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

FACING THE CHALLENGES

CASE STUDIES AND INDICATORS

United Nations
Educational, Scientific and
Cultural Organization

World Water
Assessment Programme

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The United Nations World Water Development Report 2015

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Published in 2015 by the United Nations Educational, Scientific and Cultural Organization, 7, place de Fontenoy, 75352 Paris 07 SP, France

ISBN 978-92-3-100072-0
ePub ISBN 978-92-3-100098-0

Suggested citation:
WWAP (United Nations World Water Assessment Programme). 2015. *Facing the Challenges. Case Studies and Indicators.* Paris, UNESCO.

Cover and interior design and typesetting by Phoenix Design Aid A/S, an ISO 14001 (environmental management) and a DS 49001 (corporate social responsibility) certified and approved carbon neutral company.

Printed by Dimensione Grafica (ISO 9001:2008 and FSC-COC), Spello, Umbria, Italy

This publication is printed in vegetable inks on FSC Mixed Sources paper, supporting responsible use of forest reserves, 100% recycled, acid-free and chlorine-free.

Printed in Italy

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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.

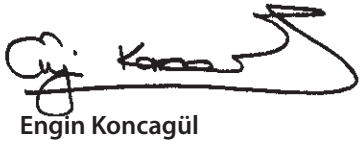
The WWDR 2015 underlines that 'groundwater supplies are diminishing, with an estimated 20% of the world's aquifers currently over-exploited. Worldwide, 2.5 billion people depend solely on groundwater resources to satisfy their daily needs for water and hundreds of millions of farmers rely on groundwater 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

ACKNOWLEDGEMENTS

We would like to thank UNESCO Member States and other partners who have volunteered their efforts. Without their dedicated involvement in every step throughout the process, this Report would have never been accomplished.

We would also like to show gratitude to Jayakumar Ramasamy at UNESCO's Bangkok Field Office who facilitated the preparation of the Asian cities case study and provided assistance to the United Nations World Water Assessment Programme Secretariat in many ways.

A special thanks goes to young professionals Maxime Turko and Sisira Saddhamangala Withanachchi for their enthusiasm and assistance that they provided in the development of the Indicators section of this Report.

A great deal of appreciation is extended to Joseph Alcamo and Martina Flörke (Center for Environmental Systems Research, University of Kassel), Karen Franken and Livia Peiser (Food and Agriculture Organization of the United Nations), Peter Koefoed Bjørnsen and Paul Glennie (UNEP-DHI Centre for Water and Environment), Nienke Ansems and Neno Kukuriç (United Nations International Groundwater Resources Assessment Centre), Francesca Grum (United Nations Statistics Division), Leena Iyengar and Richard McLellan (World Wide Fund for Nature) for their support in providing updated information on selected indicators.

Most importantly, none of this could have happened without the generous financial support of the Italian Government.

CONTRIBUTORS

Sangam Shrestha *(Towards sustainable groundwater management in Asian cities)*; Fábio Mendes Marzano and Itaipu Binacional *(The Cultivating Good Water programme in the Paraná River basin, Brazil)*; Waleed K. Al-Zubari *(Sustainable water resources management in the Gulf Cooperation Council countries)*; Massimo Bastiani, Endro Martini, Giorgio Pineschi, Francesca Lazzari, Sandra Paterni, Massimo Rovai *(River contracts for sustainable development in the Italian context: The Serchio River case study)*; Leo Berthe, Denis Chang Seng and Lameko Asora *(Challenges to freshwater security in the Pacific SIDS: Focus on saltwater intrusion in Samoa)*; Third World Centre for Water Management (Mexico), Ming Hwee Lee and Nora Farhain Hamim (National Water Agency of Singapore) and UN-Water Decade Programme on Advocacy and Communication *(Water recycling in Singapore)*; and Martijn van de Groep *(Progress on sustainable development objectives in the Mekong Delta, Viet Nam)*.

Case Studies and Indicators Report Team

Editorial team
Alice Franek
Diwata Hunziker
Engin Koncagül

Publications assistant:
Valentina Abete

Map design
Roberto Rossi at
Pica Publishing

The United Nations World Water Assessment Programme (WWAP)

Donors
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Government of the Region of Umbria, Italy

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Security: Fabio Bianchi, Michele Brensacchi and Francesco Gioffredi
Interns and volunteers: Agnese Carlini, Lucia Chiodini, Greta di Florio, Alessio Lilli, Jessica Pascucci, Emma Schiavon, Maxime Turko and Sisira Saddhamangala Withanachchi

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 – **1** Towards sustainable groundwater management in Asian cities – **2** The Cultivating Good Water programme in the Paraná River basin, Brazil – **3** Sustainable water resources management in the Gulf Cooperation Council countries – **4** River contracts for sustainable development in the Italian context: The Serchio River case study – **5** Challenges to freshwater security in the Pacific Small Islands Developing States: Focus on saltwater intrusion in Samoa – **6** Water recycling in Singapore – **7** Progress on sustainable development objectives in the Mekong Delta, Viet Nam







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.

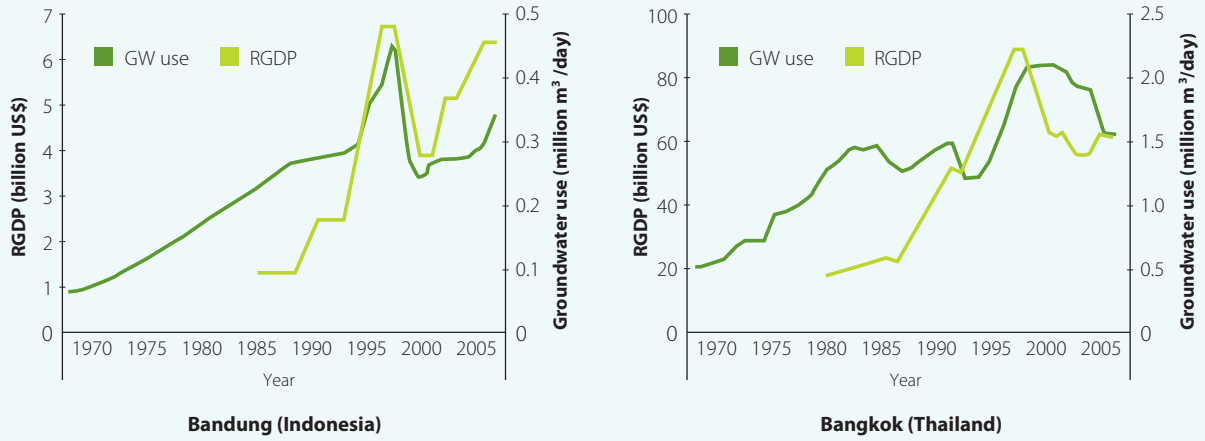
In many Asian cities, groundwater is contaminated by both natural sources (e.g. arsenic, fluoride) and human activities, posing serious health risks to millions of people. Anthropogenic pollutants include coliform bacteria, volatile organic compounds, nitrates and heavy metals such as cadmium. The main 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

References

Except where other sources are cited, information in this chapter is adapted from:

Shrestha, S. 2014. *Towards Sustainable Groundwater Management in Asian Cities.* Bangkok, Water Engineering and Management, Asian Institute of Technology. (Unpublished)

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IGES (Institute for Global Environmental Strategies). 2007. *Sustainable Groundwater Management in Asian Cities.* A Final Report of Research on Sustainable Water Management in Asia. Kanagawa, Japan, Freshwater Resources Management Project, IGES. http://enviroscope.iges.or.jp/modules/envirolib/upload/981/attach/00_complete_report.pdf

Kemper, K.E. 2007. Instruments and institutions for groundwater management. M. Giordano and K.G. Villholth (eds), *The Agricultural Groundwater Revolution: Opportunities and Threats to Development,* pp. 153-172. Wallingford, UK, CABI.

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.

Acknowledgement

Fábio Mendes Marzano, Itaipu Binacional

References

Information in this chapter is adapted from:

Itaipu Binacional. 2014. *Itaipu and the* Cultivando Água Boa Program *[Cultivating Good Water].* Brasilia, Itaipu Binacional. (Unpublished)

3 Sustainable water resources management in the Gulf Cooperation Council countries

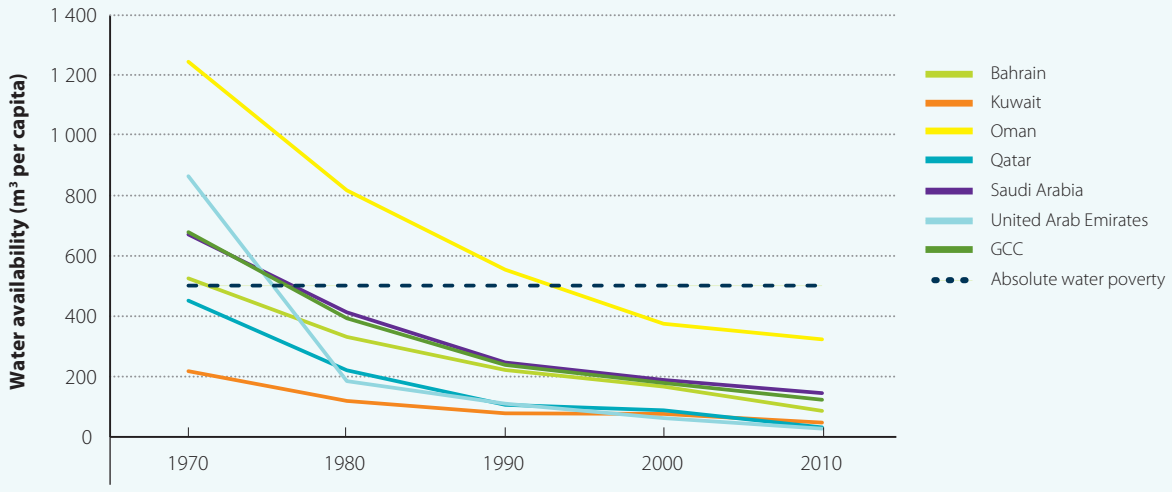
Abstract

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.

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

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.

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

Waleed K. Al-Zubari

References

Except where other sources are cited, information in this chapter is adapted from:

Al-Zubari, W.K. 2014. *Sustainable Water Resources Management in the GCC Countries.* Bahrain, Water Resources Management Program, College of Graduate Studies, Arabian Gulf University. (Unpublished)

****

The World Bank. 2005. *A Water Sector Assessment Report on the Countries of the Cooperation Council of the Arab States of the Gulf.* A report prepared for the Arab Gulf Programme for United Nations Development Organizations (AGFUND), Riyadh, Saudi Arabia. The World Bank Report No.: 32539-MNA, March 31, 2005.

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).

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

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.

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

Massimo Bastiani, Endro Martini, Giorgio Pineschi, Francesca Lazzari, Sandra Paterni, Massimo Rovai

References

Except where other sources are cited, information in this chapter is adapted from:

Bastiani, M., Martini, E. and Pineschi, G. 2014. *The Italian Experience of 'River Contracts' and Case Study of the Serchio Valley.* (Unpublished) Prepared by Massimo Bastiani (National Table of River Contracts, Gubbio, Italy), Endro Martini (Alta Scuola Cultural and Scientific Association, Perugia, Italy) and Giorgio Pineschi (Ministry of Environment, Land and Sea (Rome, Italy).

_____. 2011. Contratti di Fiume: Pianificazione Strategica e Partecipata dei Bacini Idrografici *[River Contracts: Strategic and Participatory Planning in Hydrographic Basins]*. Palermo, Italy, Flaccovio Editore. (In Italian)

_____. 2014. Stop the growth of cities: the role of marginal agricultural areas between river and city as a territorial protection and in the reduction of hydro-geological risk. *Scienze del Territorio*, 2: 55-78. Italy, Firenze University Press. doi:10.13128/Scienze_Territorio-14323

Blomquist, W. 2008. *Relating People to the Environment: Human Societies and River Basins.* Plenary address to the 60th Anniversary Celebration of the US-Italy Fulbright Program, Polytechnic Institute of Turin, Turin, Italy, 29 April 2008.

COE (Council of Europe). 2014. *The Territorial Dimension of Human Rights and Democracy.* The European Landscape Convention. Strasbourg, France, COE. http://www.coe.int/t/dg4/cultureheritage/heritage/Landscape/Pres_en.pdf

Guerra, S. 2013. *Disputed or Shared Territory? The Italian Experience of River Contract: New Relationship between River and its Region. Living Landscapes - Landscapes for Living.* Paesaggi Abitati. Conference Proceedings. Florence, Italy, February-June 2012. Planum. The Journal of Urbanism, no. 27, 2nd semester: 31-37. http://www.planum.net/living-landscapes-section-8

Martini, E. and Soccodato, F.M. 2012. *The River Contract: A Tool for Management and Rehabilitation of River Landscapes and Hydrogeological Risk Area.* Presented at 6th edition of the Remediation Technologies and Requalification of Territory Exhibition and 3rd edition of Coast Protection Exhibition, Ferrara, Italy, 21 September 2012, CD "Atti dei Convegni Nazionali".

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

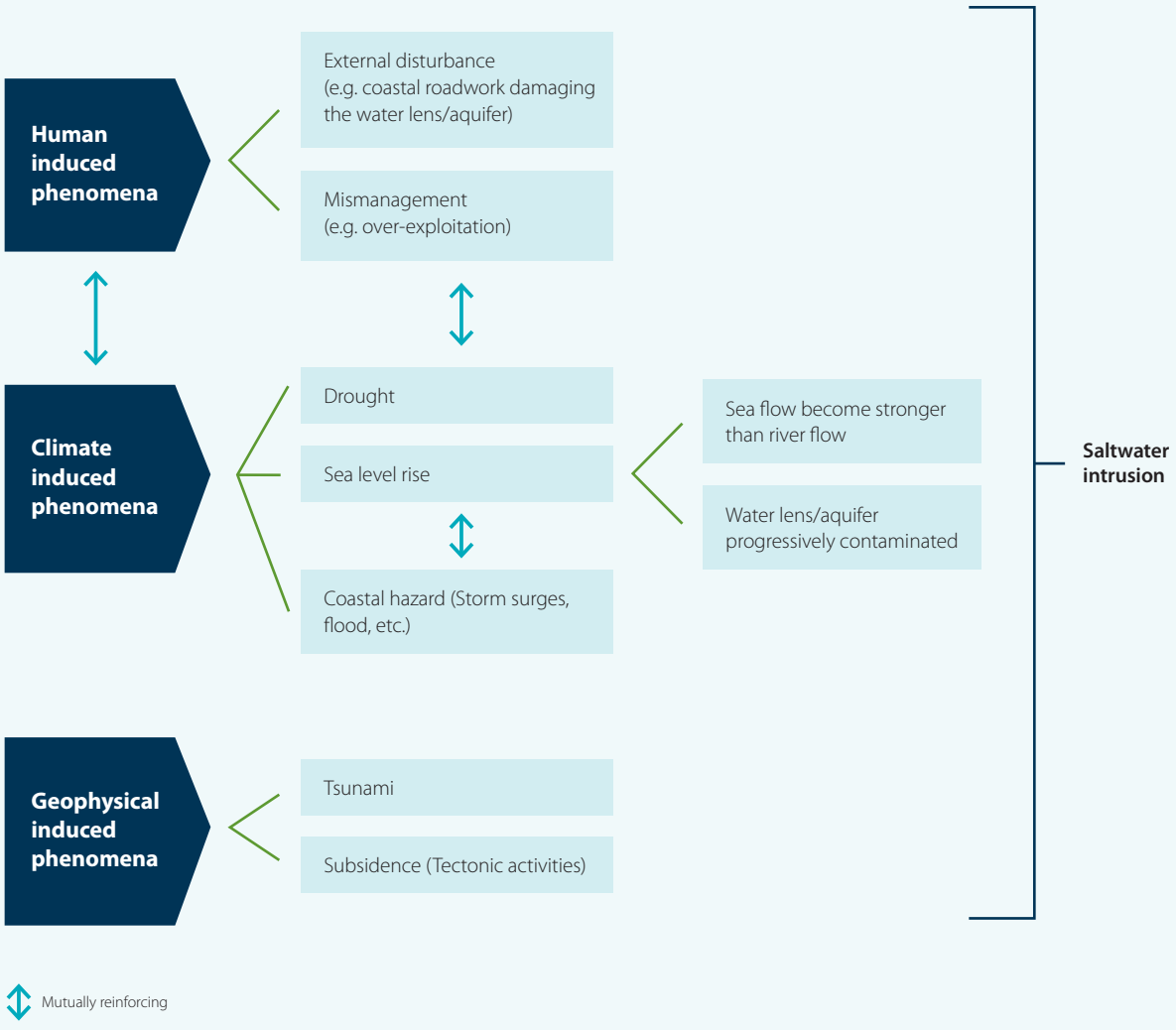


TABLE 5.1

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).

Acknowledgements

Leo Berthe, Denis Chang Seng, Lameko Asora

References

Except where other sources are cited, information in this chapter is adapted from:

Berthe, L., Chang Seng, D. and Asora, L. 2014. Multiple stresses, veiled threat: Saltwater intrusion in Samoa. L. Tovio-Alesana (ed.), *Opportunities and Challenges for a Sustainable Cultural and Natural Environment.* Proceedings of the Third Samoa Conference. Apia, National University of Samoa and UNESCO Apia Field Office.

****

Cook Islands Government. 2000. *Initial National Communication under the United Nations Framework Convention on Climate Change.* Avarua, Cook Islands Government. http://unfccc.int/resource/docs/natc/cisnc2.pdf

IPCC (Intergovernmental Panel on Climate Change). 2014a. Climate phenomena and their relevance for future regional climate change. *Working Group I, Fifth Assessment Report,* ch. 14. Geneva, IPCC Secretariat.

_____. 2014b. Small Islands. Working Group II, *Fifth Assessment Report,* ch. 29. Geneva, IPCC Secretariat.

Keener, V.W., Marra, J.J., Finucane, M.L., Spooner, D. and Smith, M.H. (eds). 2012. *Climate Change and Pacific Islands: Indicators and Impacts.* Report for the 2012 Pacific Islands Regional Climate Assessment (PIRCA). Washington, DC, Island Press. http://www.cakex.org/sites/default/files/documents/NCA-PIRCA-FINAL-int-print-1.13-web.form_.pdf

Marshall Islands Environmental Protection Authority. 2000. *Initial National Communication under the United Nations Framework Convention on Climate Change.* Majuro, Government of the Republic of the Marshall Islands. http://unfccc.int/resource/docs/natc/marnc1.pdf

NOAA (United States National Oceanic and Atmospheric Administration). n.d. *El Niño Theme Page.* Washington, DC, NOAA. http://www.pmel.noaa.gov/tao/elnino/la-nina-story.html (Accessed October 2014)

Samoa Ministry of Finance. 2012. *Strategy for the Development of Samoa 2012-2016.* Apia, Government of Samoa.

Samoa Ministry of Natural Resources and Environment. 2010. *Second National Communication under the United Nations Framework Convention on Climate Change.* Apia, Government of Samoa. http://unfccc.int/resource/docs/natc/samnc2.pdf

_____. 2012. *Water for Life: Water and Sanitation Sector Plan 2012-2016.* Apia, Government of Samoa.

_____. 2013*a*. *State of the Environment Report 2013.* Apia, Government of Samoa.

_____. 2013*b*. *National Environment and Development Sector Plan 2013-2016.* Apia, Government of Samoa.

Solomon Islands Ministry of Environment, Conservation and Meteorology. 2008. *Solomon Islands: National Adaptation Programmes of Action.* Honiara, Government of Solomon Islands. http://unfccc.int/resource/docs/napa/slb01.pdf

SOPAC (Applied Geoscience and Technology Division). 2007*a*. *National Integrated Water Resource Management Diagnostic Report: Solomon Islands.* Noumea, Secretariat of the Pacific Community. http://www.pacificwater.org/userfiles/file/GEF%20IWRM%20Final%20Docs/SI%20Diagnostic%20Report_24_10_07_.pdf

_____. 2007*b*. *National Integrated Water Resource Management Diagnostic Report: Republic of the Marshall Islands.* Noumea, Secretariat of the Pacific Community. http://www.pacificwater.org/userfiles/file/GEF%20IWRM%20Final%20Docs/MR0639RMI.pdf

_____. 2007*c*. *National Integrated Water Resource Management Diagnostic Report: Cook Islands.* Noumea, Secretariat of the Pacific Community. http://www.pacificwater.org/userfiles/file/GEF%20IWRM%20Final%20Docs/MR0635CI.pdf

_____. 2007*d*. *National Integrated Water Resource Management Diagnostic Report: Samoa.* Noumea, Secretariat of the Pacific Community. http://www.pacificwater.org/userfiles/file/GEF%20IWRM%20Final%20Docs/SOPAC%20Samoa%20IWRM%20Diagnostic%20Report%2022_10_07.pdf

_____. 2007*e*. *National Integrated Water Resource Management Diagnostic Report: Tuvalu.* Noumea, Secretariat of the Pacific Community. http://www.pacificwater.org/userfiles/file/GEF%20IWRM%20Final%20Docs/SOPAC%20Diagnostic%20Report%20Tuvalu%2022_10_07.pdf

Tuvalu Ministry of Natural Resources, Environment, Agriculture and Lands. 2007. *Tuvalu: National Adaptation Programme of Action.* Funafuti, Government of Tuvalu. http://www.sids2014.org/content/documents/162NAPA.pdf

6 Water recycling in Singapore

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.

Acknowledgements

Third World Centre for Water Management (Mexico), National Water Agency of Singapore (PUB), UN-Water Decade Programme on Advocacy and Communication (UNW-DPAC)

References

Except where other sources are cited, information in this chapter is adapted from the NEWater homepage of the National Water Agency of Singapore (PUB) website: http://www.pub.gov.sg/water/newater/Pages/default.aspx (Accessed October 2014)

****

Aik Num, P. n.d. *Smart Water: Singapore Case Study.* Singapore, Technology and Water Quality Office, PUB. Presented at Smart Water Cluster Workshop, 4th IWA-ASPIRE Conference, Tokyo, 2-6 October 2011. http://cdn2.iwahq.info/all/Specialist%20groups/Clusters/Smart%20Water%20Cluster/ASPIRE%20workshop/Smart%20Water%20-%20Singapore%20Case%20Study_aik%20num.pdf (Accessed November 2014)

HISS (Horizon International Solutions Site). 2014. *Singapore's NEWater Wins UN-Water Award on World Water Day.* New Haven, CT, Horizon International. http://www.solutions-site.org/node/1302 (Accessed November 2014)

PUB. 2008. *PUB Annual Report 2008.* Singapore, PUB. http://www.pub.gov.sg/mpublications/Lists/AnnualReport/Attachments/4/PUB_AR20072008.pdf

_____. 2014. *Water Pricing in Singapore.* Singapore, PUB. http://www.pub.gov.sg/general/Pages/WaterTariff.aspx (Accessed November 2014)

Tan, Y.S., Lee, T.J. and Tan, K. 2009. *Clean, Green and Blue: Singapore's Journey Towards Environmental and Water Sustainability.* Singapore, ISEAS Publishing.

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.

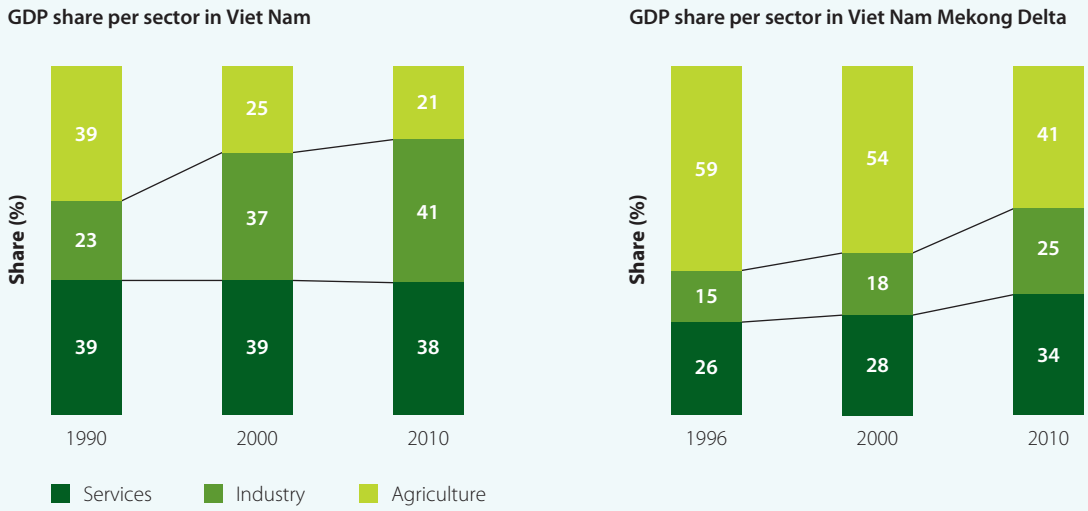
Several decentralization programmes have been deployed and several state agencies have been established to incorporate perspectives and concerns of various stakeholders. However, the integrated water management principles embedded in existing policies are not applied in practice, and water policy planning 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

Martijn van de Groep

References

Except where other sources are cited, information in this chapter is adapted from:

van de Groep, M.P.J. 2014. *The Mekong River Delta.* Wassenar, the Netherlands, Water.NL. (Unpublished)

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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).

Erban, L.E., Gorelick, S.M. and Zebker, H.A. 2014. Groundwater extraction, land subsidence, and sea-level rise in the Mekong Delta, Vietnam. *Environmental Research Letters*, doi:10.1088/1748-9326/9/8/084010.

FAO (Food and Agriculture Organization of the United Nations). 2014. *Rice Market Monitor.* Vol. XVII, No. 3, October 2014, p. 15. Rome, FAO. http://www.fao.org/economic/est/publications/rice-publications/rice-market-monitor-rmm/en/

GGGI (Global Green Growth Institute). n.d. *Green Growth on the Rise in the Mekong River Basin: From Concept to Reality.* Seoul, GGGI. http://gggi.org/green-growth-on-the-rise-in-the-mekong-river-basin-from-concept-to-reality (Accessed November 2014)

Government of Viet Nam and Government of the Netherlands. 2013. *Mekong Delta Plan: Long-term Vision and Strategy for a Safe, Prosperous and Sustainable Delta.* Ha Noi/The Hague, the Netherlands, Government of Viet Nam/Government of the Netherlands. http://www.mekongdeltaplan.com

GSO (General Statistics Office of Viet Nam). n.d. Statistical Yearbooks (in Vietnamese). Hanoi, GSO. http://www.gso.gov.vn/default_en.aspx?tabid=468&idmid=3&ItemID=15490 (Accessed December 2014)

MRC (Mekong River Commission). 2010. *State of the Basin Report.* Vientiane, Lao PDR. http://www.mrcmekong.org/assets/Publications/basin-reports/MRC-SOB-report-2010full-report.pdf

_____. 2011. *Integrated Water Resources Management-based Basin Development Strategy for the Lower Mekong Basin.* Vientiane, Lao PDR. http://www.mrcmekong.org/assets/Publications/strategies-workprog/BDP-Strategic-Plan-2011.pdf

_____. n.d. *Physiography* page on the MRC website. Vientiane, Lao PDR. http://www.mrcmekong.org/mekong-basin/physiography (Accessed November 2014)

Nicholls, R.J., Wong, P.P., Burkett, V.R., Codignotto, J.O., Hay, J.E., McLean, R.F., Ragoonaden, S. and Woodroffe, C.D. 2007. Coastal systems and low-lying areas. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds), *Climate Change 2007: Impacts, Adaptation and Vulnerability.* Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, pp. 315-356. Cambridge, UK, Cambridge University Press. http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4_wg2_full_report.pdf

Phan, M.T. and Populus, J. 2006. Status and changes of mangrove forest in Mekong Delta: Case study in Tra Vinh, Vietnam. *Estuarine, Coastal and Shelf Science,* 71(2007): 98-109. http://www.fao.org/fishery/gisfish/cds_upload/1179751412778_Thu_and_Populus__2007_.pdf

Renaud, F. and Kuenzer, C. (eds). 2012. *The Mekong Delta System: Interdisciplinary Analyses of a River Delta.* Dordrecht, the Netherlands, Springer Environmental Science and Engineering.

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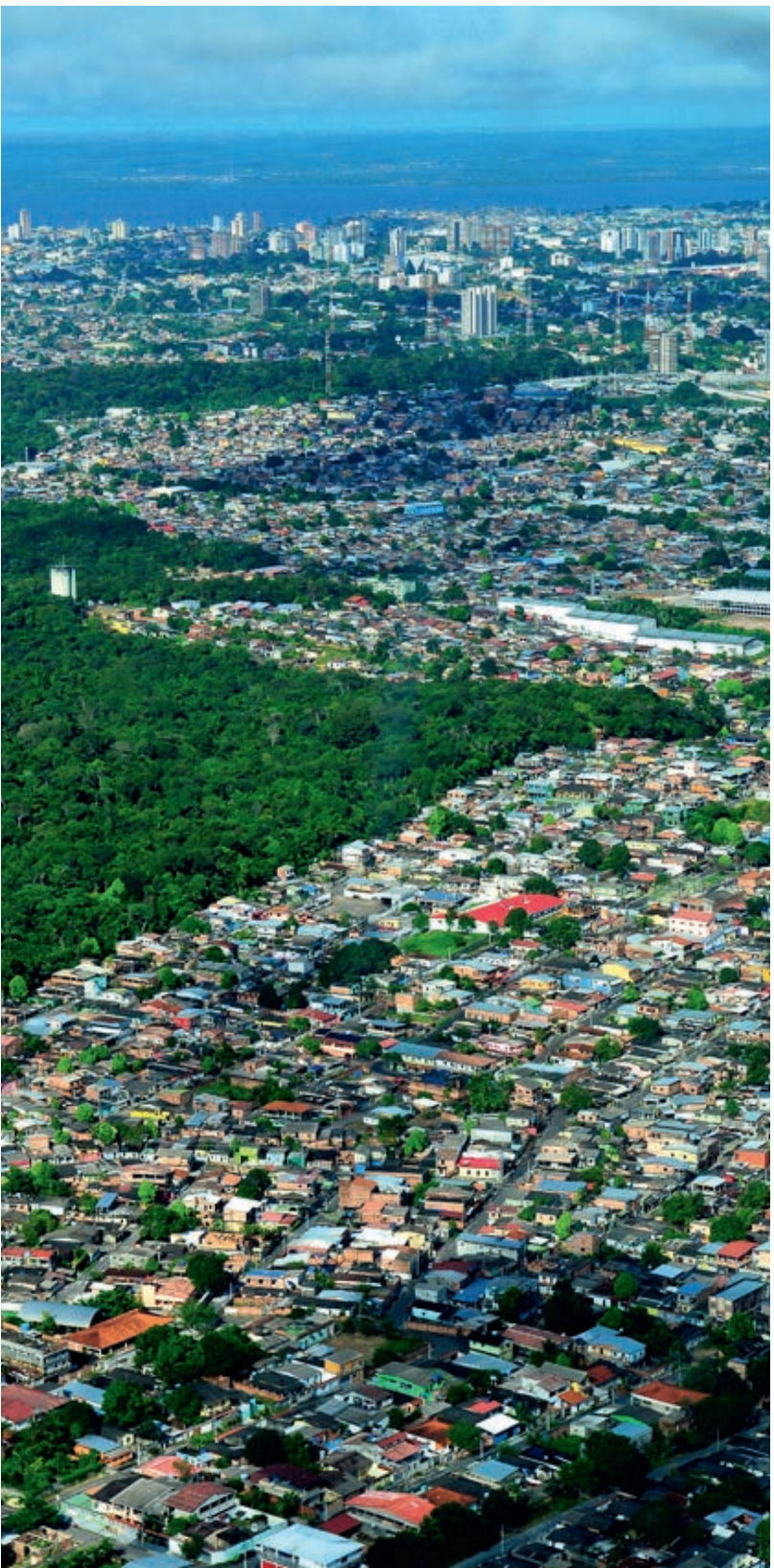
PART 2

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

INDICATOR 1

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).

INDICATOR 2

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

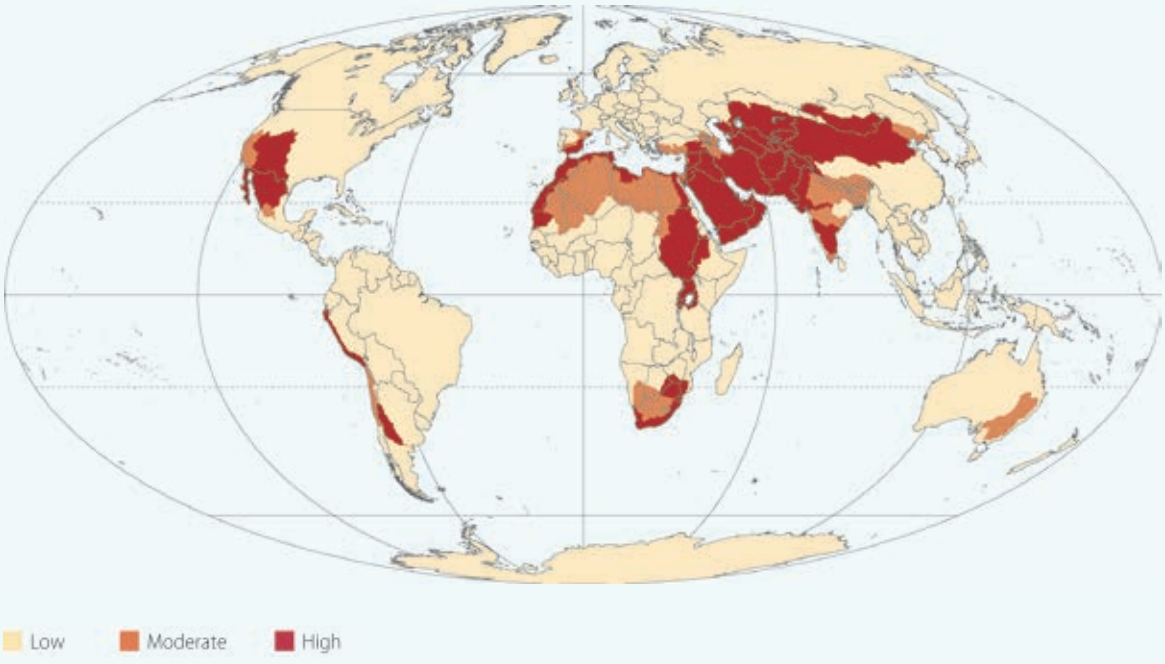
Percentage distribution of households by person responsible for water collection by region and by urban or rural area (2005–2007)

		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

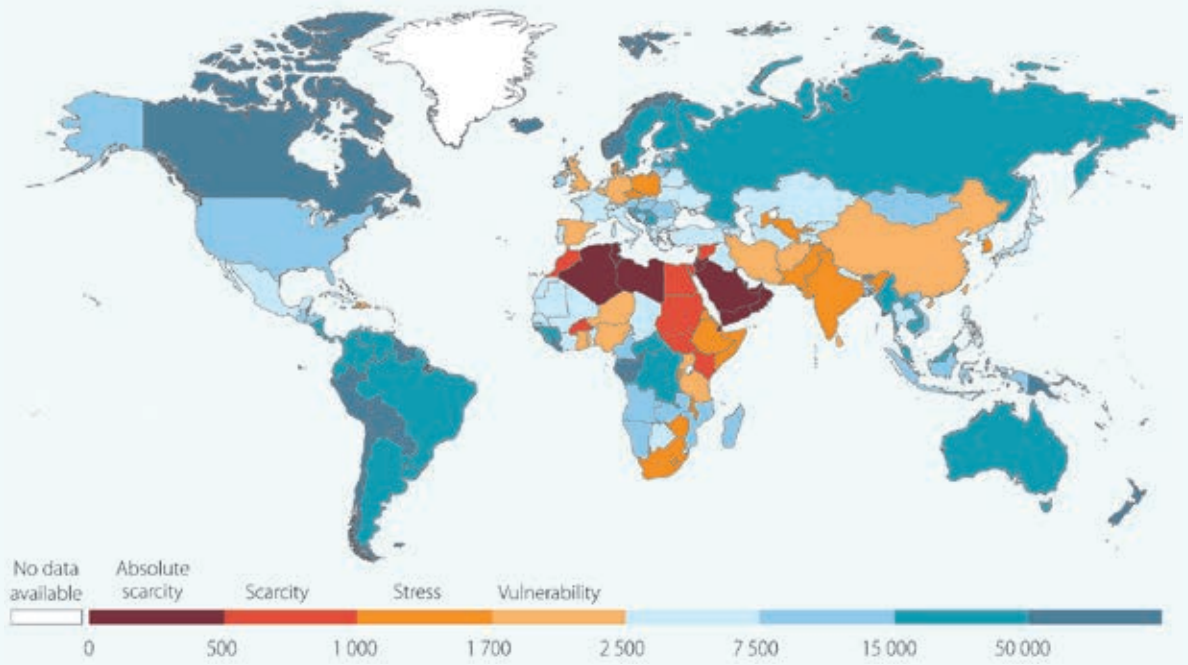
Global distribution of physical water scarcity by major basin (2011)



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

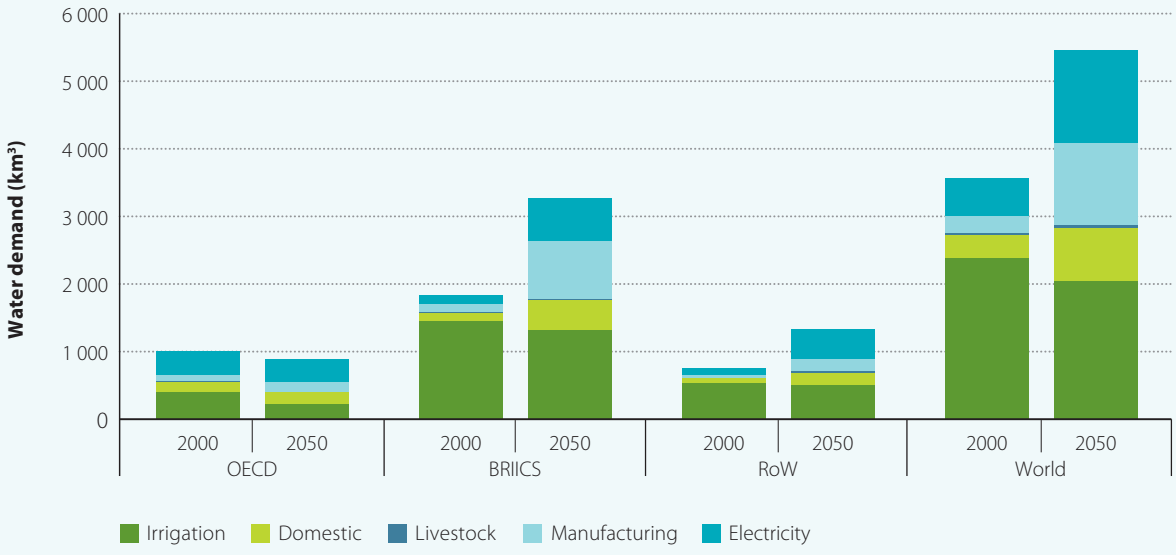
Total renewable water resources per capita (2013)



Note: The values indicate total renewable water resources per capita per year in m^3.
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

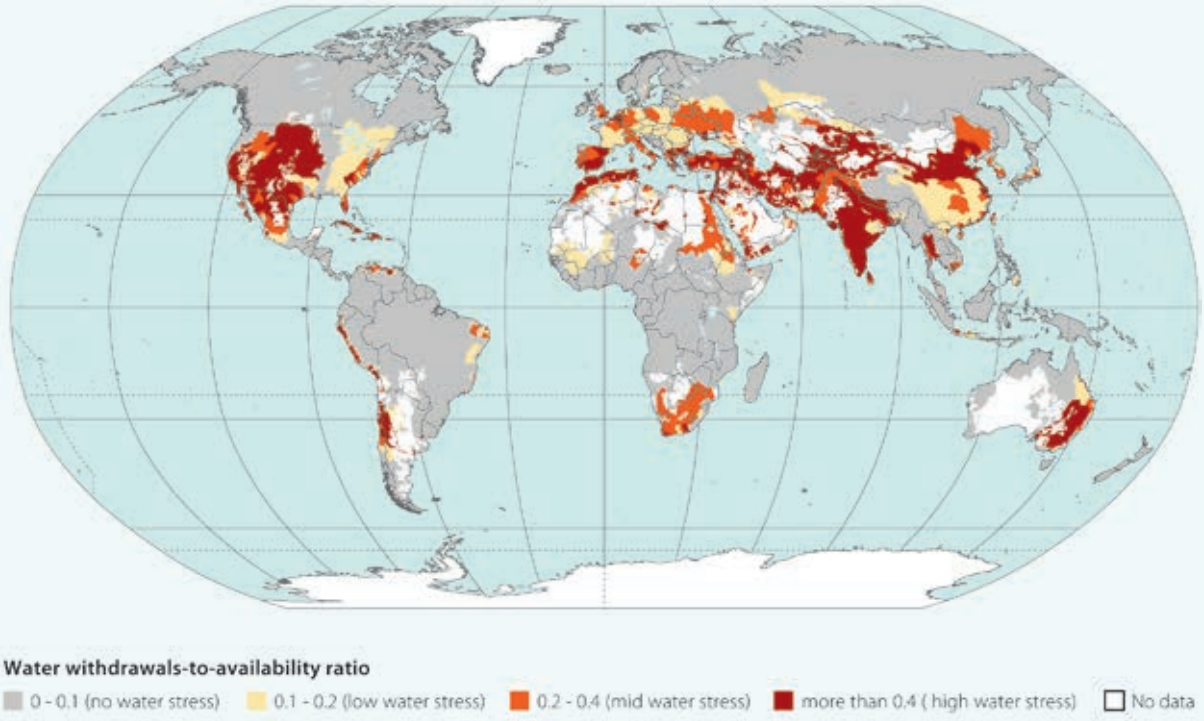
Global water demand (Baseline Scenario 2000 and 2050)



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

INDICATOR 7

Annual average water stress (1981-2010)



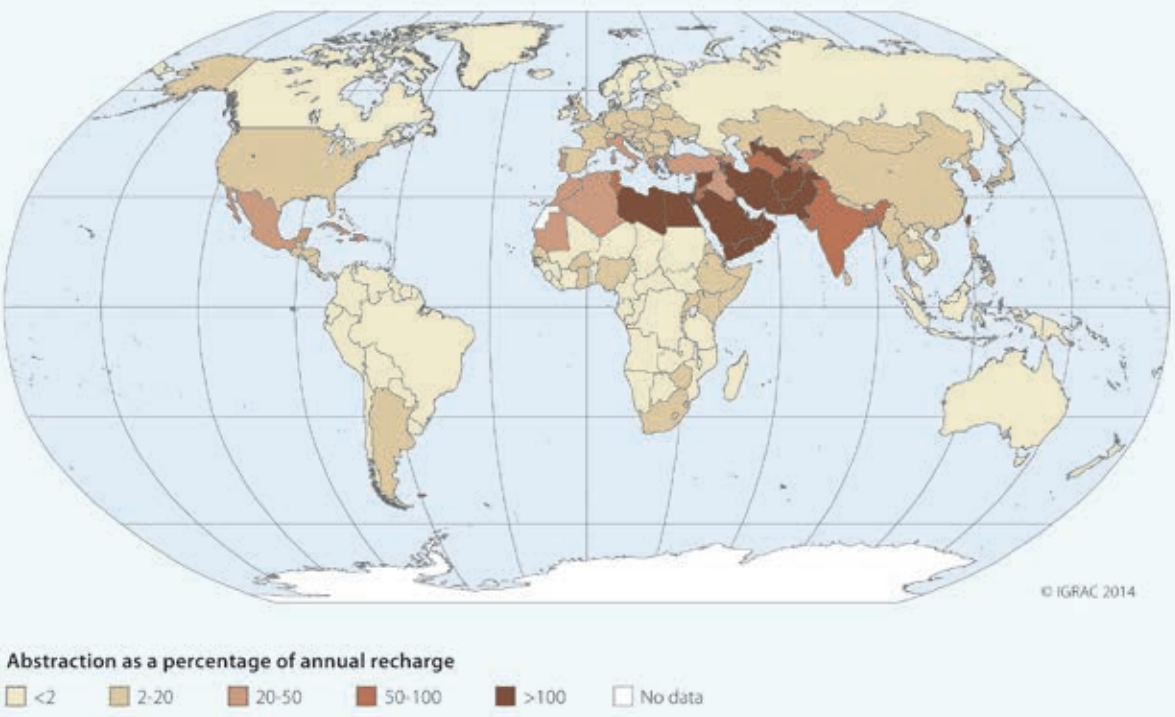
Note: Water stress measures the amount of pressure put on water resources and aquatic ecosystems by the users of these resources (households, industries, and agriculture) and can easily be compared across river basins. For calculating today's water stress, the withdrawals-to-availability ratio is used (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.

INDICATOR 8

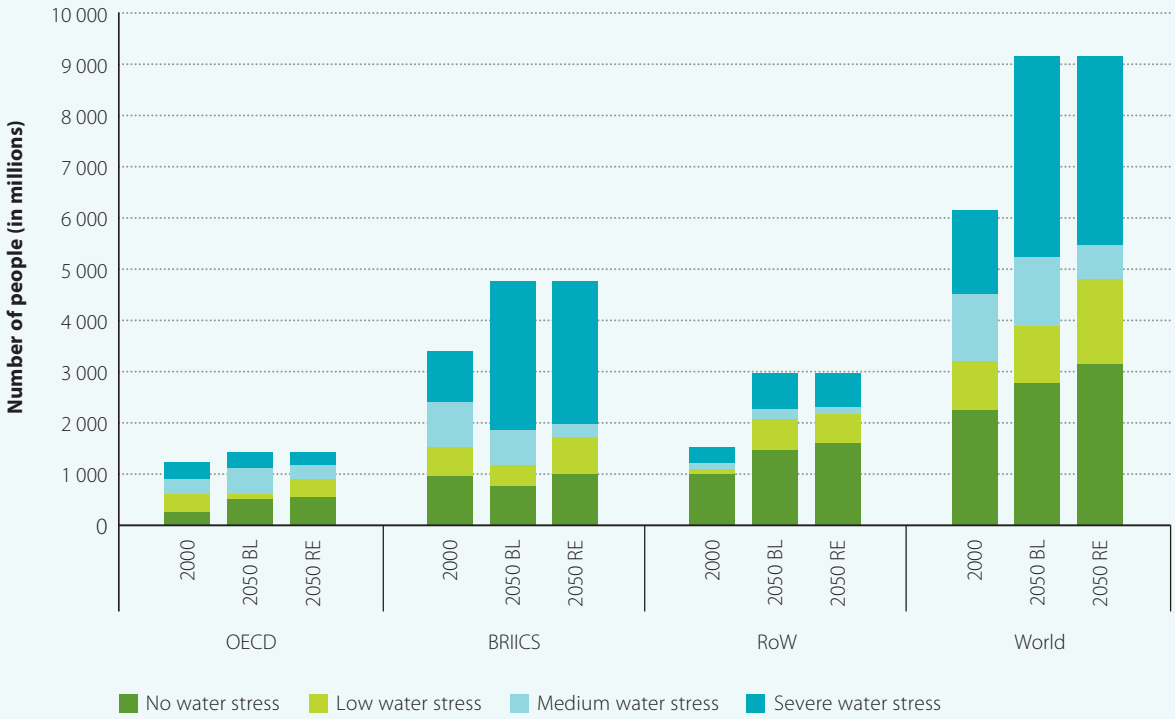
Groundwater development stress (2010)



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.

INDICATOR 9

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

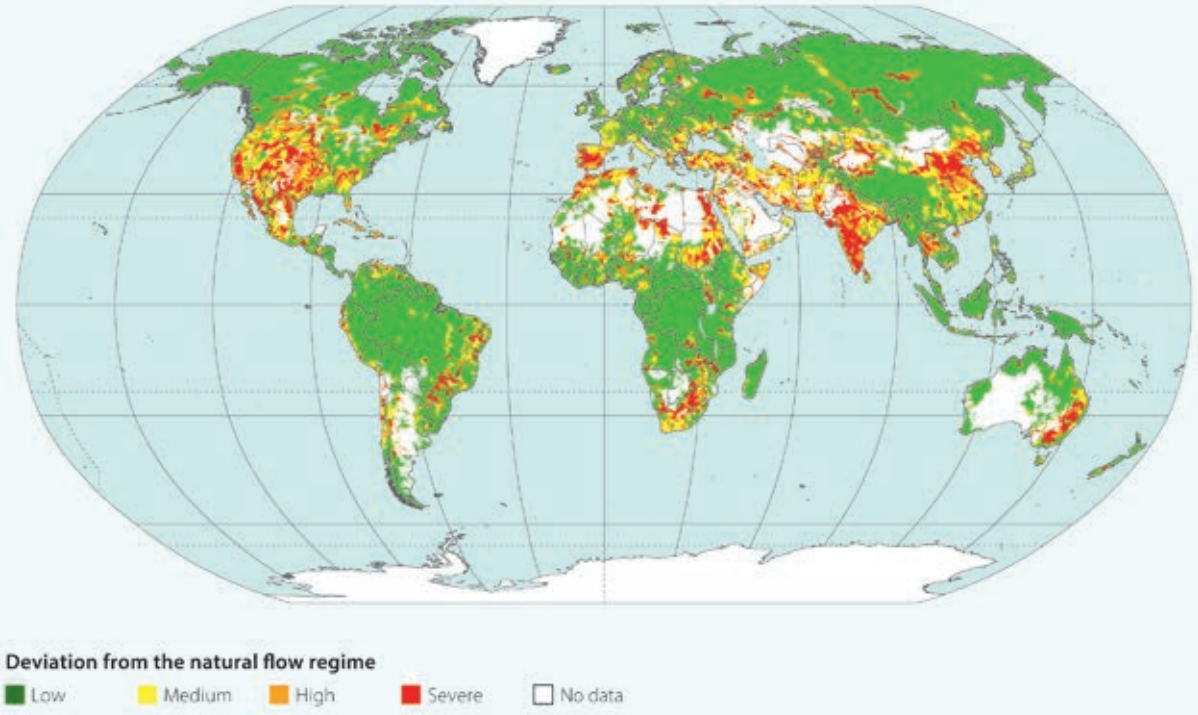
Water withdrawal by sector (around 2007)

	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).

INDICATOR 11

Environmental stress due to flow regime alterations (1981-2010)



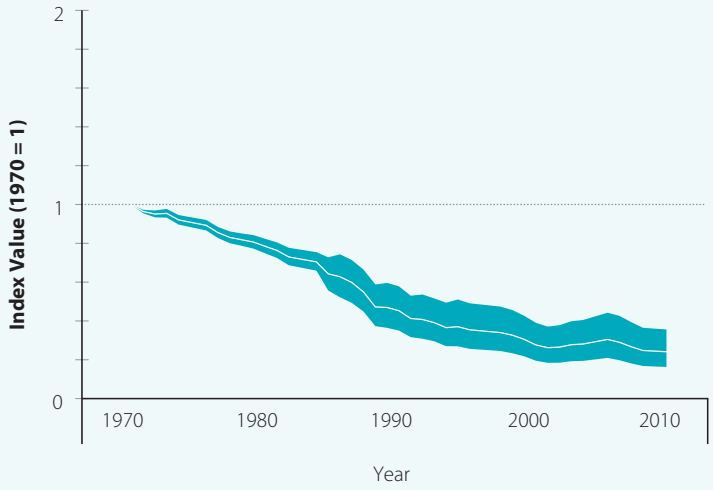
Note: Natural flow regimes are heavily modified by water abstractions and dam operations. The indicator "environmental water stress due to flow regime alterations" is used to assess the hydrological alterations resulting from these impacts (Schneider et al. 2013). Daily time series of modified and natural 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.

INDICATOR 12

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/

INDICATOR 13

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

INDICATOR 14

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

INDICATOR 15

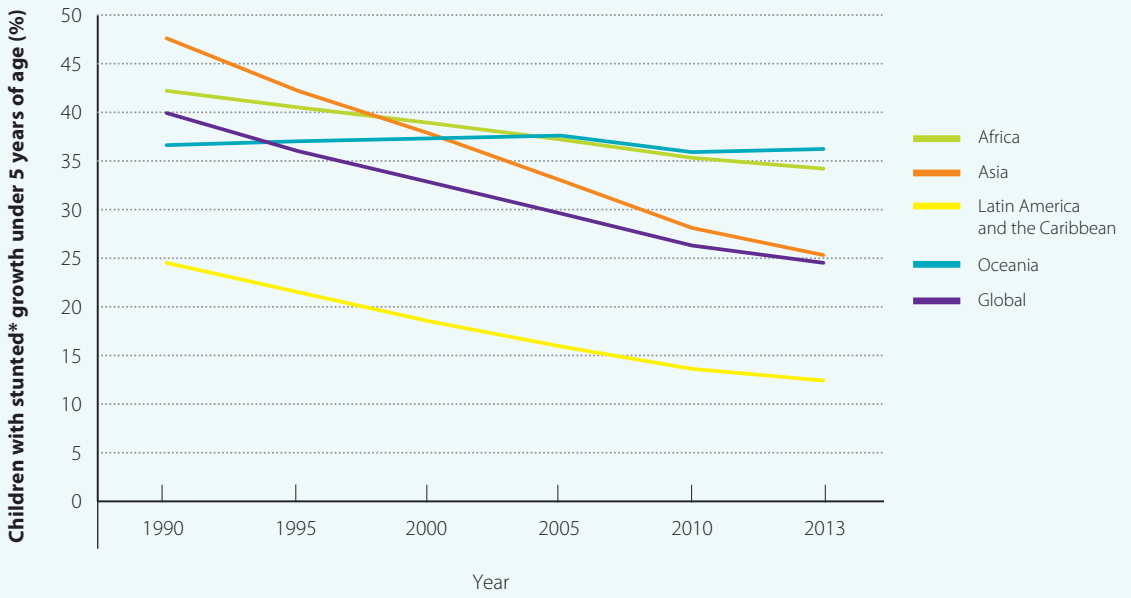
Global Hunger Index (1990–2014)

	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)

INDICATOR 17

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)****

INDICATOR 18

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**

INDICATOR 19

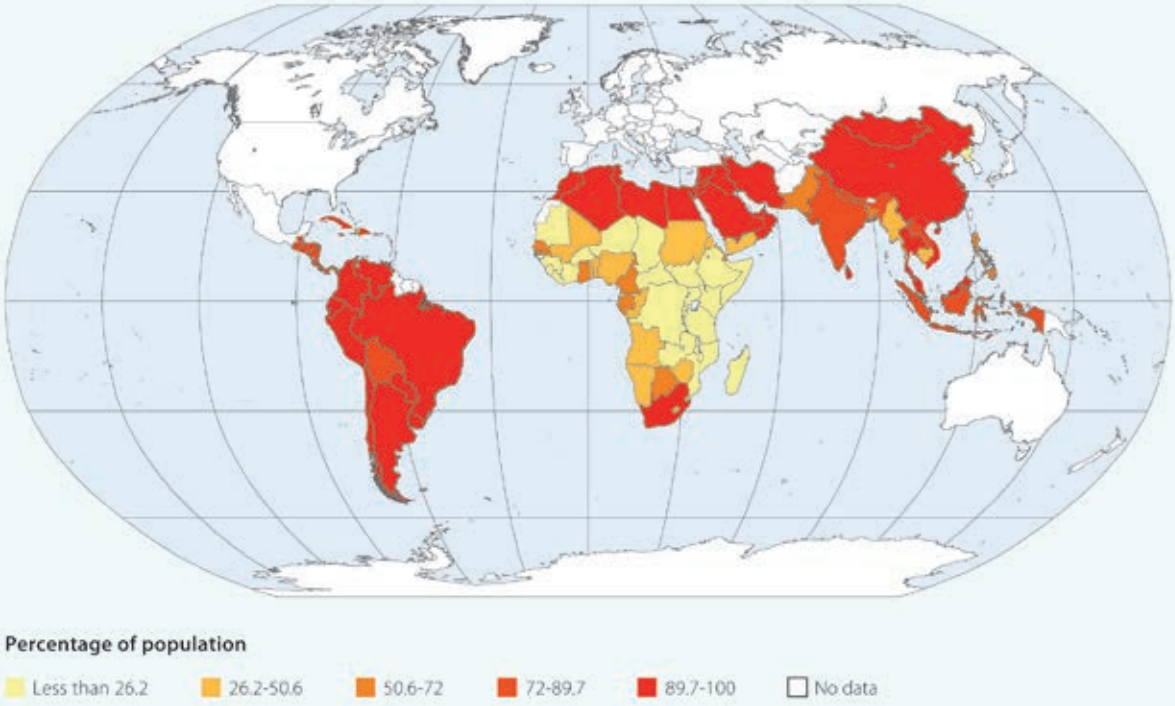
Electricity production, sources and access (2011)

	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).

INDICATOR 20

Share of people with electricity access in developing countries (2012)

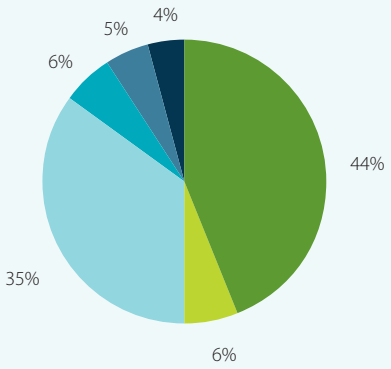


Note: Data are given as a percentage of the population.
Source: WWAP (2015), with data from the IEA World Energy Outlook 2014 Electricity Access Database.
http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/ (Accessed December 2014).

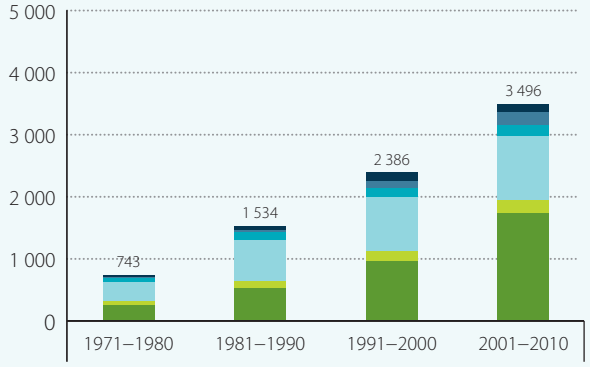
INDICATOR 21

Distribution of natural disasters

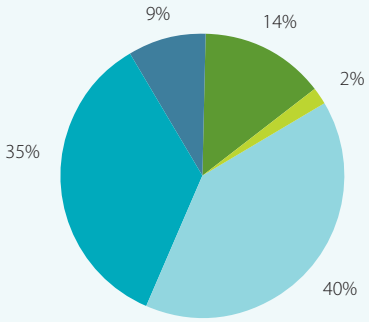
Global distribution of reported number of disasters (1970–2012)
Total: 8,835 disasters



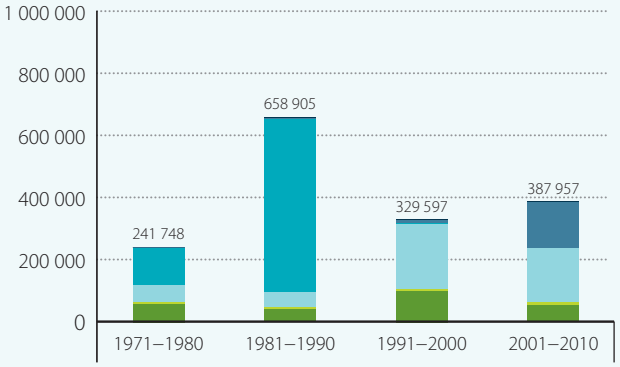
Number of reported disasters by decade by hazard type (1971–2010)



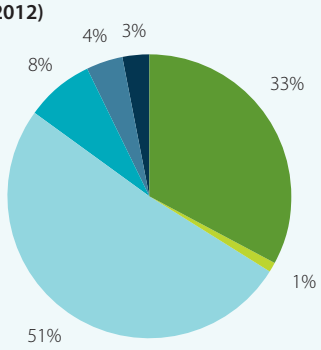
Global distribution of reported deaths (1970–2012)
Total: 1,944,653 deaths



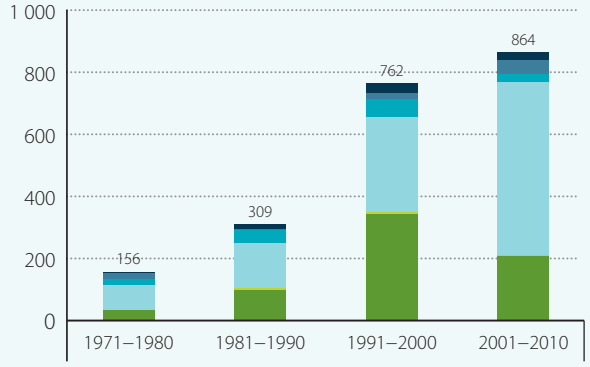
Number of reported deaths by decade by hazard type (1971–2010)



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

INDICATOR 22

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)

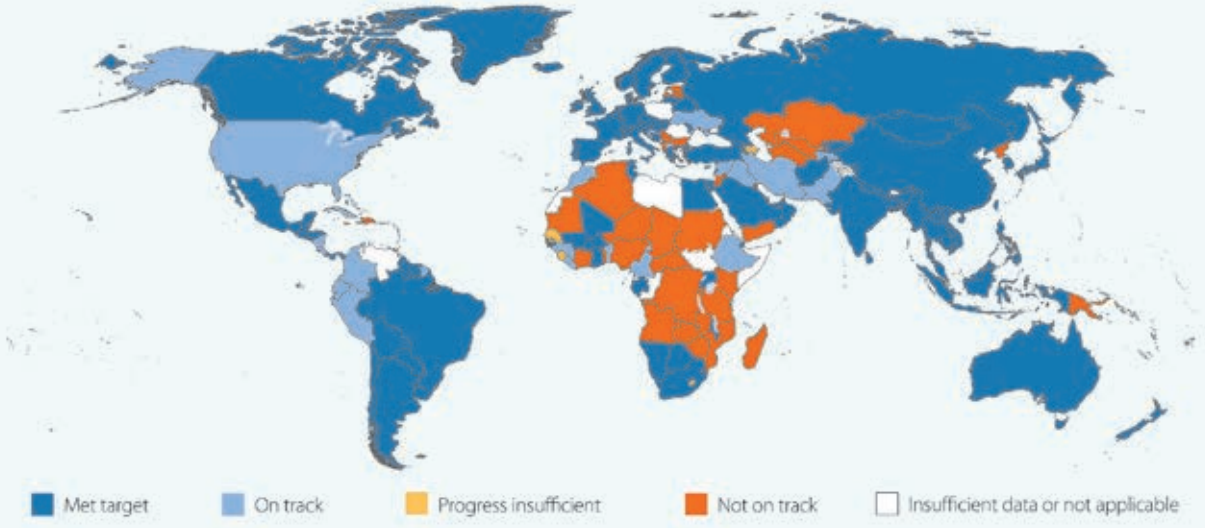
Type of hazard	People displaced
Flood	89 181 000
Storm	29 051 000
Earthquake (seismic activity)	23 604 000
Extreme cold	923 000
Landslide (wet)	577 000
Volcano	472 000
Wildfire	103 000
Landslide (dry)	3 200
Extreme heat	1 700

** 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

INDICATOR 23

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

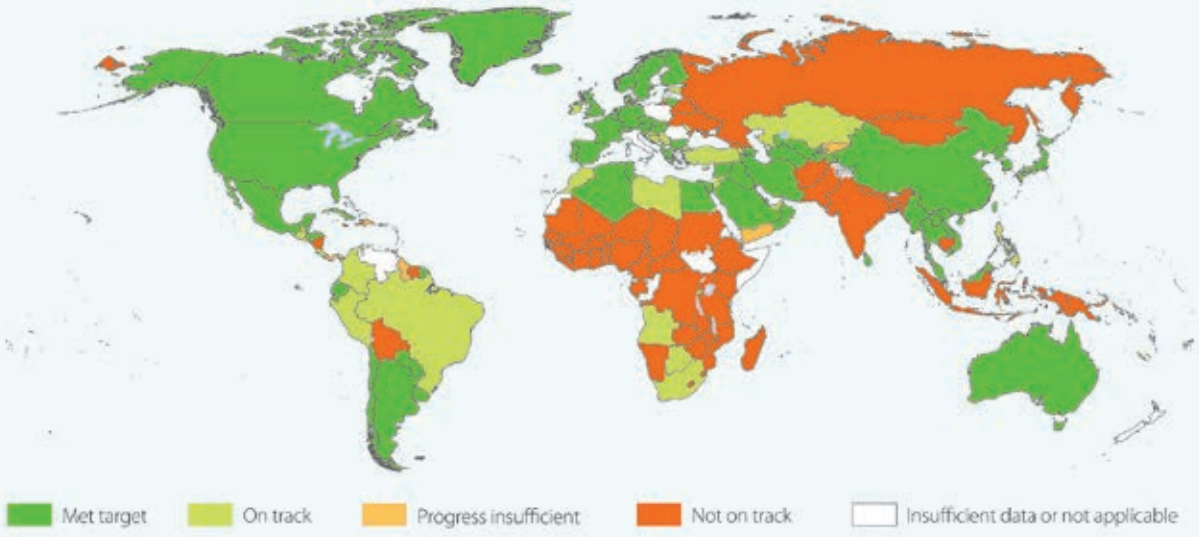


The global Millennium Development Goal (MDG) target is applied to countries, areas or territories. These assessments are preliminary; the final assessment will be made in 2015 for the final MDG report. Method: If the 2012 estimate of improved drinking water or improved sanitation coverage is (i) greater 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)

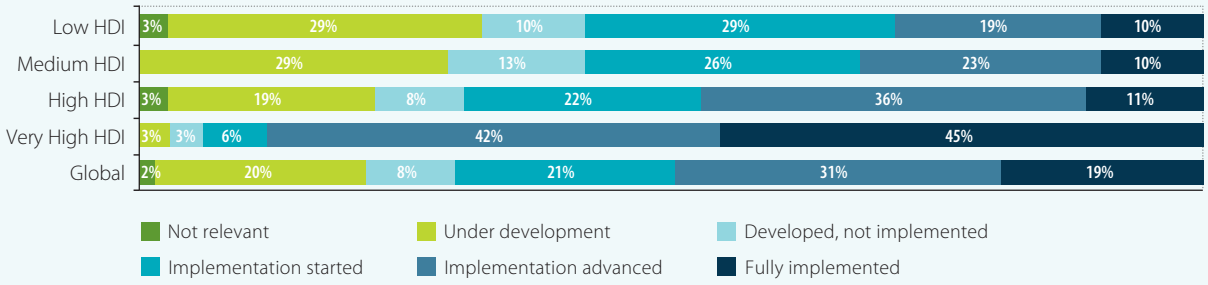
77 countries have already met the MDG sanitation target, 29 are on track and 79 are not on-track



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

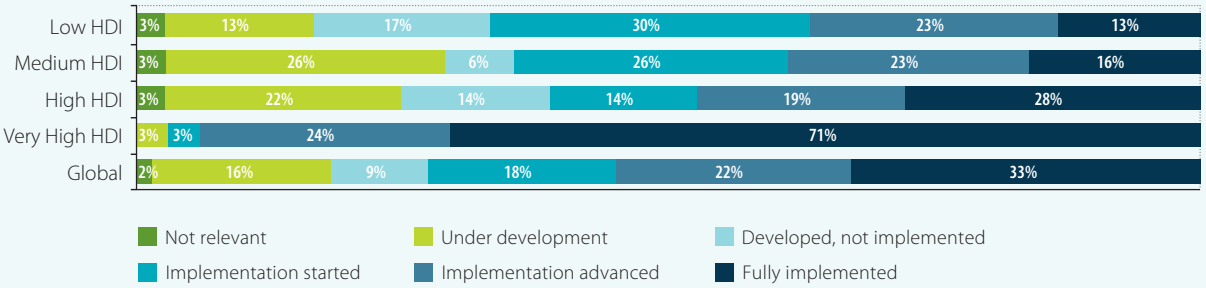
National water resources policy: Status of the main policy instrument (2012)



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

INDICATOR 26

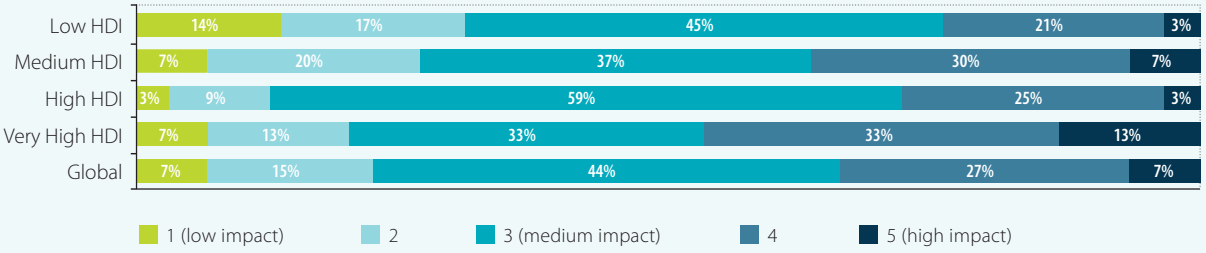
National water laws: Status of the main water law (2012)



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

INDICATOR 27

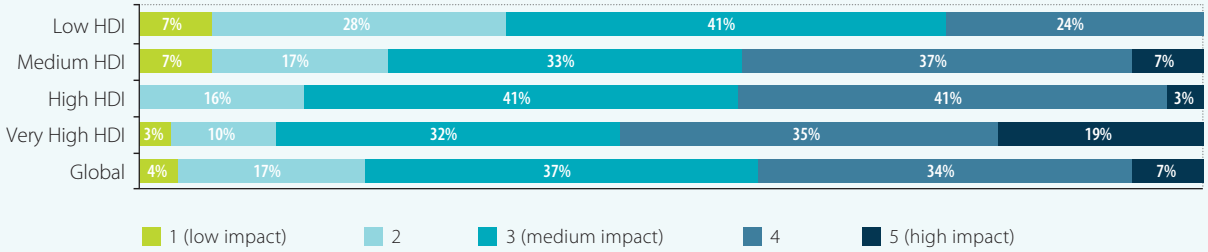
Impacts of improved water resources management on social development over the past 20 years (2012)



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

INDICATOR 28

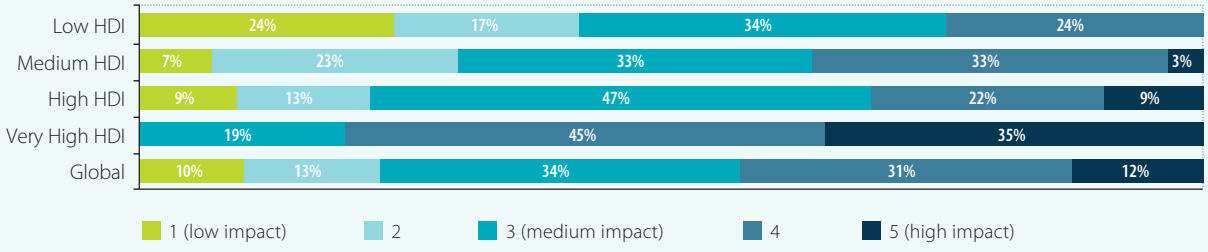
Impacts of improved water resources management on economic development over the past 20 years (2012)



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

INDICATOR 29

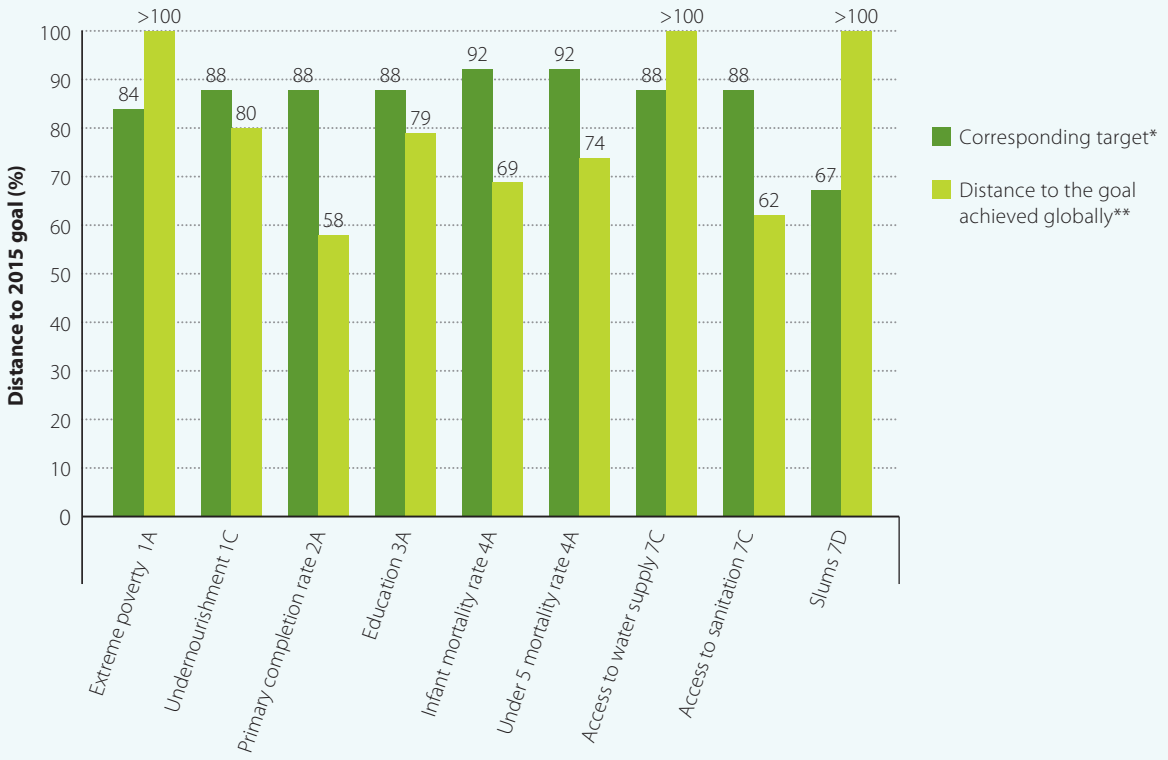
Impacts of improved water resources management on environmental development over the past 20 years (2012)



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

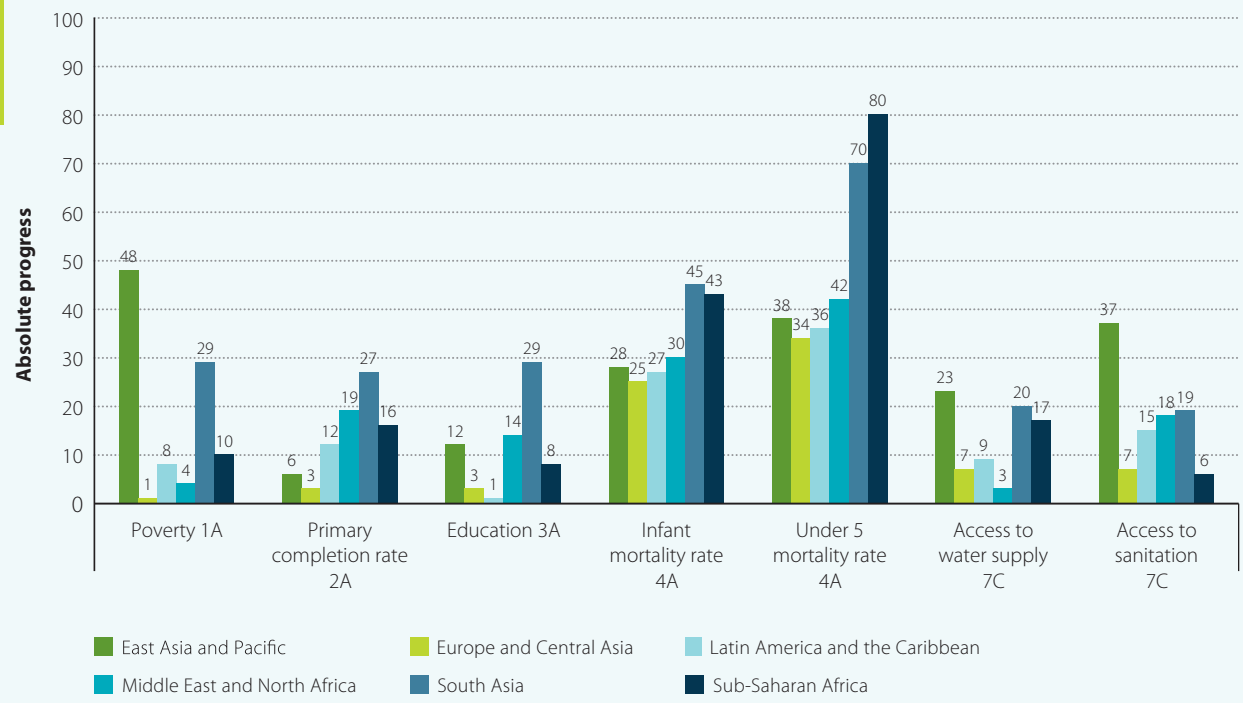


Corresponding Millennium Development Goals (MDGs):
1A Extreme poverty (population below US$1.25 per day (2005 purchasing power parity)
1C Prevalence of undernourishment (% of population)
2A Primary completion rate, total (% of relevant age group)
3A Ratio of girls to boys in primary and secondary education (%)
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

INDICATOR 31

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.

INDICATOR 32

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

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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.

This publication is financed by
the Government of Italy and Umbria Region.

Regione Umbria

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