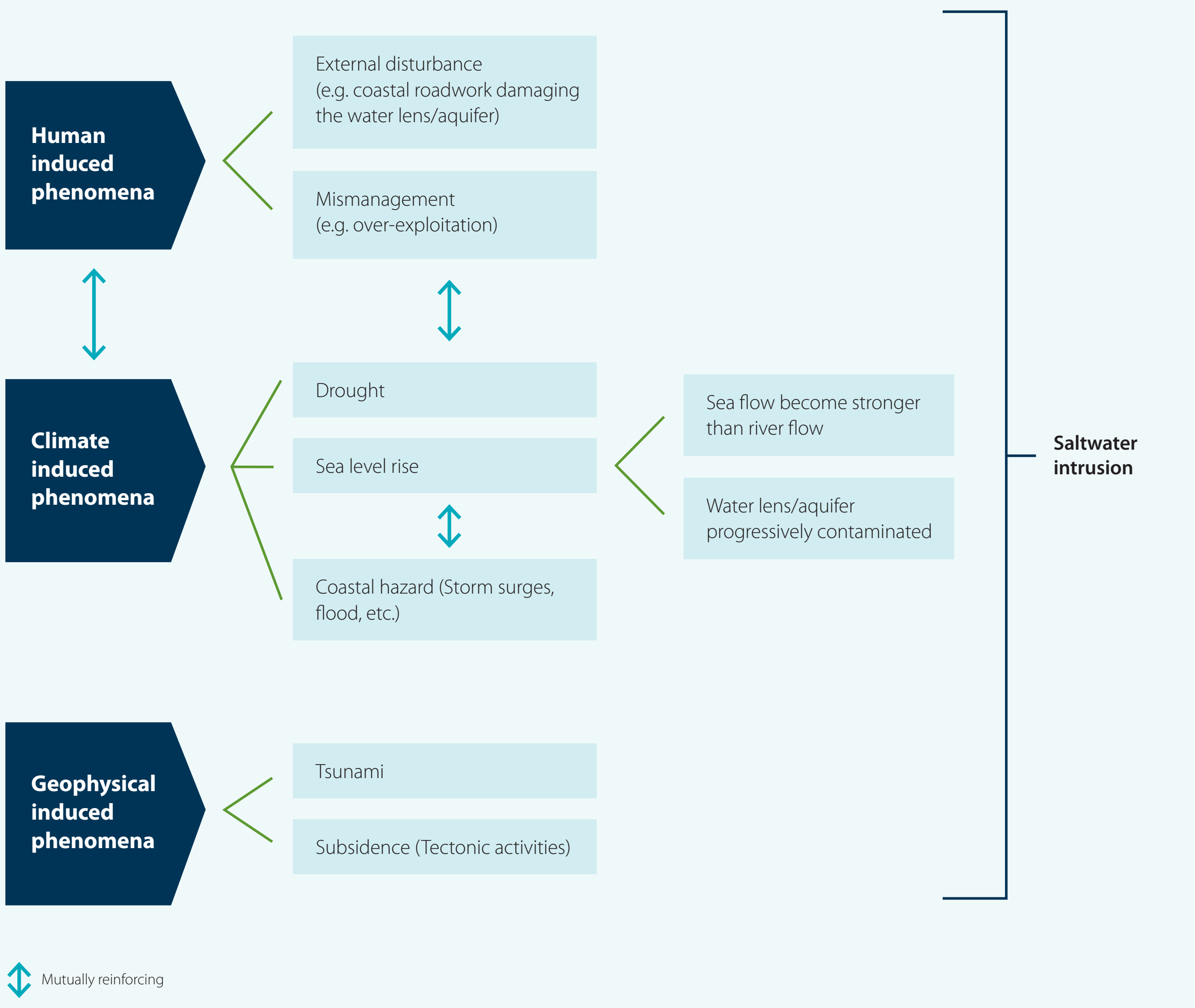

TABLE 5.1

Observed and expected saltwater intrusion in selected Pacific Small Island Developing States

Country	Topography/ fresh-water resource	Saltwater intrusion reporting[a]
Solomon Islands	Coral atolls, volcanic islands/surface water, rainwater and thin groundwater lenses (SOPAC, 2007*a*)	**Observed intrusion:** 'Salt-water intrusion, storm surge and flooding in low-lying coastal areas of the main islands and the atolls such as Ontong Java are already threatening food crops and livelihoods.' (Solomon Islands Ministry of Environment, Conservation and Meteorology, 2008)
		Expected intrusion: 'Studies suggest that hundreds of small islands could permanently inundate and their cultural heritage be lost in the event of a one meter sea-level rise. Intrusion of salt water from rise in sea level affects groundwater resources, especially small atolls and low-lying islands which rely on rainfall or groundwater for water supplies.' (Solomon Islands Ministry of Environment, Conservation and Meteorology, 2008)
Marshall Islands	Atolls/rainwater (SOPAC, 2007*b*)	**Observed intrusion:** 'During the most recent El Niño event (1997-1998), many in the community were forced to use the ocean to bathe and to drink the groundwater. In some situations this source of water was polluted due to: salt water intrusion of groundwater resources; sewerage and sullage discharges entering the groundwater aquifers; proximity to burial sites; and materials being leached from animal droppings and domestic solid waste.' (Marshall Islands Environmental Protection Authority, 2000)
		Expected intrusion: 'Public health and nutrition problems may arise from the intrusion of salt water and the general reduction in the quality of the ground water resources of the more highly populated atolls.' (Marshall Islands Environmental Protection Authority, 2000) 'Future changes in climatic conditions are likely to affect water supply and quality in the following three major ways. First, through a rise in sea level that may increase problems of salt water intrusion to the ground water system.' (Marshall Islands Environmental Protection Authority, 2000)
Cook Islands	Volcanic islands, coral atolls/surface water (southern group of islands); rainwater and groundwater (northern group of islands) (SOPAC, 2007*c*)	**Observed intrusion:** 'There is no chemical water treatment on any of the [Southern group of] islands thus water quality is non-potable and often brackish indicating that exploitation of the water lens is at the limit of sustainability, with saltwater intrusion an increasing threat.' (Cook Islands Government, 2000)
		Expected intrusion: 'Despite limestone cliffs separating the agricultural areas, the sea storm surges and cyclones can still lead to salt-water intrusion into the low-lying swampy areas. Base line salinity levels still need to be established; however it is clear that any sea level increase is going to be an issue for the island of Mangaia and other makatea type islands.' (Cook Islands Government, 2000)
Samoa	Volcanic islands/ surface water and groundwater (SOPAC, 2007*d*)	**Observed intrusion:** 'Water resources are particularly vulnerable to the effects of climate change. Significant problems associated with climate change include: salt water despoiling ground water and coastal springs as sea levels rise.' (Samoa Ministry of Natural Resources and Environment, 2010)
		Expected intrusion: 'The risk of saltwater inundating groundwater is expected to increase as sea levels rise. The recharging of groundwater is expected to lessen as annual rainfall lessens. Rising sea levels will also affect coastal springs as current boundaries become flooded.' (Samoa Ministry of Natural Resources and Environment, 2010)
Tuvalu	Atoll islands/rainwater and groundwater (SOPAC, 2007*e*)	**Observed intrusion:** 'The most damaging effects of climate change are tropical cyclones, coastal erosion, salinity intrusion and drought. These have been noted to affect crops, fruit trees and human livelihood.' (Tuvalu Ministry of Natural Resources, Environment, Agriculture and Lands, 2007) 'Groundwater resources have been polluted by saltwater intrusion and waste leachate. Therefore, they are no longer suitable for human consumption.' (Tuvalu Ministry of Natural Resources, Environment, Agriculture and Lands, 2007)
		Expected intrusion: 'Intrusion of saltwater in Tuvalu will also affect ground water availability for plant growth, and food crop productivity and security.' (Tuvalu Ministry of Natural Resources, Environment, Agriculture and Lands, 2007)

[a] *Because of a general lack of assessment capability and capacity, only a few Pacific SIDS provide data and information as evidence for saltwater intrusion.*

tourism[8] and to some extent industry[9]). Under this growing pressure, the saline contamination of some aquifers and coastal springs, which are not, however, spread evenly throughout the country, is emerging as a very serious challenge in Samoa.

Rethinking water management is one of the most prevalent and substantial challenges for the Pacific SIDS to build water resilience. The Samoan authorities have made major efforts to improve their water governance framework and institutional arrangements (Box 5.1). For example, the Water for Life sector plan (2012-2016) identifies good water management as fundamental for socio-economic development and preservation of ecosystems (Samoa Ministry of Natural Resources and Environment, 2012). To bolster these efforts, the continued need for improvements in the face of current and imminent challenges has been recognized by the Samoan national authorities and is reflected through important strategy documents such as the *Strategy for the Development of Samoa 2012-2016* (Samoa Ministry of Finance, 2012) and the *National Environment and Development Sector Plan 2013-2016* (Samoa Ministry of Natural Resources and Environment, 2013*b*), where water-related plans feature prominently.

The Samoan authorities benefit from media exposure to raise community awareness on water conservation. However, public recognition of groundwater as a vulnerable resource is still low. Furthermore, saltwater intrusion, while acknowledged, seemingly does not constitute an issue of high importance in terms of government priorities. This general attitude is evident from the lack of water data and statistics, particularly for groundwater: out of around 60 existing production boreholes, only 14 of them are monitored. Examples from other Pacific SIDS clearly demonstrate that data availability improves the overall water management and decision-making process (Box 5.2). To fill the information gap and deal efficiently with the current and imminent challenges, resources – financial but above all human – need to be enhanced in Samoa.

8 Tourism, a sector that consumes large amounts of water, is playing an increasingly important role in the economy (20% of the GDP in 2012) and the government's objective is to increase the number of tourists by 5–7% per year until 2016 (Samoa Ministry of Finance, 2012).

9 The largest water consumption by industry in the country is from beverage factories (the brewery, various water bottling companies and the coconut factory).

FIGURE 5.2

Reported cases of saltwater intrusion in Samoa

BOX 5.1

Participatory water management in Samoa

While 80% of the land in Samoa is customary and de facto under the direct stewardship of the traditional authorities, the State's perceived ownership of water resources is a rather controversial topic. To manage conflicts and mitigate their impacts, the Independent Water Schemes Association (IWSA) was established in 2008. The IWSA aims to provide safe and reliable water supply to communities and serves approximately 17% of the Samoan population (Samoa Ministry of Natural Resources and Environment, 2012). This entity also acts as a facilitator and mediator between the government and communities. Efforts have been made to reach the entire community, with a special focus on women. At the household level, women usually play a key role in water management but remain traditionally excluded from most of the decision-making process (Samoa Ministry of Natural Resources and Environment, 2012). To overcome this contradiction, the IWSA has instituted a requirement for village water committees to have at least two female members. This represents an important step towards a more participatory water management approach.

Much has also been done to enhance cooperation and coordination between different governmental agencies that are involved in water management. The establishment of the Joint Water Sector Steering Committee (JWSSC) in 2009 is an instance of such consolidation. The JWSSC is a high-level committee[a] consisting of chief executive officers that meets quarterly, attended by the Chamber of Commerce, the Samoa Umbrella of Non-governmental Organizations, the IWSA and high level representatives of concerned ministries.[b] Through these meetings, the JWSSC coordinates the implementation of reforms and provides leadership, policy guidance and monitoring for the water sector (Samoa Ministry of Natural Resources and Environment, 2012). These changes allow for permanent coordination while reinforcing already existing ad hoc cooperation between ministries. The reorganization prevents water issues being addressed in isolation and stands as an operational way to make and implement decisions collectively.

[a] *According to the water sector institutional framework, the JWSSC acts between the Cabinet and the ministries.*
[b] *Ministry of Natural Resources and Environment, Ministry of Works, Transport and Infrastructure, Ministry of Women, Community and Social Development, Ministry of Agriculture and Fisheries, and Ministry of Finance.*

BOX 5.2

Data and monitoring to enhance resilience in the Marshall Islands

Small and low-lying islands usually depend on limited aquifers that are vulnerable to saltwater intrusion during periods of drought because of a sharp increase in pumping. Majuro Atoll (Marshall Islands) experienced such a scenario during El Niño in 1997-1998. The daily groundwater withdrawals nearly tripled to counteract the drought and the freshwater shortage. In cooperation with the United States Geological Survey, island authorities installed boreholes to monitor the status of the shallow aquifers to prevent saltwater intrusion (which has a direct impact on crop production through irrigation) caused by unsustainable pumping rates. This case highlights that assessment and monitoring are essential tools for water security by enhancing the ability of authorities and the population to respond, mitigate and adapt to potential similar situations.

Source: Keener et al. (2012).

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Water recycling in Singapore

6

Abstract

Since independence, Singapore grasped the necessity for diversification of its water supply to be able to meet future needs. While plans for water recycling emerged in the 1970s, cost and reliability concerns then suspended such activities until the maturation of membrane technology in the 1990s, allowing Singapore's national water agency to revisit its plans for water recycling. In 2000, a full-scale demonstration plant was commissioned. This was followed by a comprehensive water sampling and analysis programme to determine the feasibility and dependability of water recycling for potable use. The first two water recycling plants were opened in 2003, accompanied by an awareness-raising and educational campaign to inform the public about the safety and purity of recycled water, branded 'NEWater'. Thanks to continual investments by the government in water research and development and strong political will to achieve long-term water sustainability as well as national resilience against water scarcity, NEWater was successfully introduced and accepted by the public.

Singapore is a city state with an area of 710 km^2 and about 5.5 million inhabitants. It receives abundant rainfall (2,400 mm per year). However, because of the limited land for the collection and storage of rainwater, the high evaporation rate and the lack of groundwater resources, Singapore is considered water scarce. Consequently, it has been heavily reliant on water imported from neighbouring Malaysia under long-term agreements signed in 1961 and 1962. The first agreement expired in August 2011 and the second agreement will expire in 2061. When Singapore became an independent nation in 1965, the political leadership accorded high importance to providing safe water at an affordable price to the increasing population and to meeting the water demands of all sectors. In the 1970s, rapid growth of industries and residential estates placed increasing pressure on scarce land and water resources in Singapore. This compelled the National Water Agency (PUB) to not only develop local water sources and increase reservoir storage capacity but also look for innovative ways to diversify the sources of freshwater.

The Water Master Plan, adopted in 1972, outlined plans for a diversified water supply, including recycled and desalinated water, to meet future needs. PUB accordingly established a water recycling pilot plant in 1974, which was successful in showing that high quality drinking water could be produced by treating wastewater. However, high costs and concerns about reliability of membrane technology led to a decision to temporarily suspend plans for water recycling.

By the late 1990s, membrane technology for water recycling had become sufficiently reliable and cost-efficient to operate and maintain. PUB commissioned its first demonstration plant in 2000 and initiated an in-depth study on the suitability of recycled water, now being called NEWater, for potable use and use in industry. It was demonstrated that because of its purity, NEWater would allow cost savings in manufacturing processes (such as wafer fabrication in the semi-conductor industry) by eliminating the need for pre-filtration of tap water. This convinced industrial water users to choose NEWater for their ultra-clean water requirement. The results of more than 20,000 tests carried out on approximately 190 water quality parameters showed that NEWater was purer than tap water and well within internationally accepted standards for drinking water. Based on these findings, the Government decided to utilize NEWater not only for direct non-potable use (e.g. for industry) but also for indirect potable use, which involves blending a small amount of NEWater into water reservoirs of the city. The NEWater is thus treated through the conventional water treatment process: while NEWater is safe for direct human consumption, this additional step psychologically assures the public (Tan et al., 2009).

PUB recognized that public acceptance would be the key for the NEWater project to succeed, so demonstrating the safety and quality of NEWater to the public was set as a priority. PUB embarked on a comprehensive public education campaign directed towards a wide range of stakeholders – including politicians, opinion leaders, water experts, grassroots leaders, students and the general public – to win confidence by explaining the advanced technology by which NEWater is produced, showcasing its proven quality and addressing the misconceptions around water recycling. For example, a documentary that focused on the technology used to produce NEWater and the experiences of other countries in water reuse was produced and aired on national television. Furthermore, high ranking government officials, including then Prime Minister

Goh Chok Tong, drank bottled NEWater publicly on various occasions. The media was a key partner in shaping public opinion. In this context, before the launch of NEWater in 2003, media representatives were taken on field trips to Orange County, California, and Scottsdale, Arizona, where water recycling had been practised with success. An independent survey conducted at the end of 2002 showed that NEWater had a 98% acceptance rate, with 82% of respondents indicating that they would drink NEWater directly and 16% would drink it indirectly (after blending with water from local reservoirs) (PUB, 2008).

A more prolonged public education programme followed with the establishment of the NEWater Visitor Centre in 2003, which continues to be central to the programme. The Centre is a state-of-the-art water museum, with interactive tours and educational workshops demonstrating how NEWater is produced. To enhance the learning experience, visitors can see the membranes and ultraviolet technologies used in the purification process in the water recycling plant adjoining the Centre. Visitors can also taste NEWater, which is bottled in attractive packaging and distributed to the community for promotional purposes. To date (in 2014), about 25 million bottles of NEWater have been distributed free of charge for public consumption (HISS, 2014).

NEWater is primarily intended for industrial users with high standards required for their feed-water. Using it for this purpose frees up considerable amounts of potable water for domestic consumption and enhances Singapore's resilience against periods of low rainfall and drought. As of 2014, NEWater can meet up to 30% of Singapore's total water demand. The plan is to triple NEWater capacity to meet 55% of water demand by 2060.

The process to produce NEWater is significantly more energy efficient than desalination (approximately 1 kWh per m^3 versus 3.5 kWh per m^3). PUB has undertaken numerous research and development projects to further lower energy consumption in water recycling by improving membrane technology and process efficiency. Some of these projects concern aquaporin membranes and biomimicry (Aik Num, n.d.).

In line with the principles of full cost recovery for water services (production and delivery), NEWater was introduced at a unit price of US$1.04 per m^3 in 2003. As the infrastructure expanded through the years, efficiency gains in the production process have allowed the unit price to go down to the current (in 2014) US$0.98 per m^3 (PUB, 2014).

NEWater undergoes a rigorous audit process twice a year by an external audit panel comprising international experts in engineering, water chemistry, toxicology and microbiology to ensure the continued high quality of recycled water and the reliability of the water recycling plants. To date, NEWater has undergone more than 130,000 tests to ensure its quality.

To ensure continued understanding and support of NEWater and to engage the younger generations, public information and promotion campaigns are ongoing. For example, PUB's 3P Network Division reaches out to the public and private sectors, notably through traditional media, social media and community programmes. The introduction of NEWater has been a major milestone for Singapore in diversifying its water portfolio and increasing its resilience to climate variability. Furthermore, it has formed the pillar of the country's efforts in sustainable water use. This case study illustrates that successful water resources management relies not only on physical infrastructure, but also on strong and visionary leadership, forward planning, public education, appropriate pricing, and research and development. The NEWater programme could be transferred and adapted to different conditions – wherever political support and an effective public communications campaign converge.

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Progress on sustainable development objectives in the Mekong Delta, Viet Nam

7

Abstract

This densely populated, fertile land is Viet Nam's most productive region for agriculture and aquaculture. However, population growth and rapid socio-economic changes place increasing pressure on its natural resources, and have led to land degradation and water pollution. Natural protection against water related hazards has also decreased as a result of reduction in floodplains and destruction of mangrove forests. This situation is critical as the low-lying delta plain is confronted acutely with the consequences of climate change, leading to increased vulnerability and risk of poverty. National legislation and the aspirations of the Mekong River Commission target adaptation to climate change through integrated management of water and land. In the national context, integrated water resources management is yet to be put into practice. An agro-business industrialization scenario, where the delta develops into a regional hub for high-value agricultural products, best fits the characteristics and advantages of the delta, and enables economic expansion with care for the environment. Regardless of the scenario that eventuates, adaptation to climate change impacts and emphasis on sustainable land and water use practices seems to be the key for a better future for Viet Nam.

The Mekong is the tenth-largest river in the world by discharge. From the eastern watershed of the Qinghai-Tibetan Plateau in China it flows approximately 4,900 km to the Mekong Delta in Viet Nam, passing through Myanmar, Lao People's Democratic Republic, Thailand and Cambodia (Figure 7.1). The river basin, covering an area of 795,000 km^2, is composed of seven physiographic regions featuring diverse topography, drainage patterns and geomorphology (MRC, n.d.). These regions are broadly grouped into the Upper Mekong Basin (UMB) and the Lower Mekong Basin (LMB). Most of the total flow volume of the Mekong River comes from tributaries in the LMB. However, during the dry season (from mid-February to the end of May), snowmelt in the UMB contributes more than 20% of the total flow (MRC, 2010).

The Mekong River empties into the South China Sea (known as the East Sea in Viet Nam) in south-eastern Viet Nam through a network of distributaries forming the Mekong Delta. The inner delta is low-lying (close to sea level), and the outer delta, built from coastal plain deposits, is fringed seawards by mangrove swamps, beach ridges, sand dunes, spits and tidal flats. Tidal seawater intrusion into tributaries of the Mekong River may reach as far as 65 km upstream.

The Mekong Delta covers approximately 40,000 km^2 and is home to more than 17 million people (approximately 20% of the population of Viet Nam). Its fertile land has enabled the delta to become the country's most productive region, producing 50% of its rice, 65% of its aquaculture and 70% of its fruit. Since the end of the Second Indochina War in 1975, land use in the Mekong Delta has been oriented towards a food security policy to ensure national self-sufficiency in production of rice in particular but also of other staple foods. Consequently, the share of agriculture in GDP of the delta is approximately 40%: twice as much the national average (Figure 7.2).

In 1986, the Government of Viet Nam introduced economic reforms, collectively known as Đổi Mới, to accelerate economic growth and development in the country. Among other objectives, the policy aimed for diversification in agricultural food production, and it has prompted many farmers to shift from rice monoculture to a farming system that is still based on rice, but also includes aquaculture (catfish and shrimp farming), fruits and vegetables. In addition, high-yielding rice varieties that allow double or triple crop production have replaced traditional rice varieties. This has almost doubled rice production in the Mekong Basin and has allowed Viet Nam to become one of the leading rice-exporting countries in the world (FAO, 2014).

Đổi Mới also allowed for the growth of the industrial sector. The most important factories in the Mekong Delta are for food processing and production of related equipment and machinery. Textile and other low technology manufacturing industries have also emerged. But despite economic reforms, the primary focus of Viet Nam's economy continues to be agriculture, including fisheries and forestry. The nation's dependence on this sector has led to deforestation, land degradation, water pollution and reduced natural protection against flooding, overall increasing the vulnerability of households to falling back into poverty.

In the delta, the total coverage of mangrove forests, which form an important breeding ground for aquatic organisms and a barrier against natural hazards (such as floods and storms), decreased by half in the period 1965-2001 (Phan and Populus, 2006). During the 1990s, mangrove forests declined particularly rapidly in terms of both quality and the amount of mature forest because of clearing for agriculture, haphazard development of shrimp ponds, and timber and charcoal production. This reduction in forest coverage lowers the natural resilience and increases the vulnerability of coastal communities to the impacts of climate change.

The Intergovernmental Panel on Climate Change (IPCC) ranks the Mekong Delta among the three mega deltas in the world that are most likely to be severely affected by climate change (Nicholls et al., 2007). Changes in temperature, rainfall, river flow and the periodicity and extent of water-related natural

FIGURE 7.1 **Mekong River basin**

disasters are already occurring. In the inner delta, floods are projected to have a higher magnitude (deeper inundation of the plains) and longer duration, affecting major rainfed rice production areas. In addition, reduced volume of retention areas is expected to necessitate capital-intensive protection measures against higher flood levels in urban and industrial areas. In the outer delta (coastal zone), projections indicate that the sea level may rise 30 cm by 2050 and as much as 75 cm by the end of the twenty-first century. Rises of such magnitude would aggravate the saltwater intrusion problem and have impacts on agriculture and fisheries. It is estimated that a sea level rise of 20-40 cm will lead to significant losses in all rice cropping seasons and place food security of the nation at risk. Land subsidence due to long-term drainage and groundwater extraction is likely to further exacerbate the sea level rise. By mid-century, portions of the Mekong Delta will likely experience 1 m (0.42-1.54 m) of additional inundation hazard due to land subsidence (Erban et al., 2014).

In the Mekong Delta, water resources management has traditionally focused on flood control and on the provision of freshwater, mainly for agriculture. Protection of water resources was long disregarded despite growing demand and increasing water pollution. The Law on Water Resources was enacted in 1998 and amended in 2012 to 'adopt the policy of managing, protecting and rationally, economically and efficiently exploiting the water resources with a view to ensuring water for living of the people, the economic branches … protect the environment and serve the sustainable development of the country'. However, legislation for the water domain remains complicated, and there are more than 300 regulations. Institutional fragmentation also adds to the challenge of water resources management, in which a number of ministries are involved.

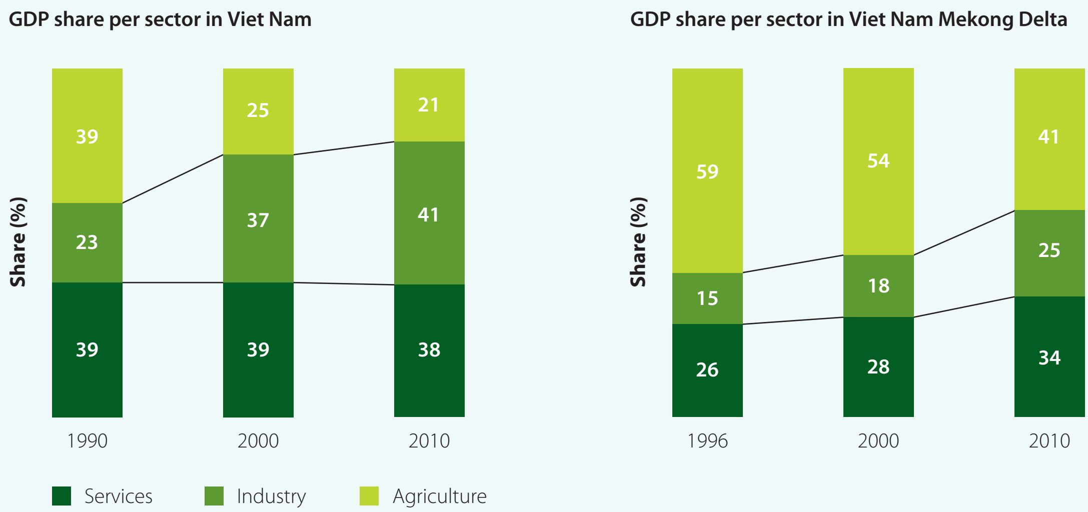
Several decentralization programmes have been deployed and several state agencies have been established to incorporate perspectives and concerns of various stakeholders. However, the integrated water management principles embedded in existing policies are not applied in practice, and water policy planning continues to target sectors separately (Renaud and Kuenzer, 2012).

To collectively manage water resources and to address related problems in the LMB, the Mekong Agreement between Cambodia, Lao People's Democratic Republic, Thailand and Viet Nam established the Mekong River Commission (MRC) in 1995. The approval of the Integrated Water Resources Management-based Basin Development Strategy in 2011 was an important milestone in cooperation among the members of the MRC. The Strategy defines a dynamic basin development planning process that will be reviewed and updated every five years and sets priorities such as preparation of a climate change adaptation strategy; expansion of irrigated agriculture for food security and poverty alleviation; improvement of knowledge on sediment transport, fish migration and changes in biodiversity; enhancement of environmental and social sustainability of hydropower development; and integration of basin planning considerations into national planning and regulatory systems (MRC, 2011).

Concerns about sustainable socio-economic development in Viet Nam have led to development of the National Green Growth Strategy. Approved in 2012, the Strategy aims to curb greenhouse gas emissions, promote resource efficiency, build resilience to climate variability, reduce poverty, and encourage recognition of the value of natural assets. In the Mekong context, green growth could foster transboundary cooperation,

FIGURE 7.2

Share of gross domestic product (GDP) per sector in Viet Nam and the Mekong Delta



Source: GSO (n.d.) and Government of Viet Nam and Government of the Netherlands (2013).

as it encourages collaborative efforts at sectoral and cross-sectoral levels, thereby reinforcing efficient water management and robust water governance in the basin (GGGI, n.d.).

Given the similarities between the Mekong Delta and the extensive river deltas in the Netherlands, Viet Nam and the Netherlands entered into the Strategic Partnership Arrangement on Climate Change Adaptation and Water Management in 2010. Under this arrangement, the Mekong Delta Plan was prepared using the Dutch Delta approach. Presented in 2013, it is a reference document for the Government of Viet Nam that provides strategic advice for government agencies and organizations at all levels. It examines uncertainties and challenges that are likely to confront the delta in the medium (2050) to longer (2100) term; provides recommendations; and explores a number of scenarios and presents a long-term vision on how the delta may best develop (Government of Viet Nam and Government of the Netherlands, 2013) (Box 7.1). Among these, Dual Node Industrialization (scenario (d)) corresponds well with the national objective of accelerating the growth of the industrial and services sector. However, this scenario is considered unlikely to be achieved in the near future. In view of current conditions and trends, pursuing a strategy targeting development of the core agro-business industry (scenario (c)) could offer the best perspective for the Mekong Delta.

Acknowledgement

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BOX 7.1

Development scenarios for the Mekong Delta

Based on two major driving forces of socio-economic development - agriculture and industry - and effective implementation of land-use and water policies, four development scenarios were designed for the Mekong Delta Plan (2013). These scenarios represent plausible outcomes based on global and regional developments, national development objectives, the natural system and its limitations, institutional barriers, and past and existing trends. Two scenarios depict intensification of current agricultural and industrial economic development trends in the delta ((a) and (b) below) while the other two scenarios depict positive economic developments for the delta with pro-active planning and optimized use of resources ((c) and (d)).

Scenario (a) Food Production: In this scenario, the delta is not able to materialize its anticipated economic transition because of an unfavourable economic climate, a lack of integrated regional policy (and enforcement) on designated economic hubs, and suboptimal infrastructural investments combined with increasing impacts of climate change. Tight government targets on rice production remain or even intensify because of resulting food commodity shortages. As a result, pressures on land and water resources will continue to increase.

Scenario (b) Corridor Industrialization: In this scenario, there is a continuation of existing trends and developments, resulting in a loss of highly fertile agricultural land to an industrialized metropolis in a flood-prone area and a rural hinterland characterized by fierce competition and stagnating growth.

Scenario (c) Agro-Business Industrialization: In this scenario, the delta develops into a regional hub specialized in high-value agricultural and agrifood products both for export and for domestic markets. The scenario is realized through a clear focus on the delta's unique advantages (low-lying lands, the network of waterways, and fertile soil). Non-agrifood, industrial and tertiary sector activities are gradually directed outside the delta. This development direction fits well with the demographic and economic structure of the delta, thus providing a good basis for long-term sustainable economic growth.

Scenario (d) Dual Node Industrialization: In this scenario, the focus is on rapid urbanization and industrialization. The delta develops into a thriving diversified economy, where high-value agrifood business prospers, congruent with secondary and tertiary sector activities in designated economic zones. Total output and productivity increases significantly. Land and water pressures are high, but are managed in an effective and coherent manner, leading to efficient use of all resources and the preservation of ecosystems.

Source: Government of Viet Nam and Government of the Netherlands (2013).

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BOXES, FIGURES AND TABLES

BOXES

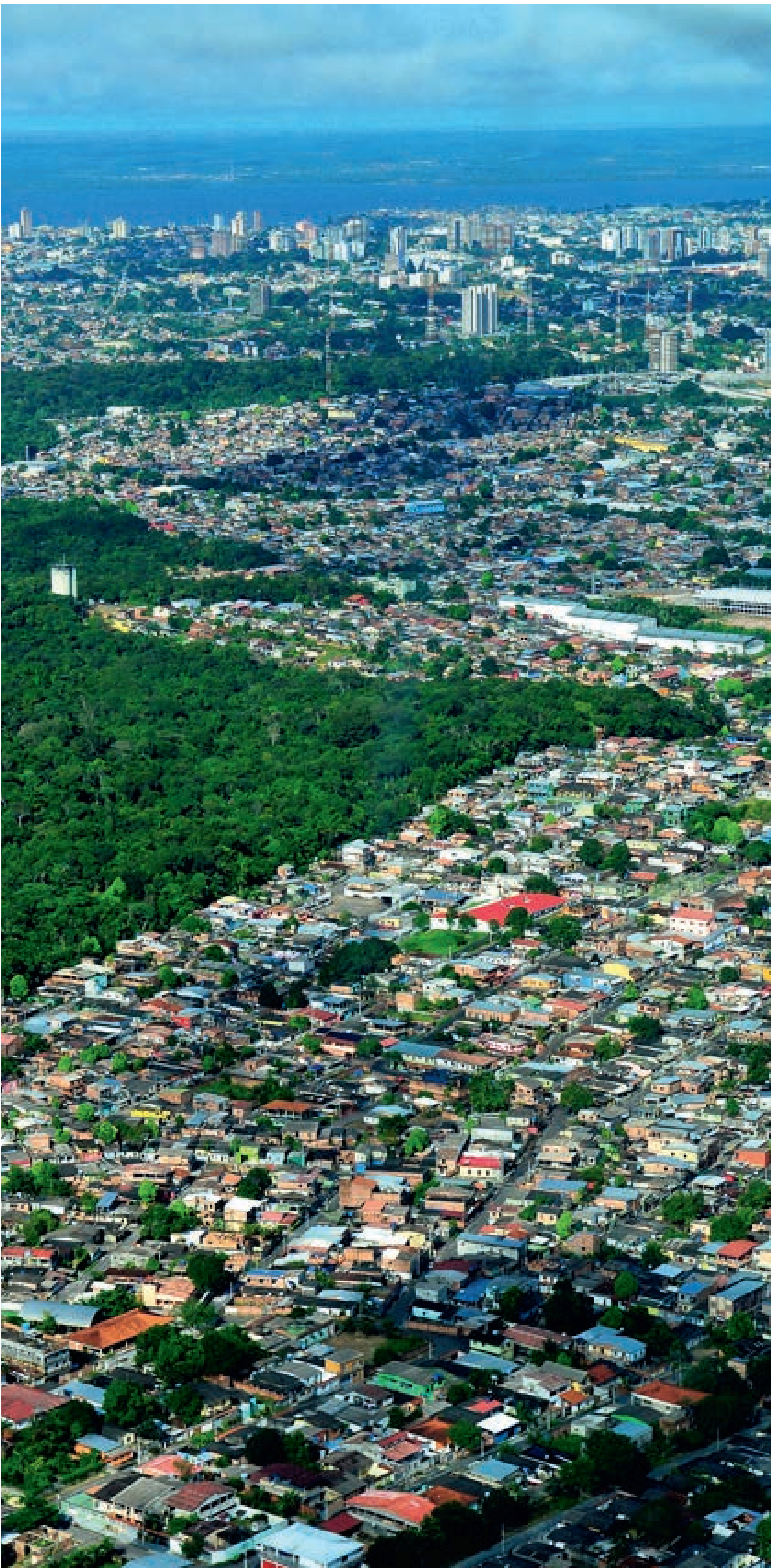
FIGURES

TABLES

PART 2

Data and indicators

Demographics – State of freshwater resources – Water demand – State of the environment – Human well-being – Electricity – Impact of hazards – Progress towards Millennium Development Goals



Data and indicators

Compiled by WWAP | Engin Koncagül, Maxime Turko and Sisira Saddhamangala Withanachchi

1 INDICATOR

World population growth (1970–2030)

Rural population	1970	1990	2010	2030
Africa	279 800	428 000	627 700	857 400
Americas	184 100	201 400	188 700	176 400
Asia	1 599 300	2 142 500	2 312 000	2 150 800
Europe	269 000	253 200	202 000	166 200
Oceania	5 600	7 900	10 700	13 300
Overall rural	**2 337 900**	**3 033 000**	**3 341 200**	**3 364 100**

Urban population	1970	1990	2010	2030
Africa	86 700	202 000	403 400	777 000
Americas	334 900	526 100	754 000	943 700
Asia	484 100	1 004 400	1 853 400	2 736 100
Europe	433 500	536 300	538 300	570 100
Oceania	14 000	19 100	25 900	34 000
Overall urban	**1 353 300**	**2 287 800**	**3 575 000**	**5 060 800**

World population	**3 691 200**	**5 320 800**	**6 916 200**	**8 424 900**

Note: Values are given in thousands.
Source: WWAP, with data from the FAOSTAT database Population domain. http://faostat3.fao.org/download/O/OA/E (Accessed November 2014).

2

INDICATOR

Slum to urban population ratio (2009)

Region	Population	Slum to urban population ratio (%)
Africa		
Central African Republic	4 266 247	95.9[1,4]
Chad	11 371 325	89.3[1,5]
Niger	15 302 948	81.7[1,10]
Asia		
Bangladesh	149 503 100	61.6[1,2]
Nepal	26 544 943	58.1[1,9]
Iraq	30 163 199	52.8[8]
Latin America and the Caribbean		
Haiti	9 765 153	70.1[7]
Bolivia	9 993 406	47.3[1,3]
Guatemala	13 988 988	38.7[1,6]

Note: In selected countries by region.
[1] Trend analysis was used to estimate the percentage of slum population; [2] DHS (2004, 2007); [3] DHS (1989, 1994, 1998, 2003); [4] DHS (1994), MICS (2000); [5] DHS (1996/1997, 2004); [6] DHS (1995, 1998); [7] DHS (2005, 2008); [8] MICS (2000, 2006); [9] DHS (1996, 2001, 2006); [10] MICS (2000), DHS (1998).
Source: WWAP, with data from the United Nations Statistics Division Millennium Development Goals Database. https://data.un.org/Data.aspx?d=MDG&f=seriesRowID%3A710 (Accessed November 2014).
DHS. DHS Program, Demographic and Health Surveys. Rockville, MD, ICF International. http://dhsprogram.com/
MICS. Statistics and Monitoring, Multiple Indicator Cluster Survey. New York, UNICEF. http://www.unicef.org/statistics/index_24302.html

INDICATOR 3

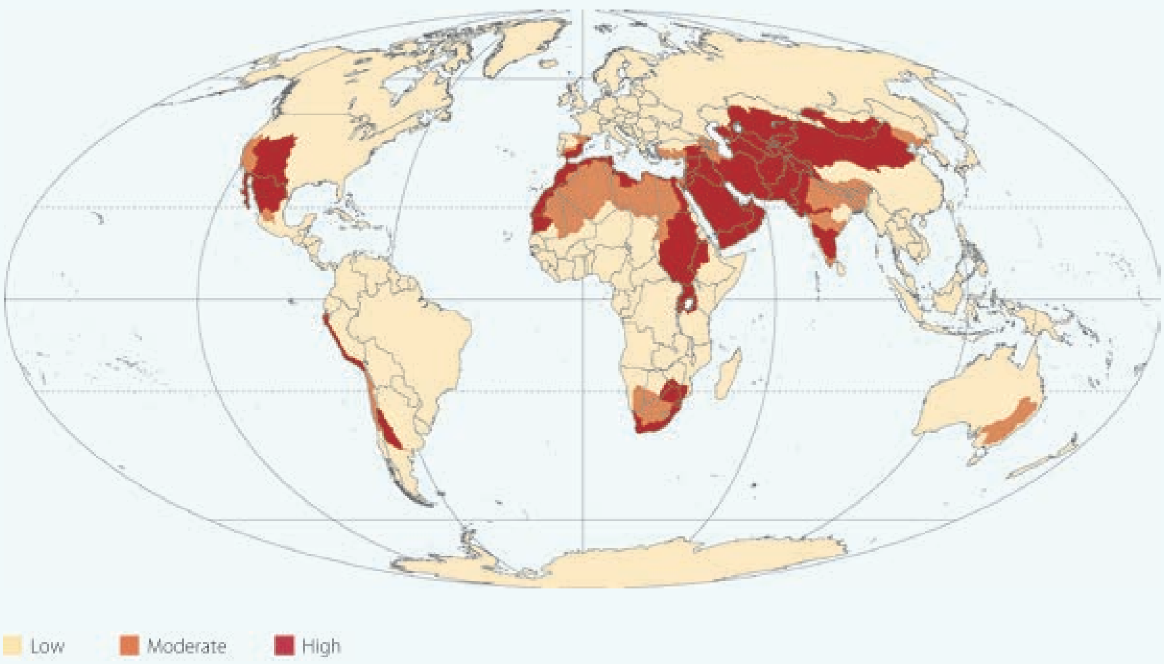
Percentage distribution of households by person responsible for water collection by region and by urban or rural area (2005–2007)

		Water on premises	Woman 15 years or older	Man 15 years or older	Girl under 15 years	Boy under 15 years
Sub-Saharan Africa (18 countries)	Rural (%)	11.9	62.9	11.2	7.0	4.1
	Urban (%)	51.5	29.0	10.2	4.3	3.1
Asia (18 countries)	Rural (%)	52.3	30.0	12.9	2.5	1.7
	Urban (%)	83.9	8.7	5.3	0.8	1.0
Latin America and the Caribbean (6 countries)	Rural (%)	74.2	10.5	12.7	1.0	0.7
	Urban (%)	90.8	3.1	4.9	0.2	0.4
Eastern Europe (6 countries)	Rural (%)	75.5	11.7	9.2	0.1	0.2
	Urban (%)	95.6	2.0	2.3	0.1	0.1

Note: Unweighted averages; the numbers in parentheses indicate the number of countries averaged. The difference up to 100% is made up by the share of households where a person from outside the household would collect the water or missing information.
Source: UNDESA (2010, Fig. 7.1, p. 143, based on sources cited therein).
UNDESA (United Nations Department of Economic and Social Affairs). 2010. The World's Women 2010: Trends and Statistics. ST/ESA/STAT/SER.K/19. New York, UNDESA. http://unstats.un.org/unsd/demographic/products/Worldswomen/WW_full%20report_color.pdf

INDICATOR 4

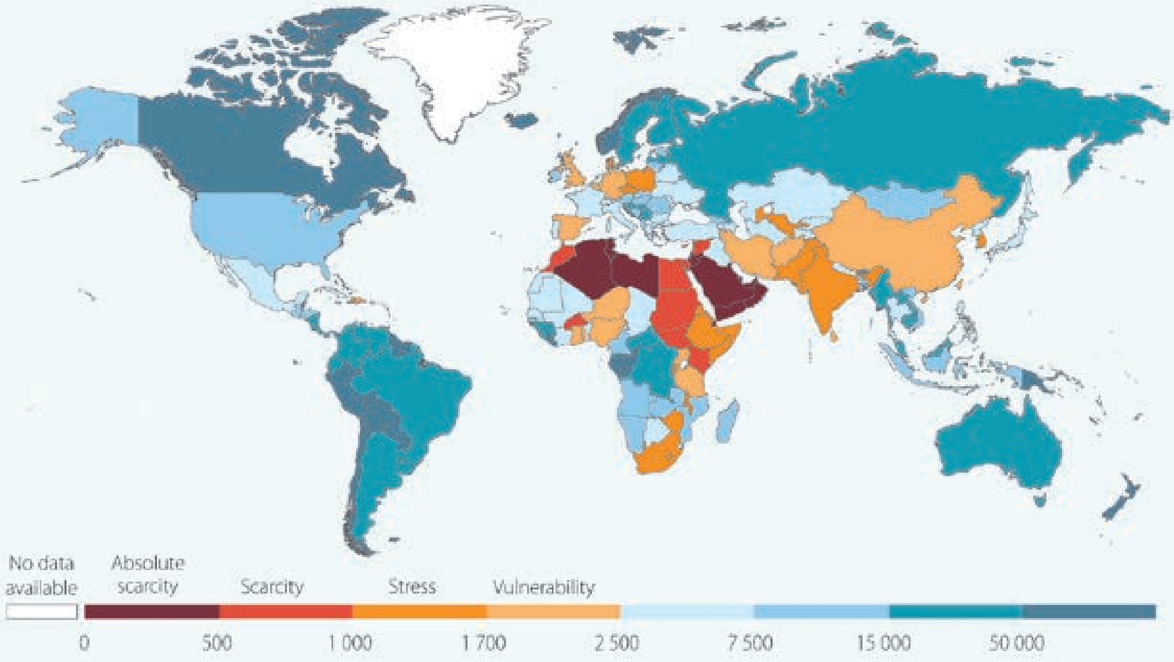
Global distribution of physical water scarcity by major basin (2011)



Note: The map shows the global distribution of water scarcity by major river basin based on consumptive use of water in irrigation.
Source: FAO (2011, map 1.2, p. 29).
FAO (Food and Agriculture Organization of the United Nations). 2011. The State of the World's Land and Water Resources for Food and Agriculture (SOLAW): Managing Systems at Risk. Rome/London, FAO/Earthscan. http://www.fao.org/docrep/017/i1688e/i1688e.pdf

INDICATOR 5

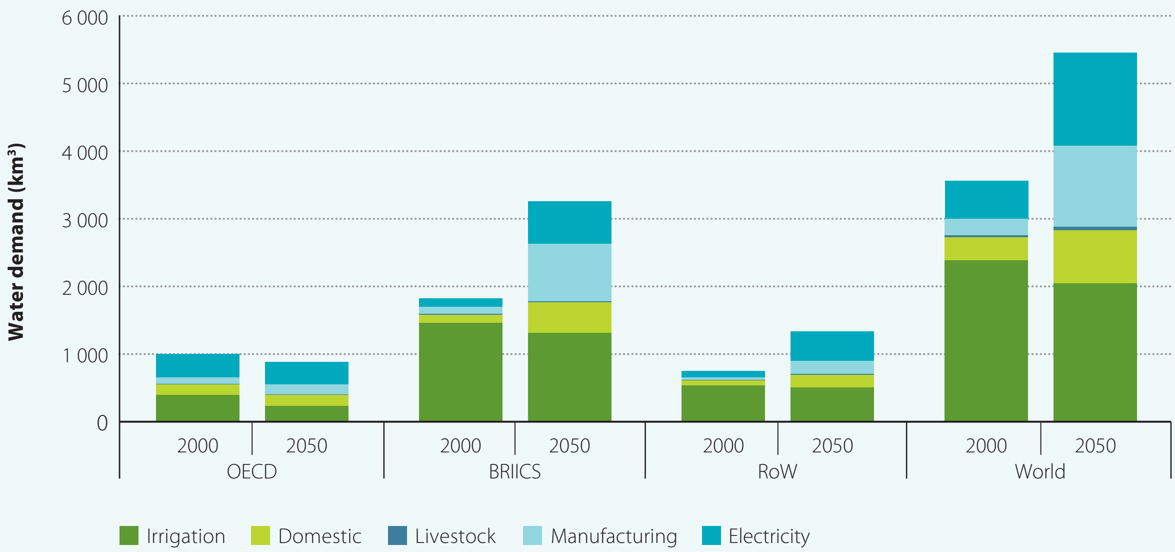
Total renewable water resources per capita (2013)



Note: The values indicate total renewable water resources per capita per year in m³.
Source: WWAP, with data from the FAO AQUASTAT database. http://www.fao.org/nr/water/aquastat/main/index.stm (Accessed November 2014) (aggregate data for all countries except Andorra and Serbia, external data), and using UN-Water category thresholds.

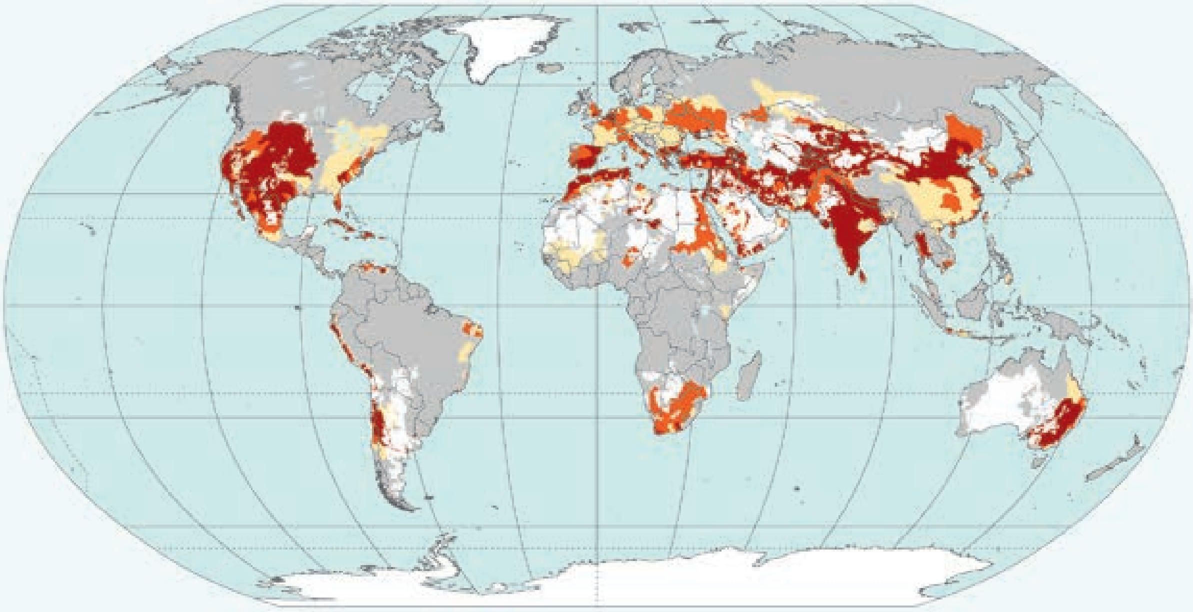
INDICATOR 6

Global water demand (Baseline Scenario 2000 and 2050)



Note: BRIICS (Brazil, Russia, India, Indonesia, China, South Africa); OECD (Organisation for Economic Co-operation and Development); RoW (rest of the world). This graph only measures 'blue water' demand and does not consider rainfed agriculture.
Source: OECD (2012, Fig. 5.4, p. 217, output from IMAGE). OECD Environmental Outlook to 2050 © OECD.
OECD (Organisation for Economic Co-operation and Development). 2012. OECD Environmental Outlook to 2050: The Consequences of Inaction. Paris, OECD. http://dx.doi.org/10.1787/9789264122246-en

Annual average water stress (1981-2010)



Water withdrawals-to-availability ratio

0 - 0.1 (no water stress) | 0.1 - 0.2 (low water stress) | 0.2 - 0.4 (mid water stress) | more than 0.4 (high water stress) | No data

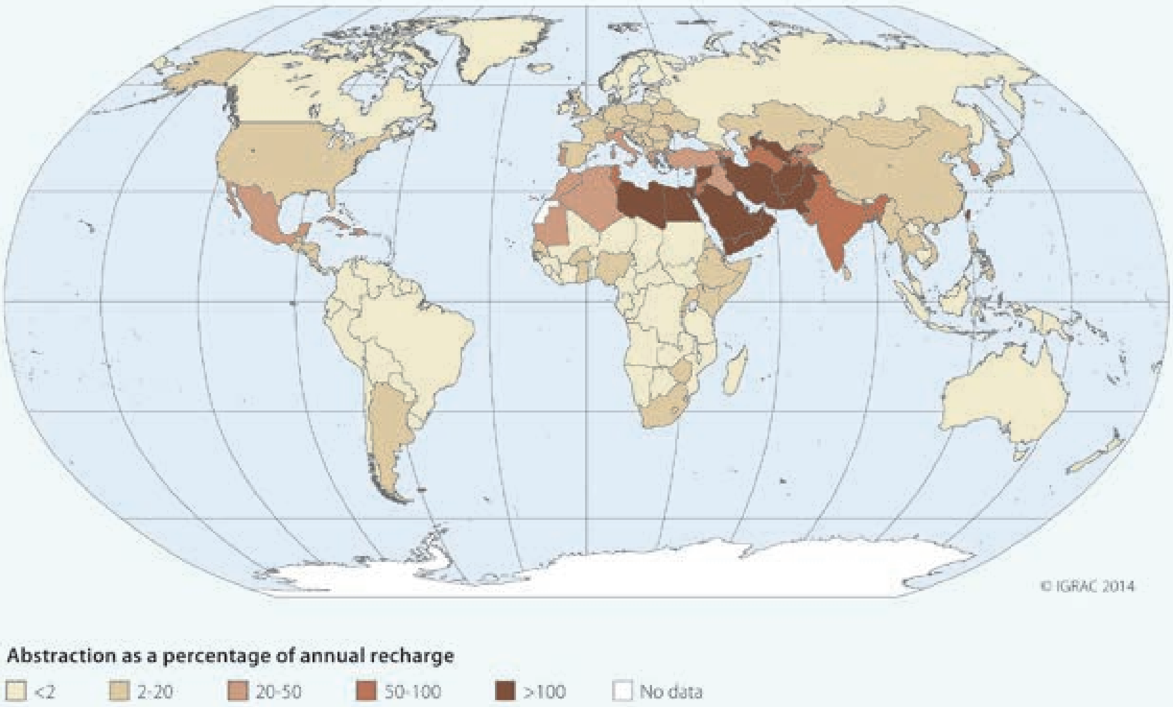
Note: Water stress measures the amount of pressure put on water resources and aquatic ecosystems by the users of these resources (households, industries, and agriculture) and can easily be compared across river basins. For calculating today's water stress, the withdrawals-to-availability ratio is used (w.t.a.). This indicator has the advantage of being transparent and computable for all river basins and has been used in several studies (e.g. Alcamo et al. 2007). The larger the volume of water withdrawn, used, and discharged back into a river, the more river flow is depleted and/or degraded for users downstream, and thus the higher the water stress. Water withdrawals and availability were computed by WaterGAP3 model on 5x5 arc minute grid cells and aggregated to river basin scale.

High water stress occurs in most of India, Northern China, Middle Asia, the Middle East, the Mediterranean rim countries, Eastern Australia (i.e. the Murray Darling basin), Western Latin America, large parts of the Western United States and Northern Mexico. Overall, river basins in these regions are at greater risk of seasonal or inter-annual variations in water flow. For a detailed description of the methodology, background work and findings:
http://www.usf.uni-kassel.de/cesr/index.php?option=com_content&task=view&id=57&Itemid=86

Source: Center for Environmental Systems Research, University of Kassel (Generated in December 2014 using WaterGAP3 model).
Alcamo, J., Flörke, M. and Marker, M. 2007. Future long-term changes in global water resources driven by socio-economic and climatic changes. Hydrological Sciences Journal, 52(2): 247-275.

8 INDICATOR

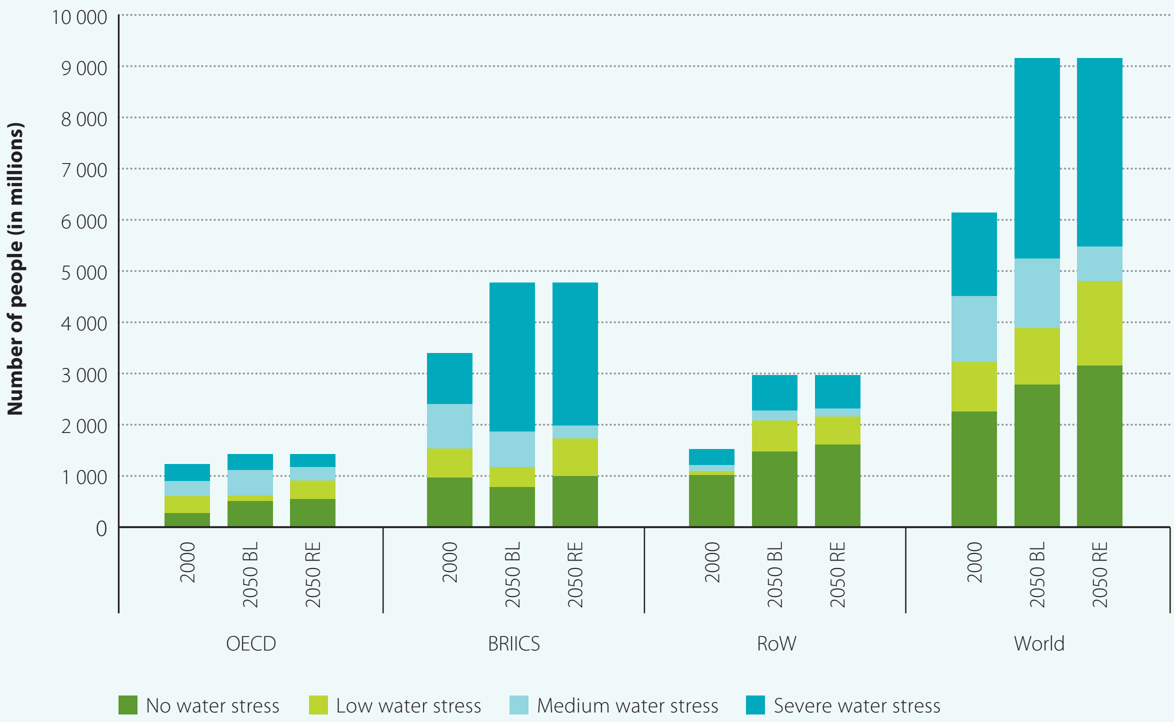
Groundwater development stress (2010)



Source: IGRAC (2014).
IGRAC (International Groundwater Resources Assessment Centre). 2014. Information System. Global Overview application. Delft, the Netherlands, IGRAC. http://ggmn.e-id.nl/ggmn/GlobalOverview.html (Accessed December 2014). © IGRAC 2014.

9 INDICATOR

Number of people living in water-stressed river basins (2000 and 2050)



Note: BL (Baseline Scenario); RE (Resource Efficiency Scenario); BRIICS (Brazil, Russia, India, Indonesia, China and South Africa); OECD (Organisation for Economic Co-operation and Development); RoW (rest of the world).
Source: OECD (2012, Fig. 5.16, p. 245, output from IMAGE). OECD Environmental Outlook to 2050 © OECD.
OECD (Organisation for Economic Co-operation and Development). 2012. OECD Environmental Outlook to 2050: The Consequences of Inaction. Paris, OECD. http://dx.doi.org/10.1787/9789264122246-en

INDICATOR 10

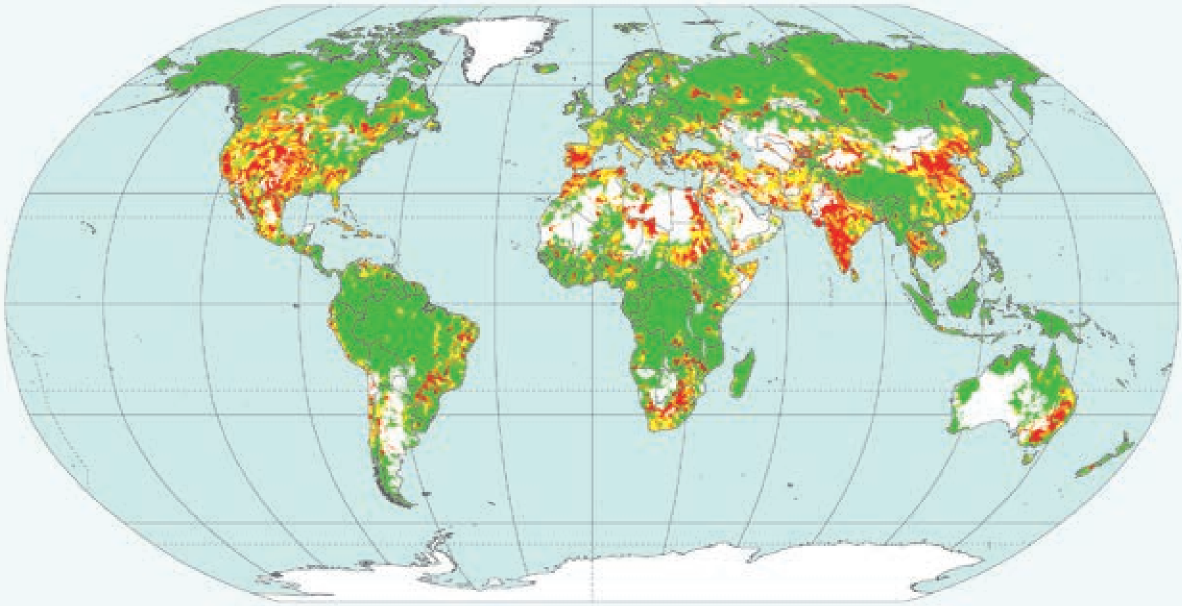
Water withdrawal by sector (around 2007)

	Total withdrawal by sector						Total water withdrawal *	Total freshwater withdrawal	Freshwater withdrawal as % of IRWR
	Municipal		Industrial		Agricultural				
	km³/year	%	km³/year	%	km³/year	%	km³/year	km³/year	
World	**462**	**12**	**734**	**19**	**2 722**	**69**	**3 918**	**3 763**	**9**
Africa	**27**	**13**	**11**	**5**	**174**	**82**	**213**	**199**	**5**
Northern Africa	9	10	6	6	79	84	94	82	176
Sub-Saharan Africa	18	15	6	5	95	80	120	117	3
Americas	**130**	**15**	**288**	**34**	**430**	**51**	**847**	**843**	**4**
Northern America	74	14	252	48	497	38	524	520	10
Central America and the Caribbean	8	28	2	9	17	63	27	27	4
Southern America	36	17	26	12	154	71	216	216	2
Asia	**228**	**9**	**244**	**10**	**2 035**	**81**	**2 507**	**2 373**	**20**
Middle East	25	9	20	7	231	84	276	268	55
Central Asia	7	5	10	7	128	89	145	136	56
Southern and Eastern Asia	196	9	214	10	1 676	80	2 086	1 969	18
Europe	**72**	**22**	**188**	**57**	**73**	**22**	**333**	**332**	**5**
Western and Central Europe	53	22	128	54	58	24	239	237	11
Eastern Europe	20	21	60	64	15	16	95	95	2
Oceania	**5**	**26**	**3**	**15**	**11**	**60**	**18**	**17**	**2**
Australia and New Zealand	5	26	3	15	11	60	18	17	2
Other Pacific Islands	0.03	33	0.01	11	0.05	56	0.1	0.1	0.1

** Includes use of desalinated water, direct use of treated municipal wastewater and direct use of agricultural drainage water.*
IRWR (internal renewable water resources).
Source: FAO AQUASTAT database. http://www.fao.org/nr/water/aquastat/main/index.stm (Accessed November 2014).

11 INDICATOR

Environmental stress due to flow regime alterations (1981-2010)



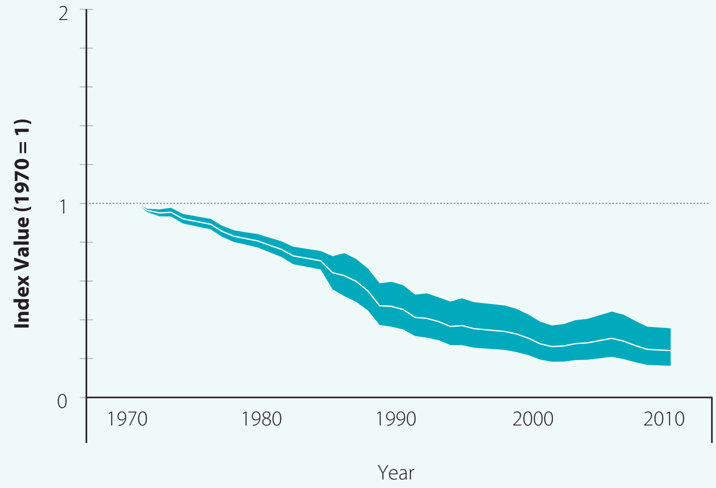
Note: Natural flow regimes are heavily modified by water abstractions and dam operations. The indicator "environmental water stress due to flow regime alterations" is used to assess the hydrological alterations resulting from these impacts (Schneider et al. 2013). Daily time series of modified and natural river discharge were simulated by the global water WaterGAP3 model on a global 5×5 arc minute grid (i.e. about 8×8km at the Equator) considering over 6 000 large dams.

Flow regimes are particularly altered due to dam and water management in the USA, Mexico, Spain, Portugal, the Middle East, India, and the Northeast and Northwest of China. In Eastern Australia, the Murray Darling basin shows severe deviations from natural conditions, and hotspots in Africa are the Nile River basin in Egypt, Sudan, South Sudan and Uganda, the Orange and Limpopo basins in South Africa, and basins in Morocco. This increases the risk for ecosystem degradation notably the intrusion of invasive species. For a detailed description of the methodology, background work and findings: http://www.usf.uni-kassel.de/cesr/index.php?option=com_content&task=view&id=57&Itemid=86

Source: Center for Environmental Systems Research, University of Kassel (Generated in December 2014 using WaterGAP3 model)
Schneider, C., Laize, C.L.R., Acreman, M.C. and Flörke, M. 2013. How will climate change modify river flow regimes in Europe? Hydrology and Earth System Sciences 17: 325-339.

12 INDICATOR

Freshwater living planet index (1970–2010)



Source: WWF (2014, Fig. 13, p. 22).
WWF. 2014. Living Planet Report 2014: Species and Spaces, People and Places. R. McLellan, L. Iyengar, B. Jeffries and N. Oerlemans (eds). Gland, Switzerland, World Wide Fund for Nature (WWF).
http://wwf.panda.org/about_our_earth/all_publications/living_planet_report/

13 INDICATOR

Net changes in major land use globally (1961–2009)

	1961 (million hectares)	2009 (million hectares)	Net increase (%)
Cultivated land	1 368	1 527	12.0
Rainfed	1 229	1 226	-0.2
Irrigated	139	301	117.0

Note: Irrigated area more than doubled over the period and the number of hectares needed to feed one person has reduced dramatically from 0.45 to 0.22 hectares per person.
Source: FAO (2011, Table 1.2, p. 24, based on FAOSTAT source cited therein).
FAO (Food and Agriculture Organization of the United Nations). 2011. The State of the World's Land and Water Resources for Food and Agriculture (SOLAW): Managing Systems at Risk. Rome/London, FAO/Earthscan.
http://www.fao.org/docrep/017/i1688e/i1688e.pdf

14 INDICATOR

Trends in ISO 14001 certification (1999–2013)

Year	1999	2000	2001	2002	2003	2004
Total	**13 994**	**22 847**	**36 464**	**49 440**	**64 996**	**90 554**
Africa	129	228	311	418	626	817
Central and South America	309	556	681	1 418	1 691	2 955
North America	975	1 676	2 700	4 053	5 233	6 743
Europe	7 253	10 971	17 941	23 305	30 918	39 805
East Asia and Pacific	5 120	8 993	14 218	19 307	25 151	38 050
Central and South Asia	114	267	419	636	927	1 322
Middle East	94	156	194	303	450	862
Regional share (%)						
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Africa	0.9	1.0	0.9	0.8	1.0	0.9
Central and South America	2.2	2.4	1.9	2.9	2.6	3.3
North America	7.0	7.3	7.4	8.2	8.1	7.4
Europe	51.8	48.0	49.2	47.1	47.6	44.0
East Asia and Pacific	36.6	39.4	39.0	39.1	38.7	42.0
Central and South Asia	0.8	1.2	1.1	1.3	1.4	1.5
Middle East	0.7	0.7	0.5	0.6	0.7	1.0
Annual growth (absolute numbers)						
Year		**2000**	**2001**	**2002**	**2003**	**2004**
Total		**8 853**	**13 617**	**12 976**	**15 556**	**25 558**
Africa		99	83	107	208	191
Central and South America		247	125	737	273	1 264
North America		701	1 024	1 353	1 180	1 510
Europe		3 718	6 970	5 364	7 613	8 887
East Asia and Pacific		3 873	5 225	5 089	5 844	12 899
Central and South Asia		153	152	217	291	395
Middle East		62	38	109	147	412

Note: ISO 14001 is a framework for environmental management systems that helps organizations both to manage better the impact of their activities on the environment and to demonstrate sound environmental management (ISO, 2009).

Source: WWAP, with data from ISO (2013).

ISO (International Organization for Standardization). 2009. Environmental Management. The ISO 14000 Family of International Standards. Geneva, ISO Central Secretariat. http://www.iso.org/iso/theiso14000family_2009.pdf

____. 2013. ISO Survey of management system standard certifications 2013. Geneva, ISO Central Secretariat. http://www.iso.org/iso/home/standards/certification/iso-survey.htm#

	2005	2006	2007	2008	2009	2010	2011	2012	2013
	111 163	**128 211**	**154 572**	**188 574**	**222 974**	**251 548**	**261 926**	**285 844**	**301 647**
	1 130	1 079	1 096	1 518	1 531	1 675	1 740	2 109	2 538
	3 411	4 355	4 260	4 413	3 748	6 999	7 105	8 202	9 890
	7 119	7 673	7 267	7 194	7 316	6 302	7 450	8 573	8 917
	47 837	55 919	65 097	78 118	89 237	103 126	101 177	113 356	119 107
	48 800	55 428	72 350	91 156	113 850	126 551	137 335	145 724	151 089
	1 829	2 201	2 926	3 770	4 517	4 380	4 725	4 946	6 672
	1 037	1 556	1 576	2 405	2 775	2 515	2 425	2 934	3 434

	2005	2006	2007	2008	2009	2010	2011	2012	2013
	1.0	0.8	0.7	0.8	0.7	0.7	0.7	0.7	0.8
	3.1	3.4	2.8	2.3	1.7	2.8	2.7	2.9	3.3
	6.4	6.0	4.7	3.8	3.3	2.5	2.8	3.0	3.0
	43.0	43.6	42.1	41.4	40.0	41.0	38.6	39.7	39.5
	43.9	43.2	46.8	48.3	51.1	50.3	52.4	51.0	50.1
	1.6	1.7	1.9	2.0	2.0	1.7	1.8	1.7	2.2
	0.9	1.2	1.0	1.3	1.2	1.0	0.9	1.0	1.1

	2005	2006	2007	2008	2009	2010	2011	2012	2013
	20 609	**17 048**	**26 361**	**34 002**	**34 400**	**28 574**	**10 378**	**23 918**	**16 993**
	313	-51	17	422	13	144	65	369	454
	456	944	-95	153	-665	3 251	75	1 128	1 688
	376	554	-406	-73	122	-1 014	1 148	1 123	344
	8 032	8 082	9 178	13 021	11 119	13 889	-1 949	12 179	7 197
	10 750	6 628	16 922	18 806	22 694	12 701	10 784	8 389	5 020
	507	372	725	844	747	-137	345	221	1 703
	175	519	20	829	370	-260	-90	509	587

15 INDICATOR

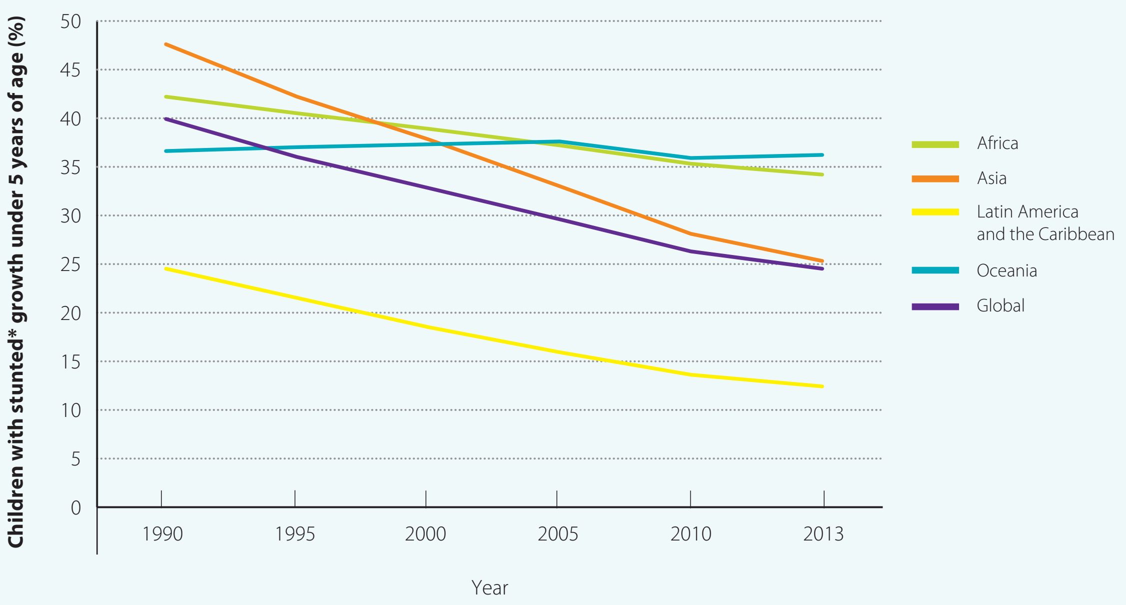
Global Hunger Index (1990–2014)

	1990	1995	2000	2005	2014
	with data from				
	1988-92	1993-97	1998-02	2003-07	2009-13
Africa					
Burundi	32.0	36.9	38.7	39.0	35.6
Comoros	23.0	26.7	34.0	30.0	29.5
Eritrea	ND	41.2	40.0	38.8	33.8
Asia					
Bangladesh	36.6	34.4	24.0	19.8	19.1
Lao PDR	34.5	31.4	29.4	25.0	20.1
Yemen	30.1	27.8	27.8	28.0	23.4
Europe					
Albania	9.1	6.3	7.9	6.2	5.3
Moldova	ND	7.9	9.0	7.4	10.8
Latin America and the Caribbean					
Bolivia (Plurinational State of)	18.6	16.8	14.5	13.9	9.9
Guatemala	15.6	16.0	17.3	17.0	15.6
Haiti	33.6	32.9	25.3	27.9	23.0
Oceania					
Fiji	6.2	5.3	<5	<5	<5

Note: In selected countries by region. ND (no data).
The Global Hunger Index score is calculated by averaging the percentage of the population that is undernourished, children younger than five years of age who are underweight and children who die before the age of five. The calculation produces a 100-point scale, on which zero is the best score (no hunger) and 100 is the worst. The extreme values of 0 and 100 are not reached in practice (IFPRI, 2014).
Source: WWAP, with data from IFPRI (2014).
IFPRI (International Food Policy Research Institute). 2014. Dataverse – 2014 Global Hunger Index data. Washington, DC, IFPRI. http://thedata.harvard.edu/dvn/dv/IFPRI/faces/study/StudyPage.xhtml?globalId=doi:10.7910/DVN/27557 (Accessed November 2014)

INDICATOR 16

Percentage of children with stunted growth under five years of age (1990–2013)



** Stunting is defined by WHO as height-for-age less than –2 standard deviations of the WHO Child Growth Standards median.*
Source: WWAP, with data from the Global Health Observatory Data Repository of the World Health Organization (WHO).
http://apps.who.int/gho/data/node.main.NUTUNREGIONS?lang=en (Accessed October 2014)

17

INDICATOR

Population using solid fuel for cooking and without access to electricity, improved water and sanitation

Africa					
	Population (2012)[a] (in thousands)	**Population without access to electricity (2012)[b] (%)**	**Population without access to improved water (2012)[a] (%)**	**Population without access to improved sanitation (2012)[a] (%)**	**Population using solid fuel for cooking*, c (%)**
Benin	10 051	71.6	23.9	85.7	94.3 (2006)
Burkina Faso	16 460	83.6	18.3	81.4	95.6 (2003)
Cameroon	21 700	45.9	25.9	54.8	77.7 (2004)
Congo	4 337	65.0	24.7	85.4	82.9 (2005)
Democratic Republic of the Congo	65 705	91.0	53.5	68.6	95.3 (2007)
Egypt	80 722	0.4	0.7	4.1	0.3 (2005)
Ethiopia	91 729	76.7	48.5	76.4	96.6 (2011)
Ghana	25 366	28.0	12.8	85.6	85.4 (2008)
Kenya	43 178	80.0	38.3	70.4	84.8 (2008)
Lesotho	2 052	72.0	18.7	70.4	58.2 (2009)
Madagascar	22 294	85.3	50.4	86.1	99.2 (2008)
Malawi	15 906	91.0	15.0	89.7	98.2 (2010)
Morocco	32 521	1.1	16.4	24.6	8.5 (2003)
Mozambique	25 203	61.0	50.8	79.0	97.4 (2003)
Namibia	2 259	70.0	8.3	67.8	57.2 (2006)
Nigeria	168 834	55.0	36.0	72.2	72.0 (2008)
Senegal	13 726	45.5	25.9	48.1	56.1 (2005)
Uganda	36 346	85.2	25.2	66.1	98.6 (2006)
United Republic of Tanzania	47 783	76.0	46.8	87.8	95.9 (2010)
Zambia	14 075	74.0	36.7	57.2	85.5 (2007)
Zimbabwe	13 724	60.0	20.1	60.1	67.1 (2005)

*Note: In selected countries by region. * The reference year for the data is given in parentheses. ** Excludes coal.*
Source: WWAP, with data from [a] WHO/UNICEF (2014); [b] IEA (2014) and [c] WHO (n.d.).
WHO/UNICEF (World Health Organization/United Nations Children's Fund). 2014. Data Resources and Estimates. New York, WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation. http://www.wssinfo.org/data-estimates/table/
IEA (International Energy Agency). 2014. World Energy Outlook 2014. Paris, OECD/IEA http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/
WHO (World Health Organization).n.d. Global Health Observatory Data Repository – Solid cooking fuels by country http://apps.who.int/gho/data/view.main.EQSOLIDFUELSTOTv

Latin America					
	Population (2012)[a] (in thousands)	**Population without access to electricity (2012)[b] (%)**	**Population without access to improved water (2012)[a] (%)**	**Population without access to improved sanitation (2012)[a] (%)**	**Population using solid fuel for cooking[*, c] (%)**
Bolivia (Plurinational State of)	10 496	11.7	11.9	53.6	31.5 (2008)
Colombia	47 704	2.9	8.8	19.8	13.9 (2010)
Haiti	10 174	72.0	37.6	75.6	94.0 (2005)
Honduras	7 936	13.9	10.4	20.0	53.6 (2005)
Nicaragua	5 992	26.3	15.0	47.9	60.9 (2001)
Peru	29 988	8.9	13.2	26.9	40.9 (2004)

Asia					
	Population (2012)[a] (in thousands)	**Population without access to electricity (2012)[b] (%)**	**Population without access to improved water (2012)[a] (%)**	**Population without access to improved sanitation (2012)[a] (%)**	**Population using solid fuel for cooking[*, c] (%)**
Bangladesh	154 695	40.2	15.2	43.0	91.2 (2007)
Cambodia	14 865	65.9	28.7	63.2	88.3 (2010)
India	1 236 687	24.6	7.4	64.0	71.1 (2005)
Indonesia	246 864	24.1	15.1	41.2	54.8 (2007)
Nepal	27 474	23.7	11.9	63.3	75.7 (2011)
Pakistan	179 160	31.3	8.6	52.4	66.9 (2006)
Philippines	96 707	29.7	8.2	25.7	64.5 (2008)

World	**7 056 768**	**18.0**	**10.6**	**35.8**	**38.0 (2012)****

18

INDICATOR

Prevalence of undernourishment globally (1990–2014)

	1990-92		2000-02	
	Undernourished[a] (in millions)	**Prevalence of undernourishment[b] (%)**	**Undernourished[a] (in millions)**	**Prevalence of undernourishment[b] (%)**
World	**1 014.5**	**18.7**	**929.9**	**14.9**
Developed Regions	**20.4**	**<5**	**21.1**	**<5**
Developing Regions	**994.1**	**23.4**	**908.7**	**18.2**
Africa	**182.1**	**27.7**	**209.0**	**25.2**
Northern Africa	6.0	<5	6.5	<5
Sub-Saharan Africa	176.0	33.3	202.5	29.8
Asia	**742.6**	**27.3**	**637.5**	**25.2**
Caucasus and Central Asia	9.6	14.1	10.9	15.3
Eastern Asia	295.2	23.2	222.2	16.0
South-Eastern Asia	138.0	30.7	117.7	22.3
Southern Asia	291.7	24.0	272.9	18.5
Western Asia	8.0	6.3	13.8	8.6
Latin America and the Caribbean	**68.5**	**15.3**	**61.0**	**11.5**
Caribbean	8.1	27.0	8.2	24.4
Latin America	60.3	14.4	52.7	10.7
Oceania	**1.0**	**15.7**	**1.3**	**16.5**

** Projections. [a] Undernourishment or chronic hunger is a state, lasting for at least one year, of inability to acquire enough food, defined as a level of food intake insufficient to meet dietary energy requirements (FAO, n.d.). [b] The prevalence of undernourishment shows the proportion of the population suffering from such chronic hunger.*

Source: Modified from FAO, IFAD and WFP (2014, Table 1, p. 8).

FAO (Food and Agriculture Organization of the United Nations). n.d. The FAO Hunger Map 2014 – Basic Definitions. Rome, FAO. http://www.fao.org/hunger/en/ (Accessed November 2014)

FAO, IFAD and WFP. 2014. The State of Food Insecurity in the World 2014: Strengthening the Enabling Environment for Food Security and Nutrition. Rome, FAO. http://www.fao.org/3/a-i4030e.pdf

2005-07		2008-10		2012-14*	
Undernourished[a] (in millions)	**Prevalence of undernourishment[b] (%)**	**Undernourished[a] (in millions)**	**Prevalence of undernourishment[b] (%)**	**Undernourished[a] (in millions)**	**Prevalence of undernourishment[b] (%)**
946.2	**14.3**	**840.5**	**12.1**	**805.3**	**11.3**
15.4	**<5**	**15.7**	**<5**	**14.6**	**<5**
930.8	**17.3**	**824.9**	**14.5**	**790.7**	**13.5**
211.8	**22.6**	**216.8**	**20.9**	**226.7**	**20.5**
6.4	<5	5.6	<5	12.6	6.0
205.3	26.5	211.2	24.4	214.1	23.8
668.6	**17.4**	**565.3**	**14.1**	**525.6**	**12.7**
8.5	11.3	7.4	9.5	6.0	7.4
218.4	15.3	185.8	12.7	161.2	10.8
103.3	18.3	79.3	13.4	63.5	10.3
321.4	20.2	274.5	16.3	276.4	15.8
17.0	9.3	18.3	9.1	18.5	8.7
49.2	**8.7**	**41.5**	**7.0**	**37.0**	**6.1**
8.4	23.7	7.6	20.7	7.5	20.1
40.8	7.7	33.9	6.1	29.5	5.1
1.3	**15.4**	**1.3**	**13.5**	**1.4**	**14.0**

19 INDICATOR

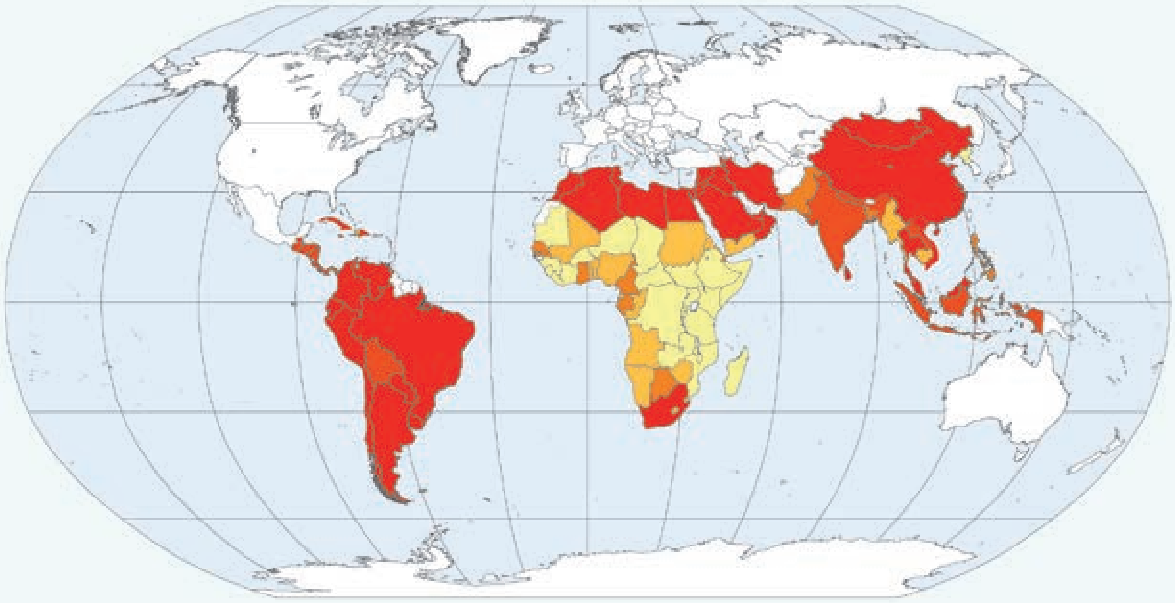
Electricity production, sources and access (2011)

	Electricity production (in billion kWh)	Sources of electricity production						Access to electricity
		Coal	Natural gas	Oil	Hydro-power	Renewable sources	Nuclear power	
		% of total	% of total	% of total	% of total	% of total	% of total	% of population
World	**22 159**	**41.2**	**21.9**	**3.9**	**15.6**	**4.2**	**11.7**	**83.1**
East Asia and Pacific	5 411	73.0	6.5	1.3	14.5	2.4	1.6	94.8
Europe and Central Asia	909	35.7	29.6	0.5	17.9	1.2	15.0	99.9
Latin America and Caribbean	1 348	4.2	22.5	10.6	55.1	4.4	2.4	94.7
Middle East and North Africa	654	1.8	64.3	25.5	5.5	0.5	0.1	94.6
South Asia	1 216	59.0	14.5	4.4	13.8	4.3	3.2	73.2
Sub-Saharan Africa	445	55.3	6.3	3.5	20.0	0.6	3.0	31.8

Note: kWh (kilowatt-hour).
Source: WWAP, with data from The World Bank 2014 World Development Indicators (Electricity production, sources and access). http://wdi.worldbank.org/table/3.7 (Accessed November 2014).

20 INDICATOR

Share of people with electricity access in developing countries (2012)

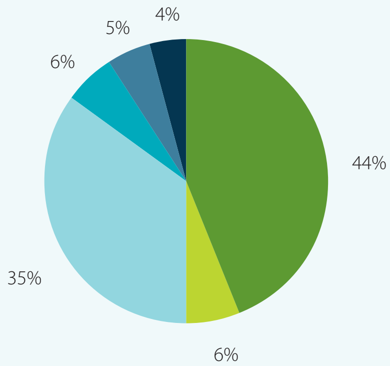


Note: Data are given as a percentage of the population.
Source: WWAP (2015), with data from the IEA World Energy Outlook 2014 Electricity Access Database.
http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/ (Accessed December 2014).

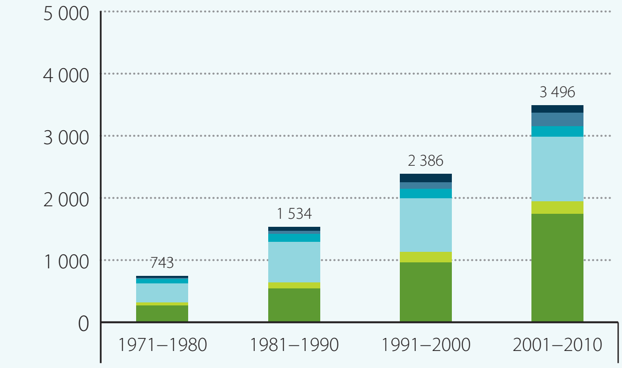
21 INDICATOR

Distribution of natural disasters

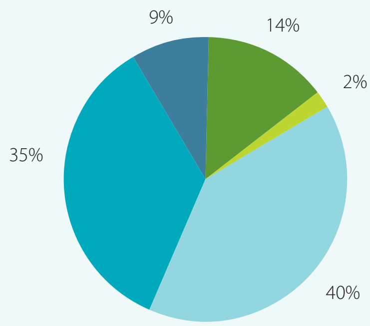
Global distribution of reported number of disasters (1970–2012)
Total: 8,835 disasters



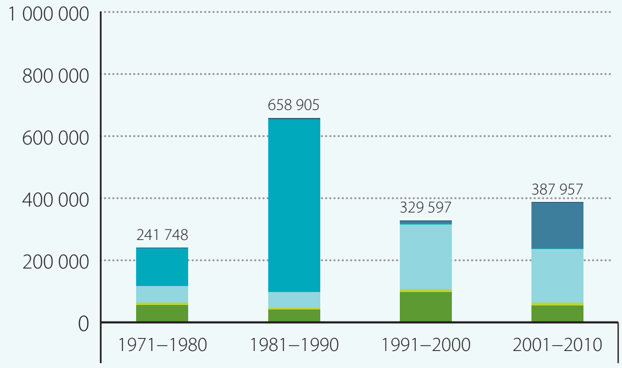
Number of reported disasters by decade by hazard type (1971–2010)



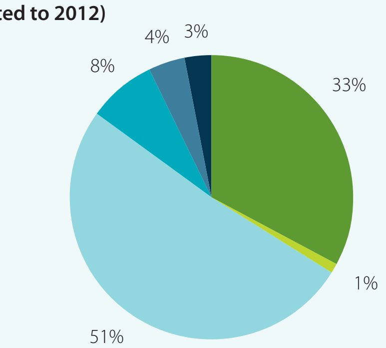
Global distribution of reported deaths (1970–2012)
Total: 1,944,653 deaths



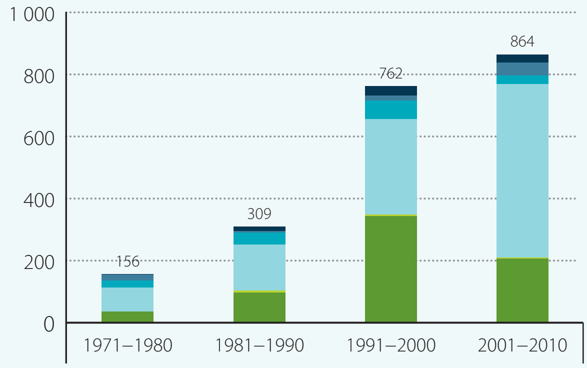
Number of reported deaths by decade by hazard type (1971–2010)



Global distribution of reported total economic losses by hazard type (1970–2012)
Total: US$2,390.7 billion (in US$ billion, adjusted to 2012)



Reported economic losses by decade by hazard type (1971–2010) (in US$ billion, adjusted to 2012)



Floods · Mass movement · Storms · Drought · Extreme temperature · Wildfires

Source: WMO (2014, p. 9).
WMO (World Meteorological Organization). 2014. Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970–2012). WMO-No. 1123. Geneva, WMO. http://www.wmo.int/pages/prog/drr/transfer/2014.06.12-WMO1123_Atlas_120614.pdf

22 INDICATOR

Displacement by type of hazard (2008–2012)

Proportion of displacement by hazard category (2008–2012)

Hazard subgroup*	Proportion of displacement
Hydrological	68.2
Metereological	29.6
Geophysical	2.1
Climatological	0.2

Number of people displaced by type of hazard (2008–2012)

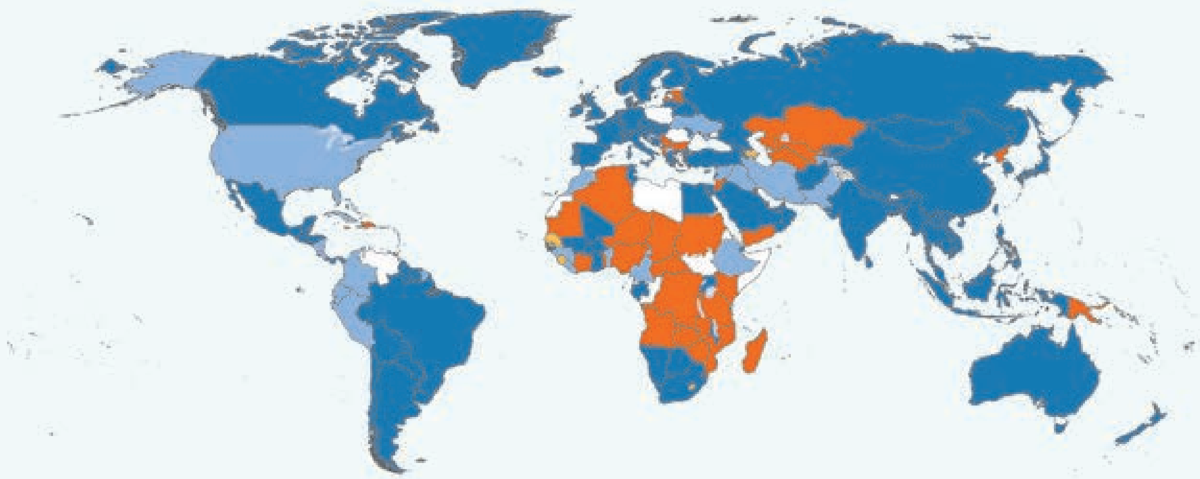
Type of hazard	People displaced
Flood	89 181 000
Storm	29 051 000
Earthquake (seismic activity)	23 604 000
Extreme cold	923 000
Landslide (wet)	577 000
Volcano	472 000
Wildfire	103 000
Landslide (dry)	3 200
Extreme heat	1 700

** Based on the classification used by the International Disaster Database (CRED, 2009), geophysical hazards include earthquakes and tsunamis, volcanic eruptions, dry mass movements (rock falls, landslides, avalanches and subsidence) and volcanic mud flow; meteorological hazards include storms (tropical, winter, tornados, snow and sand); hydrological hazards include floods (flash, coastal, riverine, snow melt, dam releases), wet mass movements (landslides, avalanches, sudden subsidence) and sea-level rise; and climatological hazards include extreme winter conditions, heatwaves, wildfires and drought.*
Source: Adapted from IDMC (2013, Table 6.1, p. 37).
CRED (Centre for Research on the Epidemiology of Disasters). 2009. EM-DAT: The International Disaster Database – Classification. Brussels, CRED. http://www.emdat.be/new-classification
IDMC (Internal Displacement Monitoring Centre). 2013. Global Estimates 2012: People Displaced by Disasters. Geneva, IDMC. http://www.internal-displacement.org/assets/publications/2013/2012-global-estimates-corporate-en.pdf

23 INDICATOR

Progress towards the MDG target: Access to improved drinking water (2012)

116 countries have already met the MDG drinking water target, 31 are on track and 45 are not on-track

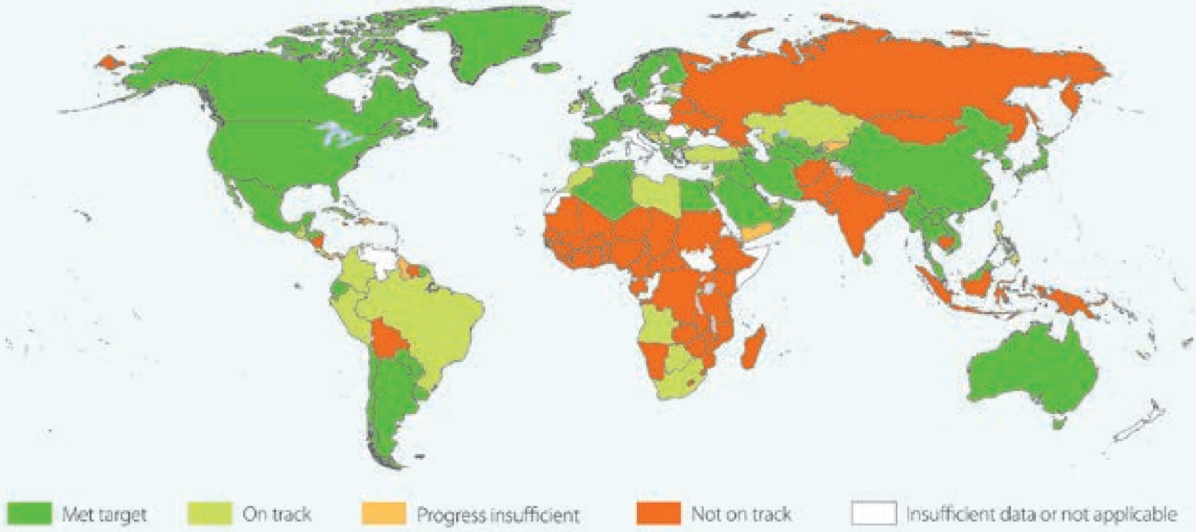


The global Millennium Development Goal (MDG) target is applied to countries, areas or territories. These assessments are preliminary; the final assessment will be made in 2015 for the final MDG report. Method: If the 2012 estimate of improved drinking water or improved sanitation coverage is (i) greater than or equal to the 2015 target or the 2012 coverage is greater than or equal to 99.5%: Met target; (ii) within 3% of the 2012 coverage-when-on-track: On track; (iii) within 3–7% of the 2012 coverage-when-on-track: Progress insufficient; (iv) >7% of the 2012 coverage-when-on-track or 2012 coverage ≤1990 coverage: Off track.
Source: WHO/UNICEF (2014, p. 2).
WHO/UNICEF (World Health Organization/United Nations Children's Fund). 2014. A Snapshot of Progress: 2014 Update. New York, WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation.
http://www.wssinfo.org/fileadmin/user_upload/documents/Four-page-JMP-2014-Snapshot-standard-on-line-publishing.pdf

INDICATOR 24

Progress towards the MDG target: Access to improved sanitation (2012)

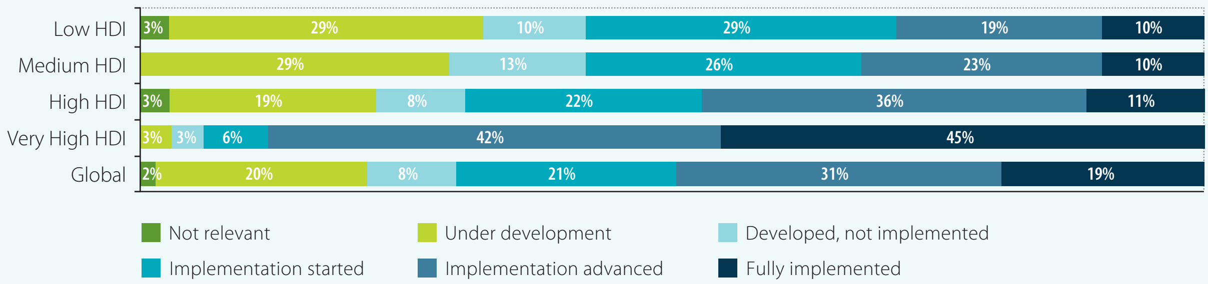
77 countries have already met the MDG sanitation target, 29 are on track and 79 are not on-track



Source: WHO/UNICEF (2014, p. 2).
WHO/UNICEF (World Health Organization/United Nations Children's Fund). 2014. A Snapshot of Progress: 2014 Update. New York, WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation.
http://www.wssinfo.org/fileadmin/user_upload/documents/Four-page-JMP-2014-Snapshot-standard-on-line-publishing.pdf

INDICATOR 25

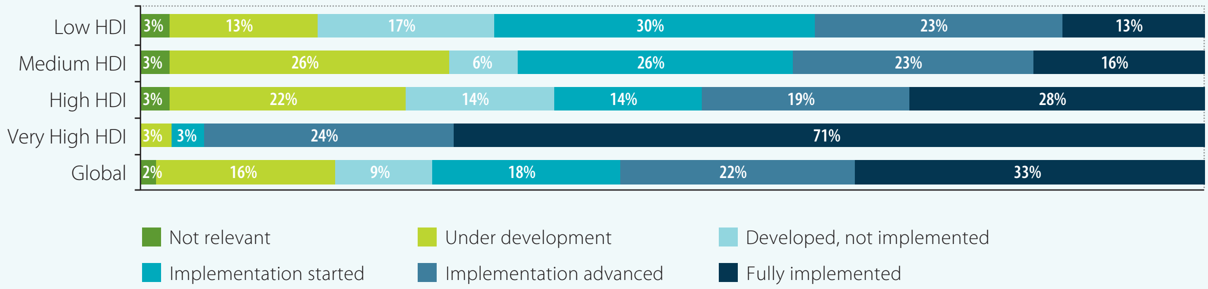
National water resources policy: Status of the main policy instrument (2012)



Note: The indicator shows responding countries by HDI (Human Development Index) group.
Source: UNEP (2012, Fig. 2.1, p. 12).
UNEP (United Nations Environment Programme). 2012. The UN-Water Status Report on the Application of Integrated Approaches to Water Resources Management. Nairobi, UNEP. http://www.unwater.org/publications/publications-detail/en/c/204523/. Databook available at http://www.unepdhi.org/rioplus20

26 INDICATOR

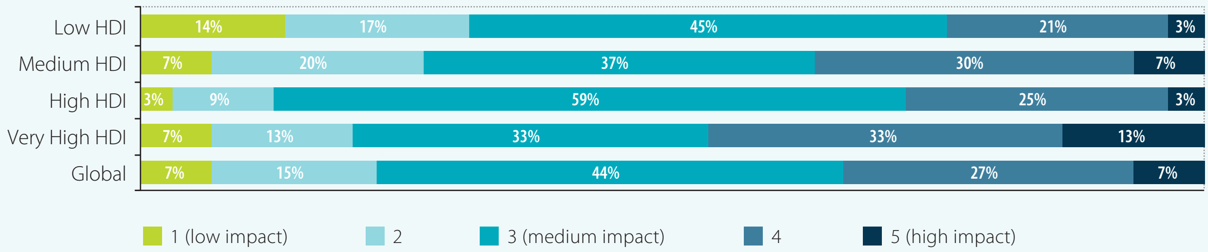
National water laws: Status of the main water law (2012)



Note: The indicator shows responding countries by HDI (Human Development Index) group.
Source: UNEP (2012, Fig. 2.2, p. 12).
UNEP (United Nations Environment Programme). 2012. The UN-Water Status Report on the Application of Integrated Approaches to Water Resources Management. Nairobi, UNEP. http://www.unwater.org/publications/publications-detail/en/c/204523/. Databook available at http://www.unepdhi.org/rioplus20

27 INDICATOR

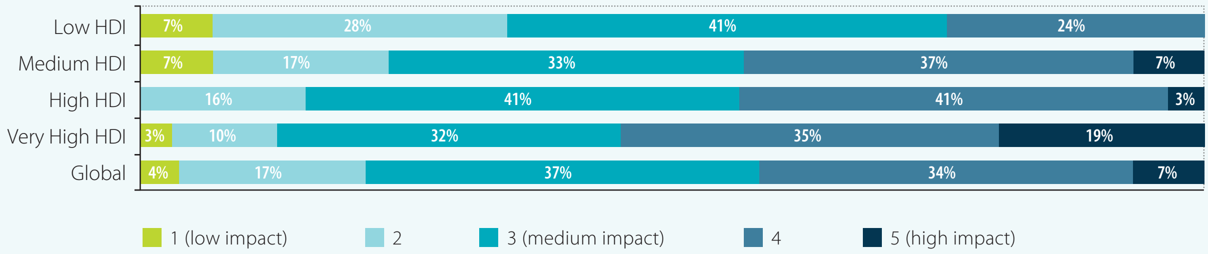
Impacts of improved water resources management on social development over the past 20 years (2012)



Note: The indicator shows responding countries by HDI (Human Development Index) group.
Source: UNEP (2012, Fig. 9.2, p. 70).
UNEP (United Nations Environment Programme). 2012. The UN-Water Status Report on the Application of Integrated Approaches to Water Resources Management. Nairobi, UNEP. http://www.unwater.org/publications/publications-detail/en/c/204523/. Databook available at http://www.unepdhi.org/rioplus20

28 INDICATOR

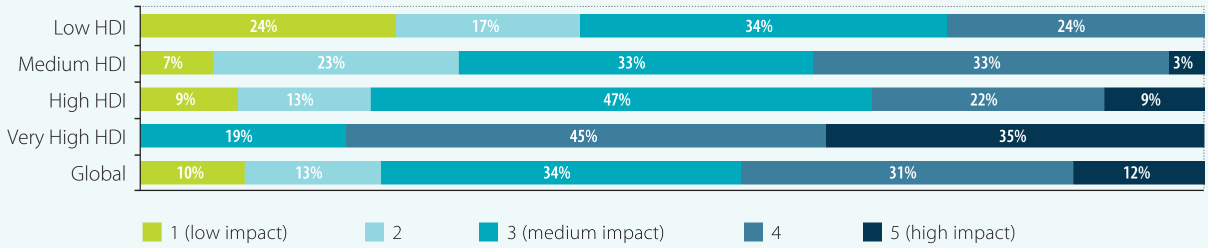
Impacts of improved water resources management on economic development over the past 20 years (2012)



Note: The indicator shows responding countries by HDI (Human Development Index) group.
Source: UNEP (2012, Fig. 9.3, p. 71).
UNEP (United Nations Environment Programme). 2012. The UN-Water Status Report on the Application of Integrated Approaches to Water Resources Management. Nairobi, UNEP. http://www.unwater.org/publications/publications-detail/en/c/204523/. Databook available at http://www.unepdhi.org/rioplus20

29 INDICATOR

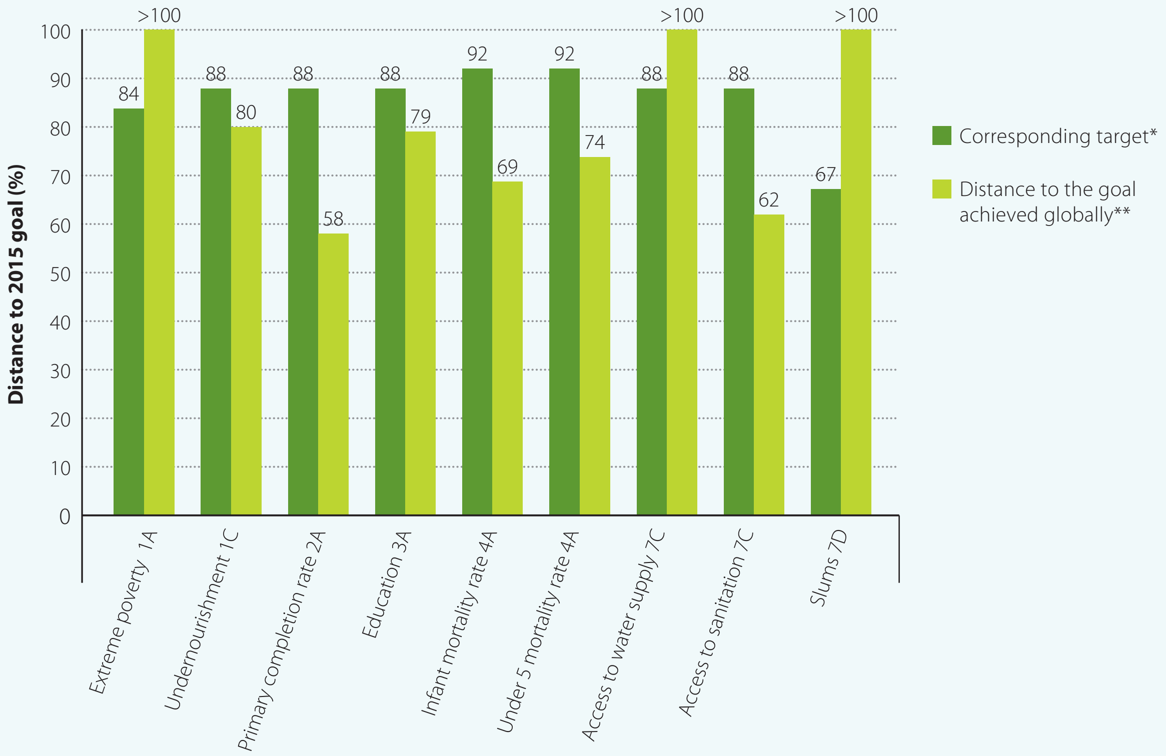
Impacts of improved water resources management on environmental development over the past 20 years (2012)



Note: The indicator shows responding countries by HDI (Human Development Index) group.
Source: UNEP (2012, Fig. 9.4, p. 72).
UNEP (United Nations Environment Programme). 2012. The UN-Water Status Report on the Application of Integrated Approaches to Water Resources Management. Nairobi, UNEP. http://www.unwater.org/publications/publications-detail/en/c/204523/. Databook available at http://www.unepdhi.org/rioplus20

INDICATOR 30

Global progress towards achieving the Millenium Development Goals



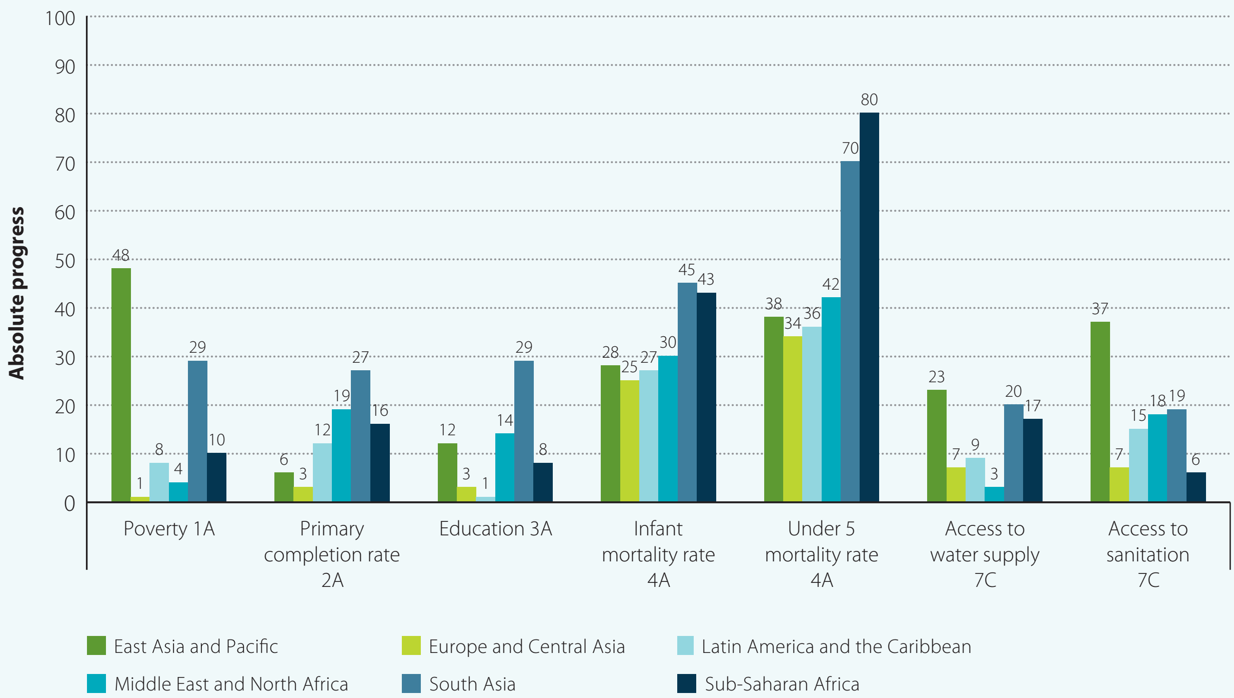
Corresponding Millennium Development Goals (MDGs):

1A Extreme poverty (population below US$1.25 per day (2005 purchasing power parity)
1C Prevalence of undernourishment (% of population)
2A Primary completion rate, total (% of relevant age group)
3A Ratio of girls to boys in primary and secondary education (%)
4A Mortality rate, infant (per 1 000 live births)
4A Mortality rate, under five (per 1 000 live births)
7C Access to safe drinking water (% of population with access)
7C Access to basic sanitation facilities (% of population with access)
7D Improve the lives of at least 100 million slum dwellers (by 2020)

Note: A value of 100% means that the respective MDG has been reached.
** Corresponding target indicates progress currently needed to reach the goal by 2015.*
*** Latest available value denotes current progress as illustrated by the most recent available data: extreme poverty, 2011; primary completion rate, total, 2012; ratio of girls to boys in primary and secondary education, 2012; mortality rate, infants, 2013; mortality rate, children under five, 2013; improved water source, 2012; improved sanitation facilities, 2012.*
Source: Adapted from The World Bank Group (2015, Fig. 12, p. 30, based on sources cited therein [World Bank calculations based on data from the World Development Indicators database]).
The World Bank Group. 2015. Global Monitoring Report 2014/2015: Ending Poverty and Sharing Prosperity. Washington, DC, World Bank. doi:10.1596/978-1-4648-0336-9. http://www.worldbank.org/content/dam/Worldbank/gmr/gmr2014/GMR_2014_Full_Report.pdf

31 INDICATOR

Absolute progress made by Millenium Development Goal by region



Corresponding Millennium Development Goals (MDGs):

1A Poverty headcount ratio at US$1.25 per day (purchasing power parity) (% of population)
2A Primary completion rate, total (% of relevant age group)
3A Ratio of girls to boys in primary and secondary education (%)
4A Mortality rate, infant (per 1 000 live births)
4A Mortality rate, under five (per 1 000 live births)
7C Improved water source (% of population with access)
7C Improved sanitation facilities (% of population with access)

Note: Weighted by population, absolute differences, between 1990 and latest available observation: extreme poverty, 2011; primary completion rate, total, 2012; ratio of girls to boys in primary and secondary education, 2012; mortality rate, infants, 2013; mortality rate, children under five, 2013; improved water source, 2012; improved sanitation facilities, 2012.
Source: Adapted from The World Bank (2014, Fig. 2, p. 4, based on source cited therein [World Development Indicators]).
World Bank. 2014. United Nations System Chief Executives Board for Coordination (CEB), Review of MDG Acceleration at the Country Level Fourth Review Session. Washington, DC, World Bank.

32 INDICATOR

Progress towards achieving the Millennium Development Goals by number of countries

	MDGs met	Sufficient progress[a] (<2015)	Insufficient progress[b] (2015-2020)	Moderately off target[c] (2020-2030)	Seriously off target[d] (2030)	Insufficient data[e]
Population living below US$1.25 per day (%)	74	9	6	5	22	28
Prevalence of undernourishment (% of population)	35	8	4	13	52	32
Primary completion rate (% of relevant age group)	44	11	14	16	36	23
Ratio of girls to boys enrollment in primary and secondary education (%)	65	10	6	13	28	22
Under five mortality rate, infant (per 1 000 live births)	37	18	16	37	34	2
Mortality rate, infant (per 1 000 live births)	6	9	22	28	77	2
Access to improved water source (% of population)	66	1	3	2	53	19
Access to improved sanitation facilities (% of population)	35	6	3	8	69	23

Note: Progress is based on extrapolation of latest five-year annual growth rates for each country, except for Millennium Development Goal (MDG) 5, which uses the last three years.
[a] Sufficient progress indicates that an extrapolation of the last observed data point with the growth rate over the last observable five-year period shows that the MDG can be attained.
[b] Insufficient progress is defined as being able to meet the MDG between 2016 and 2020.
[c] Moderately off target indicates that the MDG can be met between 2020 and 2030.
[d] Seriously off target indicates that the MDG will not even be met by 2030.
[e] Insufficient data points to the fact that not enough data points are available to estimate progress or that the MDG's starting value is missing (except for primary completion rate and enrolment ratio). In the poverty target, 11 out of the 66 countries that have met the target have less than 2% of people living below US$1.25 per day.
Source: Adapted from The World Bank Group (2015, Fig. 13, p. 31, based on sources cited therein [WDI and GMR team estimates]).
The World Bank Group. 2015. Global Monitoring Report 2014/2015: Ending Poverty and Sharing Prosperity. Washington, DC, World Bank. doi:10.1596/978-1-4648-0336-9.
http://www.worldbank.org/content/dam/Worldbank/gmr/gmr2014/GMR_2014_Full_Report.pdf

PHOTO CREDITS

Page 1 (clockwise from top-left):
1. Ponte del Diavolo (Maddalena Bridge), Serchio River (Italy). Photo: Patrizio Boschi
2. Rapid urbanization in Vietnam. Photo: Tran Viet Duc/World Bank
3. Gardens by the Bay (Singapore). Photo: Edmund Gall
4. The Mekong Delta. Photo: G. Smith (CIAT)
5. Traditional irrigation channels in Al Hamra', Ad Dakhiliyah (Oman). Photo: Simon Monk
6. Along the main south road in 'Upolu (Samoa). Photo: Matti Vuorre
7. Spring recovered and protected (Brazil). Photo: Itaipu Binacional

Page 33 (clockwise from top-left):
1. Aerial view of Manaus, the capital of the Brazilian state of Amazonas (Brazil). Photo: Neil Palmer (CIFOR)
2. Water being poured into tank (Ghana). Photo: © Arne Hoel/The World Bank
3. Pedestrians at Shibuya crossing in Tokyo (Japan). © Thomas La Mela/Shutterstock.com

Around the globe, the international community faces a number of water-related challenges – overuse of freshwater resources, pollution, environmental degradation, loss of biodiversity, desertification, increasing intensity and progression of natural disasters are a few to name. While the issues are comparable, what is different are the approaches and methodologies adopted by countries in different regions to cope with these mounting problems.

Since its establishment in 2000, the World Water Assessment Programme has utilized case studies to illustrate the conditions on the ground in various regions and actions taken by stakeholders to confront current and impending water crises.

The *Case Studies and Indicators Report*, which is UNESCO's contribution to the 2015 edition of the World Water Development Report, features diverse and encouraging examples that illustrate the dynamic new partnerships that are being formed, preventive actions taken and effective institutional and regulatory frameworks being put in place at levels ranging from the local community on up to central government – all of which can go a long way towards attenuating the water crisis.

In addition to case studies, this publication also includes a number of selected indicators reflecting the trends in a broad range of issues closely affecting the sustainable use of water resources as well as the state of environment, human well-being and the progress made towards a number of Millennium Development Goal targets.

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