The United Nations World Water Development Report 3

Case Studies Volume

FACING THE CHALLENGES

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Published jointly by:
The United Nations Educational, Scientific and Cultural Organization (UNESCO), 7, place de Fontenoy, 75007 Paris, France, and
Earthscan, Dunstan House, 14a St Cross Street, London EC1N 8XA, United Kingdom.

UNESCO Publishing: http://publishing.unesco.org
Earthscan: www.earthscan.co.uk

Suggested citation: World Water Assessment Programme. 2009.
The United Nations World Water Development Report 3,
Case Study Volume: Facing The Challenges

Cover design: Peter Grundy, London, UK
Page design, layout and typesetting: Baseline Arts Ltd, Oxford, UK

A catalogue record for this book is available from the British Library.

Library of Congress Cataloging-in-Publication data has been applied for.

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This case studies volume has been published on behalf of the United Nations World Water Assessment Programme (WWAP), with the support of the following countries:

Argentina, Bangladesh, Bolivia, Brazil, Cameroon, China, Estonia, Finland, Italy, the Republic of Korea, the Netherlands, the Pacific Island States, Pakistan, Paraguay, the Russian Federation, Spain, Sri Lanka, Sudan, Swaziland, Tunisia, Turkey, Uruguay, Uzbekistan, and Zambia.

Foreword

Water in a Changing World: As the title of the third edition of the *World Water Development Report* (WWDR3) suggests, we live in a world where adaptation to change has become a critical necessity in many areas to assure the socio-economic well-being of societies. Climate, social and economic conditions, markets, consumer values and technology are only a few of the areas of change that the WWDR3 describes and discusses in detail. This case study volume complements and compounds the analyses provided in the report by taking a critical look at the state of water resources, varying conditions and the resilience of national mechanisms for coping with change. It examines these and other elements in 20 case studies from four regional settings involving 23 countries and numerous small island developing states.

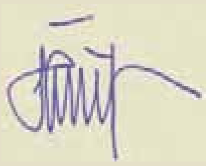
Since the inception of the World Water Assessment Programme (WWAP) in 2000, case study development has been an integral part of the programme's work, and our case study partners have significantly contributed to the contents of the World Water Development Reports. The study projects initiated in participating countries served as a platform bringing relevant national stakeholders together to identify the gaps in knowledge, the shortcomings in the legislative system and the aspects of institutional capacity that need to be enhanced. Case study development has provided an impetus for the national agencies responsible for water management to organize their data collection and reporting efforts more efficiently. It has also helped raise public awareness of the global water crisis and the visibility of integrated water resources management on national agendas. Most importantly, in the process, the skills and experience of both local water professionals and policy-makers are engaged and enhanced. WWAP activities have also influenced action elsewhere, thanks to actively conducted research on the protection and sustainable use of water resources.

In the past nine years, the number of case studies has continuously risen, from seven in the WWDR1 to 20 in the WWDR3. The coverage figures have also changed, from 12 countries in the WWDR1 to over 23 in the WWDR3. Over the life of the programme to date, more than 54 countries have been covered at basin or national level. This prompted the WWAP Secretariat to allocate more space to present findings of the case study projects. Hence the need for a separate, stand-alone publication.

It is my great pleasure to present this volume, *Facing the Challenges*, where you will find case studies initiated in Africa, Asia, Europe and Latin America, providing a succinct account of the state of freshwater resources in a range of physical, climatic and socio-economic conditions. Our readers will also be able to find comprehensive case study reports on our website *(www.unesco.org/water/wwap/wwdr/wwdr3/case_studies/).*

I would like to express my appreciation to all our country partners who actively participated in the development of the WWDR3 and to Mr Engin Koncagül, the case studies coordinator, for his work in making this volume possible.

I trust you will find this report both informative and stimulating.



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Acknowledgements

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Overview

Background

A global assessment of the state of freshwater resources is essential for two main reasons: first, to foster an informed society capable of taking on the important role of shaping sustainable socio-economic development policies that affect the future of humanity, and second, to help policy-makers reach informed choices to protect society from emerging water resources-related problems while assuring the well-being of ecosystems. The World Water Assessment Programme (WWAP), established in 2000, is a collective response of the United Nations system to an international call for global assessment of freshwater resources that goes back to the late 1970s (see Milestones). Driven by this demand, and bolstered by the outcomes of several important international meetings, the first edition of the World Water Development Report (WWDR) was launched in 2003. Entitled *Water for People, Water for Life*, it presented a state of the art overview of information and knowledge on freshwater resources from the 24 UN agencies then comprising UN-Water (the number rose to 25 in 2008). It included a case study section describing the major issues and challenges affecting seven river basins in various parts of the world. The second edition of the triennial World Water Development Report (WWDR2, 2006), *Water, a Shared Responsibility*, presented 16 such case studies.

Now, in an innovative departure from this format, the third edition (WWDR3), *Water in a Changing World*, features a companion volume of 20 case studies: *Facing the Challenges*. In addition to studies conducted at basin, national and transboundary level, as in the previous editions, for the first time a group of countries with similar characteristics (Pacific islands) is included to widen the scope of analysis. All three editions of the WWDR, including their case studies, can be found at *www.unesco.org/water/wwap/*

The case studies in this volume are grouped into four regions: Africa (Cameroon, Sudan, Swaziland, Tunisia, Zambia), Asia and the Pacific (Bangladesh, China, Pacific islands, Pakistan [Cholistan desert], the Republic of Korea, Sri Lanka, Uzbekistan), Europe and North America (Estonia, Italy [Po River basin], the Netherlands, Spain [Basque Country], Finland and the Russian Federation [Vuoksi River basin], Turkey [Istanbul]), and Latin America and the Caribbean (La Plata River basin and Lake Merín basin). Although each country or basin has distinct characteristics, the grouping by region makes it clear that there are many shared features and common concerns that need to be addressed.

This volume focuses on the state of freshwater resources and the management challenges facing over 25 countries, and seeks answers to core questions present since the first edition of the WWDR: How successfully have different elements have been integrated into a coherent whole? How well does the national system take account of competing needs and uses? Do all stakeholders have a voice in decision-making? Do water policies build in incentives for conserving water and controlling pollution? How resilient is the water management system and how well is it able to meet changing human needs and conditions? Is the human, institutional and financial capacity sufficient to meet challenges? These questions aim to identify the problems in achieving integrated approaches to water management, while the main volume analyzes these issues from a multisector perspective and makes recommendations for addressing the challenges.

Location of case study countries

Milestones

1977 Mar del Plata Action Plan (UN Conference on Water): The relative lack of priority on systematic measurement of water resources is stressed.

1992 Agenda 21 (UN Conference on Environment and Development): The importance of holistic management of freshwater is underlined.

1998 CSD-6: The need for periodic assessment of a 'global picture' of the state of freshwater is recognized.

2000 Ministerial Declaration of the Second World Water Forum: Elaboration of a World Water Development Report is urged as part of the overall monitoring of Agenda 21.

2000 The WWAP is established.

2003 The first edition of the WWDR, ***Water for People, Water for Life***: Case studies on the Chao Phraya River basin (Thailand), Greater Tokyo (Japan), Lake Peipsi/Chudskoe-Pskovskoe (Estonia and the Russian Federation), Lake Titicaca basin (Bolivia and Peru), Ruhuna basins (Sri Lanka), Seine-Normandy basin (France) and Senegal River basin (Guinea, Mali, Mauritania and Senegal) are presented.

2006 ***Water, A Shared Responsibility*** (WWDR2): 16 case studies are presented Autonomous Community of the Basque Country (Spain), Danube River basin (Albania, Austria, Bosnia-Herzogovina, Bulgaria, Croatia, the Czech Republic, Germany, Hungary, Italy, Moldova, Poland, Romania, Serbia and Montenegro, the Slovak Republic, Slovenia, Switzerland, The Former Yugoslav Republic of Macedonia and Ukraine), Ethiopia, France, Japan, Kenya, Lake Peipsi (Estonia and the Russian Federation), Lake Titicaca (Bolivia and Peru), Mali, the state of Mexico (Mexico), Tuul River basin (Mongolia), La Plata River basin (Argentina, Bolivia, Brazil, Paraguay and Uruguay), South Africa, Sri Lanka, Thailand and Uganda.

2009 ***Water in a Changing World*** (WWDR3) is accompanied by the present volume *Facing the Challenges*, a separate book of 20 case studies.

Findings: In many of the WWDR3 case studies, poverty, the burden of disease, unsustainable use of water resources, pollution, degradation of ecosystems and insufficient water and sanitation coverage have surfaced as main challenges. However, there is reason for cautious optimism. In most cases, the problem stems overwhelmingly from insufficient capacity for better management of existing resources, along with poor cooperation among and across sectors, rather than from unavailability of water for development.

Participation and decision-making: Another important issue on the agenda of all the WWAP case study partners is the need for user participation in decision-making about water resources. The Netherlands provides one of the best examples of successful real life decentralization of water resources management through water boards called *Waterschappen*. The principle of 'interest-pay-say', applied in this country for centuries, allows local communities to play a direct role in socio-economic development through effective management of water resources. The use of integrated water resources management (IWRM) and reduction of the fragmentation in the water sector constitute a dual challenge that applies to developed and developing countries alike. For example, in the Republic of Korea, where functions and responsibilities for water resources management are distributed among multiple agencies practically working in a vacuum, local governments face complications in executing the national water management plan. Reforms under way in this and other case study countries take a bottom-up approach, establishing basin networks to allow management of resources at grass roots level.

Integrated water resources management: While the concept of IWRM is gaining popularity among the WWAP case study partners, its implementation varies considerably by country at regional level. For example in Africa, while Tunisia has developed IWRM-based national policies and a master plan, conditions for effective use of the IWRM approach are not yet in place in Cameroon. In European Union countries (Estonia, Finland, Italy, the Netherlands and Spain) IWRM is applied as an integral part of the Water Framework Directive. In Latin America, the National Water Law in Brazil enshrines the core principles of decentralized water resources management and stakeholder participation, and these are applied in practice. In Uruguay, although the Constitution provides for the IWRM principles, wide implementation of them is still lacking. In Asia and the Pacific, IWRM is a relatively new concept. For example, a Water Law emphasizing IWRM was passed in China in 2002. All in all, global recognition and implementation of IWRM will require institutional reforms, sustainable funding and political commitment.

Water supply, sanitation, public health and poverty: Although access to safe water has not been formally recognized as a human right in international law, certain country partners have incorporated such recognition into their constitutions. A recent example is Uruguay, where access to safe drinking water and improved sanitation has been accepted as a fundamental human right since a national referendum in 2004. Brazil and Paraguay have identified water resources as public property. Although there is progress towards meeting the targets in the Millennium Development Goals (MDGs) related to water and sanitation, achieving universal access to safe water and improved sanitation will require time and considerable investment in most regions. Among the case studies featured in this volume, Estonia, Italy, the Netherlands, Spain, Finland and Uruguay are the countries that have already reached this goal.

Countries where the burden of disease is the highest are those in which water and sanitation infrastructure is not sufficient to meet needs. For example, in Swaziland and

Sudan, where access to improved sanitation is very limited, water-related diseases, particularly malaria and diarrhoea, are among the leading causes of death. Cameroon and Zambia are also affected by this problem. The situation is often exacerbated by persistent poverty and malnutrition. In Bangladesh, for instance, about 70% of mothers suffer from nutritional deficiency anaemia and over 90% of children have some degree of malnutrition. Poverty varies even within countries, being more prevalent in rural settings where subsistence farming predominates. For example, in Swaziland about 84% of the country's poor live in rural areas, where per capita income is one-fourth the urban average and people consume half as much food. Overall, rural people are at a disadvantage because their access to almost all services – water supply, sanitation, electricity, health care, education, job markets – is poorer than that of urbanites. The international community is urging governments to take bolder action by introducing more effective policies allowing better mobilization of national funds to help lift millions out of extreme poverty, and urging donor agencies to step up their financial assistance programmes. As an example of what national efforts can accomplish, effective strategies in Argentina helped reduce the share of the population living in poverty from 45.4% in 2002 to 21% in 2006. As a recent example of innovative financing, in 2008 the Government of the Autonomous Community of the Basque Country in Spain agreed to allocate 5% of the ecological tax revenue to support sub-Saharan countries' efforts to meet the water and sanitation targets of the MDGs. In Istanbul, a megalopolis with close to 12 million inhabitants, US$3.6 billion was invested between 1994 and 2004 to improve the water supply and sanitation infrastructure.

The role of climate change and variability: No matter what the regional setting is, water-related natural hazards linked to climatic variability and climate change cause substantial socio-economic damage. Among the case studies, the Pacific islands are likely to be most affected by projected sea level rise, increasing intensity and frequency of water-related hazards and fluctuation in freshwater availability. The Netherlands is also at risk from a possible overall sea level rise of up to 1.30 metres by 2100. This would have serious repercussions, as the area already below sea level accounts for 60% of the population and about 70% of GDP. For centuries, Sri Lanka and Bangladesh have also been severely affected by natural disasters. In Bangladesh, from 1970 to 2008, 12 major cyclones killed more than 620,000 people and affected some 45 million. The 2004 tsunami, which caused widespread destruction in coastal areas of Sri Lanka, claimed some 40,000 lives, displaced over 400,000 people and resulted in property damage estimated at US$1 billion. The El Niño event of 1983/1984 affected over 40,000 people in more than 70 cities of central Uruguay and caused losses estimated at over US$1 billion for the entire La Plata River basin. Droughts have had equally disastrous effects. For example, El Niño and La Niña events, combined with other climatic and oceanographic conditions, have resulted in catastrophic droughts in parts of the Pacific. During the 1990s, prevailing drought in the North China Plain caused a 24% drop in runoff and led to a lack of flow in the lowest 700 km of the Yellow River, seriously limiting water availability for human and environmental needs.

Such events have prompted governments to take action aimed at mitigating the effects of future disasters. However, in developing countries, while structural measures are heavily used, non-structural measures (the policy dimension) are often overlooked or receive insufficient attention. For instance, the five riparian countries of La Plata River basin are still attempting to reach agreement on the definition of extreme hydrological events. On the other hand, in the Netherlands, projections of increased extreme events have led the authorities to integrate spatial planning with water management to create a 'comfort zone' for rivers. In addition, innovative and comprehensive risk management policies and strategies are being based on the key principles of resistance, resilience and adaptation. Similarly, in the aftermath of the tsunami, attention to policy and institutional aspects in Sri Lanka led to enactment of a disaster management law, strengthening of institutional capacity and active community participation in disaster management.

Cooperation in transboundary contexts: Management of water resources in transboundary basins requires close cooperation among riparian governments to establish mechanisms allowing for the protection and utilization of resources. Such mechanisms are in place in most of the relevant case study countries. Examples are the Intergovernmental Coordinating Committee (La Plata River basin), the Transboundary Water Commission (Finland and Russia), the Tripartite Permanent Technical Committee (Mozambique, South Africa and Swaziland) and the Zambezi River Authority (Zambia and Zimbabwe). The Nile Basin Initiative, representing nine of the ten riparian countries, also aims to create a cooperative environment. The establishment and functional effectiveness of such arrangements, however, depend heavily on the political will to cooperate. In the Republic of Korea, despite ongoing negotiations, there is no mechanism for jointly managing the transboundary tributaries of the Han River basin with the Democratic People's Republic of Korea.

Gaps in knowledge:A lack of comprehensive information on the availability of surface and groundwater resources and decaying hydrographical networks are identified as shared problems in African and Latin American case studies. In Africa, the lack of information is among the leading barriers to sustainable management of water resources. In the Lake Merín basin, shared by Brazil and Uruguay, accurate long term water resources assessment is difficult because of the deterioration of already limited coverage of the hydrometeorological monitoring network due to declining funding and maintenance since the 1970s. Allocation of funds to establish, maintain and expand monitoring systems is an often overlooked prerequisite for effective decision-making.

Food security: Food security is an important concern in all the case studies, and agriculture accounts for a significant share of water consumption. Sustainable use of water resources in this sector, however, did not seem to be an immediate priority. In the Po River basin, especially during high consumption months, low water availability creates tension among users and aggravates quality-related problems. Yet there are no national or regional plans for reducing high water consumption in agriculture. Furthermore, low efficiency irrigation methods, which are the main culprit in this situation, are still widely used in the basin. In Uzbekistan, unsustainable irrigation practices have led to irreversible environmental destruction and severe shrinkage of the Aral Sea. In some cases, the water footprints of nations are larger than usage figures suggest. For example, the Republic of Korea is the world's fifth largest net importer of virtual water. Water use efficiency is equally important in other sectors. A good example of how economic tools can be used to promote effective use of water resources is Estonia, where combined water consumption decreased by half while the average price of water increased by nearly 25 times between 1992 and 2006.

Environmental health and biodiversity: Reversing loss of environmental resources and reducing biodiversity loss are important MDG targets. Yet evidence suggests these concerns are not always built into national development policies and programmes. Similarly, public awareness and political sensitivity regarding these issues are not fully in place. Extensive areas of forest, mangroves and other ecologically important habitats have deteriorated, leading to reduction in or loss of biodiversity. Development efforts undertaken without due consideration of environmental values can cause substantial socio-economic damage. In Cameroon, for instance, the cost of the Waza Logone project to mitigate the adverse environmental effects of the Maga Dam was estimated to be two to three times higher than that of building the dam. Often environmental degradation has a substantial impact on the poorest and most vulnerable, whose livelihoods depend on goods and services provided by healthy ecosystems. Mainly due to poor enforcement of existing regulations and lack of integration with development activities in other sectors, environmental damage continues to increase at an alarming rate.

Conclusions

The major drivers of water demand and supply remain demographics, land use changes and the implications of economic development. Climate change, the impacts of which becoming ever more apparent, makes these drivers generally more negative and further aggravates the situation. With mounting pressure on water resources stemming from population growth and development, the typical response of increasing supply to meet demand has reached its limits. Given the cross-cutting role of water in achieving many of the MDGs, effective management of scarce water resources is one of the key tools decision-makers can use to attain the overarching goal of sustainable socio-economic development.

The field evidence from the case studies clearly supports the main message of the WWDR3: inaction is no longer an option, and stepping out of the single sector 'water box' is necessary to properly address mounting problems. Though the challenges are considerable, our common future lies in the full understanding and realization of the 'common but differentiated responsibilities' principle of the 1992 Rio Declaration. Examples of success in addressing the challenges exist. A few of them are depicted in this volume. The main issue is creating the conditions necessary to replicate such success at local, national and regional level. The main volume of the WWDR3 provides comprehensive coverage of many issues relevant to decision-making and represents an important attempt to give leaders in government, civil society and the private sector a broader selection of possible solutions to water issues from both within and outside the water box.

1

Africa

Africa faces the toughest challenges of any continent. While most of the developing world has managed to reduce poverty, the rate in sub-Saharan Africa has not changed much since the 1980s. With 40% of the population living below the extreme poverty line of US$1 per day and 73% of the population below US$2 a day, according to World Bank figures, this continues to be the world's poorest region.

A heavy burden of disease (including the HIV and AIDS epidemic), poor capacity in almost every aspect and continuing social unrest are only some of the issues adding to an already heavy socio-economic toll and putting sub-Saharan Africa off track to meet the Millennium Development Goals.

This section contains five case studies, for countries ranging from one of the smallest in Africa (Swaziland) to the largest (Sudan). They reflect the highly complex real-life issues involved in addressing water-related challenges on this vast continent. Tunisia, the one country case study outside of sub-Saharan Africa, shows what might be achieved.

Cameroon

Although endowed with abundant freshwater resources, the country faces a lack of comprehensive information, an inadequate legal and institutional framework, weak enforcement capacity, poor coordination among agencies and other obstacles to sound, sustainable water management. Cameroon is lagging on the Millenium Development Goals, in part because its water sector is highly fragmented and underfunded.

Setting the scene

Cameroon is situated between West and Central Africa at the extreme north-eastern end of the Gulf of Guinea. It is bordered by Chad in the north-east, the Central African Republic on the east, the Congo, Gabon and Equatorial Guinea on the south, and Nigeria on the west. It has about 400 km of Atlantic coastline in the south-west, and shares Lake Chad with Chad in the north (Map 1.1). The country's total surface area is about 475,650 km^2, and the estimated population is 18 million (WHO/UNICEF, 2008), with more than half under age 25. The urban and rural populations are about the same size, although urbanization is increasing by 4.7% per year, on average. About 35% of the urban population lives in the economic capital, Douala, or the administrative capital, Yaoundé.[1]

The country's 1,200 km length, proximity to the sea and topography give it a varied climate with wide differences in rainfall and vegetation. The maximum rainfall of 10,000 mm occurs in the equatorial climate zone in the south, and the minimum of 500 mm in the extreme north on the edge of the Sahara. The average annual rainfall is about 1,684 mm.

Climate change and variability

Average rainfall has been declining since the 1950s. In the last three decades it has decreased by about 5%. Reduced flow rates have been more pronounced in areas with a Sahelian climate, where reductions ranging from 15% to 25% have been recorded. These changes have led to increased desertification in the north and a falling water table due to reduced recharge. In addition, previously permanent wells are drying up late in the dry season.

State of the resource and water use

Cameroon has a dense network of rivers, most of which arise on the central Adamawa plateau and flow north or south. These provide it with abundant water resources in relation to current demand. The six main basins are Sanaga, Sanaga West, Sanaga South, Benoue, Congo and Lake Chad. The Sanaga basin, located in the centre of the country, is the largest, covering about 29% of the territory. It and the Sanaga West and South basins constitute the Atlantic basin. Cameroon's total annual renewable water resources amount to some 283.5 billion m^3 or about 17,000 m^3 per capita, using 2006 population estimates (Aquastat, 2007). The groundwater resources have not yet been comprehensively evaluated, so their potential is not known precisely, but is estimated at 100 billion to 120 billion m^3. Due to the lack of comprehensive monitoring of water resources, consumption patterns are not known exactly. However it is estimated that about 1 billion m^3 of the total renewable water resources is withdrawn annually. Of this, roughly 74% is used in agriculture, 18% for municipal consumption and 8% in industry (Aquastat, 2007).

Agriculture is the backbone of Cameroon's economy, accounting for about 41% of GDP (World Bank, 2007) and 55% of the workforce (WRI, 2007). At about 69,750 km^2, arable land amounts to 15% of the overall surface area. About 29% of the arable land is cultivated, mostly in the west and south-west. The share of the population working in agriculture has been decreasing since the 1970s, but as productivity has increased over the same period, food security has not been directly affected. Irrigation has contributed substantially to productivity, making cultivation possible during the dry season. In 2000, irrigated area of about 224.5 km^2

Map 1.1 Cameroon

[1] Except where otherwise noted, information in this case study is adapted from Fonteh (2003).

(excluding 28 km^2 of spate irrigation, where floods are diverted from ephemeral rivers to cultivate crops) corresponded to around 8% of the potentially irrigable area. Large irrigation projects (more than 2 km^2) accounted for roughly 65% of the irrigated area (Aquastat, 2005). Some large state-owned systems were abandoned due to low performance, while others that were privatized succeeded in improving efficiency of banana production for export. Consequently, the government has been privatizing larger irrigation systems and supporting projects of less than 5 ha (0.05 km^2), aiming to increase irrigation efficiency and sustainability.

Although Cameroon has sufficient water resources, choices in water use have started to affect water availability and ecosystems. For example, plantation of eucalyptus in the western highlands to provide firewood and construction material induced a very high evapotranspiration rate, which has altered the ecosystem and greatly diminished groundwater recharge and the flow rate in the area.

The country's estimated hydroelectric potential is 35 GW. Even with only around 2% of this potential developed, hydroelectricity accounts for about 97% of electricity generation in Cameroon (EIA, 2004). Because there is no nationwide grid, 20% of the electricity produced is lost, even though the south is undersupplied. Also undersupplied are rural areas in general, where only some 20% of the population has access to electricity, compared with 80% in urban areas. Overall, about 8.7 million people, or 53% of the population, lack access to electricity (IEA, 2006). To improve the situation, the Rural Electrification Agency promotes micro hydro projects and has demanded an increase in the national budget for rural electrification. Cameroon's heavy reliance on hydropower leaves its energy sector extremely vulnerable to drought, however. Existing hydroelectricity capacity falls short of meeting current demand, and shortages are especially acute in the dry season. Pending further hydropower development, the National Electricity Company has begun building thermal power plants. Despite the country's weak industrial base, the main user of electricity is the aluminium industry, which accounts for about half of all electricity consumed in Cameroon.

Due to the absence of an effective monitoring system, data on industrial effluent emissions are patchy, and the extent of water pollution in Cameroon is not fully known.

Policy framework and decision-making

Water is considered to be public property in Cameroon, and thus water protection and management are government responsibilities. Several institutions are involved in water management. Under the 1998 Water Law, the National Water Committee coordinates their actions. The committee is also responsible for:

- proposing actions to the government to assure the conservation, protection and sustainable use of water resources;
- providing advice on water-related problems;
- making recommendations on rational water management, particularly concerning the development and implementation of sustainable water and sanitation projects.

Chaired by the minister in charge of water resources, the National Water Committee includes high-level representatives of major stakeholders involved in water management in Cameroon, including the ministries in charge of finance, public health, environment, land management, urban development and housing, agriculture, livestock and fisheries, commerce and industry, territorial administration and meteorology, as well as associations of mayors and concessionaires of public water and energy services. The National Water Committee was formed by decree in 1985 as a consultative body to coordinate activities in the water sector. It has met only infrequently and never fulfilled its intended role. Recently signed enabling decrees under the 1998 Water Law, however, could give the committee new impetus and allow it to function more effectively (UN Water/Africa, 2006).

Integrated water resources management (IWRM) is accepted in Cameroon as the starting point for policies that can enhance sustainable water resources management and development, and assure water security. However, conditions for effective use of the IWRM approach are not yet in place. Not only does Cameroon lack comprehensive information on water resources, but the distribution of water management authority is highly fragmented, and sectoral management approaches predominate. Moreover, the political will and commitment to enforce existing laws and regulations is inadequate, as are human and institutional capacity and investment for assessment and monitoring. Nevertheless, measures to improve water security have been carried out or are under way, including:

- public-private partnerships for electricity and urban water supply;
- an IWRM plan, expected by the end of 2009;
- transfer of some water management responsibilities to local levels following implementation of a law on decentralization.

The main challenges

Poor water services, rural-urban disparities: While Cameroon is not yet on track to meet the targets of the Millennium Development Goals (MDGs) for water and sanitation, it has made notable progress since 1990. In 2006, 70% of the population had access to safe drinking water. The coverage in urban centres is 88%, significantly better than the 47% in rural areas (WHO/UNICEF, 2008). Of Cameroon's 300 urban centres with 5,000 inhabitants or more, however, only 98 have water supply networks. Moreover, rapid urbanization in smaller towns has often rendered existing infrastructure inadequate, with frequent service interruptions. Many periurban dwellers

Box 1.1 Combating degradation of Waza Logone floodplains

The Maga Dam was built in 1979 on the Logone River to provide a continuous supply of water and to improve rice cultivation in the region. The project was carried out without a comprehensive environmental impact assessment. The dam led to reduced flooding of the plain, which in turn led to reduced groundwater recharge, less fish farming and a reduction in the production of sorghum and wild rice. Pastures on the vast floodplains were degraded and herdsmen in the region did not have sufficient grazing for their cattle. Wild animals, like the elephants of Waza National Park, were forced out of their normal grazing areas to search for food on nearby farms. The reduced flooding had disastrous consequences for the ecosystem and the lifestyle of the local people, who are among the poorest and most vulnerable in the country. To mitigate the effects of the dam and increase flooding in the plain, the Waza Logone project was carried out, at a cost estimated to be two to three times higher than that of building the dam.

also lack access to safe drinking water. Another problem is the amount of water unaccounted for: the average rate of loss rose from 25% in 1990 to 40% in 2000, clearly indicating an aging network and poor maintenance. Hence, in reality, the supply situation is worse than the figures imply.

Sanitation coverage is also poor. In urban areas only 58% of the population has access to improved sanitation facilities, and the rate in rural areas is 42% (WHO/UNICEF, 2008). Studies from different parts of the country indicate that many water resources used for household consumption are polluted to varying degrees because waste disposal infrastructure is insufficient in urban areas, and the capacity to enforce existing laws is very weak. Especially affected are areas where latrines and septic tanks, for example, are located near springs and shallow wells used without treatment for household water supply.

There is little information on the amount of pollution reaching surface and groundwater resources, or on the severity of the problem. Some studies have indicated that most industrial facilities discharge waste into the environment with little or no treatment. A 2002 study of the effluent from a textile plant in the coastal region indicated that some water quality parameters exceeded recommended limits by up to 2,700%. The company knows it is polluting, but because monitoring and enforcement are inadequate, it lacks any incentive to invest in wastewater treatment.

Water-related disease is quite common in Cameroon and particularly affects children. The main causes of death in children under 5 are diarrhoea, malaria and measles. Among children under 4, diarrhoea accounts for about 10% of all deaths. Malaria affects about 46% of the population. Health expenditure in Cameroon for 2001 2002 amounted to around US$110 million, which corresponded to 4.5% of the national budget and about 1% of GDP.

Poverty is another major issue in Cameroon. Although the poorest areas are in the far north, all regions suffer to varying degrees. The first national household survey in 1996 estimated that 51% of the population was living in poverty. The figure had fallen to 40% by the time the second survey was conducted in 2001. However, the decline mainly benefited urban dwellers. Just over 22% of people in urban areas are poor, compared with nearly 50% in rural areas (IFAD, 2008).

Decreasing biodiversity, wetland degradation:
Cameroon has a wide variety of natural resources, including its forests, which occupy about 50% of the country's surface area. With its climatic and ecological variety, Cameroon is rich in terms of biodiversity. However, an inadequate legal and institutional framework, combined with insufficient political will and commitment to enforcement of regulations, has led to decreased biodiversity. Wetlands are also at risk because of various pressures, including overgrazing and pollution. Other activities that have resulted in degraded wetlands include drainage for agriculture and for construction in urban and periurban areas. In the past, some development projects were carried out without adequate environmental impact assessment (Box 1.1), which affected wetlands and other ecosystems. Today, however, environmental impact assessment is required for all major development projects in Cameroon.

Conclusions

The biggest problem in Cameroon is not the availability of water it is the poor management and development of the resources, coupled with inadequate political will and commitment for the long term. The patchiness of information available on the quality and quantity of water resources is a major constraint for successful water resources management and a handicap for poverty alleviation efforts. Although progress has been made in water supply and sanitation coverage, much more needs to be done to improve the situation, especially in rural areas. The enabling environment for application of the IWRM approach is weak, as are institutional frameworks. In this situation, Cameroon is lagging in meeting the MDG targets. Improving water information systems, as well as completion and implementation of an IWRM plan, would go a long way towards improving water security in Cameroon, in addition to contributing to poverty alleviation.

References

Aquastat. 2005. Rome, Food and Agriculture Organization. http://www.fao.org/nr/water/aquastat/countries/cameroon/tables.pdf#tab3 (Accessed December 2008.)

Aquastat. 2007. Rome, Food and Agriculture Organization. http://www.fao.org/nr/water/aquastat/data/query/index.html. (Accessed February 2008.)

Energy Information Administration (EIA). 2004. *Country Analysis Briefs: Chad and Cameroon*. EIA, U. S. Department of Energy, http://www.eia.doe.gov/emeu/cabs/Chad_Cameroon/Electricity.html (Accessed December 2008.)

Fonteh, M. F. 2003. Water for people and the environment: Cameroon water development report. Background paper for *African Water Development Report*, Addis Ababa, Economic Commission for Africa.

International Energy Agency (IEA). 2006. *World Energy Outlook*. Paris, IEA. http://www.worldenergyoutlook.org/2006.asp (Accessed December 2008.)

International Fund for Agricultural Development (IFAD). 2008. *Rural Poverty in Cameroon*. Rural Poverty Portal. http://www.ruralpovertyportal.org/web/guest/country/home/tags/cameroon (Accessed November 2008.)

UN-Water/Africa. 2006. *African Water Development Report*. Addis Ababa, Economic Commission for Africa. http://www.uneca.org/awich/AWDR_2006.htm (Accessed December 2008.)

WHO/UNICEF. 2008. *Coverage Estimates: Improved Sanitation, Cameroon*. Joint Monitoring Programme for Water Supply and Sanitation. http//documents.wssinfo.orgdownload?id_document=932 (Accessed December 2008.)

World Bank. 2007. *2007 World Development Indicators Online*. Washington, DC, World Bank. http://go.worldbank.org/3JU2HA60D0 (Accessed February 2008.)

World Resources Institute (WRI). 2007. EarthTrends: Environmental Information. Washington, DC, WRI. http://www.earthtrends.wri.org (Accessed February 2008.)

Sudan

Receiving most of its lifeline water supply from the Nile River, the country is suffering from water-related natural hazards, disease and conflict, which put a heavy toll on sustainable socio-economic development and have led to deepening poverty.

Setting the scene

Sudan is the largest country in Africa. It is bordered by Egypt and the Libyan Arab Jamahiriya on the north, Chad and the Central African Republic on the west, the Democratic Republic of the Congo, Uganda and Kenya on the south, and Ethiopia and Eritrea on the east. The Red Sea lies to the north-east and forms a coastline of 700 km (Map 1.2). Most of the country is part of the Nile River basin. Largely composed of a flat plain, it ranges from 200 to 500 metres in altitude except for isolated hills at Jabel Mera, the Nuba Mountains and the Red Sea Hills. Annual rainfall varies from 25 mm in the Sahara desert, in the north, to over 1,500 mm in the south. Temperatures generally vary from 4°C to 50°C. Surface features range from tropical forest and marsh in the south and centre to savannah and desert in the north, east and west. The population was estimated at 37.7 million in 2006 (WHO/UNICEF, 2008). About 25% of the inhabitants live in the capital, Khartoum.[1]

Climate change and variability

Sudan is so vast (about 2,000 km from north to south and 1,800 km from east to west) that it lies in multiple climatic zones. In the north, where the Sahara extends into much of the country, the climate is arid, while the south is influenced by a tropical wet-and-dry climate. This variation directly affects rainfall: a rainy season runs from April to October in southern Sudan, but the rainy period gradually diminishes in length towards the north, and rainfall is scarce in the far north. Overall, December to February is the driest period except on the Red Sea coast.

[1] Except where otherwise noted, the information in this case study is adapted from Ahmed (2005).

In addition to geographic and seasonal variability in rainfall distribution, there are indications of a decreasing trend in the amount of rainfall in the last 30 years, with the dry zone increasingly extending towards the south.

State of the resource and water use

Almost 80% of the country falls in the basin of the Nile River and its two main tributaries: the White Nile, originating in the equatorial lake region (shared by Burundi, Kenya, Rwanda, Uganda, the United Republic of Tanzania and Zaire), and the Blue Nile, which rises in the Ethiopian highlands. The two join at Khartoum to form the Nile, which flows northwards through Egypt to the Mediterranean Sea. About 67% of the Nile River basin lies within Sudanese territory. Estimates of the availability of water resources in Sudan range from 36 billion m^3 (SNWP,

Map 1.2 Sudan

Table 1.1 Water availability estimates, 2002 and 1982

Water resources	Estimate by SNWP (2002) (billion m^3)	Estimate by Salih et al. (1982) (billion m^3)	Constraints and remarks
Sudan's share of the Nile River	20.50[a]	20.35[a]	Seasonal pattern, limited storage.
Non-Nile streams	5.50	8.00	Highly variable flows of short duration, difficult to monitor or exploit.
Renewable groundwater[b]	4.00	2.00	Deep water, entailing high pumping costs. Remote areas with weak infrastructure.
Water conserved through improved irrigation efficiency		2.00	Based on assumption of a 10% efficiency gain.
Subtotal	30.00	32.35	
Swamp reclamation	6.00	12.00	Capital intensive, with considerable social and environmental impact.
Potential annual availability	36.00	44.35	

a Measured at Sennar Dam in central Sudan b Salih et al further estimated that the non-renewable groundwater potential totalled 564 billion m^3

2002) to 44 billion m^3 (Salih et al., 1982) (Table 1.1). In both cases, the biggest and the most reliable source is the Nile.

Sudan has an agrarian economy: farming and animal husbandry are the mainstay of 80% of the population. Agriculture accounts for 34% of GDP. Livestock raising contributed about half the agricultural GDP in 1998 2001 (Central Bureau of Statistics, 2003). Industry generated 18% of GDP in 2001. Of an estimated 0.84 million km^2 of potentially arable land, some 0.17 million km^2, or 20%, was in use as of 2002. The irrigated area totals around 0.02 million km^2, or a modest 12% of the cultivated land area, but consumes about 20 billion m^3 of water approximately equal to Sudan's share of the Nile River flow (Box 1.2). Agricultural water consumption is expected to increase significantly, and likely to double by 2025. Although irrigation efficiency is high, a considerable amount of water is lost to evaporation and because of poor maintenance of irrigation systems. Water rates for irrigation are based on the extent of cultivated area rather than the actual quantity used. This approach, coupled with a lack of clarity about the role of farmers in the irrigation system, exacerbates the already high water consumption. Adoption of rainwater harvesting techniques could contribute significantly to improvement in agriculture and livestock production.

The incidence of rural poverty is quite high, an issue closely linked to national agricultural strategy. In the 1970s Sudan introduced large-scale mechanized farming and promoted expansion of the irrigated area to increase output, especially of cash crops. The new farming systems and land allocation policies led to displacement

Box 1.2 Cooperation in the Nile River basin

Creating a more cooperative environment for management of the Nile River has been an aim in the region for centuries. In recent years political conditions in basin countries have provided a window of opportunity for progress on cooperative development of the shared waters. With the support of external agencies, since the late 1990s nine of the ten Nile riparian countries have begun a process of institutional development that has cemented cooperation and charted a way towards future development in the Nile basin. Yet, the main issue remains to put this institutional development and cooperative thinking into practice through the development of projects of mutual benefit that are sustainable and can alleviate the worst poverty.

This key challenge is being faced by the parties to the Nile Basin Initiative (NBI). Based in Entebbe, Uganda, the NBI, with representatives of all basin states except Eritrea, is helping coordinate two programmes with broad development agendas. The implementation of these programmes is now paramount. Success in cooperation needs to be followed by a transition to development activities, which should become the mainstay of this initiative, aiming to move towards benefit sharing rather than water sharing. Meanwhile, a 1959 agreement between Sudan and Egypt is still the basis for allocation of the Nile River water resources. Accordingly, the average annual flow of 84 billion m^3 is divided between the two countries: Egypt receives 55.5 billion m^3 and Sudan 18.5 billion m^3 (measured at Aswan Dam in southern Egypt); some 10 billion m^3 is assumed to be lost to evaporation from the reservoir of Aswan Dam.

of subsistence farmers and nomads, and dismantled traditional systems of communal ownership and management (IFAD, 2008).

Sudan is rapidly urbanizing: the share of urban dwellers in the population increased from 27% in 1990 to 42% in 2006 (WHO/UNICEF, 2008). Household water consumption is estimated at 1.1 billion m^3. Safe water and improved sanitation coverage is biased towards urban settlements. In 2006, the percentage of population with access to safe water supply was 78% in urban areas and 64% in rural ones. The disparity is even greater for access to improved sanitation, which is available to 50% of urban dwellers but only 24% in rural areas (WHO/UNICEF, 2008). Consequently, water-related communicable diseases, particularly malaria and diarrhoeal illnesses, are among the leading causes of morbidity, especially in the north, and they are exacerbated by widespread malnutrition. Malaria is epidemic: some 75% of the population nationwide is at risk (WHO, 2008*a*). In 2007 alone, over 2.7 million cases were reported and nearly 6% of all hospital deaths were linked to malaria (WHO, 2008*b*).

Pollution from households, agriculture and industry seriously threatens the quality of freshwater resources. In many places, such as southern and western Sudan, where the groundwater table is only a few metres below the surface, sanitation practices (mainly on-site disposal systems such as septic tanks and pit latrines) and improper urban waste disposal have caused very high chemical and bacteriological contamination. Almost all disposal wells and pit latrines tap the water table, and they are often within 10 to 20 metres of wells used for drinking water.

Thanks to the Nile River and its tributaries, Sudan has an estimated hydropower potential of 9 GW, with development of 5 GW being economically feasible. Yet, the hydroelectric production capacity of the four existing multipurpose dams is only 0.335 GW. Sudan's total electricity production capacity (thermal and hydroelectric combined) of 1.2 GW (2004) does not meet demand, and in fact is greater than the country's limited distribution capacity. A major factor limiting the development of irrigation in Sudan is the poor storage capacity of existing dams. Furthermore, siltation has reduced the design capacity of the dams by one-third, from 9.1 billion m^3. Enhancing reservoir capacity is critical to assure food security, since about 85% of the annual water potential of the Nile River flows from July to September and for the rest of the year the flow is very low, especially in the Blue Nile, in whose vicinity 70% of the irrigated area is located.

The Nile and its tributaries have always been used for transport. At present, around 1,700 km of the waterways are navigated, but this could be substantially improved. Until 1977 the River Transport Corporation of Sudan had one of the largest fleets in Africa, but continuous deterioration since then has reduced the fleet to only about 10% of its former size (2005). Waterway navigation is not considered a priority; the service is mainly between the north and the south, and has never been significantly extended to other parts of the country. Moreover, a lack of coordination among relevant authorities has meant no consideration is given for navigation when major structures such as dams and bridges are built.

Policy framework and decision-making: Legal and institutional aspects of water management

Water resources management is fragmented in Sudan. In an attempt to address this problem, the Water Resources Act (1995) gave responsibility for managing freshwater resources to the Ministry of Irrigation and Water Resources. Four years later, a National Council for Water Resources was formed. It is headed by the ministry, with participation by central and state government representatives. Its objective is to formulate general policies and the outline of water resources development and management for the whole country, and to coordinate actions between the state and central levels. The main laws concerning water resources and their protection are the Environmental and Natural Resources Act (1991), the Water Resources Act (1995) and the Groundwater and Wadis Directorate Act (1998). They cover the entire spectrum of development, management and protection of freshwater resources.

These efforts have not been successful, however, as various dimensions of water resources management are still spread among different ministries and dealt with by many government organizations without integration or coordination. Thus, many aspects of the legislation are not enforced, with responsibilities ill defined and coordination lacking. Moreover, major gaps in the laws exist. For example, in irrigation development projects, protection of groundwater resources from agricultural pollution is not taken into consideration. Nor do mining projects or the newly introduced oil development include any provision for groundwater protection. Efforts to produce a national water policy are continuing.

The main challenges: increasing pressures on scarce resources

Cycle of poverty, droughts, floods and conflict: Sudan, like other countries of the Sahel, has long suffered from lengthy, devastating droughts. The most severe droughts of recent decades occurred in 1980 1984, 1989, 1990, 1997 and 2000, causing widespread population displacement and famine. In addition, floods in Sudan have caused extensive damage, especially around the Nile and its main tributary, the Blue Nile. Severe floods on the latter river in 1988 and 1998 caused property losses estimated at hundreds of millions of dollars. Flooding of the Nile proper in 2007 affected over 500,000 people and destroyed thousands of homes (WHO, 2008*a*). Seasonal rivers can also cause serious flood damage. In 2003, for example, heavy flooding along the Gash River affected 79% of the city of Kassala, leaving 80% of the population homeless, and inflicted heavy losses on agriculture in the region (NASA, 2008).

It is estimated that 85% of Sudan's rural population lives on less than US$1 per day. Overall, some 20 million people were living in extreme poverty in 2002 (IFAD, 2008). The incidence of poverty varies considerably because economic growth is geographically uneven and conflict has devastated parts of the country. Severe regional inequalities exist in access to even the most basic services, such as education, sanitation, safe drinking water and job opportunities. For example, health services in southern Sudan reach only about 25% of the population. People living in areas that have been or continue to be affected by drought and conflict particularly the south and Darfur are the most vulnerable to poverty (IFAD, 2008). As of late 2007, 4.2 million people were affected by conflict, including 2.4 million internally displaced as a result of the conflict in Darfur (WHO, 2008*a*).

Biodiversity: There is little public awareness or political sensitivity about ecosystem protection in Sudan. Since the 1970s, expansion of large-scale rain-fed agriculture, urbanization and other types of development have caused the destruction of over 5,000 km^2 of forest, and the extent of reforestation amounts to just 300 km^2. Many wildlife species have been lost for similar reasons, as well as because of the conflict in the south, and numerous other species are endangered or vulnerable. Pasture lands have been destroyed or degraded by overgrazing, droughts and fires.

Conclusions

In spite of substantial land and water resources, Sudan is seriously handicapped by floods, droughts and the burden of disease. Agriculture, which provides the livelihoods of 80% of the population, currently claims about 55% of available freshwater resources. Given that the water use in this sector may as much as double by 2025, water saving through better irrigation methods will become a critical factor for meeting the needs of other sectors in a sustainable fashion. A decreasing rainfall trend associated with climatic variability and likely climate change might further limit water availability and lead to serious scarcity. Overall, the lack of accurate assessment of water resources and of a national water policy are the major obstacles hindering effective management of water resources. A fragmented water sector, lack of coordination among bodies responsible for water management, gaps in legislation and poor enforcement are other issues further aggravating the situation. These challenges, combined with social unrest, have led to deepening poverty, which affects a majority of the rural population. However, there is considerable potential for improvement through adoption and implementation of better policies on water and land resources.

References

Ahmed, A. A. 2005. *Sudan National Water Development Report*. Contribution to *African Water Development Report*. Addis Ababa, UNECA.

Aquastat. 2005. *Sudan*. Rome, Food and Agriculture Organization. http://www.fao.org/nr/water/aquastat/countries/sudan/index.stm (Accessed December 2008.)

IFAD. 2008. *Rural poverty in Sudan*. Rural Poverty Portal, http://www.ruralpovertyportal.org/web/guest/country/home/tags/sudan. (Accessed December 2008.)

National Aeronautics and Space Administration (NASA). 2008. Earth Observatory. http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=12099 (Accessed January 2009.)

Nicol, A., with Shahin, M. 2003. *The Nile: Moving Beyond Cooperation*. Paris, UNESCO International Hydrological Programme and World Water Assessment Programme. http://unesdoc.unesco.org/images/0013/001333/133301e.pdf (Technical Documents in Hydrology, PC-CP Series, No. 16, accessed December 2008.)

Salih M. A. et al. 1982. *Water Resources in Sudan*. Report submitted to the National Council for Research, Khartoum.

Sudan National Water Policy (SNWP). 2002. Khartoum, Ministry of Irrigation and Water Resources.

World Health Organization (WHO). 2008*a*. *Emergency Preparedness and Humanitarian Action: Sudan, From Emergency to Sustainability*. http://www.emro.who.int/sudan/pdf/Sudan_Generic_donor_report.pdf (Accessed December 2008.)

World Health Organization (WHO). 2008*b*. *World Malaria Report*. http://malaria.who.int/wmr2008/malaria2008.pdf (Accessed December 2008.)

WHO/UNICEF. 2008. Joint Monitoring Programme for Water Supply and Sanitation. http://www.wssinfo.org/pdf/JMP_08.pdf.zip (Accessed December 2008.)

Swaziland

Relying on transboundary rivers, Swaziland would benefit from continued cooperation with its neighbours as well as strengthened water resources management legislation at home. These would help alleviate the heavy burden of poverty and disease as well as the country's reliance on external funding in the water sector.

Setting the scene

Swaziland, one of the smallest countries in Africa, is almost enclosed within South Africa, sharing just the northern half of its eastern border with Mozambique.[1] Its population of 1.13 million (2006) is distributed over an area of 17,370 km^2. From west to east, the country is divided into four well-defined regions: the Highveld, Middleveld and Lowveld, and the Lubombo plain and escarpment. The altitude ranges from 150 metres in the east to 1,800 metres in the west. The climate varies accordingly, though a generally subtropical climate with summer rains prevails. Between 75% and 83% of the annual rainfall comes from October to March. Precipitation ranges from 500 mm in the south-east to 1,500 mm in the west, the average being 1,200 mm.

Climate change and variability

Swaziland is situated at a transition of major climatic zones. Consequently, the country is prone to extreme events, such as cyclones and droughts. The latest and longest drought occurred over 1989 1994, while the most recent severe cyclone, designated Domonia, hit in 1984.

[1] Except where otherwise noted, information in this case study is adapted from Mwendera (2005).

Climatic models assessing the impact of climate change in the Great Usutu River basin reveal higher temperatures and more intense rainfall in early summer (October to January), dissipating in late summer and winter (February to September). The projections also indicate a maximum reduction in annual runoff of up to 12.6% or 133.6 million m³. The combined effect of high temperatures and low runoff, especially in winter, could adversely affect groundwater recharge, particularly in the Lowveld, and aggravate existing groundwater salinity. Taken together, these changes are very likely to negatively affect the agriculture-based economy as well as ecosystems. The Great Usutu River basin locally often called the Lusutfu is considered fairly representative, as about three-quarters of the population lives within and is supported through it (UNFCC, 2004).

State of the resource and water use

Swaziland has five principle river basins (the Lomati, Komati, Mbuluzi, Great Usutu and Ngwavuma) whose total annual renewable water resources amount to 4.5 billion m³. Of this, 42% or 1.87 billion m³ originates in South Africa. The seasonal nature of the rainfall makes discharge of surface waters extremely variable. In dry areas such as the Lowveld, while the larger rivers are through-flowing, most watercourses tend to flow only after heavy local rainstorms. Hence, development of groundwater resources is crucial. Although no quantitative assessment of groundwater resources has yet been undertaken, the annual potential is estimated at 0.66 billion m³. The Middleveld and Highveld have the highest potential for groundwater exploitation, but the number of wells in the Highveld is limited due to the greater depth needed to reach the water table. In the Lowveld, where the potential recharge is the lowest and the need for groundwater is the highest, installed wells tap about 42% of the estimated potential. Nationwide, only about 6% of the potential is exploited.

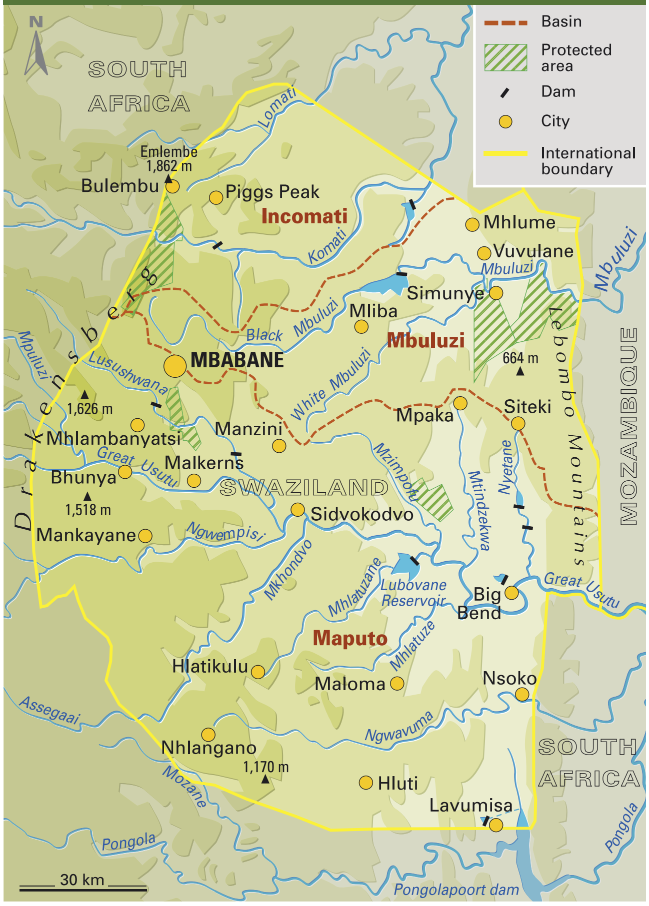
As Table 1.2 shows, agriculture is the main consumer of freshwater resources, accounting for almost 97% of withdrawal. Of this, over 90% is used in growing sugarcane as the main cash crop. The country is split between largely rain-fed subsistence production by smallholders and cash cropping on large private estates. Smallholders constitute some 70% of the population and occupy 75% of the crop land, but their productivity is low, accounting for only 11% of total agricultural output. Poor availability of water for irrigation is a major constraint to smallholder production; in years of low rainfall, harvests plummet and further aggravate the food crisis (New Agriculturist, n.d.).

Table 1.2 Water demand by sector, 2002

Sector	Demand (million m³/year)	% of total demand
Households	30	1.7
Animal husbandry	14	0.8
Industry	17	0.9
Other agriculture	1,734	96.6
Total	1,795	100.0

Source GOS, 2002

Map 1.3 Swaziland



Note The principal basins in Swaziland are those of the Lomati, Komati, Mbuluzi, Great Usutu and Ngwavuma rivers This map shows the Lomati and Komati grouped into the Incomati basin, and the Great Usutu and Ngwavuma forming the Maputo basin

Grazing is the predominant land use in Swaziland: about 67% of the total land area, or 11,630 km², is used solely for this purpose. During the dry season an additional 2,500 km², which is under cultivation during the summer, is used for grazing. Rangelands on communal land, as opposed to commercial ranches, appear to be deteriorating (WSSD, 2002).

The population of Swaziland is predominantly rural. In 2006, 24% of the population lived in urban areas, which have significantly better water supply and sanitation coverage than do rural areas. About half the urban population is concentrated in the main cities Mbabane, the administrative capital, and Manzini, the main commercial centre. Overall, 60% of the population has access to safe water supply and 50% to improved sanitation (WHO, 2008).

Commercial forestry and the related wood processing industry form an important part of the economy, contributing about 15% to GDP, mainly through exports. The sector employs some 8,000 people, amounting to 8% of formal employment in Swaziland. The sugar industry is another major economic player, providing between 17% and 22% of total export revenue and employing 16,000 people directly and 80,000 indirectly. Sugarcane represents more than half of all agricultural output and

30% of agricultural employment. Industrial pollution is a problem. Most companies do not report on their environmental records or their use of energy and natural resources (WSSD, 2002).

Policy framework and decision-making

In the past, ad hoc management of water resources prevailed in Swaziland. Carried out by several ministries and by institutions outside the government, it involved multiple laws aimed at solving disparate issues. They included the Water Act of 1967, the Water Services Act of 1992, the Komati River Basin Water Resources Development and Utilization Act of 1992, the Joint Water Commission Act of 1992, the Swaziland Environmental Authority Act of 1992 and the Swaziland Administrative Order of 1998 (Aquastat, 2005).

Today the 2003 Water Act provides guidelines on how the water sector in Swaziland is coordinated. It establishes the National Water Authority, which is the highest policy-making body responsible for the development and management of the national water sector. The Act also provides for the formation of river basin authorities and water user associations to enhance public involvement in water resources management. In addition, the Act includes the private sector as a partner in water development (Aquastat, 2005). One objective of the Act is to guide the development of policies on water allocation and pricing, pollution control, water storage and basin management.

A draft national water policy (2001) has been harmonized with the regional policy and strategy that the South African Development Community (SADC) adopted in 2007. The national policy has since been reviewed by the National Water Authority and is being finalized in consultation with stakeholders.

The National Development Strategy was launched in 1999 to provide guidelines on equitable allocation of resources for socio-economic development in the next 25 years, strengthen government planning and management capacity on development and seek national consensus on the direction of development. The strategy includes several recommendations on water resources development, such as formulating an overall policy to cover all water uses, expanding smallholder irrigation within a national irrigation development plan while encouraging farmers to make use of all available water resources, and building small and medium-sized dams to provide a reliable source of water for small-scale irrigation, livestock, fisheries and municipal use (Aquastat, 2005).

The Swaziland Environmental Authority Act of 1992 addresses the issue of pollution control for water and the environment and includes provisions for the establishment of standards. The National Development Strategy also highlights environmental management as a key policy area, and stresses the importance of tackling major environmental issues, such as soil erosion, deforestation, waste disposal and industrial and urban pollution, especially as regard the livelihoods of rural people. Nevertheless, the country needs to strengthen integration of environmental concerns in all sectors and examine the potential environmental implications of economic policies (WSSD, 2002).

The main challenges

Poverty and infectious diseases: The country suffers from a heavy disease burden. The main causes of Swaziland's high rate of infant mortality diarrhoea, malnutrition and infectious diseases can be linked to constraints on access to safe water supply and improved sanitation. Malaria remains a major health problem, especially in the Lowveld, the Lubombo plateau and parts of the Middleveld. The disease occurs mainly during or after the rainy season. It is estimated that 30% of the population resides in malaria risk areas and 38% in malaria receptive areas (Aquastat, 2005).

Box 1.3 Combating HIV and AIDS: a heavy toll in sub-Saharan Africa

Thanks to a sixfold rise in this decade of financing for activities to fight HIV in low- and middle-income countries, the annual number of AIDS deaths worldwide declined from 2.2 million in 2005 to 2.0 million in 2007, partly as a result of a substantial increase in access to HIV treatment. In a number of heavily affected countries, such as Kenya, Rwanda, Uganda and Zimbabwe, dramatic changes in sexual behavior have been accompanied by declines in the number of new HIV infections, contributing to stabilization in the percentage of HIV-positive adults (people aged 15 to 49).

However, sub-saharan Africa still bears the burden of the HIV/AIDS epidemic. An estimated 1.9 million people were newly infected with HIV in sub-Saharan Africa in 2007, bringing the number of people living with HIV to 22 million. Alarmingly, 67% of the 33 million people worldwide with HIV live in the region, and 75% of all AIDS deaths in 2007 occurred there.

In Swaziland, the number of persons affected by HIV increased from 160,000 in 2001 to 190,000 in 2007. The total includes 15,000 children below age 14. The HIV prevalence rate appears to have stabilized. A national population-based survey in 2006 put the rate at 26% the highest prevalence ever documented in such a survey anywhere in the world (Central Statistical Office [Swaziland] and Macro International, 2007). On the positive side, the country has made marked progress in expanding coverage for HIV-positive pregnant women in recent years: between 2004 and 2006, coverage of prevention of mother-to-child transmission increased from 5% to 67%. In addition, donor funding for child-focused initiatives has increased, with care and support services now provided for 100,000 children orphaned as a result of HIV (Global Fund, 2008).

Source Adapted from UNAIDS, 2008

Table 1.3 Recurrent expenditure in the water sector

Sector	2002/2003		% of total	2003/2004*		% of total	2004/2005*		% of total
	emalangeni (thousands)	(US$) (thousands)		emalangeni (thousands)	(US$) (thousands)		emalangeni (thousands)	(US$) (thousands)	
Water resources management	24,483	2,310	0.8	26,274	3,457	0.8	24,139	3,713	0.8
Other expenditure	2,932,434	276,644	99.2	3,282,145	431,861	99.2	2,907,404	447,293	99.2
Total	2,956,917	278,954	100	3,308,419	435,318	100	2,931,543	451,000	100

* Estimates
Note Average exchange rates used for calculations: 2002, US$1 E 10 6; 2003,US$1 E 7 6; 2004, US$1 E6 5
Source: GOS, 2004

According to the Central Statistics Office (GOS, 2005), 69% of the country is affected by poverty. The incidence of poverty is much higher in rural areas (75%) than in urban settlements (49%). About 84% of the country's poor people live in rural areas, where per capita income is one-fourth of the urban average, and people consume half as much food. About 66% of the population cannot meet basic food needs, and 43% live in chronic poverty (IFAD, 2008).

Productivity at both household and national level is increasingly affected by the high rate of HIV and AIDS infection (Box 1.3). It is estimated that 26% of people aged 15 to 49 have the virus (UNAIDS, 2008), and that HIV and AIDS cause 47% of deaths among children under age 5 (WHO, 2006). Over 10% of households are headed by children who have lost both parents, and a significant number by very old grandparents who cannot do physical work (WSSD, 2002).

Limited investment in water sector: The share of government spending allocated to the water sector has averaged less than 1% in recent years (Table 1.3). To improve water supply and sanitation coverage, the level of government funding needs to be raised. Meeting the national target of providing water and sanitation services to all rural people by 2022 would require a tenfold increase in investment.

The majority of funds for the sector come from external sources. In fiscal 2003/2004, nearly two-thirds of estimated capital expenditure was in the form of international grants (Table 1.4). Current trends, however, show external donors in the water sector reducing their assistance to Swaziland. Thus, the government will need to allocate a greater share of the national budget for improving water and sanitation coverage, and increase the efficiency of investment.

Improving regional cooperation: Although located in a generally arid part of southern Africa, Swaziland is considered well situated because it is traversed by several large rivers (the Komati, Mbuluzi, Great Usutu and Ingwavuma) flowing from or into South Africa and Mozambique. Given that 58% of overall water potential is derived from Swaziland and the rest originates in South Africa, upstream water resource development could reduce the water supply availability for Swaziland as well as downstream Mozambique.

Table 1.4 Estimated capital expenditure in the water sector by source of funds, 2003/2004

Source of funds	Amount emalangeni (thousands)	Amount US$ (thousands)
Local funds	20,831	2,740
Foreign grants	35,348	4,650
Total capital	56,179	7,390

Note The average interbank exchange rate in 2003 was US$1 E7 6
Source GOS estimates, 2004

In recognition of the importance of a coordinated approach to the use and preservation of water resources, a technical committee was formed under the SADC framework to stimulate development and cooperation in the region. The SADC member states, including Swaziland, signed a Protocol on Shared Watercourse Systems in 1995, which was reinforced in 2000 by a revised protocol seeking to foster closer cooperation for sustainable management, protection and use of shared watercourses.

In 1983, Mozambique, South Africa and Swaziland established the Tripartite Permanent Technical Committee to advise the three governments on water use and policy-related issues concerning the Incomati and Maputo rivers (as the Komati and Great Usutu are known in Mozambique). Swaziland signed treaties with South Africa in March 1992 to establish a Joint Water Commission and the bilateral Komati Basin Water Authority, which is responsible for the design, construction and management of the Driekkopies and Maguga dams. A treaty establishing a Joint Water Commission between Swaziland and Mozambique was signed in July 1999. Mozambique, South Africa and Swaziland signed the Tripartite Interim Agreement for Cooperation on the Protection and Sustainable Utilisation of the Water Resources of the Incomati and Maputo Watercourses in August 2002, and are undertaking studies into the possible elaboration of a comprehensive water sharing agreement for the two rivers.

The development, finalization and satisfactory implementation of such agreements are important to foster cooperation in the region and minimize water-related conflicts that might arise as water needs increase.

Conclusions

Swaziland is well endowed with freshwater resources. As more than 40% of the water potential originates in South Africa, and the water requirements of downstream Mozambique need to be considered, functional cooperation agreements on the use of transboundary waters are vital to the sustainable socio-economic development of Swaziland and its neighbours. Swaziland needs to strengthen its own legislation to improve the management of water resources, as well as raise the level of investment in the water sector, in order to alleviate the excruciating poverty and heavy disease burden that its people suffer.

References

Aquastat. 2005. *Swaziland*. Rome, Food and Agriculture Organization. http://www.fao.org/nr/water/aquastat/countries/swaziland/index.stm (Accessed December 2008.)

Central Statistical Office and Macro International Inc. 2007. *Swaziland Demographic and Health Survey 2006 2007: Preliminary Report*. Calverton, Md., Macro International.

Global Fund to Fight AIDS, Tuberculosis and Malaria. 2008. *Monthly Progress Update 31 January 2008*. http://www.theglobalfund.org/en/files/publications/basics/progress_update/progressupdate.pdf (Accessed January 2009.)

Government of Swaziland (GOS). 2002. Prioritised Action Programme on Poverty Reduction. Mbabane, Ministry of Economic Planning and Development,

Government of Swaziland (GOS). 2002. Swaziland's National Report on the World Summit on Sustainable Development 2002. Mbabane, Swaziland Environmental Authority.

Government of Swaziland (GOS). 2004. Medium Term Expenditure Framework, Budget 2005/05-2007/08. Mbabane, Ministry of Natural Resources and Energy.

Government of Swaziland (GOS). 2005. Swaziland Household Income and Expenditure Survey (SHIES) 2000/01. Mbabane, Central Statistical Office, Ministry of Economic Planning and Development.

International Fund for Agricultural Development (IFAD). 2008. *Rural Poverty in the Kingdom of Swaziland*. Rural Poverty Portal. http://www.ruralpovertyportal.org/web/guest/country/home/tags/swaziland (Accessed November 2008.)

Joint United Nations Programme on HIV/AIDS (UNAIDS). 2008. *Report on the Global AIDS Epidemic*. Geneva, UNAIDS. http://www.unaids.org/en/KnowledgeCentre/HIVData/GlobalReport/2008/2008_Global_report.asp

Mwendera, E. J. 2005. *Swaziland Country Water Status*. Contribution to *African Water Development Report*. Addis Ababa, Economic Commission for Africa.

New Agriculturist. No date. *Country Profile: Swaziland*. http://www.new-ag.info/02-6/countryp.html (Accessed December 2008.)

United Nations Framework Convention on Climate Change (UNFCCC). 2004. *Swaziland's First National Communication*. http://www.ecs.co.sz/unfccc/chapter4_3.htm (Accessed December 2008.)

World Health Organization (WHO). 2006. *Country Health System Fact Sheet 2006: Swaziland*. http://www.afro.who.int/home/countries/fact_sheets/swaziland.pdf (Accessed December 2008.)

World Summit on Sustainable Development (WSSD). 2002. National Assessment Report: Swaziland. http://www.ecs.co.sz/wssd/wssd_swaziland_national_assessment_2002.zip (Accessed December 2008.)

Tunisia

Amid economic growth and urbanization, this developing country has made big gains in water and sanitation coverage, as well as a shift towards long term sustainable practices, but faces mounting tensions between competing users.

Setting the scene

Tunisia, located in North Africa, is bounded by Algeria to the west, by the Libyan Arab Jamahiriya to the south-east, by the Sahara to the south and by the Mediterranean (with a 1,200 km coastline) to the north (Map 1.4). The country covers 164,420 km^2 and has a population of 10.25 million (2007). Its landscape is diverse, ranging from mountains in the north-west to the arid south and the Sahara. In 2006, 66% of the population lived in urban areas (WHO/UNICEF, 2008). Urbanization is expected to continue, largely through migration to coastal areas. On current trends, by 2025 some 75% of the population will live in urban areas.[1]

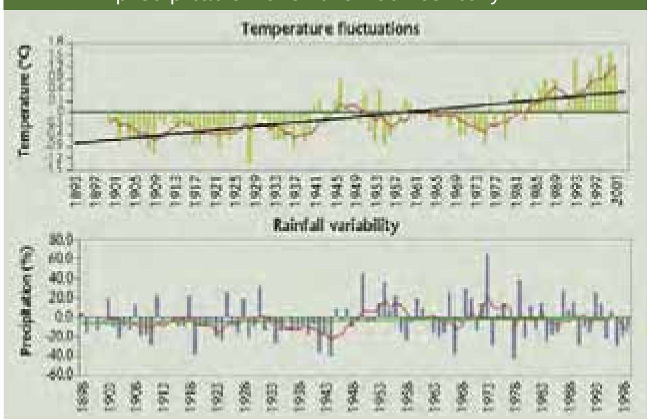
The predominant climate types are Mediterranean in the north and Saharan in the south. Four climatic subregions can be identified: subhumid in the far north, semi-arid in the north-west and at Cap Bon, arid in the centre and hyper-arid and desert in most of the south. Over 40% of the country lies in the hyper-arid zone. Although average annual rainfall amounts to 220 mm, geographic variation is substantial, with regional averages ranging from 1,500 mm in the north to 50 mm in the far south, in the heart of the Sahara.

The arid plains that mark the northern limit of the Sahara include many depressions, locally called *chotts* and *sebkhats*, which fill with water in winter and dry up in summer. Their water is highly saline. The largest *chott*, Jerid, is a 500 km^2 salt lake.

Climate change and variability

Analysis of changes in average temperature and rainfall in Tunisia over the 20th century (Figure 1.1) indicates that while temperatures have risen significantly, by 1.2°C, no trend in rainfall is apparent, although greater variability can be observed in 1961 1990 than in 1901 1930 or 1931 1960 (King et al., 2007).

Figure 1.1 Anomalies in average temperature and precipitation over the 20th century



Source King et al , 2007

[1] Except where otherwise noted, information in this case study is adapted from the draft *Tunisia Case Study Report*, prepared in 2008 (in French) by Besbes et al.

Map 1.4 Tunisia

Since 2006, studies have been undertaken in Tunisia to aid in elaboration of a national climate change adaptation strategy. The aim is to move from reaction to crises, such as droughts and floods, to management of risk associated with climate change (early adaptation). Projections for 2030 and 2050 form the basis of this effort. Models for 2030 indicate a slight increase in the frequency and intensity of dry years, though the north-west might benefit from a slight increase in precipitation in wet years. However, by 2050 the average annual temperature could rise by between 0.4°C and 1.2°C, and the variability of rainfall could increase, especially in spring and autumn (MARH/GTZ, 2006).

State of the resource and water use: storage is essential

Tunisia has a dense hydrographic network in the north, whose river basins account for 81% of the national surface water potential. Oued Mejerda, which rises in Algeria, is the biggest river, with an annual water potential of around 0.8 billion m^3. The south is characterized by large, deep aquifer networks whose low recharge rates make them barely renewable. Tunisia's annual water potential is estimated at 4.8 billion m3, with groundwater amounting to about half (2.1 billion m^3). In 2005, the exploitation rate was roughly 80% for deep aquifers and an unsustainable 108% for shallow aquifers. (These averages are approximations, as the figures for withdrawal and exploitable resources used in calculation are quite uncertain.)

The high variation in rainfall, amount of arid land and overuse of groundwater resources make storage of freshwater a vital necessity in Tunisia. In 2005, there were 27 large dams, 200 small hillside dams and 660 hillside lakes, with a combined capacity of 1.8 billion m^3 per year, amounting to 66% of the total surface water potential. Despite the number of dams, Tunisia lacks major hydroelectric generation capacity. Modest projects carried out since the 1950s have allowed it to exploit 40% of its hydropower potential. Even so, hydroelectricity represents barely 1% of overall energy production. Given the long term rise in fuel prices, however, hydroelectric production is expected to expand.

Of the country's approximately 110,000 km^2 of arable land, only 49,000 km^2 is currently in use, mainly producing grain and olives. In 2006, agriculture accounted for 81% of overall water consumption. Although its share of GDP is gradually decreasing, agriculture still plays an important role in the economy. It employs 25% of the workforce, and was the third biggest contributor to GDP in 2006 at 11%, behind industry and mining (29%) and services (60%).

In urban areas, drinking water coverage had reached almost 100% by 1993. Tunisia achieved this by transferring large amounts of water from the humid north to the arid south, and by installing desalination facilities to treat brackish water in the tourist areas of the south-east. In rural areas, access to drinking water expanded from 62% in 1990 to 84%, on average, in 2006. Over the same period, coverage for the country as a whole advanced from 82% to 94% (WHO/UNICEF, 2008).

The share of urban households connected to sewerage was 96% in 2006. In rural areas, where sanitation relies on more traditional methods such as septic tanks and field disposal, access to improved sanitation is around 64% (WHO/UNICEF, 2008). Efforts are also being made to minimize health risks by altering hygiene practices through education.

Industry consumes around 0.1 billion m^3 of water per year, of which almost 60% is abstracted from deep aquifers. In the absence of incentives for conservation, water-efficient production processes and water recycling are seldom if ever used.

Tourism is a big source of income in Tunisia with a modest water footprint: the whole sector consumes only

Box 1.4 Water resources management in Tunisia

Tunisia's 1975 Water Code introduced the principles of 1) protection of water resources as a public good; 2) government responsibility in supplying water and in planning and monitoring water use; 3) the necessity of water conservation to alleviate scarcity throughout the country; 4) recyc-ling of treated wastewater in agri-culture; 5) the possibility of stake-holder involvement in water resources manag-ement through community assoc-iations; and 6) private sector involvement in managing non-conventional resources. The Ministry of Environment and Sustainable Development is responsible for pollution reduction and wastewater recycling, while the Ministry of Agricul-ture and Water Resources has broad responsibilities covering everything else.

Basing the institutional framework on the principle of stakeholder involvement has allowed Tunisia to manage its limited water resources effectively. The fact that the water management system is centralized has facilitated the trade-offs necessary to balance supply with demand while reconciling the needs of various users. Having furnished itself with appropriate tools for integrated resources management and begun planning for the day when demand will outstrip availability, the country is well placed to avoid many problems it might otherwise have encountered.

25 million m^3 per year, or 1% of the total exploited resource. The rate is slightly higher in the south, where tourism is expected to be developed intensively in the future.

Policy framework and decision-making

Since 1970, as both knowledge about water resources and demand from various sectors have increased, plans and directives concerning water management have been developed in Tunisia (Box 1.4).

A master plan for water use has been implemented for each of the country's three natural regions the north, the centre and the south. The master plans include provisions on the transfer of surface and groundwater and on flood protection for large urban centres. These guidelines have allowed water resources to be allocated in terms of present and expected demand from the different users. They have also helped identify the areas where irrigation makes the best use of available resources. The national strategy for water resources mobilization is now in its second decade (2001 2010), and the aim is to mobilize 95% of conventional resources by building dams, reservoirs and flood runoff infrastructure, and to develop non-conventional resources such as recycled and desalinated water.

These plans and strategies have helped Tunisia make several reforms since the early 1990s. The most important of these was a transition from supply-side management towards a strategy of demand-driven management. Thus, the emphasis is on institutional, regulatory and technical practices that are likely to change water users' behaviour, encourage more efficient use of resources and maintain a sustainable consumption level. Measures have also been taken to reduce the environmental impact of water policies, particularly by protecting the most fragile ecosystems and limiting the sources and effects of water pollution.

The main challenges: promoting sustainable use of scarce resources

To promote economic growth, past policies encouraged water use through preferential rates or subsidies. The low value thus imputed to water gave users the mistaken impression that resources were abundant. This led to overexploitation of water resources especially groundwater resources, from which 75% of irrigation water is abstracted. Because of the large share of agriculture in water consumption, efforts have been made since the late 1980s to increase efficiency of water use by charging a user fee for irrigation water. From 1990 to 2000, the price was increased by 9% per year. The total of user fees collected quadrupled between 1991 and 2003, permitting recovery of much of the cost of running and maintaining the water system. In 1995, a vast irrigation rehabilitation programme was begun, involving a generous incentive package in which small agricultural holdings were offered subsidies of up to 60% of the cost of modernizing installations. As a result, by 2007 some 80% of the irrigation system had been improved with sprinkler systems, drip irrigation and the like. This strategy has allowed Tunisia to stabilize demand for irrigation water despite the growing extent of the area under irrigation (Figure 1.2).

To maximize freshwater availability, other methods, such as recycling of treated wastewater and desalination of brackish water, are also being adopted. Desalinated water is reserved for essential uses such as drinking water, meeting the needs of tourist facilities and certain industrial uses (chiefly in food processing and the chemical and pharmaceutical industries) in regions where local water resources are insufficient or of poor

Figure 1.2 Trends in agricultural water use and the extent of irrigated land, 1990 2006

quality. However, tariffs are identical for all water, regardless of whether it is desalinated or not. Although the official policy is to provide access to clean drinking water for all, which has bolstered the principle of social equity, the approach to tariff-setting does not necessarily favour protection and appropriate valuation of the resources.

Conclusions

Tunisia is a semi-arid country with limited water resources in which desertification is reducing the availability of arable land. Modern irrigation techniques, promoted since 1995, have allowed optimum utilization of water resources. In recent decades, water and sanitation coverage has increased, especially in rural areas. Increasing water demand in various sectors has led to increasing tension, with each trying to satisfy ever-increasing demand for water. Application of integrated water resources management has helped create an enabling environment for a flourishing and productive economy driven by the service sector. To retain its competitive edge, it remains essential for Tunisia to continue implementing policies geared towards sustainable socio-economic development by reconciling user needs with the social and environmental value of water.

References

Besbes, M., Hamdane, A., Chahed, J. and Hamza, M. 2008. *Tunisia Case Study Report* (in French), executive summary. (Draft.)

King, L., Nasr, Z , Almohamad, H. and Maag, C. C. 2007. Le Climat. *Stratégie nationale d'adaptation de l'agriculture tunisienne et des écosystèmes aux changements climatiques*, Ch. 7.2. Eschborn, Germany/Tunis, GTZ/MARH.

Ministry of Agriculture and Water Resources (MARH)/GTZ. 2006. *Elaboration d'une étude nationale d'adaptation de l'agriculture tunisienne et des écosystèmes aux changements climatiques*. Tunis/Eschborn, Germany, MARH (Direction Générale des Etudes et du Développement Agricole)/GTZ.

WHO/UNICEF. 2008. Latest JMP Country Files. Joint Monitoring Programme for Water Supply and Sanitation. http://documents.wssinfo.org/resources/documents.html (Accessed December 2008.)

Zambia: the Zambezi and Congo river basins

Zambia is facing difficult challenges such as persistent poverty and increasing climatic variability. Although it has sufficient land and water resources, its success in addressing its problems depends largely on how it implements its plans and strategies for water resources.

Setting the scene

Zambia is a landlocked country in southern Africa surrounded by Angola, Botswana, the Democratic Republic of the Congo, Malawi, Mozambique, Namibia, the United Republic of Tanzania and Zimbabwe (Map 1.5). The country lies mainly in the Zambezi River basin, and partially in the Congo River basin in the north. Zambia has a population of 11.7 million (2006) and a surface area of 752,614 km^2. It sits on the high plateau of Central Africa at an average altitude of 1,200 metres, and enjoys a mild, subtropical climate. Annual average rainfall ranges from 600 mm in the south to 1,500 mm in the north.[1]

Climate change and variability: increasing frequency of extreme events

A 2007 survey concluded that in the previous nine years, local communities had been exposed to extreme climatic variation that included droughts, floods, increased rain intensity, extreme heatwaves and a shorter rainy season. In fact, between 2000 and 2007 Zambia experienced unusually unstable weather, with a sequence of two flood years, two drought years and two years with normal rainfall. Figure 1.3 shows fluctuations in rainfall in Zambia between 1975 and 2006. Because of a lack of data, it is difficult to assess how such climate change will affect the country's water resources.

State of the resource: future competition among sectors

Zambia's surface water potential totals some 100 billion m^3, with the Zambezi River contributing over 60% of the runoff. Consequently, as a major stakeholder in the Zambezi River Authority, along with Zimbabwe, Zambia is helping establish the Zambezi Watercourses Commission. Groundwater is also a major resource, especially during the dry season. Although no accurate assessment is available, the average renewable groundwater potential is estimated to be 49.6 billion m^3.

By far the largest user of water is hydropower generation. Of about 38.5 billion m^3 of overall water withdrawal, 36.3 billion m^3 is used to generate electricity for internal use and export to neighbouring countries. Some 70% of the country's hydropower potential awaits development. There is as yet no real competition for water among the various sectors (Table 1.5). However, with irrigation expanding and awareness on environmental issues growing, water released from hydropower stations will need to be regulated so that the needs of agriculture and the environment are both served. The government recognizes the role of integrated

Figure 1.3 Annual rainfall variation, 1975 2006

[1] Except where otherwise noted, information in this case study is adapted from the draft *Zambia National Water Resources Report*, prepared in 2008 by Imasiku A. Nyambe and Miriam Feilberg.

water resources management (IWRM) in meeting the needs of all users, but successful application of the IWRM approach will require prioritizing investment and strengthening the capacity to manage national and transboundary water resources.

Around 40% of Zambia's population lives in urban settings. The capital, Lusaka, and the Copperbelt region in the north-west are the most densely populated areas. In 2005, 86% of people living in towns had access to safe water, compared with only 37% in rural areas. For the same year, just 13% of the rural population had access to improved sanitation, whereas there was 41% coverage in urban areas.

Map 1.5 Zambia

Zambia has good agricultural potential, with 56% of its surface arable. Only 14% of the arable land is farmed, and most cultivation is rain fed. Irrigated crops cover only about 1,000 km². The government established an Irrigation Development Fund in 2007 and is encouraging farming operations by making loans available at concessionary rates. However, agricultural development is hampered by insufficient financing, a lack of accurate data and capacity information on water resources, and inadequate market services and infrastructure.

Policy framework and decision-making: towards integrated and participative approaches

The Water Act of 1948, the foundation of Zambia's water legislation, deals with ownership, allocation and regulation of the nation's surface water resources without covering groundwater or the transboundary aspects of rivers such as the Zambezi which constitute international boundaries.

Table 1.5 Water use by sector, 2008

Sectoral use	Water consumption (billion m³)	Share in overall water consumption (%)
Agricultural	1.8	4.67
Industrial and municipal	0.4	1.03
Hydroelectric	36.3	94.30
Total	38.5	100.00

To address these shortcomings, reforms have been undertaken since the early 1990s, including the adoption of the National Water Policy in 1994. It recognized water as an economic good, highlighted the important role of the water sector in overall socio-economic development, promoted water resources development through an integrated management approach and defined institutional responsibilities of stakeholders in the sector so as to achieve effective management and coordination. The policy also provided for adequate, safe and cost-effective water supply and sanitation services while assuring environmental protection.

In carrying out its reforms in the water sector, the Government of Zambia started with the water supply and sanitation subsector, enacting the Water Supply and Sanitation Act in 1997 (Box 1.5). It later turned to the water resources management subsector with the Water Resources Action Programme in 2001. The programme developed a Water Resources Management Bill, a new Water Resources Institutional Framework, an improved Water Resources Management Information System and a draft action plan on addressing challenges related to water resources. Moreover, the Fifth National Development Plan (FNDP, 2006 2010) is specifically geared towards applying IWRM nationwide. To assist in carrying out the water-related programmes in the FNDP, in 2008 the government adopted an IWRM and water efficiency implementation plan, with crucial stakeholder participation (which also took place when the FNDP was being drawn up). These processes are intended to help Zambia plan and manage its water resources to further socio-economic development.

Box 1.5 Institutional arrangements for urban water supply and sanitation

The 1997 Water Supply and Sanitation Act obliges local authorities to provide water and sanitation services using various arrangements, such as partnerships with private firms for build-operate-transfer models as well as for concessions and management contracts. They may also create organizations known as Commercially Viable Water Supply and Sanitation Utilities, or CUs. All these institutional arrangements must undergo viability testing in order to be licensed by the regulator, the National Water Supply and Sanitation Council (NWASCO). CUs operate as commercial businesses within a framework regulated by NWASCO. They are expected to deliver efficiencies meeting private sector standards and to be self-financing, though the government may help modestly with initial working capital and infrastructure investment. CU managers are recruited under competitive private sector conditions.

The CUs have made significant progress even though government investment in water and sanitation infrastructure has been limited. Though many struggled to meet the wage bill when first established in 2000, some CUs averaged 102% recovery of operation and maintenance costs in 2007/2008. It is hoped that by 2010 more than half the CUs will reach a similar level of effectiveness. Although performance and quality of service had been on a downwards trend, today an upwards trend is evident in a number of service indicators.

Stakeholder participation was also secured through the formation of the Water Sector Advisory Group, which consists of four subsector advisory groups: (a) water supply and sanitation, (b) water resources management, (c) water resources infrastructure development, and (d) monitoring, evaluation and capacity building. The subsector groups provide for inclusion of stakeholders from outside the water sector, such as the Ministry of Finance and National Planning, which chairs the subgroup on monitoring, evaluation and capacity building. Inclusion of outside stakeholders in planning and decision-making is important for achieving an integrated approach to water management and for long term sustainability of decisions (see Chapter 15, Section 5 in the third edition of the *World Water Development Report*).

The main challenges

Combating poverty: Zambia is among the world's least developed countries, ranked by the United Nations Development Programme as 163rd out of 179 countries on the Human Development Index. Since 2005, under the Heavily Indebted Poor Country Initiative, Zambia has received debt relief equivalent to some US$6 billion. This has had a positive impact on the national budget and hence on poverty. Nevertheless, 63.8% of the population still lives on less than US$1 a day, and 46% of Zambians are undernourished. Conflicts in neighbouring countries have caused movement of refugees into Zambia, further aggravating the situation. Extreme poverty is especially significant in rural areas, where the majority of households depend on subsistence farming.

Meeting public health needs: Water-related diseases such as malaria and diarrhoea are major health problems in Zambia. The toll of malaria alone is nearly 4 million clinical cases and 50,000 deaths per year: it accounts for as much as 20% of maternal mortality and 23% of all deaths. Diarrhoea accounts for 6.9% of all illness reported (2003). Zambia has also been affected by HIV and AIDS, with about 9% of the population being HIV positive (2000). The 2008 Health Survey indicated that HIV and AIDS affected 14% of people aged 15 to 49 the country's prime workforce. Another issue is that increasing environmental degradation, affecting forests, wildlife and fish populations, especially hurts the livelihoods of the poor, who depend the most on these resources. Wealthier communities are less affected.

Addressing environmental concerns: Copper mining is an important source of income in Zambia, but it involves pumping water out of mines and into natural waterways, which degrades the environment and water quality. For example, Konkola Copper Mine discharges some 300,000 m^3 of water per day into the Kafue River, which supports most of the country's economic activities and over 40% of the population. The Copperbelt Environment Project has aimed at addressing environmental consequences of mining. Stronger regulation is needed for mines and other industries whose effluents affect the environment. Although there are some positive effects from mine discharges, such as making more water available in the Kafue River for downstream users, particularly in drought years, these have not received much attention. Furthermore, the effects of mine pumping on groundwater have not been studied in detail yet.

Deforestation in Zambia is advancing at a rate of 3,000 km^2 per year. It has resulted in localized flooding, increased erosion, reduction in surface and groundwater availability and loss of aquatic life. Accurate estimates are hampered by the lack of an updated forest resources inventory.

Decreasing surface and groundwater quality, due to an increasing nutrient load, industrial and agricultural pollutants and a falling groundwater table, is a growing problem in highly populated urban areas. Sanitation and solid waste management are also major concerns. Waste collection and management are inadequate, posing a serious threat to groundwater quality, particularly in periurban areas and informal settlements, where between 40% and 80% of the urban population resides.

Conclusions

Zambia is a country with enough water and land resources to facilitate development. However, inadequate data and capacity, in every dimension, seriously impair the government's ability to address many challenges, most notably poverty and hunger. Increasing the share of the population with access to safe water and improved sanitation, especially for people living in periurban and rural settings, would help curb the spread of preventable diseases that claim too many lives and reduce productivity. Application of IWRM, which is awaiting the necessary legal and institutional structure, will help combat poverty and malnutrition while assuring sustainable socio-economic development and preserving a healthy ecosystem.

References

Nyambe, I. A. and Feilberg, M. 2008. *Zambia National Water Resources Report*, executive summary. Lusaka. (Draft.)

2

Asia and the Pacific

This region supports some 60% of the world's population with only 36% of the world's water resources. Growing population, rapid urbanization and economic development put heavy pressure on freshwater resources and further accentuate the disparities in their natural distribution.

The case studies presented in this section include striking examples from six Asian countries and the Pacific subregion, including the poorest country (Bangladesh), the richest (Republic of Korea), the smallest (in the Pacific islands) and the largest (China). The differing challenges, and the degree to which the countries are equipped to cope with them, show great variation, largely due to the wide range of economic development. However, water-related disasters are a common threat affecting all the countries, and the need to develop strategies for adaptation to climate change is a shared concern.

With major transboundary rivers characterizing much of Asia, regional cooperation among riparian countries surfaces as an important issue, and benefit-sharing is a paramount concern – one that is also highlighted in the third edition of the World Water Development Report, which this volume accompanies.

Bangladesh: the confluence of the Ganges, Brahmaputra and Meghna rivers

Recurring water-related hazards, declining freshwater availability and poisoning from naturally occurring arsenic in groundwater have undermined the health and livelihoods of millions in this densely populated country. Climate change might further aggravate this situation. Efforts to institutionalize integrated water resources management will play a significant role in reducing the burden of persistent poverty, especially among rural populations.

Setting the scene

Bangladesh is situated in the deltaic plain formed by three large rivers the Ganges, the Brahmaputra and the Meghna. The combined total catchment of about 1.7 million km^2 extends over Bhutan, China, India and Nepal.[1] Only about 7% of this huge catchment lies in Bangladesh. With its 140 million inhabitants (2004) and a surface area of 147,570 km^2, Bangladesh is one of the most densely populated countries in the world. It is almost completely surrounded by India, except for the Bay of Bengal in the south and a short border with Myanmar in the south-east. The only significant highlands are in the north-east and south-east. Most of Bangladesh is low-lying and relatively flat. A network of about 230 rivers, of which 57 are transboundary, forms a web of interconnecting channels throughout the country.[2]

Bangladesh has a subtropical monsoon climate, characterized by wide seasonal variations in rainfall, moderately warm temperatures and high humidity, with a hot, humid summer from March to June; a cool, rainy monsoon season from July to October; and a cool, dry winter from November to February. The annual rainfall varies from 1,200 mm in the north-west to more than 4,000 mm in the north-east.

About 90% of the annual rainfall occurs during the monsoon season. From November to May there is almost no dependable rainfall. Drought is widespread during this dry period, and irrigation becomes necessary for any crop production. Tropical cyclones, storms and tsunami-like tidal bores are quite common from March to May and during the monsoon season.

Climate change and variability: continuing vulnerability

Data indicate that minimum temperatures in the monsoon season have generally increased by 0.05°C and maximum temperatures by 0.03°C. Tidal data covering 22 years show that the sea level is rising about 4 to 7 mm per year.

Detailed climate modelling has not been carried out in Bangladesh. However, scenarios by the Intergovernmental Panel on Climate Change have consistently simulated potential warming throughout the country in all seasons, a moderate increase in monsoon rainfall and a moderate decrease in dry season rainfall. Accordingly, projections for the Ganges-Meghna-Brahmaputra river basin predict a temperature increase of up to 2.6°C by 2050 and a rise in annual rainfall of up to 5.5% by 2020. Bangladesh has long been vulnerable to water-related hazards due to its high population density, location in a low-lying delta subject to heavy rainfall, and inflows of large volumes of surface water that are confined to a relatively short monsoon season. Any change in climatic conditions is likely to aggravate the situation.

State of the resource: wide seasonal variation in surface water availability

A network of rivers, channels and other water bodies covers 8.23% of the surface area of Bangladesh. Overall,

Map 2.1 Bangladesh

[1] A simplified map showing the full extent of the Ganges, Brahmaputra and Meghna river basins can be found in the CD accompanying this volume of case studies.

[2] Except where otherwise noted, information in this case study is adapted from the executive summary of *Bangladesh Case Study Report*, prepared in 2008 by the Institute of Water Modelling and DHI.

the annual freshwater potential of the country is estimated to be 1,200 billion m³, of which more than 90% is inflow from upstream countries (Aquastat, 1999). Bangladesh has a treaty with India on sharing the water resources of the Ganges River.

The quantity of surface water varies greatly by season. During the dry season, which lasts from November to May, there is a serious shortage of water and demand exceeds availability (Table 2.1). In particular, the south-west and north-west are prone to drought. During the monsoon season, however, surface water is available in excess of water demand. Unfortunately, due to the flat topography of Bangladesh, storing this excess has not been possible. Storage would require a regional plan and the construction of facilities in the upstream countries of India and Nepal.

Table 2.1 Seasonal fluctuation in surface water availability and overall demand

	Critical dry period *(February–April)*	**Wet season** *(June–October)*
Average water availability	60 billion m³	1,030 billion m³
Demand	90 billion m³	142 billion m³

Bangladesh has a predominantly agrarian economy. Agriculture generates about 21% of total GDP and provides employment for about 52% of the national workforce. It also claims the biggest share of the country's land resources (55.8% of the overall surface area), followed by forests (14.2%) and urban areas (5.9%). Irrigation is common but not fully developed. Out of some 85,000 km² of arable land, about 52% is irrigated (FAO, 2003). Due to the shortage of surface water during the dry season and absence of diversion structures, groundwater resources are heavily used. For example, about 70% of irrigation water is abstracted from aquifers (Figure 2.1). Groundwater also accounts for nearly 95% of the household water supply. This has led to declining water levels, especially in urban areas. In Dhaka, the capital, the water table has declined at an alarming rate of 2 to 3 meters per year over the last decade. There is also evidence of wells drying up in rural areas.

Despite its agrarian base, Bangladesh is experiencing rapid urbanization. In 2006, only about 25% of the population was urban, but the share is expected to reach 40% by 2025. On average, 85% of urban dwellers and 78% of rural inhabitants have access to safe water supply. Although sanitation programmes have been implemented since the 1970s, on average only 36% of the population has access to improved sanitation (WHO/UNICEF, 2008). In the slums of major cities like Dhaka and Chittagong, access to sanitary latrines is estimated to be as low as 14%. Significant investment in infrastructure is required to improve water supply and sanitation coverage nationwide, especially in expanding urban areas.

About 57% of the rural population and 51% of city dwellers are poor. Poverty alleviation is central to the country's development agenda. Assuring equity in access to water and sanitation services has become critical for addressing poverty issues effectively. Bangladesh has made important gains in the fight against poverty: the proportion of people living below the poverty line has dropped significantly since the 1990s. In general, the depth and severity of poverty have been reduced more successfully in rural areas than in urban ones, although the former still lag far behind the latter in terms of development.

The country's industrial capacity has been growing since the 1970s. Industry's contribution to national income has reached almost 22%. However, industrial growth, especially in textile production and leather processing, has had dramatic consequences for water resources. Many companies withdraw water on their own property and tend to consider it a free commodity, resulting in inefficient water use. Moreover, companies do not monitor or keep a record of the wastewater they generate. Therefore, data on the pollution load of various industries are not readily available.

The potential for hydropower generation or conservation of surface water is limited by Bangladesh's flat terrain and high population density. Kaptai Dam is the only major hydropower facility in the country, and hydropower represents a minimal share of energy production. The upstream parts of the major river basins, however, have potential for water conservation and hydroelectricity generation, especially during the monsoon season.

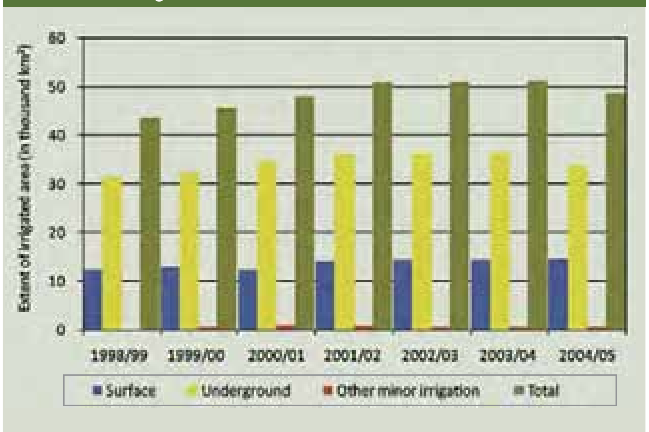
Thermal power stations and some industries use large quantities of water for cooling. When the water is released it is up to 10°C hotter, with adverse effects for both the environment and the operating efficiency of other power plants and industries downstream.

Policy framework and decision-making: action on reform is lagging

As many as 35 central government institutions, affiliated with 13 different ministries, have responsibilities and activities relevant to the water sector.

The National Water Policy (NWPo), published in 1999, aims for a holistic, multisector approach to water resources management and highlights the need to

Figure 2.1 Extent of irrigated surface area, by type of irrigation



Source Ministry of Agriculture, 2004

manage water as a commodity essential for human survival, socio-economic development and environmental preservation.

The NWPo identifies National Water Sector Apex Bodies (NWSABs), which include the National Water Resources Council (NWRC) and its Executive Committee (ECNWRC), the Water Resources Planning Organization (WARPO) and the Ministry of Water Resources (MoWR). The NWSABs are responsible for reforms in the water sector.

In this set-up, the NWRC is the highest national water management body. With 37 members and chaired by the Prime Minister, it is responsible for coordinating all water resources management activities in the country and formulating policy on various aspects of water resources management. The ECNWRC is essentially in charge of guiding national, regional and local water management institutions in formulating and implementing policies and plans for improved water management and investment. WARPO is the sole government institution for macro-level water resource planning and serves as the secretariat of the ECNWRC. The MoWR is the executive agency responsible to the government for all aspects of the water sector (ADB, 2004).

In 2001, the government introduced a National Water Management Plan, prepared by WARPO. The plan's aim is to implement NWPo directives and decentralize water sector management. It provides a framework within which line agencies and other organizations are expected to coordinate planning and implementation of their activities. It includes components for the short term (2000 2005), medium term (2006 2010) and long term (2011 2025). The original intention was to update it every five years, but the first update is pending.

A Water Act now being drafted will incorporate existing water laws related to ownership, development, appropriation, use, conservation and protection of water resources. It is also expected to establish a legal basis for ensuring that water rights are equitable, taking account of all uses and resolving inconsistencies and conflicts among various uses. The Act is expected to be finalized in 2009.

Integrated water resources management (IWRM) is a relatively new concept in Bangladesh. The institutional framework to deal with IWRM is not yet fully developed. Although Bangladesh has a capable private sector and a large network of non-government organizations dealing with water, it needs to create an enabling environment for IWRM. This will not be easy given the highly fragmented water sector and the differing views and priorities of the various agencies regarding the effective use of water resources. Nevertheless, the government is actively implementing a programme called Guidelines for Participatory Water Management.

Despite continuing reductions in funding from development partners, external agencies continue to play an important role in the water sector. A network of local consultative subgroups and other formal and informal mechanisms promotes consultation, coordination and, in some cases, active cooperation among these partners.

The main challenges

Disasters and hazards: Bangladesh is prone to water-related hazards such as floods, cyclones, storm surges, flash floods, droughts, riverbank erosion and rain-induced landslides. In addition, salinity intrusion and waterlogging affect nearly one-third of the country in the south-west. The country suffered approximately 170 disasters between 1870 and 1998. Every year some 20% to 25% of the territory is inundated during the monsoon season (WMO/GWP, 2008). The frequency of major floods (Table 2.2), covering up to 70% of the country, is growing. During the 2007 flood and cyclonic storm, the death toll exceeded 300, with 8 million people displaced and serious consequences for the national economy and people's livelihoods. From 1970 to 2008, 12 major cyclones killed more than 620,000 people and affected 45 million others (MoFDM, 2008).

Because of the almost flat terrain, flood prevention through flow regulation is not an option for Bangladesh. A flood forecasting and warning system established in the 1970s covers all flood-prone areas and provides real-time flood information, with early warning for lead times of 24 and 48 hours. The country's flood management strategies have continuously evolved over the last 50 years, so that now more emphasis is put on other non-structural means of mitigating floods, including controlling development in flood plains and wetlands through legislation and involving communities in flood management (WMO/GWP, 2008).

Bangladesh is also vulnerable to recurrent droughts, such as those that occurred in 1973, 1978, 1979, 1981, 1982, 1989, 1992, 1994 and 1995. The droughts of 1994 and 1995 in north-western Bangladesh led to a 3.5 million tonne shortfall in rice production.

There is potential for regulating river flow in upstream countries to reduce flooding, especially during the monsoon season, and to augment water availability in the

Table 2.2 Socio-economic damage caused by floods in Bangladesh, 1954 2007

Year	Impact
1954	Affected 54% of the country.
1974	Moderately severe, over 2,000 deaths, affected 58% of the country, followed by famine with over 30,000 deaths.
1984	Inundated 53,520 $km^{2,}$ did damage estimated at US$378 million.
1987	Inundated over 50,000 km^2, did damage estimated at US$1.0 billion, caused 2,055 deaths.
1988	Inundated 61% of the country, caused damage estimated at US$1.2 billion, affected more than 45 million people, caused 2,000 to 6,500 deaths.
1998	Inundated nearly 100,000 km^2, affected 30 million people, damaged 500,000 homes, caused 1,100 deaths and heavy infrastructure loss. Damage estimated at US$2.8 billion.
2004	Inundated 38% of the country, caused damage estimated at US$6.6 billion, led to 700 deaths, affected nearly 3.8 million people.
2007	Caused more than 300 deaths. Over 8 million displaced.

dry season, as well as to maintain river levels to facilitate inland waterway navigation and sustain ecosystems. A better regulated flow could also reduce salinity intrusion caused by the decline in freshwater availability in the dry season. This, however, would require strengthened regional cooperation, which has not yet been realized.

River bank erosion takes a terrible toll on people, property and infrastructure. Major rivers, including the Jamuna, Ganges and Padma, consume several thousand hectares of flood plain per year and carry huge sediment loads. As a result, riverbank erosion and siltation occur frequently. An estimated 100 km^2 of land per year has been lost to erosion over the past 20 years. The mostly rural victims of river erosion sometimes lose all their personal belongings and property. Bangladesh also loses several kilometres of roads, railways and flood embankments annually to shifting waterways.

Response efforts for water-related natural disasters still focus primarily on emergency relief rather than on seeking ways to reduce vulnerability to natural hazards. There is a need to strengthen the awareness that risk reduction and disaster prevention make better economic sense than responding to consequences through emergency relief.

Health and water-related issues: The unreliable availability and fluctuating quality of surface water resources prompted the authorities to start developing a groundwater supply system in the 1970s, installing wells in an effort to provide safe drinking water. Bangladesh now has some 9 million wells, of which about half are public wells installed by government agencies (Jones, 2000).

Wells made it possible for about 97% of the rural population to have access to bacteriologically safe water by 2000 and helped lower the infant mortality rate from 156 per thousand in 1990 to 69 per thousand in 2006 (UNICEF, 2008). Unfortunately, particularly in shallow aquifers, the groundwater often contains arsenic at levels that can cause poisoning (arsenicosis). Only about 74% of the rural population has access to arsenic-free water. The naturally occurring arsenic is a major concern for drinking water supply and for animal husbandry and irrigation. It is also a major development constraint in coastal aquifers. In 61 of the country's 64 districts, groundwater arsenic levels are above the permissible limit. It is estimated that between 25 million and 35 million people depend on wells that expose them to the risk of arsenicosis.

The main cause of death in Bangladesh, however, remains poverty-related infectious diseases, which are exacerbated by malnutrition. A marked gender differential in health persists. About 70% of mothers suffer from nutritional deficiency anaemia and over 90% of children have some degree of malnutrition.

Pollution and environmental degradation: Water bodies in Bangladesh receive a large amount of pollution in the form of municipal, industrial and agricultural waste, including pesticides and fertilizers. There is also pollution originating in the upstream parts of the major river basins.

The National Water Policy and National Water Management Plan stress the importance of preserving the natural environment as a condition for the socio-economic development of the country. Both state that care must be taken to conserve goods and services provided by ecosystems, including fisheries and wildlife biodiversity. Yet the country's rivers, flood plains, mangroves and natural lakes continue to deteriorate. The situation is mainly due to poor enforcement of regulations and lack of integration with development activities in other sectors.

The degradation of water resources has a particularly detrimental effect on poor communities that are highly dependent on ecosystems for their livelihoods. In part to address these challenges, the Ministry of Environment and Forest supported the Environment Conservation Act of 1995 and the Bangladesh Environmental Regulation of 1997. These form the basis of modern pollution control in Bangladesh. The revised industrial policy of 2005 also recognizes the need to control pollution as stipulated under the Environment Conservation Act. However, pollution control legislation has only gradually been implemented.

Environmental impact assessments (EIAs) have been carried out in Bangladesh since the late 1990s to minimize the adverse effects of development projects. However, a lack of resources and capacity often hampers the process: most EIA consultants are poorly trained, developers lack the resources to conduct EIAs appropriately and there is inadequate awareness at decision-making level of the benefits of conducting EIAs.

Conclusions

Although significant progress has been made, poverty continues to plague the people of Bangladesh, particularly in rural areas. They depend mainly on land for subsistence and are severely affected by seasonal variation in surface water availability, frequent floods, droughts and cyclones, which cause substantial socio-economic damage. The effects of potential climate change are likely to worsen the situation, especially for the rural poor and the disadvantaged, who already bear the brunt of the consequences. To prosper in the 21st century, Bangladesh needs to improve the way it manages its water resources internally while continuing to work towards better regional cooperation that can offer benefits for all basin countries. A combination of these factors will also play a pivotal role in key economic sectors and in breaking the vicious circle of poverty.

References

Aquastat. 1999. Review of water resources statistics by country. Rome, Food and Agriculture Organization. http://www.fao.org/nr/water/aquastat/water_res/index.stm (Accessed November 2008.)

Asian Development Bank (ADB). 2004. Bangladesh Country Paper. www.adb.org/Water/NWSAB/2004/Bangladesh_Country_Paper.pdf (Accessed 22 November 2008.)

Food and Agriculture Organization (FAO). 2003. *Selected Indicators of Food and Agriculture Development in Asia-Pacific Region 1992 2002*. FAO Regional Office for Asia and the Pacific, Bangkok. http://www.fao.org/DOCREP/004/AD452E/AD452E00.HTM (RAP Publication 2003/10. Accessed 22 November 2008.)

Institute of Water Modelling/DHI. Forthcoming. *Bangladesh Case Study Report*, executive summary.

Jones, E. M. 2000. *Arsenic 2000: An Overview of the Arsenic Issue in Bangladesh*. Dhaka, WaterAid Bangladesh, December 2000. (Draft Final Report.)

Ministry of Agriculture. 2004. http://www.moa.gov.bd/statistics/Table5.11_TAI.htm. Department of Agricultural Extension and Water Development Board. (Accessed November 2008.)

Ministry of Food and Disaster Management (MoFDM). 2008. http://www.mofdm.gov.bd/sidr%20damage.htm (Accessed November 2008.)

UNICEF. 2008. http://www.unicef.org/infobycountry/bangladesh_bangladesh_statistics.html (Accessed December 2008.)

WHO/UNICEF. 2008. www.wssinfo.org/en/36_san_leastDev.html. Joint Monitoring Programme for Water Supply and Sanitation. (Accessed December 2008.)

World Meteorological Organization/Global Water Partnership (WMO/GWP). 2008. http://www.apfm.info/pdf/case_studies/bangladesh.pdf. Associated Programme on Flood Management. (Accessed November 2008.)

China: the Yellow River basin

Prolonged drought, floods and severe pollution combined with high demand from booming agricultural, industrial and urban sectors are challenging China to take remedial measures and implement a more integrated approach to managing its water resources.

Setting the scene

The Yellow River is the second longest river in China after the Yangtze River, and the sixth longest in the world. Originating on the Qinhai-Tibetan plateau in western China, it runs for some 5,500 km across the vast North China Plain, traversing nine provinces before draining into the Bo Hai Sea (Map 2.2). Its catchment area of 795,000 km^2 is home to 110 million people (2000) or about 8.7% of China's population. (The figures increase to 189 million and 14.9% if the flood plain surrounding the lower reach is included.) In 2000, about 26.4% of the basin was urbanized. As the cradle of the northern Chinese civilizations and the centre of China's current political, economic and social development, the river is known as 'the mother river of China'.[1]

Climate change and variability: declining tendency in rainfall

The basin lies in two different climatic zones: arid and semi-arid continental monsoon in the north-west and semi-humid in the south-east. More than 60% of the annual precipitation falls between June and September, during the crop growing season. Average rainfall recorded during 1956 2000 was 454 mm over the entire basin, the lowest level being in the upper reach (372 mm) and the highest in the lower reach (671 mm). There is a declining tendency observed in rainfall over the entire basin (Figure 2.2). During the 1990s, because of prevailing drought conditions, average precipitation was about 7.5% below the long term average (Box 2.1).

According to various models of the effects of climate change on temperature and annual precipitation in the Yellow River basin, annual average temperature could rise by up to 3.90°C and precipitation by 8.67% by 2080 (Xu et al., n.d.). Significant warming could reduce the availability of the water resources (Zhang et al., 2008). Consequently, better water management and adaptation of technology to improve water use efficiency will need to be considered to avoid a critical water shortage in the basin in the coming century.

State of the resource: declining quality and quantity

Average total renewable water resources for 1956 2000 were estimated at 66.1 billion m^3, including 17.2 billion m^3 of groundwater. However, in 2000, the total available water supply was around 48.4 billion m^3.[2] Water demand in the basin sharply increased from 10 billion m^3 in 1949 to 37.5 billion m^3 in 2006. Groundwater has been extensively exploited in the basin since the introduction of the tube well in the late 1950s. In 2000, groundwater abstraction reached 10.7 billion m^3 and there were some 380,000 tube wells in the basin. Consequently,

Map 2.2 The Yellow River basin

1 Except where otherwise noted, information in this case study is adapted from the draft *Yellow River Basin Case Study Report*, prepared in 2008 by the Yellow River Conservancy Commission, Ministry of Water Resources.

2 About 3 billion m^3 of this comes from groundwater resources outside the basin's topographic boundaries.

Box 2.1 The drought decade

In 1987 the State Council of China established a Yellow River Water Allocation Scheme, to better balance available supply and actual demand by setting a cap on abstraction at 37 billion m^3 per year for average runoff of 58 billion m^3.

During the 1990s, however, drought prevailed throughout the North China Plain, including the Yellow River basin. Two main tributaries, the Wei He and Fen He, were reduced to a bare trickle. Runoff dropped by 24% compared to the long term annual average. Furthermore, flow in the lower part of the river dropped to 14% of its long term average. From 1995 to 1998, for some 120 days each year, there was no flow at all in the lowest 700 km of the river. This had serious repercussions, such as extreme water shortages in downstream provinces, the inability to flush sediment out to sea, and impaired sustainability in the delta ecosystem and coastal fisheries.

Since 1999 the scheme has managed to nominally end absolute flow cutoff, though the flow levels are sometimes so low as to be largely symbolic.

Managing water scarcity is now the number one priority in the Yellow River basin. Given the growing imbalance between supply and demand, it is difficult to meet any new water demand from one sector without lowering supply to the others. It is clear that hard choices will have to be made to address these diverging needs. Since agriculture is by far the largest consumer of water, one unavoidable conclusion is that water supply to agriculture must be reduced and new ways found to make agricultural water use more efficient.

overexploitation of groundwater resources has been a serious concern, particularly in the large and mid-size cities along the Yellow River. Springs in Jinan, once known as 'the city of springs', dried up in the late 1990s. Overall, groundwater levels have dropped significantly in 65 locations due to extensive withdrawals.

The biggest direct impact of a booming economy coupled with rapid industrialization and population growth was on water quality. For example, the amount of untreated industrial sewage being dumped into the Yellow River has doubled since the 1980s to 4.2 billion m^3 per year. The river receives over 300 pollutants, and only about 60% of its course is now fit for drinking water supply. The reduction in quality has caused environmental problems and contributed to the reduction in quantity. Under the Water Pollution Protection Law, a legislative framework for better protection of water resources is being prepared. Necessary regulations and effluent standards have also been formulated. In parallel, the Water Resources Protection Law on the Yellow River Basin is being modified.

As a result of intensive water development between 1951 and 1987, many structures were built in the basin for flood control, hydropower and irrigation. In 2000, there were over 10,000 reservoirs in operation, with total storage capacity of 62 billion m^3; 23 involve large dams. Hydropower production in the basin amounts to 40 TWh per year.

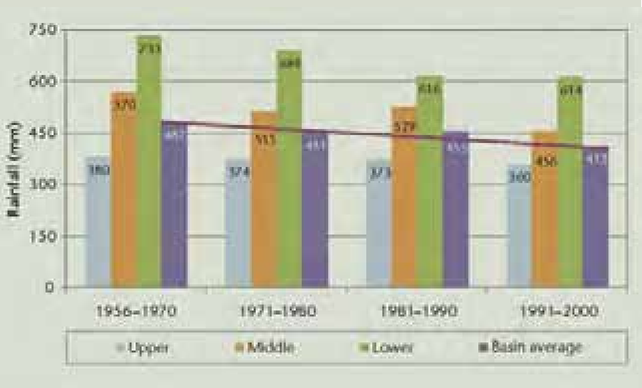
The expansion of irrigation in the basin has been rapid. The irrigated area rose from 8,000 km^2 in 1950 to 75,000 km^2 in 2000. Demand for irrigation water grew steadily, reaching 38.1 billion m^3 in 2000 (Li, 2005; YRCC, 2007). Although the trend stabilized in the early 1980s and agricultural water use has decreased since 2000 in accordance with the Yellow River Water Allocation Scheme, agriculture still accounts for 84% of total water consumption, followed by industry with 9% and households with 5%. The remaining 2% goes for environmental use (2006). When consumption exceeds water availability in the basin, the deficit is met by using groundwater resources outside the basin, as well as recycling.

Policy framework and decision-making

On a national scale, increasing water consumption due to the booming economy has led to water shortages. Consequently, the central government has increased its investment in the water sector and enacted legislation to alleviate water scarcity and assure continued economic growth. Many laws were passed in the 1990s, such as the Water Law, the Soil and Water Conservation Law, the Flood Control Law, the Environmental Protection Law, the Fishery Law, the Forestry Law and the Mineral Resources Law. Some related administrative rules and regulations for water management were also promulgated. In 2002, a new Water Law, emphasizing integrated water resources management, was passed. It has paved the way for a transition from engineering-dominated and demand-based development to a resource-oriented strategy that focuses on water availability.

At basin level, the Yellow River Conservancy Commission (YRCC), established in 1946, manages the water resources of the basin on behalf of the Ministry of Water Resources and the State Council. The YRCC prepares and implements the basin water development plan, decides the allocation of water resources at provincial level and is in charge of constructing and maintaining structures (except large dams) for water resource development and flood prevention.

Figure 2.2 Rainfall in various reaches of Yellow River basin, 1956 2000



Source YRCC, 2002

The water allocation is based on the integrated scheme approved by the State Council in 1987 (see Box 2.1). The provinces in the middle reach of the basin are allocated 22% of the available flow. The remainder is split equally between the provinces of the upper and lower reaches. The allocation is revised annually to reflect seasonal variations in availability.

Since 2000, in line with the most recent approach adopted by the Ministry of Water Resources, water management and related development activities in the Yellow River basin have aimed to integrate the interests of all regions and sectors. Consequently, to balance available water supply and the demand of various sectors, the YRCC developed a water use plan based on medium to long term supply and demand patterns. Annual water use plans are issued to users to assure adequate supply for priority areas, especially in the case of drought. Furthermore, the YRCC established regulations encouraging household users to install water-saving devices, farmers to adopt water-efficient practices and industry to promote techniques minimizing water use and waste discharge. It also established a market pricing system.

The main challenges

Managing sedimentation: The Yellow River gets its name from the colour of the heavy sediment concentration that it transports while flowing through an extensive loess plateau covering 640,000 km^2. The loose soil of the plateau is easily eroded, and it is carried into the Yellow River and its tributaries in massive quantities, particularly during the intense summer rainstorms. The average sediment load that the river carries is 1.6 billion tonnes per year. Of this, only about 25% is carried to the sea, while the rest is deposited on the riverbed. Due to this sedimentation, the riverbed has risen at an average rate of 5 to 10 cm per year and the dikes have been periodically raised in response. The impact of sedimentation on channel dynamics has made management of the river difficult, especially in its lower reaches.

Meeting environmental water requirements: Due to problems associated with the heavy sediment load of the river, the YRCC has made flushing out sediment its most critical environmental priority. Protecting biodiversity and sustaining the wetlands and fisheries at the mouth of the river are also important environmental concerns. The minimum flow required to flush out sediment is calculated as 14 billion m^3, and an additional 5 billion m^3 is necessary for other environmental requirements. With the surface water capacity almost fully used already, and with industrial, urban and agricultural demand growing as well as climatic variation putting further stress on the resource, assuring the required minimum environmental flow, which roughly equals one-third of total average annual flow, is a very difficult challenge to address.

Coping with floods and droughts: Millions of lives have been lost to floods and droughts during the long history of the Yellow River basin. From 206 BC to AD 1949, 1,092 major floods were recorded, along with 1,500 dike failures, 26 river rechannellings and 1,056 droughts. The flat North China Plain, which was formed by alluvial deposits from the Yellow River, was always prone to floods. However, following the establishment of the People's Republic of China in 1949, master planning for flood control and construction of numerous hydraulic structures significantly reduced the vulnerability and losses due to floods.

Embankments, reservoirs and flood retention areas have been established to increase flood control and enable drought management (see Box 2.1). The structural flood control system in China is designed basically for the discharge capacity of the maximum flood recorded since the 1950s for large rivers, and for five- to ten-year flood frequency for smaller rivers.

Non-structural flood control measures have been improved, mainly by developing and applying flood forecasting and warning systems, and by implementing laws, regulations, policies and economic approaches. These include managing river channels and controlling settlement in flood-prone areas. Potential flood risks are being reduced to a level which the society and economy can address, and flood management schemes have been established for extremely large floods.

The YRCC and the provinces of Shanxi, Shaanxi, Henan and Shandong have jointly set up a Yellow River flood control and drought relief headquarters, which provides crucial input to planning for such disasters and mitigating their impact.

Conclusions

Throughout history, the Yellow River basin has been associated with floods, droughts and a rising river bed. With large population increases, combined with rapid growth in all sectors, declining water quality and quantity have had a direct impact on the sustainable socio-economic development of the basin and the health of ecosystems. The water allocation scheme introduced in 1987 and various laws and regulations enacted in the 1990s aim to address these problems while taking a holistic approach that addresses the requirements of all stakeholders. However, the need to strike a balance between water demand for various sectors, sediment management and some serious pollution issues remains the major challenge facing the Yellow River Conservancy Commission and the ministries concerned.

References

Li, G.Y. 2005. Maintaining the Healthy Life of the Yellow River. Zhengzhou, China, Yellow River Conservancy Press.

Xu, Z. X., Zhao, F. F. and Li, J. Y. No date. Impact of climate change on streamflow in the Yellow River Basin. http://www.ifwf2.org/addons/download_presentation.php?fid=1077 (Accessed January 2008.)

Yellow River Conservancy Commission (YRCC). 2009. *Yellow River Basin Case Study Report*.

Yellow River Conservancy Commission (YRCC). 2002. Information made available during meetings between the YRCC and the International Water Management Institute, Zhengzhou, China, September–October 2002.

Yellow River Conservancy Commission (YRCC). 2007. *Yellow River Water Resources Bulletin*, March 2002. www.yrcc.gov.cn. (In Chinese; accessed December 2008.)

Zhang, Q., Xu, C.-Y., Zhang, Z., Ren, G. and Chen, Y. D. 2008. Climate change or variability? The case of Yellow river as indicated by extreme maximum and minimum air temperature during 1960–2004. *Theoretical and Applied Climatology*, Vol. 93, Nos 1–2.

Pacific islands

The unique geography of the many small islands dotting the Pacific Ocean exposes them to water-related natural hazards compounded by the effects of climate change and variability, including sea level rise. Pacific island countries are struggling to build the capacity to address many challenges, such as developing coherent policy frameworks and integrated approaches to managing scarce freshwater resources.

Setting the scene

There are about 30,000 islands in the Pacific Ocean, only 2,000 of which are inhabited. Many of the populated islands are less than 10 km², while some, especially atolls, are less than 1 km². The 18 Pacific Island countries and territories considered in this study account for 550,000 km² of land and some 7 million inhabitants spread across 180 million km² of ocean about 36% of the earth's surface. If Papua New Guinea, a large island country, is excluded, the land mass drops to 88,000 km², occupied by 2.6 million people. Of this population, 1.6 million live in Melanesia, 600,000 in Polynesia and 450,000 in Micronesia.[1]

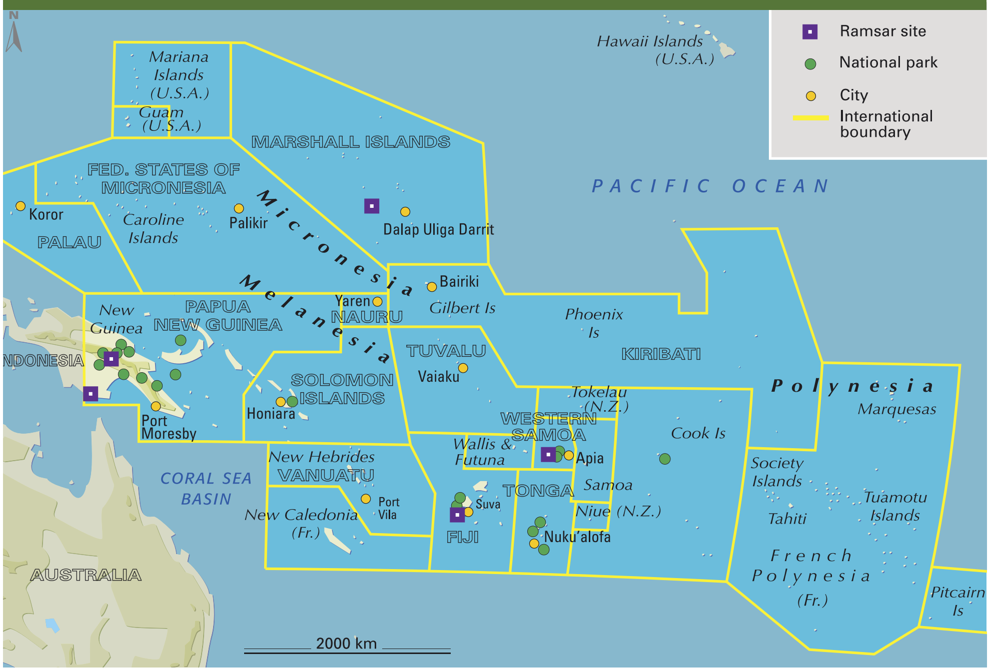
The climate of the small tropical Pacific islands depends on location and season, but is usually hot and humid, except in the cool highlands of some Melanesian islands. The year in many areas is equally divided between the dry and wet seasons. South of the equator in Melanesia and Polynesia, the dry season is from May to October. The wet season, which lasts the other six months, can include a period of cyclones in some locations. North of the equator in Micronesia, these seasons are reversed. Average annual rainfall varies considerably in the tropical Pacific, from over 4,000 mm to less than 500 mm. The higher altitudes of volcanic islands receive more rain, with about a 10% increase per 100 metre rise in elevation.

Climate change and variability: air-sea interactions and frequent storms

Two of the most important climatic influences on small Pacific islands are tropical storms and the El Niño and La Niña phenomena. The natural pattern of El Niño and La Niña episodes has a significant impact on many small islands, producing extensive wet and dry cycles. For example, an El Niño event combined with other climatic and oceanographic conditions brings abundant rainfall in the central Pacific but can cause catastrophic drought in Indonesia, Papua New Guinea and the other Melanesian islands. The reverse condition, known as La Niña, causes serious drought in the low equatorial islands of western Kiribati.

In addition to problems stemming from existing climatic variability, climate change and sea level rise could significantly exacerbate the situation. Climate change scenarios for the Pacific islands vary widely, depending on location and the model used. Most models predict an increase in frequency of El Niño episodes and intensity of cyclones (World Bank, 2000). There is less certainty about changes to rainfall, which could affect the availability of freshwater resources, although a general increase in sea temperature might favour an increase in rainfall for very small islands. Current scenarios indicate a rise in sea level of about 0.2 to 0.4 metres over the next few decades. Even the slightest rise is of great concern for small, low-lying island countries whose maximum elevations are only a few meters above sea level. Tarawa atoll in Kiribati has been the focus of impact studies under various scenarios for sea level rise and climate change. Results of groundwater modelling studies to assess the combined effect of pumping, climate change

Map 2.3 Pacific islands



[1] Except where otherwise noted, information in this case study is adapted from *Pacific Dialogue on Water and Climate: Synthesis Report*, (SOPAC, 2002), prepared by Tony Falkland, Marc Overmars and David Scott.

Box 2.2 Rainwater collection

On small islands with high rainfall (e.g. in Tuvalu), rainwater catchments, using the roofs of houses and some community buildings, are the primary source of freshwater (Taulima, 2002).

On other small islands, rainwater helps meet essential water needs (e.g. for drinking and cooking). During periods when rainfall is scarce or non-existent for months, household rainwater storage may be depleted unless very strict rationing is imposed. On Funafuti, the main island of Tuvalu, rainwater is collected in household and communal tanks. When households experience shortages during extended dry periods, small tankers deliver water from the communal tanks as a public service, for a fee. The Tuvalu Government recently resolved to combat drought by maximizing storage and spending disaster preparedness funds to buy rainwater harvesting tanks for households.

In addition to using roof catchments, islanders sometimes collect rain from specially prepared surfaces such as paved runways (e.g. in Majuro), which may be near storage tanks, and in artificially lined reservoirs (e.g. on some islands in the Torres Strait, between Australia and Papua New Guinea). Simple rainwater collection systems consisting of containers such as plastic barrels placed under the crown of a coconut palm, where rainfall is concentrated, are still used in some places (e.g. outer islands of Papua New Guinea).

and sea level rise indicate that the impact of initial sea level rise on aquifers is not detrimental (World Bank, 2000). This is particularly so when they are compared with the impact of current climate variability, pollution of groundwater from human settlements and overpumping (White et al., 2007).

Preliminary assessment of vulnerability and adaptation in some Pacific island countries in relation to climate change identified improved management and maintenance of existing water supply systems as a high priority, given the relatively low costs associated with reducing system losses and improving water quality.

State of the resource and water use

The limited freshwater supply in small Pacific islands is used for various purposes, including for towns, industrial activities, agriculture and forestry, tourism, environmental needs and mining. Non-consumptive uses include hydropower generation (e.g. in Fiji, Samoa and Vanuatu), navigation and recreation.

To meet growing demand, naturally occurring water resources are supplemented with non-conventional ones. The former are surface water, groundwater and rainwater collection (Box 2.2); the latter include desalination, imports, wastewater recycling and use of seawater or brackish water for selected purposes where potable water is not needed.

Some islands, including in Fiji and Tonga, have imported water as an emergency measure during severe drought. In some instances, people move from water-scarce islands to others nearby with more water. On many small islands, local or imported bottled water is an alternative for drinking water, although it costs more than water supplied by local water authorities.

The use of seawater and brackish waters can conserve valuable freshwater resources. For example, in densely populated parts of Tarawa and Majuro (Marshall Islands), dual pipe systems distribute freshwater and seawater. Seawater or brackish well water is used for baths, power plant cooling and firefighting, as well as in swimming pools.

Recycled wastewater is not a common source in small island countries but is sometimes used to irrigate gardens and recreational areas at tourist resorts and hotels, notably in Fiji and Maldives.

During severe droughts or after natural disasters, coconut water can substitute for fresh drinking water. People on some of the smaller outer islands of Fiji, Kiribati, the Marshall Islands and Papua New Guinea, for example, have survived on coconuts during extremely dry periods. The coconut palm is very salt-tolerant and can continue to produce fruit even when groundwater turns brackish.

Per capita freshwater use varies considerably between and within island states. It depends on availability, quality, type and age of water distribution system, cultural and socio-economic factors and administrative procedures. Although typical water use is of the order of 50 to 150 litres per person per day, leakage in poorly maintained systems can lead to unnecessarily high consumption. Water supply to resorts can also account for a high proportion of total water use on some small islands or parts thereof. Daily personal consumption in such resorts can be as high as 500 litres (UNESCO, 1991).

Many small islands, particularly coral atolls and small limestone islands, generally do not have sufficient water resources for irrigated agriculture, or suitable soil conditions. Irrigation on small islands thus tends to occur on a relatively minor scale except in cases like that of Fiji, where agriculture primarily water-intensive cultivation of sugar cane as a cash crop is the largest water user.

Policy framework and decision-making: highly complex and rooted in tradition

Water governance in small islands is highly complex because of socio-political and cultural structures related to tradition. Many inherited practices, rights and interests concerning the extended family, community, or tribal and inter-island relations (Box 2.3) may conflict with the demands of urbanized societies. Addressing related difficulties requires political will and institutional reform at all levels to create a framework for integrated water resources management (IWRM), as well as behavioural change through long term awareness

Box 2.3 Important considerations of culture and tradition in IWRM

Understanding the subtle fabric of a community's culture improves prospects for projects' sustainability and increases the ability to assure equity in participation. For example, in the traditional Fijian concept of the *vanua*, land, water, customs and human environments are not separate, but rather are indivisible. Water governance thus is not seen as separate from overall governance.

Similarly, projects relying on women's groups would need to be aware that in some communities, women who have married into a village are not seen as belonging to their husbands' village and so are not given the right to participate in decision-making at any level.

Examples from Papua New Guinea also reveal difficulties of working amid various ethnic communities. Social friction between families and villages, for instance, can hinder efforts at cooperation, especially when members of ethnic groups want to work only with their own leaders. In other cases, non-landowners may be indifferent to the sensitivities of landowners (SOPAC, 2007).

and advocacy campaigns, education, training and the like.

IWRM is a relatively new concept for Pacific island countries, and the formal development of this holistic approach within national governance structures is not widespread. Only a few countries have started drafting national IWRM plans. Yet the underlying approach, which involves taking socio-cultural, technical, economic and environmental factors into account in the development and management of water resources, has existed in traditional practices for centuries in Pacific island countries. In addition, since the 1990s it has been increasingly recognized that IWRM is necessary to adequately address competing water demands sustainably.

The major governance-related difficulties facing Pacific island countries are fragmented management structure, with multiple agencies dealing with water resources; lack of an overarching policy; outdated laws; poor administration capacity for integration, stemming from insufficient interministerial cooperation; and inadequate budgetary resources allocated to the water sector (PIFS/SOPAC, 2005). These combine to hamper progress towards preparation of water use efficiency plans and application of IWRM.

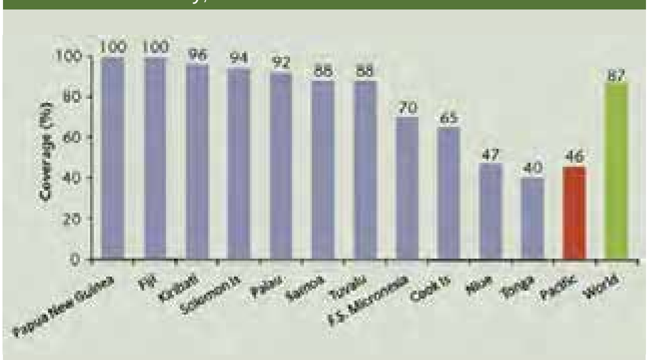
Some major challenges

Meeting the Millennium Development Goals: Pacific island countries have progressed at varying rates on the water and sanitation related Millennium Development Goals (MDG). For example, in 2006 only 46% of the population in the Pacific islands had access to improved drinking water. This corresponds to about half the 2006 global coverage rate. Although less populated countries such as the Cook Islands, the Federal States of Micronesia, Niue, Tonga and Tuvalu have high coverage, the low coverage of Papua New Guinea, which alone represents three-quarters of the region's population, pushes the regional average to levels comparable with those of the least developed regions (Figure 2.3). To make matters worse, rapid population growth, increasing urbanization, damage to water catchments resulting from deforestation, poor waste management practices leading to water pollution, and climate change are expected to exacerbate the challenge of providing access to safe water.

The proportion of households with access to improved sanitation varies greatly among the small Pacific island countries (Figure 2.4). Coverage is below 50% in nearly 40% of the islands. Sanitation systems in the Pacific islands rely principally on pit toilets and septic tanks.

Contamination of water supplies caused by inadequate sanitation, along with other sources of pollution, low water availability and the use of poor quality groundwater as drinking water, leads to outbreaks of diarrhoea, cholera and other infectious diseases, such as hepatitis and typhoid. Installation of affordable sanitation systems and the introduction of social programmes focused on behavioural change are needed in small island communities to improve water quality and human health.

Figure 2.3 Access to improved drinking water supply, by country, 2006



Source WHO/SOPAC, 2008

Figure 2.4 Access to improved sanitation, by country, 2006

Source WHO/SOPAC, 2008

The figures on water supply and sanitation clearly demonstrate the need for regional improvement to meet the MDGs. However, the lack of priority on water and sanitation issues in national development strategies, along with the inadequacy of budgetary resources allocated to the water sector, jeopardize the progress made by Pacific island countries as regards the MDGs. Forecasts indicate that in most parts of the Pacific region, problems resulting from increasing demand for water and increasing pollution of water may be much more significant than the expected effects of climate change (Hay, 2000).

The Mauritius Strategy for the Further Implementation of the Barbados Programme of Action (BPoA+10) has emphasized that water and sanitation should be given high priority on global and national agendas during the 'Water for Life' Decade, especially within small island developing states. The Mauritius Declaration of 2005 highlighted water management and water access issues in Pacific island countries.

Vulnerability to water natural hazards: Pacific island countries are susceptible to floods, droughts and cyclones. Droughts are particularly dangerous as they affect the most vulnerable communities, such as those occupying marginal environments (ESCAP, 2000). Among the most widely used coping strategies are measures taken by individual households to conserve freshwater supplies and seek substitutes. Ideally, water management plans should address the inevitability of climate variability so that droughts do not necessarily require emergency response (SOPAC, 1999). This necessitates adequate hydrological data for analysis and design, as well as financial resources. But there is a significant lack of national capability for conducting water resource assessments in the South Pacific countries, and capacity-building is needed.

Floods are also a significant hazard, especially in high Pacific island countries of volcanic origin. The hazard is greatest when the islands are within the zone affected by cyclones and associated extreme precipitation. Yet in many island countries, flood forecasting systems are either non-existent or not functioning due to poor maintenance.

Tropical cyclones are more frequent in the western and central Pacific than in the eastern Pacific. The very high wind speeds of cyclones are often accompanied by extremely intense rainfall and storm surges, which can destroy buildings and coral reefs, damage crop trees, cause coastal flooding and erosion, and pollute water supplies. It is considered likely that climate change will result in increased cyclone wind speeds and even more damaging storm surges. Several island countries have taken initiatives to develop disaster management plans, often in response to particular disasters. However, resource constraints and the lack of coordinated national response plans continue to reduce the effectiveness of countries' preparedness, for example in Papua New Guinea.

Conclusions

Small island developing states in the Pacific face many constraints, including their small size and remoteness, the limited availability of freshwater, increasing population and insufficient human and financial resources. These, coupled with vulnerability to climatic conditions, sea level rise and the degradation of water quality due to inadequate sanitation and waste disposal, present tough challenges for water resource management. Failure to give adequate attention to water and sanitation issues in national development strategies hampers the region's ability to meet the MDGs and deal with climate variability and change.

References

Hay, J.E. 2000. Climate change and small island states: A popular summary of science-based findings and perspectives, and their links with policy. Presented at 2nd Alliance of Small Island States (AOSIS) workshop on climate change negotiations, management and strategy, Apia, 26 July – 4 August.

Pacific Islands Forum Secretariat/South Pacific Applied Geoscience Commission (PIFS/SOPAC). 2005. *Pacific Cooperation Plan: Preliminary Sector Analysis for Water, Sanitation and Hygiene.* Suva, PIFS/SOPAC.

South Pacific Applied Geoscience Commission (SOPAC). 1999. *ENSO Impact on Water Resources in the Pacific Region: Workshop Report.* Nadi, Fiji, November 1999. (Miscellaneous Report 336.)

South Pacific Applied Geoscience Commission (SOPAC). 2002. *Pacific Dialogue on Water and Climate: Synthesis Report.* Prepared by Tony Falkland, Marc Overmars and David Scott. www.adb.org/water/Operations/Partnerships/Synthesis-Report-Pacific-Dialogue.pdf (Accessed November 2008.)

South Pacific Applied Geoscience Commission (SOPAC). 2007. *Mobilising People towards Integrated Water Resources Management: A Guide in Community Action, Live and Learn Environmental Education*. Suva, SOPAC. (Joint Contribution Report 191.)

Taulima, F. 2002. Water management in Tuvalu with special emphasis on rainwater harvesting: Case study presented as part of Theme 1, Water Resources Management. Pacific Regional Consultation Meeting on Water in Small Island Countries, Sigatoka, Fiji, 29 July – 3 August.

UNESCO. 1991. *Hydrology and Water Resources of Small islands, a Practical Guide.* Prepared by A. Falkland (ed.) and E. Custodio. Paris, UNESCO. (Studies and reports on hydrology No 49.)

United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). 2000. Pacific Islands Background Information, Ministerial Conference on Environment and Development in Asia and the Pacific, Kitakyushu, Japan, September. http://www.unescap.org/mced2000/pacific/background (Accessed November 2008.)

White, I. et al. 2007. Society-Water Cycle Interactions in the Central Pacific: Impediments to Meeting the UN Millennium Goals for Freshwater and Sanitation. *Proceedings of RIHN 1st International Symposium Water and Better Human Life in the Future*, Kyoto, Japan, 6–8 November.

World Bank. 2000. Cities, *Seas and Storms: Managing Change in Pacific Island Economies - Vol. IV: Adapting to Climate Change*. Washington, DC, World Bank, Papua New Guinea and Pacific Island Country Unit. http://siteresources.worldbank.org/INTPACIFICISLANDS/Resources/4-VolumeIV+Full.pdf

World Health Organization/South Pacific Applied Geoscience Commission (WHO/SOPAC). 2008. *Sanitation, hygiene and drinking-water in the Pacific island countries: Converting commitment into action.* Geneva/Suva, WHO/SOPAC.

Pakistan: the Cholistan desert

The presence of a semi-nomadic population and 2 million head of livestock in the middle of a fragile desert ecosystem is encouraging the government to explore new ways to improve livelihoods by increasing availability of water resources through capture, storage and treatment.

Setting the scene

Cholistan is the largest of four major deserts of Pakistan. It is bordered on the south by the Thar desert in Sindh province and on the east by the Rajasthan desert in India (Map 2.4). The Cholistan desert covers about 26,000 km^2, which corresponds to 26% of the 110,000 km^2 of the country's total desert area and 3% of its overall surface area. Typical Cholistan vegetation consists of species adapted to a limited water supply. They provide fodder for the inhabitants' livestock and protect the soil against wind erosion. Over the years, continued overgrazing and cutting of shrubs and trees for firewood and temporary shelters have reduced the vegetative cover, so that only about 20% of it remains.[1]

State of the resource and use: rainwater harvesting and migration

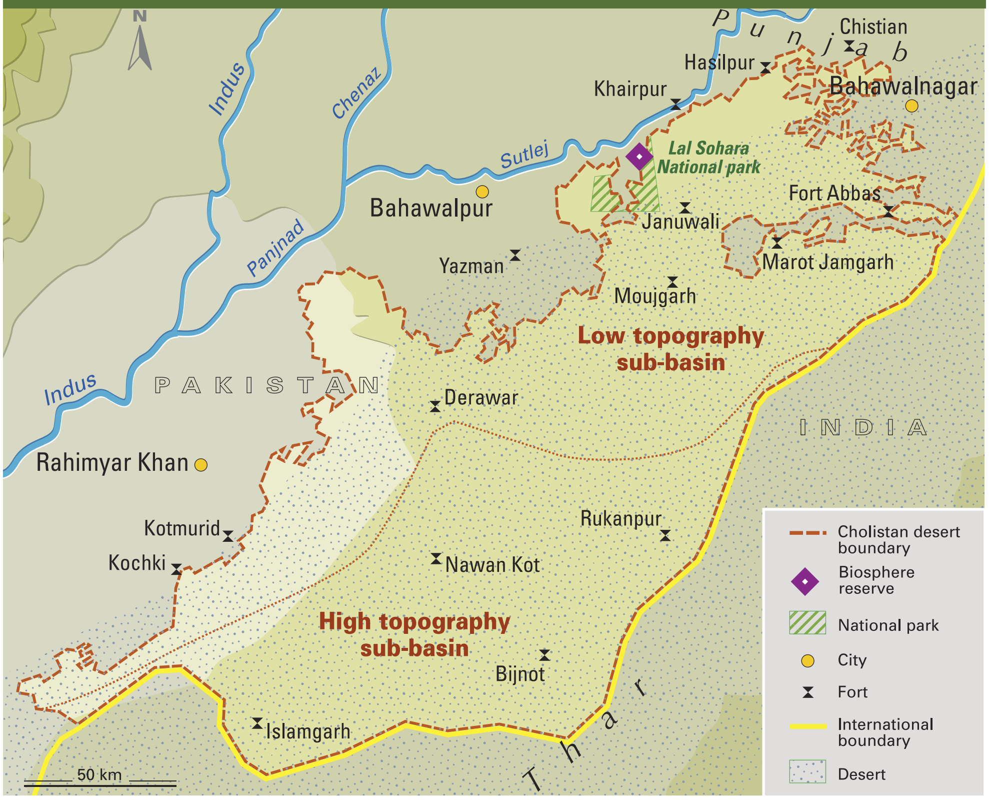
While most of the rainfall is received during the monsoon months of July through September, smaller quantities of rainfall sometimes occur in winter. The average annual rainfall in the desert ranges from 100 to 200 mm. Consequently, freshwater availability is very limited. There are no perennial or ephemeral streams, and most of the groundwater is saline with a medium to high range of dissolved solids that make it generally unfit for drinking (Akram and Chandio, 1998). High salt concentration also makes groundwater impossible to use even for saline agriculture without costly treatment. Because of the extreme aridity, the local people and their livestock are migratory (PCRWR, 2004). The only source of freshwater for about 110,000 inhabitants and their approximately 2 million head of subsistence livestock is the occasional rainfall. Fortunately, the average annual potential of 300 million m^3 for rainwater harvesting is more than sufficient to satisfy the combined water demand of the people and livestock (Table 2.3). To make the best use of this potential the herders have found ponds known locally as *tobas*. These store runoff water for use during the dry periods. Harvested rainwater is also stored for household use in large circular or rectangular tanks called *kunds*.

National legislation and responsibilities

In Pakistan, the provision of water for agriculture, industry and households has historically been the responsibility of provincial governments. However, provision of drinking water for the inhabitants of deserts and their livestock has not received much attention at this level. When runoff rainwater collected in *tobas* does not last through the dry season, the inhabitants migrate with their livestock to the edges of the desert, where perennial sources of water are available. These migrations impose severe physical hardships on families and create financial risks due to loss of livestock.

With Pakistan's population growing and the need to produce more food increasing, the national planning and development agencies are turning their attention to the vast expanses of the deserts. To provide more water

Map 2.4 The Cholistan desert



[1] Except where otherwise noted, information in this case study is adapted from the draft *Cholistan Desert (Pakistan) Case Study*, prepared in 2008 by the Pakistan Council of Research in Water Resources.

Box 2.3 Prospects for using renewable energy to desalinate water

Saline groundwater bearing dissolved minerals in amounts ranging from 400 to 20,000 parts per million is abundantly available at shallow depths throughout most of the Cholistan desert. Using reverse osmosis membrane technology, salt content can be lowered to levels that are acceptable for drinking and household use. The Pakistan Council of Research in Water Resources has built a desalination plant at the Dingarh Research Station that can treat up to 50 m^3 (50,000 litres) per day at a unit cost of about 1 Pakistani rupee (US$0.01). This is affordable for drinking water but quite high for livestock and other agricultural use. The long term increasing trend in the price of fossil fuel, combined with the availability of large amounts of solar energy and heat in the desert, argue strongly for research to find ways of using solar and thermal energy with reverse osmosis membranes to obtain drinkable water from saline groundwater in the desert.

and enhance water use efficiency, projects aimed at improving rainwater harvesting and reducing evaporation loss have been initiated. At the same time, to assure the economic development of the people living in the Cholistan desert, integrated approaches such as improved rainwater collection and rangeland management, as well as use of saline groundwater for fish production, are being studied and implemented to maximize benefits from water, land and livestock.

The main challenges

Health concerns: *Kunds* are concrete structures built to store rainwater for human consumption. There are about 200 *kunds* in the Cholistan desert. Generally, the stored water stays clean unless there are external contaminants. Analysis of water samples from several *kunds* showed that water was being polluted by human and livestock waste transported in runoff.

Drought and water availability: There is no reliable hydrometeorological data from which to draw conclusions about the frequency and duration of droughts. Estimates based on the recollections of longtime residents of the Cholistan desert indicate, however, that droughts are quite common and can last from a few months to a few years. Because of the limited availability of surface and groundwater resources, locals and government officials are working together to develop the potential of rainwater harvesting to meet current water needs and provide for future economic development. Various storage units, such as *tobas*, *kunds* and ponds, are in place. However, while *tobas* remain abundant, only 600 of the 1,600 existing ones are functional due to high sedimentation rates. *Kunds* are less susceptible to this kind of problem, but water quality issues limit their use. To increase storage capacity and reduce contamination, the government has built ponds equipped with slow sand filters, which have performed well. This has increased rainfall storage to 4 million m^3 per year. Given the 14 million m^3 in water supply capacity of wells, available water resources are sufficient to meet the annual water demand of inhabitants and their livestock. Nevertheless, the global scenario of climate change and climatic variation and their effect on water resource availability, coupled with the increasing price of fossil fuel (mainly used for pumping), has prompted the government to consider low cost solutions based on renewable energy sources (Box 2.3).

Conclusions

In an arid environment where there can be as few as three rains a year, freshwater resources become critical not only for socio-economic development but also simply for survival. While Pakistan's government has been making efforts to find good-quality groundwater and create rainwater storage units in parts of the Cholistan desert, water scarcity persists because of the size of the desert, the poor quality of the groundwater, high evaporation rates, contamination, the low storage efficiency of *tobas* and the reduction in their capacity due to siltation. Severe water scarcity forces the people of the Cholistan to migrate with their herds in pursuit of water and grazing land, which entails social and economic hardships. Although authorities have carried out projects intended to diversify the economy, animal husbandry remains the main source of livelihood. The

Table 2.3 Rainwater availability and estimated water demand in the Cholistan desert

	Population[1] (million)	Human water demand[2] (million m^3)	Livestock[3] (million)	Livestock water demand[4] (million m^3)	Available potential for water storage (million m^3)	Surplus water available for other uses[5] (million m^3)
1990	0.08	0.50	1.52	11	215	204
2000	0.10	0.670	2.04	15	273	258
2005	0.12	0.76	2.30	17	220	203
2006	0.12	0.78	2.36	17	369	352
2007	0.12	0.80	2.40	18	227	208

1 Population is based on actual figures
2 Human water demand is estimated at 18 litres per person per day
3 The number of livestock is estimated at 20 head per capita
4 Livestock water demand is estimated at 20 litres per animal per day, on average, for small and large ruminants; actual demand may be less than the calculated value
5 The number indicates remaining freshwater potential that can be tapped if the rainwater harvesting capacity is improved

success of integrated approaches designed to boost the inhabitants' health and the economic opportunities available to them, while also improving the quality and availability of water, will require determination and continuous support on the part of the government.

References

Akram, M. and Chandio, B. A. 1998. Conjunctive use of rainwater and saline groundwater for desertification control in Pakistan through agro-forestry and range management. *Journal of Arid Land Studies*, Vol. 7S, pp. 161–4.

Pakistan Council of Research in Water Resources (PCRWR). 2004. *Pre-project socio analysis of 25 selected settlements in Cholistan desert*. Islamabad, PCRWR. (Publication No. 130/2004.)

Pakistan Council of Research in Water Resources (PCRWR). 2009. *Cholistan Desert (Pakistan) Case Study*.

Republic of Korea: the Han River basin

Efforts to respond to new pressures and expectations stemming from the economic success of this developed country include water sector reforms, while measures to address shifts in demand and competition between upstream and downstream interests would benefit from the presence of a central coordinating mechanism.

Setting the scene

The Republic of Korea is located at the eastern tip of the Asian continent, where it is bounded on the north by the Democratic People's Republic of Korea. In the east it is characterized by high mountain ranges, whereas the west is composed of flat coastal plains. The annual average precipitation is about 1,200 mm, 70% of which falls during the flood season from June to September. The Han River basin, located in the centre of the Korean Peninsula (Map 2.5), accounts for 23% of the territory of the Republic of Korea and is the country's largest river basin, covering some 23,000 km². The Han River region is divided into the main Han River basin and the Imjin River basin; this case study focuses only on the Han River basin.[1]

The capital, Seoul, one of the world's largest cities, is located in the Han River basin. The population of the basin, now 41% of the national total, almost tripled between 1966 and 2005, from about 7 million to almost 20 million. Nevertheless, urban areas account for just 1% of the basin. Forests make up 78%, cultivated areas 16%, and grasslands and water bodies 5%. The Han River basin is considered the heart of South Korea.

Climate change and variability: fewer rainy days but heavier storms

Statistical analysis of rainfall data in the Han River basin reveals two noticeable changes since the early 1970s: a rapid increase in heavy storm frequency and an increase in storm intensity. The number of heavy storms associated with intense rainfall of 100 mm per day or above went from 222 in 1971 1980 to 325 in 1992 2001. In addition, the number of rainy days has decreased while precipitation has increased, which means greater likelihood of floods.

State of the resource

Annual renewable water resources in the Han River basin are estimated at 16 billion m³. As of 2003, 8.5 billion m³ of this amount was actually in use. Owing to the high rate of urbanization, the household sector   which accounts for 2.8 billion m³ (33% of overall consumption)   is the number one source of consumption, followed by agriculture (1.6 billion m³ or 19%) and industry (0.8 billion m³ or 9%). The remaining 3.3 billion m³ is allocated for environmental purposes. The quality of surface water varies by location, with downstream Seoul being the worst. However, implementation of the Environmental Water Management Master Plan should make a big difference throughout the basin: it aims to

Map 2.5 The Han River basin

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[1] Except where otherwise noted, information in this case study is adapted from the draft *Han River Basin Case Study Report*, prepared in 2008 by the Ministry of Land, Transport and Maritime Affairs (formerly Ministry of Construction and Transportation).

Box 2.4 Equity tools: water use charges and basin management funds

The quality and quantity of water resources, as well as land development decisions, have always been sources of contention between upstream and downstream users. What usually happens is that tighter restrictions are imposed on upstream users, who may suffer financial losses due to land regulation practices meant to preserve water quality for downstream uses. Meanwhile, downstream users usually have more flexibility in their use of water and land resources. This situation violates the principle of equity.

In the Republic of Korea, the 'polluter pays' principle is reinforced by the 'user pays' principle, which requires downstream residents to pay additional water use charges. Collected charges have been used to create basin management funds, beginning in the Han River basin in 1999, (Table 2.4), and in three other basins in 2002. The funds have been used since 2003 to actively support water quality improvement projects, community awareness programmes and the installation and operation of environmental facilities. By the end of 2004, some US$350 million (515.6 billion won)* had been spent on community support projects and US$545 million (804.6 billion won) on the installation, operation and maintenance of environmental facilities.

* US$1 equalled about 1,475 won as of December 2008

Table 2.4 Han River water use charges, 1999 2006, in million US$ (won)

1999	2000	2001	2002	2003	2004	2005	2006	Total
18.8	118.9	156.4	167.3	182.1	192.4	206.3	229.1	1,271.2
(27,675)	(175,358)	(230,688)	(246,741)	(268,644)	(283,732)	(304,326)	(337,908)	(1,875,072)

bring drinking water source quality to 'good' or 'better' (based on biochemical oxygen demand) by 2015 by increasing the number and capacity of wastewater treatment facilities. To promote more efficient use of water resources in the city of Seoul, wastewater recycling and rainwater collection are required by law.

Agricultural water use in the Han River basin accounts for about 10% of water use for agriculture in the Republic of Korea. Rice fields alone consume 70% of the total. As the Han River basin receives some 74% of its annual runoff in just four months, storing water is crucial for meeting year-round needs. Consequently, there are 724 reservoirs, primarily serving the agricultural water requirements in the basin. Of these, 127 meet the international standards for large dams. The increase in agricultural water withdrawal is expected to be stabilized or even reversed as a result of the long term master plan for water resources, which forecasts a reduction in cultivated area. In parallel, to minimize water loss in agriculture, a plan for irrigation channel improvement and agricultural water management automation is being implemented. As of 2003, almost 40% of the irrigation channels had been rehabilitated, and the share is expected to reach 55% by 2011.

The Republic of Korea has a much larger water footprint than figures suggest: statistics indicate it is the world's thirteenth largest importer of virtual water, and number five in terms of net imports of virtual water, taking both imports and exports into account (Hoekstra and Hung, 2002). Some 74% of its virtual water imports are in the form of grain.

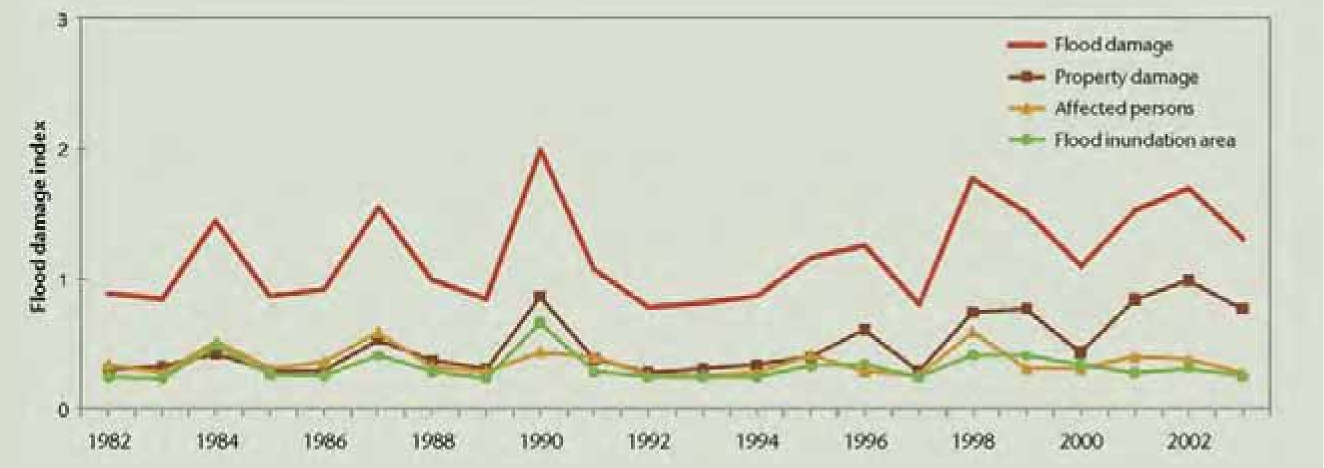
Access to water and sanitation facilities improved rapidly as what is now the Republic of Korea became industrialized. By the end of 2007, 92.1% of the population had access to safe drinking water, compared with 18% in 1945. Access to sanitation facilities increased from 6% in 1979 to 85.5% at the end of 2007. Subsidized water rates and extended grace periods before service cutoff, available to the poor and disadvantaged, help assure a minimum standard of living for everyone.

Three multipurpose dams and eight hydroelectric dams are located in the Han River basin. The Government of the Republic of Korea has identified energy efficiency as a key priority and has started promoting an increase in the share of renewable energy in overall energy production, setting a goal of 5% by 2011. Hydropower, one of the most conventional forms of renewable energy, is getting a boost through measures aiming to increase the capacity and performance of existing facilities. In 2006, the share of hydropower in overall energy production was 1.4%, down from 5.3% in 1980.

While the rapid increase in agricultural, industrial and municipal water consumption in the Han River basin has been slowing, the environmental value of water is getting more political attention and the share of water for environmental purposes is increasing. Since the beginning of the 2000s, this positive trend has been reflected in policies and in various large river environment restoration projects. Implementation of water use charges and creation of watershed management funds also helped increase water use efficiency, especially in industry, and protection of water resources was improved as well (Box 2.4).

Although the Han River basin is well endowed with water resources and no shortage is expected in the near future, the overall picture is different in the rest of the country. In the past, increased demand could be met by developing new water resources, but conditions no longer allow this. Although agricultural and industrial water use is expected to fall, there is no national or regional coordinating institution capable of redistributing and reassigning traditional water rights to different sectors. This lack seems to be a major obstacle to optimum use of the resources.

Figure 2.5 Variations in the flood damage index, 1982-2003



Note The flood damage index for a basin is calculated by taking into account the number of human casualties, property damage and the extent of inundated area The index has no unit and its value ranges from 0 to 3

Source Ministry of Land, Transport and Maritime Affairs

Policy framework and decision-making: Poor coordination

In the Republic of Korea, water management has not been adequately decentralized. Local authorities merely execute policies set by the central government. The lack of an integrated approach means each ministry works more or less in a vacuum, developing and executing work plans without much interaction. Local governments face complications in executing the national water management plan because functions and responsibilities are distributed among a number of agencies. The main problem lies in the absence of a body or a mechanism to coordinate the tasks of the organizations in charge of water resource management. To address these challenges, since 2000 the water management system has been undergoing restructuring towards a more holistic approach promoting involvement by local governments, public organizations, the private sector and other stakeholders, including local communities. Notable outcomes of this reform include formation of local and basin networks and increased voluntary river restoration efforts.

A recently proposed Water Management Act, taking the basin as the principal watershed management unit, would have provided for the preparation of a national integrated water resources management plan and established basin commissions and a national water management commission. However, the Act did not win approval in the National Assembly in 2008. A national commission such as that proposed in the Act could play an important role in bringing together the agencies responsible for water management, and thus serve as a platform for settling conflicts among different land and water users.

The main challenges

Sharing water resources: Two tributaries of the Han River the Imjin River and the northern part of the Bukhan River are shared between the Republic of Korea and the Democratic People's Republic of Korea. Although negotiations are ongoing, South and North Korea have not yet reached agreement on joint development of common water resources. Meanwhile, upstream water development efforts are having a negative effect on water availability in the south. The hydrological properties of certain parts of the basin have not been studied adequately, mainly because of the demilitarized zone between the countries. Although the potential for waterways exists in the Han River basin, none have been developed due to political and environmental problems.

Coping with water-related disasters: In the Republic of Korea, although the extent of floods has decreased thanks to continuous improvement in flood management, the economic damage has increased significantly (Figure 2.5). This is basically due to dense urbanization and encroaching development on the river's natural flood plains. Non-structural measures such as early warning systems have helped reduce the number of casualties, but the number of people vulnerable to floods is increasing, not only due to growth in the urban population but also because the society is aging, which means more individuals at greater risk from the impact of frequent flash floods.

Conclusions

The Han River basin is considered the heart of the highly developed Republic of Korea. Given the availability of sufficient water resources, the water demand from various sectors does not pose a critical problem in terms of quantity, at least for the time being. Rather, the outstanding issues are at the national level, where a national commission is needed to coordinate the agencies responsible for water resource management and the sharing of transboundary waters. Although current water sector reforms and a possible future Water Management Act will address the coordination challenge, dealing with transboundary issues will require more effort.

References

Hoekstra, A. Y. and Hung, P. Q. 2002. *Virtual Water Trade: A Quantification of Virtual Water Flows Between Nations in Relation to International* Crop Trade. Delft, Netherlands, UNESCO-IHE. (Value of Water Research Report Series No. 11.)

Ministry of Land, Transport and Maritime Affairs. Forthcoming. *Han River Basin Case Study Report*.

Sri Lanka: the Walawe River basin

In an area hard hit by the 2004 tsunami, integrated approaches and community management of resources are examples of the tools being applied to reduce poverty and environmental degradation.

Setting the scene

Sri Lanka is an island country in the Indian Ocean with a total land area of 65,600 km². About 78% of its 20 million inhabitants live in rural areas. The terrain is mostly coastal plains, with mountains rising in the south-central part. Rainfall varies greatly, from about 900 mm in parts of the dry zone to about 6,000 mm in the central hills. The dry zone, defined as the area that receives less than 2,000 mm of annual rainfall, covers 80% of the land.[1]

There are 103 distinct river basins. The Walawe River basin, located in the south-east, has an area of 2,500 km². Covering 4% of the total land mass of the country, it is one of Sri Lanka's biggest basins (Map 2.6).

Recent water resources development has linked some adjacent small river basins to the Walawe basin. Thus, the total area covered in this study is 3,300 km² and includes the Malala Oya, Kachchigal Oya and Karagan Oya.

The study area has a population of about 650,000. To address poverty, the Sri Lankan Government has begun paying more attention to industrial and commercial development of the region.

Climate change and variability: much less rainfall for agriculture

Nationwide, statistical analysis indicates that air temperature increased by 0.016°C per year between 1961 and 1990. A similar rise was observed in the Walawe basin, which lies in the dry zone. A decline in rainfall is mostly noticeable during the north-east monsoon and the second inter-monsoon period, which bring the bulk of the rainfall to the dry zone. Measurements covering the last 50 years show that rainfall has decreased by at least 18% at some stations and by as much as 42% at others. Nevertheless, there is still a debate revolving around climate change and other external factors affecting water availability. As about 45% of the employed population is in agriculture, the changes to rainfall and runoff patterns are having a pronounced impact not only on water availability but also on farm livelihoods. The impact is most pronounced on small-scale water diversions in the upper Walawe basin and on small tank cascade systems, which usually depend on rainwater for their supply and do not have much carryover storage.

[1] Except where otherwise noted, information in this case study is adapted from the draft *Walawe River basin (Sri Lanka)*, prepared in 2008 by the Ministry of Agriculture, Irrigation and Mahaweli Development.

Map 2.6 The Walawe River basin

State of the resource and water use

The annual flow of the Walawe River is 1.5 billion m³, or 3% of the country's total renewable water resources.

Agriculture is the biggest water user in Sri Lanka. In the Walawe basin, more than 95% of the total volume of water diverted is for irrigation. To address the high level of water consumption, programmes are being put in place to improve efficiency through better scheduling, participation of stakeholders in water management, augmentation of water supply to small reservoirs, improvement of groundwater recharge and rehabilitation, and modernization of irrigation systems. High yielding rice varieties with a shorter growth period have been developed locally to reduce water use. Although limited, some improvements in efficiency have been observed as a result of these efforts. In the mid-1980s attempts to introduce a fee for irrigation water ended in failure. As the issue is socially and politically sensitive, the government is not keen to repeat the experiment. But some farmer organizations collect fees from their members, which are used to improve irrigation systems.

Irrigation and other developments have brought environmental problems, such as contamination and unsustainable use of groundwater, loss of cropland within coastal wetlands due to salinity, and degradation of coastal ecosystems. Excessive drainage has prompted residents to open lagoons to the sea. The drainage and artificial sea

Box 2.5 Community participation in water project management

Because rural facilities tend to be relatively small and widely dispersed, it is difficult for centralized agencies to manage them. A more appropriate approach is to actively involve the beneficiary communities in the management of their own water resources. To this end, Sri Lanka recently established independent, voluntary community-based organizations (CBOs) to manage rural water projects serving a population of 6,000 or fewer. The CBOs are formed during the early planning stages, and capacity-building is carried out to enable them to take over responsibility for operations and maintenance once the system is operational. Among projects promoting community management of rural water supply in the Walawe basin are the Community Water Supply and Sanitation Project and the Third Water Supply and Sanitation Project. CBOs fund operations and maintenance of these projects through tariff structures specially formulated for each individual system. In rural and small-town piped water systems, the tariffs aim for full cost recovery, and in some cases may be higher than the national water tariff. Some CBOs have already managed to recover about 20% of the capital cost. The achievements thus far of CBOs are promising, and their contribution lessens the government burden in achieving the relevant MDG targets.

outlets have caused fluctuations in salinity. In addition, the drainage has resulted in siltation and decreased the lagoon area. Chemicals contained in agricultural runoff have also contributed to the deterioration of water quality. All these factors combine to adversely affect fish populations and thereby the livelihoods of those who depend on fisheries and tourism. These negative observations have been confirmed in several coastal wetlands, including Bundala National Park, the first Sri Lankan wetland listed as a protected area under the Ramsar Convention.

The recently concluded Uda Walawe Left Bank Development Project introduced innovative water management measures that should address some of these problems. The measures include night storage reservoirs to minimize drainage losses from the irrigation system. Other successful technological innovations in the Walawe basin that have the potential to be replicated elsewhere in the country include the Mau Ara and Weli Oya development projects, where the storage capacity of small village reservoirs was used in lieu of larger storage structures.

Hydropower generation was the main source of energy production in Sri Lanka until a few decades ago. However, frequent droughts since the late 1990s have made hydropower a less reliable source, and electricity generation has shifted towards petroleum-intensive operations. Nevertheless, proposals have been prepared to make maximum use of the hydropower potential of the water infrastructure. There are four hydroelectric power plants in the Walawe basin, with total installed capacity of about 130 MW, representing about 10% of the country's overall installed hydropower capacity. In 2006, 78% of the households in Sri Lanka had access to electricity.

District values indicate that access to safe drinking water in the Walawe basin ranges from 73% to 83%, which compares well with the national average of 85%. However, as piped water is not available around the clock in several locations and there are quality problems during dry periods, those percentages represent an optimistic upper limit. In 2006, about 92% of Sri Lanka's population had access to improved sanitation, and estimates for the study area ranged from 85% to 95%. Rural settlements have less drinking water and sanitation coverage than urban settlements, but community involvement programmes are being developed to improve the situation (Box 2.5). Overall the country is on track to achieve the Millennium Development Goal concerning access to safe drinking water and improved sanitation.

Current water consumption in industry is not significant in the Walawe and adjacent basins, though there are plans for major industrial development that could increase industrial water demand in the future.

Policy framework and decision-making

Policy-making in Sri Lanka's water sector has been only moderately successful. Studies in the early 1990s identified policy gaps and institutional problems in the sector, including much overlap among a multiplicity of institutions and laws. Since 1996 several attempts to prepare a national water resources policy have been made, but progress stalled around 2005 before a comprehensive policy was produced. Despite substantial policy development in such allied sectors as environment, agriculture, and the management of watersheds, rainwater and disasters, the policy gaps make it difficult to adequately address the important issues of deteriorating water quality, the need to regulate water extraction and the lack of full stakeholder participation in water resources management.

Consequently, Sri Lanka does not yet have a national plan formulated on the basis of integrated water resources management planning and development. The new Dam Safety and Water Resources Planning Project, launched in August 2008, is expected to address some of these concerns by formulating a master plan for national water use.

In the Sri Lankan agricultural sector, farmer participation in decision-making at project level has improved over the years, resulting in better accountability and greater transparency in use of funds. In the case of the Walawe basin, the Mahaweli Water Panel manages water resources to achieve optimum benefit from irrigation as well as from hydropower. It decides water allocation for irrigation from the reservoirs of hydropower facilities. Though farmers and households are not directly represented in real-time decision-making, their interests are usually covered by the service delivery agencies.

Coordination among stakeholders is critical in the Walawe basin because of the area's substantial contribution to agriculture, hydropower generation, water-related risk management and expected industrial development. Case studies from Sri Lanka in the first and second editions of the *World Water Development Report* also highlighted this issue (UN-WWAP, 2003; UNESCO-WWAP, 2006*a*, 2006*b*).

The main challenges

Healing the wounds: The worst disaster of recent times, the Asian tsunami of 2004, devastated the coastal regions of the Walawe basin. Prior to the tsunami, Hambantota district, which forms the downstream portion of the Walawe basin, accounted for 5.5% of the fishing fleet and 12.9% of total marine fish production in Sri Lanka. In addition, about 93% of the people working in the fisheries lived in coastal areas, which greatly increased the tsunami's impact on the sector.

Official statistics indicate that the tsunami affected 16,994 families, caused more than 3,067 deaths and left 963 people missing in Hambantota district. Total damage to the district was estimated at US$220 million. More than 90% of the fishing fleet and 3.9 million m^2 of farmland were affected. Today, most of the fishing fleet and housing have been restored, together with public infrastructure.

In addition to the rebuilding, several developments in policy and institutional development can be observed. A disaster management law was enacted in 2005, and institutions have been strengthened. Also, community participation in disaster management is now actively promoted in the Walawe basin. Through such activities, flood-prone areas and vulnerable families in the coastal plains have been identified. Emergency action plans have been developed with the participation of the communities involved.

Poverty reduction, showing signs of improvement: Poverty is a general problem in Sri Lanka. Although the share of the population living on less than US$1 per day was only 5.6% in 2001 2004, 41.6% of the population lives below US$2 per day. In the poorer areas of the country, such as the east and south, where the Walawe basin lies, the poverty rates are higher than the national average. The percentage of population below the poverty line ranges from 13% to 33% in the Walawe basin, while the national average is 15.2%.

In the last 50 years, thanks to major investments in rice production, provision of health facilities, safe drinking water and improved sanitation, the infant mortality rate has been reduced and life expectancy has increased. Studies in the Walawe basin indicate that water resource development has helped reduce poverty levels. However, despite a declining percentage of poor households over the last decade, current statistics indicate that Sri Lanka is not on track to achieve the MDG target on poverty by 2015; poverty remains a major challenge.

Safeguarding public health: Some areas of the Walawe basin were almost unpopulated for centuries due to malaria. Government-sponsored campaigns to address the problem have made noteworthy gains. For example, the number of cases was 591 in 2006, down from 210,000 in 2000. Furthermore, while malaria claimed 76 lives in 2000, no deaths were reported in 2006. On the other hand, the incidence of water-related diseases such as Japanese encephalitis, leptospirosis (rat fever) and dengue have increased significantly in recent years. Reports show that leptospirosis resulted in 150 deaths from January to September 2008, including patients from the Walawe basin. Furthermore, Ratnapura and Hambantota districts in the Walawe basin are identified as being high risk areas for dengue, where the incidence of disease has increased by 35% over the corresponding period in 2007. In 2008 there were 18 dengue-related deaths. Continuous and persistent national and international input is needed to combat these water-related health problems.

Capacity-building: The Sri Lanka National Water Development Report (UNESCO-WWAP, 2006*a*), prepared for the second *World Water Development Report*, concluded that a substantial amount of international investment had been made in infrastructure development. However, funding in several water-related subsectors, such as irrigation management, water quality monitoring, pollution control and water related research, is not adequate. Serious investment in research and capacity-building is considered the most urgent priority, as it will make the earlier investments sustainable.

The knowledge gap in the water sector is a constraint for water resource management. Although noteworthy changes in climate and weather patterns are being observed, scientific conclusions about trends and future scenarios are not being drawn. Recent studies have exposed the inadequacies of the existing databases in this regard. Similar gaps exist concerning water-related issues. Although water quality problems are believed to be responsible for some ailments peculiar to agricultural areas in the dry zone, it is not clear what type of pollution is causing them, and hence effective action to control the pollution is not being taken. The gaps in databases and research outputs constitute a constraint on mobilization of the community, policy-makers and decision-makers to meet water challenges. These issues, as well as deficiencies in access to data and its dissemination, are highlighted in the earlier *World Water Development Report* case studies cited above.

Conclusions

The major challenge in the Walawe basin is to address environmental problems while assuring the sustainable socio-economic development essential for alleviating poverty. Successful but isolated water sector innovations in the basin give hope for the future; however, nationwide problems, such as gaps in capacity and the knowledge base as well as the absence of any comprehensive water policy, seriously handicap the country in its ability to address current challenges and make the adaptation needed to cope with future pressures from climate change and climatic variation.

References

Ministry of Agriculture, Irrigation and Mahaweli Development. Forthcoming. *Walawe River basin (Sri Lanka)* Case Study Report.

UNESCO-World Water Assessment Programme (UNESCO-WWAP). 2006*a*. Sri Lanka National Water Development Report (in full). *Water, a Shared Responsibility: The United Nations World Water Development Report 2*. Paris/Oxford, UNESCO/Berghan Books. http://unesdoc.unesco.org/ images/0014/001476/147683e.pdf

UNESCO-World Water Assessment Programme (UNESCO-WWAP). 2006*b*. Sri Lanka National Water Development Report (summary). *Water, a Shared Responsibility: The United Nations World Water Development Report 2*. Paris/Oxford, UNESCO/Berghan Books. www.unesco.org/water/wwap/wwdr2/case_studies/pdf/sri_lanka.pdf

United Nations-World Water Assessment Programme (UN-WWAP). 2003. Ruhuna Basins Case Study. *Water for People, Water for Life: The United Nations World Water Development Report*. Paris/Oxford, New York, UNESCO/Berghan Books. www.unesco.org/water/wwap/ case_studies/ruhuna_basins/ruhuna_basins.pdf

Uzbekistan: the Aral Sea basin

Regional cooperation and moves towards efficient water use are the keys to recovering from loss of livelihoods, mass migration, rampant pollution and ecosystem damage resulting from unsustainable irrigation practices and other legacies of the past.

Setting the scene

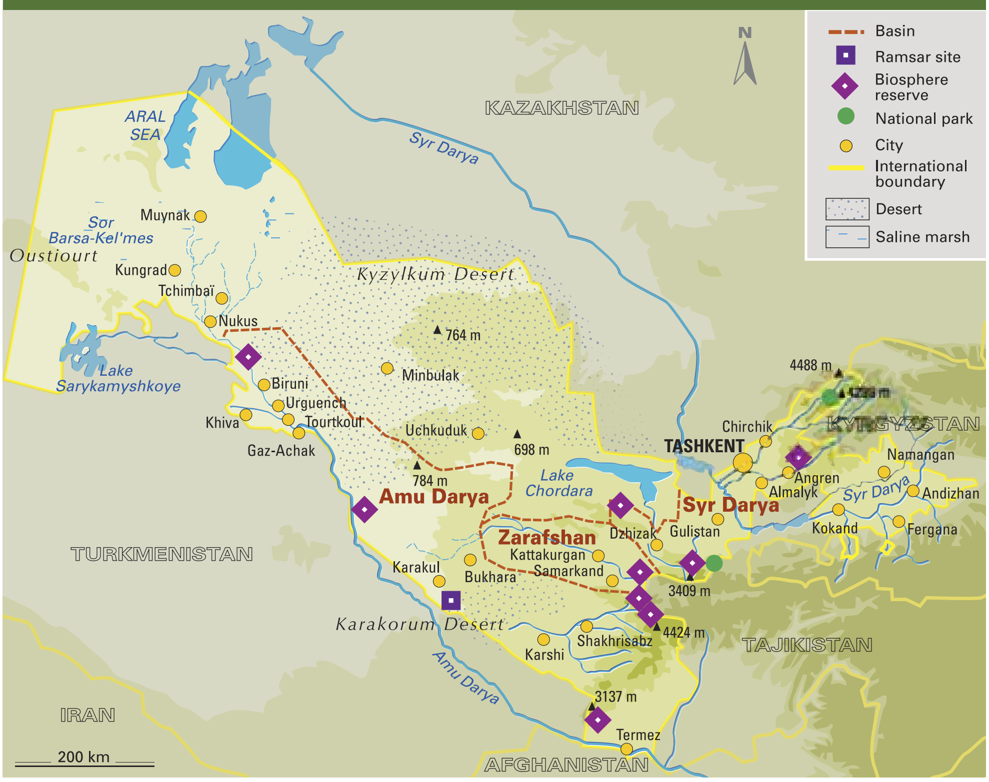
Uzbekistan is located in Central Asia, bordered by Afghanistan and Turkmenistan to the south, Kyrgyzstan and Tajikistan to the east and Kazakhstan to the west and north (Map 2.7). The South Aral Sea, which formed in the late 1980s as the main Aral Sea (a saltwater lake) shrank, lies largely in northern Uzbekistan. The population of around 27 million (2007) occupies a land area of 447,400 km². Uzbekistan is a dry country with a continental climate.[1]

Climate change and variability: higher temperatures, more rainfall, increased flood risk

The Aral Sea basin contains over 14,752 glaciers with a total area of some 1,043 km². The ones located in Uzbekistan account for 1.1% of the total glaciated area in Central Asia. Recent assessments indicate that the country's glaciers and ice reserves are receding. Since 1957 the glaciers have shrunk by almost 20%, losing 104 billion m³ of water. A fluctuation in water resources ranging from -7% to +3% is forecast for the near future, which falls within the range of normal variability. An expected rise in ambient temperatures is likely to be accompanied by higher rainfall, potentially causing a 30% to 35% increase in floods by 2030.

Another negative impact of increasing temperatures will be higher evaporation rates and a likely rise in agricultural water consumption of up to 10%.

Map 2.7 Uzbekistan



State of the resource and water use: unsustainable agriculture is predominant

The bulk of freshwater resources in Uzbekistan comes from the Syr Darya, a river originating in Tajikistan; the Amu Darya, which flows in from Kyrgyzstan; and, to a lesser extent, the Kashka Darya and Zarafshan rivers. Available freshwater resources in Uzbekistan are estimated at 67 billion m³ per year. Of this amount, 55.1 billion m³ comes from surface waters and

[1] Except where otherwise noted, information in this case study is adapted from the draft *Uzbekistan Case Study Report* (unpublished), prepared in 2008 by the Institute of Water Problems at the Academy of Sciences.

7.8 billion m^3 from groundwater. The rest is reclaimed in the form of return water from leaking irrigation channels and infiltration from irrigated fields, which collects in localized depressions.

Agriculture plays an important role in the economy, employing over 60% of the population. Although only 10% of the 444,000 km^2 of arable land is irrigated, the irrigation efficiency is low, so this water demand amounts to 92.5% of overall annual water consumption in Uzbekistan (Table 2.5).

Table 2.5 Water use, by sector, 2001

Water use	Annual demand (billion m^3)	Share in overall consumption (%)
Agriculture	52.10	92.5
Households	2.90	5.2
Energy production	0.12	0.2
Industry	0.77	1.4
Fisheries	0.40	0.7
Total	56.29	100.0

With demand for water growing in all sectors, it will be impossible to meet the combined needs in the medium term. Projections based on existing consumption trends indicate there could be a water deficit of up to 14 billion m^3 by 2015. Although the growth in household and industrial water demand could be met through increased efficiency, the need to reduce agriculture's overall share is clear. Despite a decision of the Cabinet of Ministries not to revise water allocation to the various sectors for 15 years, a regulation adopted in May 2007 is aimed at developing a programme of water conservation and efficient use of water resources.

Policy framework and legislation

The main legislation governing water management is the 1993 Law on Water and Water Use. Uzbekistan is in the process of adopting a series of measures intended to improve water supply so as to promote employment and better living standards. In 2002, Uzbekistan developed the Concept of Sustainable Water Supply of the Regions of the Republic of Uzbekistan, which sets forth Principal Directions of Water Management and Amelioration Measures for 2008 2011. These directives envisage major improvement in land use through better drainage, an increase in agricultural water supply through modernization of irrigation, and the introduction of integrated water resources management.

The main challenges

Mass migration: Mass population movement in the Aral Sea basin began as early as 1966 when a major earthquake destroyed much of Uzbekistan's capital, Tashkent. From then until the collapse of the Soviet Union in 1991, mass migration was mainly due to compulsory movement of labour from overpopulated regions to new development areas. Since 1991, ethnic and environmental factors have played increasingly important roles in shaping migration. Deteriorating environmental conditions, combined with recurring drought, have resulted in agricultural and fisheries production declining by as much as 50%, spelling economic disaster for almost 3 million people (including those in areas of Turkmenistan and Kazakhstan near the Aral Sea) whose main source of income was agriculture. Aggregate losses in Uzbekistan associated with mass migration from provinces near the Aral Sea between 1970 and 2001 are estimated to be above US$20 million. Many people still living in the high-migration areas suffer protein and vitamin deficiencies resulting from malnutrition and extreme poverty. In addition, since the migrants have generally been young, the birth rate has decreased significantly.

Environmental degradation: Uzbekistan faces pressing problems due to water pollution and environmental degradation. Unsustainable irrigation projects, introduced during the Soviet period, have irreversibly damaged the Aral Sea and its basin. Continuing use of similar practices since the collapse of the Soviet regime poses a still greater danger for local people's livelihoods. Pollution and other environmental contamination are causing major public health problems, and diseases stemming directly from exposure to untreated water and toxic waste are on the rise. Direct discharges of wastewater containing high concentrations of pesticide, fertilizer, and industrial and household waste have rendered much of the surface water unfit to drink. In addition, nearly 38% of groundwater reserves are now unusable.

Inefficient use of water in irrigation, combined with ineffective drainage systems, has flooded large areas of land with a mixture of fresh and polluted return water. Aerial photos taken in 2005 reveal pools of semi-contaminated water, covering as much as 800 km^2 in all. On the other hand, these areas have become diverse and flourishing ecosystems, which contribute to the region's socio-economic development through recreational uses as well as fishing, hunting and reed collection. Yet because there is no legislation regulating their management, these ecosystems have no economic or environmental status and are at risk from invasive species, gradual salinization and eutrophication (nutrient pollution).

Allocation of transboundary water resources: the need to set common priorities

Following the Second World War, as part of the regional socio-economic development plan under the Soviet regime, the water resources of the major transboundary rivers, the Amu Darya and Syr Darya, were mainly allocated for irrigating vast tracts in the Aral Sea basin. Water resources development projects were prioritized to meet irrigation needs. In the 1990s, the potential of the Syr Darya-Narin basin was almost fully developed to assure a constant flow of 32 billion to 33 billion m^3, or 94% of the river's natural regime. The Amu Darya was also modified to maintain a flow of 60 billion to 64 billion m^3. The regional development plan also relied on hydropower generation to meet electricity needs in Central Asia, although this was considered only a side benefit because agriculture contributed more to the region's GDP.

After the Central Asian countries became independent in 1991, water management problems began to surface. They largely stem from differences in the needs and priorities of the five Aral Sea basin countries: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. Most notably, a shift in upstream countries towards using water for hydropower generation has upset the balance for areas needing irrigation water. The water administration agencies of the five countries urgently need to come up with a sustainable water management framework that favours socio-economic development and a stable water supply without ignoring the ecological needs and priorities required to offset the environmental catastrophe caused by previous practices.

Conclusions

Unsustainable use of water resources in Uzbekistan since the mid-20th century, carried out as a part of a larger Aral Sea basin development plan, has caused irreversible damage in terms of water quality and ecosystem degradation. The damage has rendered many soil and water resources unusable, seriously threatening the livelihoods of Uzbeks and leading to major population movements. Although environmental protection and sustainable socio-economic development remain priorities in the national agenda, the sheer scale of the problems, combined with economic difficulties, leaves the government short of solutions. Transboundary water resources, long the lifeline of extensive irrigation in Uzbekistan, now pose quantity and quality challenges due to rampant pollution and changing priorities in upstream countries. Development of national plans and establishment of regional cooperation, along with international assistance, are necessary to assure sustainable development while reversing environmental damage, to the extent possible.

References

Institute of Water Problems, Academy of Sciences. 2008. *Uzbekistan Case Study Report.* (Draft.)

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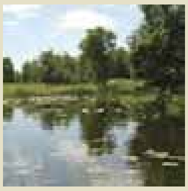
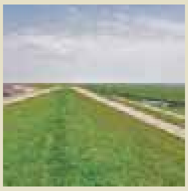
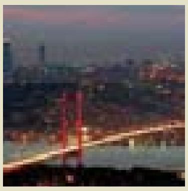
Europe and North America

The world's wealthiest region is not immune to water-related problems. The members of the European Union are making efforts to implement the strict rules and high standards imposed by various directives, including the Water Framework Directive, which poses special challenges even for the most industrially advanced. While various climate change scenarios project reduced rainfall, especially in the Mediterranean basin, overall water quantity does not appear to be an immediate concern. The issues highest on national agendas are usually flooding, water quality and ecosystem protection.

The six European case studies presented in this companion volume to the third edition of the World Water Development Report also reveal the impact of scale issues, especially in dealing with urban areas. In the case of Istanbul, in particular, authorities face the challenge of solving water-related problems in a megalopolis of 12 million inhabitants straddling two continents.







Estonia

Increasing prosperity, water use efficiency and close adherence to European Union requirements characterize this Baltic Sea state.

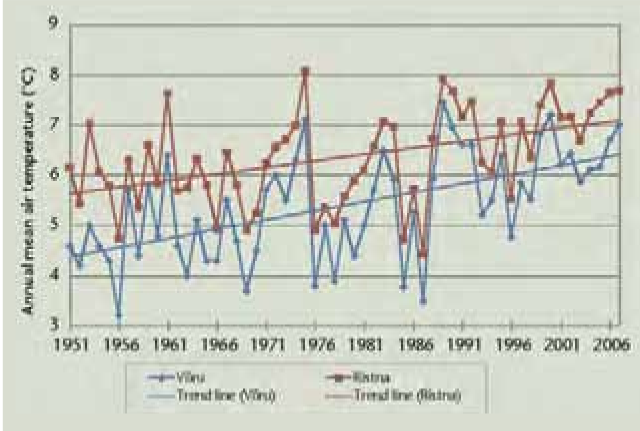
Setting the scene

Estonia, located on the Baltic Sea and Gulf of Finland, is bordered on the south by Latvia and on the east by the Russian Federation (Map 3.1). It is a flat country, with plains along the coastline and uplands, and many lakes in the southeast. Its population of 1.3 million (2007) is dispersed across an area of 45,227 km². There are over 1,500 islands and islets, two of which, Saaremaa and Hiiumaa, are big enough to be considered counties. Although the life expectancy is over 70, the population is steadily declining due to a low birth rate.[1]

Climate change and variability: some warming expected

Several studies have been carried out to estimate the effect of climate change on water management. Statistical evidence suggests that annual mean air temperature increased during the second half of the 20th century by 1.0 to 1.7°C at various locations in Estonia. The greatest warming has been observed in the south-east (Võru) and the lowest in the north-west (Ristna) (Figure 3.1).

Figure 3.1 Trend of annual mean air temperature at Võru and Ristna monitoring stations, 1951 2006



The warming effect has not been equally distributed throughout the seasons: the most significant changes have occurred during the first five months of the year, with that in March being the most significant. Over the last 50 years, the average monthly temperature in March has risen by between 3 and 5°C. The models for climate change suggest that winters will be milder, leading to a more rapid snow-melt, an earlier spring with reduced runoff, an extension of the dry period in summer and a likely increase in autumn precipitation. Especially in dry periods, these variations might cause significant water deficit in rivers fed by groundwater. So far, however, the results lie well within normal observed climatic variations (JRC, 2005).

Analysis of data from 1949 to 2004 shows that the number of days with sea ice has decreased significantly at all monitoring stations except those on the southern coast of the Gulf of Finland. The most substantial decrease was observed at the westernmost stations on the Baltic coast (Jaagus, 2006). Some models indicate winters could be ice-free by the end of the 21st century, even in the Gulf of Finland (HELCOM, 2007). The shortening of the period of ice cover, together with increased frequency of winter storms, will have a strong impact on coastal ecosystems. The most marked coastal changes in Estonia have resulted from a combination of big storms, high sea levels induced

Map 3.1 Estonia

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[1] Except where noted otherwise, information in this case study is adapted from the draft *Estonia Case Study Report*, prepared in 2008 by the Ministry of the Environment.

Box 3.1 Setting a fair price for water

Within the last 15 years, Estonia has taken major steps towards applying the full cost recovery principle and the polluter pays principle. In 2007, the average price of water was US$0.96 per cubic metre for households and US$1.16 for businesses. The respective average wastewater charges were US$1.15 and US$1.64.

While an effort is made to reflect the economic value of water in various uses, social factors are taken into consideration to make it affordable for the general public. For example, in 2007, average net household income was US$460 per month and average per capita water consumption was 2.8 m^3; the monthly cost corresponds to 1.3% of average household income. In rural areas, where income levels tend to be lower, the percentage is higher but still in line with the acceptable EU level.

As an incentive to revive the agricultural sector, however, water used for irrigation is not charged for or taxed. Although this has not had an impact on water quantity, in areas where agricultural activities are concentrated water quality is compromised, and the dissolved nitrate concentration in water has returned to near 1992 levels.

by storm surges, ice-free seas and unfrozen sediment. An extremely strong storm like Gudrun in January 2005 could cause substantially larger changes to the depositional shores in western Estonia than all the storms over the entire preceding 10 to 15 years (Kont et al., 2003).

On the other hand, Estonia is not likely to be seriously affected by global sea level rise, which would be counteracted by uplifting caused by tectonic movement.

State of the resource and water use: substantial decrease in water consumption

Estonia's annual average surface water availability is 12 billion m^3 and the groundwater potential is 3.2 billion m^3. The rivers are characterized by short flow distances and low flow rates. Only 10 rivers are longer than 100 km. The longest is the Võhandu (162 km) and the largest is the Narva, with a catchment area of 56,200 km^2, only about one-third of which is within Estonia.

Of Estonia's approximately 1,200 lakes, half have a surface area of less than 0.03 km^2. The largest, Lake Peipsi, covering some 3,500 km^2, is the fourth largest lake in Europe. It was the subject of in-depth case studies in the first and second editions of the *World Water Development Report* (UN-WWAP, 2003; UNESCO-WWAP, 2006).

Water consumption has decreased significantly since Estonia regained its independence in 1992 (Figure 3.2). For a quick comparison, combined water use in 2006 was half that of 1992. Between 1992 and 2007, agricultural water consumption decreased by almost a factor of seven, and the average price of water increased nearly 25 times (Box 3.1). Daily per capita water consumption fell from 188 litres in 1992 to 90 litres in 2007 (Figure 3.3). The main reasons for the abrupt decrease in overall water use were the introduction of a water use charge, an increased unit price, the closure of a pulp factory in the capital, Tallin, adoption of water saving technology in industry, and reductions in numbers of livestock and in agricultural production after the system of collective farms collapsed.

Groundwater resources are used mainly for municipal water supply and to some extent in industrial processes. In line with the price increase and deployment of water saving technology, groundwater consumption decreased by one-third from 1992 and amounted to 50 million m^3 in 2006.

Reductions in agricultural area, animal husbandry and certain industrial activities have resulted in a decreased contaminant load and a general improvement in surface and groundwater quality. At the same time, Estonia's economic indices have improved. The unemployment rate has been halved since 2000 and GDP has more than doubled since 1995. Better water management through increased efficiency in water use in all sectors has enabled Estonia to achieve a strong decoupling of water use and economic output, which in turn has helped boost the economy.

Figure 3.2 Trends in sectoral water use, 1992 2007

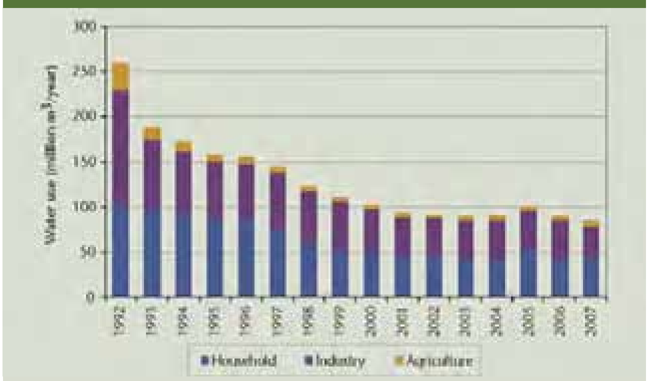


Figure 3.3 Trends in household water consumption, 1992 2007

Note 1 Estonian kroon US$0 087 (December 2008)

Thermal power plants burning oil shale account for 92% of the country's electricity production. Until recently, about 90% of overall surface water extraction was used for cooling these plants at the main power generation complex in Narva. However, thanks to reduced electricity demand, the use of water saving technology and a substantial increase in the water extraction charge, the rate of abstraction has decreased by half. The share of renewable forms of energy, including hydropower, has been minimal, accounting for about 1.7% of total electricity production in 2006. But, as required by the European Union (EU) accession agreement, Estonia has undertaken to raise the share of renewables to 5.1% by 2010. Thus, significant growth in this energy subsector is expected, especially for wind turbines.

Policy framework and decision-making: following the EU example

The Water Act is the main law establishing the regulatory framework of water resource management in Estonia. It takes an integrated water resources management approach, and states that while the main responsibility for the use and protection of water resources lies with the central government, local governments have the authority to take temporary measures within their jurisdictions, if necessary, regarding the use of water resources.

Water management issues in Estonia are dealt with under several plans of differing time scales. Long term goals and objectives, up to 2030, are set forth in the Estonian National Environmental Strategy. The Estonian National Environmental Action Plan for 2007 2013 contains detailed actions to achieve the short and medium term goals.

As a member of the European Union, Estonia bases its water management planning on the guidelines of the Water Framework Directive (WFD) and other EU directives regulating the use and protection of water resources and the environment. As the WFD requires, water management is based on management plans compiled for eight river basin subdistricts forming three main river basin districts. Compiling the plans is a complex process. It includes general characterization of the districts, identification of pressures, the setting of monitoring standards for assessment of the status of surface and groundwater resources, establishment of environmental objectives, identification of the measures necessary to bring water bodies to 'good' status and to supply the population with drinking water of good quality, and procedures for reporting back to the European Commission.

The Minister of the Environment established a Commission on Water Resource Management to coordinate and supervise water management planning. The commission includes representatives of relevant ministries, along with scientists and other experts. Sub-basin water management plans are overseen by working groups that include representatives of the Ministry of the Environment and of county environment services, along with relevant experts. Working groups, established by a decree of the Minister of the Environment, coordinate the implementation and updating of the management plans. Representatives of other relevant stakeholders can participate in the meetings on cases in which they have an interest.

In achieving the WFD objectives, water supply and sanitation development plans have a very important role. Upon accession to the EU, Estonia undertook to ensure by the end of 2010 that the appropriate wastewater collection and treatment was in place for all wastewater collection areas whose waste load was more than 2,000 population equivalents, and, by the end of 2013, that all communities of more than 50 people were supplied with safe drinking water.

The main challenges

Chemical contents of groundwater: Drinking water often fails to meet quality requirements due to the presence of substances such as manganese and ammonium. Although these minerals affect the sensory properties of water (taste, colour, odour), they pose no direct threat to human health. In some parts of Estonia, the groundwater also contains excessive amounts of fluorine and boron. There is an effort to regulate mineral content: drinking water purification plants are being improved, with the installation of technology to remove such minerals, and the infrastructure is being renovated where necessary.

Eutrophication of lakes: The main problem facing Estonia's multiple lakes, including many impounded lakes, is eutrophication. Many lake ecosystems are endangered due to overgrown vegetation that significantly reduces the oxygen content in water during summer and winter, with a devastating impact on fish populations. The status of Lake Peipsi has been assessed as moderate, and that of the country's second largest lake, Lake Võrtsjärv, as good. Studies regarding the environmental status of small lakes have revealed that out of 68 lakes, 3 were in a poor state, 17 were in moderate condition and the rest were ranked as good or very good.

Hydromorphological alteration of rivers: Due to the decrease in agricultural pollution and more efficient wastewater treatment, the water quality of Estonian rivers has improved significantly in the last 15 years. At present only a few rivers and their biota are limited by poor quality. However, additional effort is needed to improve fish migration in rivers where numerous small dams without fish passes now impede their passage.

Conclusions

As an EU member country endowed with sufficient water resources, Estonia does not have many water management problems. The initial economic difficulties that followed independence have been diminishing since the late 1990s and industrial production has increased in almost all branches since 2000. Although climate change scenarios point to potential alteration in the flow regimes of rivers and in recharging of groundwater reservoirs, this does not seem to pose a serious problem for socio-economic development in Estonia. Drinking water quality, sanitation and environmental protection are being handled in line with strict EU legislation.

References

Jaagus, J. 2006. Trends in sea ice conditions in the Baltic Sea near the Estonian coast during the period 1949/1950-2003/2004 and their relationship to large scale atmospheric circulation. *Boreal Environment Research*, Vol. 11, pp. 169–183.

Joint Research Centre (JRC). 2005. *Climate Change and European Water Dimension: A Report to European Water Directors*. Steven J. Eisenreich, ed. European Commission-JRC, Ispra, Italy.

Helsinki Commission (HELCOM). 2007. Climate Change in the Baltic Sea Area: HELCOM Thematic Assessment in 2007. *Baltic Sea Environment Proceedings*, No. 111.

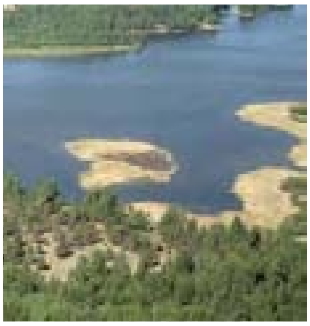
Kont, A., Jaagus, J. and Aunap, R. 2003. Climate change scenarios and the effect of sea-level rise for Estonia. *Global and Planetary Change*, Vol. 36, No. 1–2, pp. 1–15.

Ministry of the Environment. Forthcoming. *Estonia Case Study Report*.

UNESCO-World Water Assessment Programme (UNESCO-WWAP). 2006. Lake Peipsi/Chudskoe-Pskovskoe. *Water, a Shared Responsibility: The United Nations World Water Development Report 2*. Paris/Oxford, UNESCO/Berghan Books. www.unesco.org/water/wwap/wwdr/wwdr2/case_studies/pdf/lake_peipsi.pdf

United Nations-World Water Assessment Programme (UN-WWAP). 2003. Lake Peipsi/Chudskoe-Pskovskoe, Estonia and the Russian Federation. *Water for People, Water for Life: The United Nations World Water Development Report*. Paris/Oxford, New York, UNESCO/Berghan Books. www.unesco.org/water/wwap/case_studies/peipsi_lake/peipsi_lake.pdf

Finland and the Russian Federation: the Vuoksi River basin



Through concerted efforts, water quality has been significantly improved in the basin since the 1970s, when large amounts of untreated industrial waste were being dumped into waterways. Today, both the water quality and the environmental status are much better. However, increasing industrial activities in the Russian Federation may pose a renewed risk of some degradation.

Setting the scene

The Vuoksi is a transboundary river that flows 150 km from Lake Saimaa in south-eastern Finland to Lake Ladoga in north-western Russia. The Vuoksi River basin extends between these two lakes and covers an area of 4,100 km^2 (Map 3.2). It is part of the much larger basin through which the Neva River flows to the Baltic Sea. Human activities have divided the Vuoksi basin into two independent parts. The northern part, the Lake Vuoksi sub-basin, is not connected to Lake Saimaa. This case study examines only the southern part, through which the Vuoksi River passes.[1]

Average precipitation in the region is 775 mm per year and the mean annual temperature is around 3.2°C. The period without frost lasts from April to October. Up to 70% of annual precipitation falls during this period, mostly in August. The total population is about 80,000 people, of whom at least 52,000 live in towns in the Russian part of the basin.

Climate change and variability: sparse population, reduced risks

At national level, certain climatic trends are observed in both Finland and the Russian Federation. For example, over the last 150 years, the yearly average temperature in Finland has risen by 1°C (Finnish Ministry of Agriculture and Forestry, 2005); during the 20th century, the increase was 0.7°C (Carter, 2007). March to May was the period that saw the greatest increase in monthly mean temperatures, ca. 1.5ºC (Pöyry & Toivonen, 2005). Moreover, there was a statistically significant increase of 1°C in winter temperatures between 1961 1990 and 1971 2000 (Finnish Meteorological Institute, 2006). In the Russian Federation, the mean annual ambient temperature increased by about 0.4°C between 1990 and 2000 (Roshydromet, 2005).

In Finland, the rising mean temperature has led to a decrease in the duration of the snow cover and in the amount of snow in southern Finland. Fluctuations in precipitation remain within the range of climatic variability, however (Finnish Ministry of Agriculture and Forestry, 2005). To address the inevitable socio-economic impact of climate change and variation, Finland prepared a National Strategy for Adaptation to Climate Change (2005). The strategy describes the likely effects of climate change for a range of sectors and outlines actions and measures to improve the capacity to deal with them. It also aims at reducing negative effects and taking advantage of the opportunities climate change may offer.

In the Russian Federation, out of 11 anomalous winters in the last 109 years (i.e. with more than a 2°C deviation from the annual average), eight were observed in the last 30 years. In addition to warmer winters, climatic changes observed in the Russian Federation include increased evaporation in warmer periods combined with unchanged or decreased precipitation, a higher number of droughts, alteration of the amounts and periods of water discharges, and changes in ice conditions (Roshydromet, 2005). In 2005, under the UN Framework Convention on Climate Change, the Russian Federation adopted an action plan on implementation of the Kyoto Protocol to mitigate the effects of climate change (Ministry of Economic Development and Trade of the Russian Federation, 2006).

Not many water-related disasters on a big scale have been observed in or around the Vuoksi River basin. Nor has a link between climate change and water-related disasters been clearly identified. Nevertheless, scenarios for the basin and its surroundings project a rise of 3 to

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[1] Except where otherwise noted, information in this case study is adapted from the draft *Vuoksi River Basin Case Study Report*, prepared in 2008 by the Finnish Environment Institute and the Center for Transboundary Cooperation, St. Petersburg.

Map 3.2 The Vuoksi basin

4°C in temperature and a 10% to 25% increase in annual precipitation between 1971 2000 and 2071 2100. Extreme runoff is expected to be more frequent and winter floods are likely to become more severe (Silander et al., 2006). The discharge volume of the highest flood recurring about once in a 250 year period could rise from 1,100 m^3 per second to as much as 1,400 m^3/s by 2100, and the water level in Lake Saimaa could increase by almost a meter during such floods (Veijalainen, 2006). Over the same period, the duration of snow cover could decrease from 150 days to 30. Overall, climate change in the Vuoksi River basin is likely to make water-related disasters both floods and droughts more frequent and costly for society. However, as the basin is sparsely populated and has abundant water resources, the impact at basin level is not expected to be critical.

State of the resource and water use

The Vuoksi River has an annual water potential of some 20.4 billion m^3. The part of the basin that lies in Finland, although very limited in extent (10% of the overall basin area), contributes almost 94% of the average flow.
The Vuoksi River basin also contains several freshwater lakes. On both the Russian and Finnish sides of the basin, groundwater resources exist but are of limited capacity (0.03 billion m^3 and 0.001 billion m^3 per year, respectively) (VIVATVUOKSIA, 2003).

The abundance of surface water resources means that meeting water demand is usually not an issue in the Vuoksi River basin. However, during severe droughts, low water levels can affect fish farms, water transport, industrial and household water supply (with intake pipes not reaching the water level), and recreational activities (Box 3.2).

Most parts of the Vuoksi River basin are in a natural state and unpopulated. On the Russian side, 76% of the basin is forested, 17% is used for agriculture and 7% for other purposes. The main towns in the Russian part of the basin are Priozersk (pop. 21,000), Svetogorsk (pop. 15,600), Kamennogorsk (pop.12,000) and Lesogorsk (pop.4,000). The small part of the basin area that is located in Finland is centred on the town of Imatra (pop. 29,000) (VIVATVUOKSIA, 2003).

Industry is a leading water user in the Vuoksi River basin. Industrial production in the region grew steadily during the 20th century before declining in the recession of the early 1990s, then started to recover after 1997 (VIVATVUOKSIA, 2003). In the Russian part of the basin, industrial water consumption is 66 million m^3 per year (2004), close to 80% of which is used by the pulp and

Box 3.2 Recreational activities in the Vuoksi River basin

With its abundant water resources, numerous lakes and islands, good water quality and extensive shorelines offering vast and peaceful natural areas, the Vuoksi River basin is one of the most popular areas for recreation in the north-western part of the Russian Federation. The Vuoksi River itself is not used for large-scale goods or public transport as dams block the upper part of the river. However, residents and tourists in Finland and the Russian Federation use the river for boating. The water quality of the river has greatly improved since the 1970s, and fish of the salmon family have been introduced on the Finnish side, which has become very popular for recreational fishing. As the local standard of living has risen, other leisure activities, such as swimming, hiking and boating, have become more popular and are likely to contribute increasingly to the economy of the region.

paper industry. In the Finnish part, annual industrial water use is around 210 million m^3 (2007): 17 million m^3 directly withdrawn from the Vuoksi River and the rest from Lake Saimaa. As on the Russian side, most of the water on the Finnish side is used by the pulp and paper industry (99%), with the metal industry accounting for most of the rest. Despite increased production, industrial water use has been declining in Finland thanks to higher productivity and water recycling. In fact, water consumption in 2007 was 50% lower than in 1974.

Access to drinking water is widespread. In towns, more than 80% of residents are connected to centralized cold and hot water infrastructure and sewer networks (VIVATVUOKSIA, 2003). In rural areas, wells are quite common for providing drinking water. In some places in the Russian part of the basin, however, private wells are in poor condition and their water quality is not always adequate or has not even been analysed. Overall, municipal water consumption in the basin amounts to about 2.7 million m^3 per year, of which around 60% is withdrawn from surface waters (VIVATVUOKSIA, 2003). By 2015, municipal water use in the basin is expected to have decreased by up to 4.5% because of a reduction in water loss and decline in population. As adequate wastewater treatment is lacking in some settlements, however, ground and surface water pollution is likely to be a problem.

Farming and animal husbandry are mainly practised in the Russian part of the Vuoksi River basin to assure local self-sufficiency. The extent of the cultivated area, including pasture land, is 77 km^2. The sector seems to be recovering from the effects of the recession that ended in 1997 (VIVATVUOKSIA, 2003). Due to the climate of the basin, agricultural land is excessively damp and requires drainage. This in turn has led to phosphorous contamination of water resources because of fertilizer use (Kondratyev et al., 2007). Although the potential impact of climate change on agriculture in the Vuoksi River basin has not yet been fully studied, there are indications that rising temperatures may lead to increased production. Such a change could translate into higher water demand and fertilizer consumption, potentially aggravating surface and groundwater pollution. Finland's response to such pressures is guided by the European Union (EU) Water Framework Directive, to which it adheres as an EU member. Similarly, policy in the Russian Federation calls for adoption of modern agricultural methods that help reduce nutrient loads to the environment.

The four hydropower plants in the basin (two in each country) harness about 93% (2.5 TW) of its hydropower potential. As construction of new dams is not considered profitable, the preferred option for increasing energy production is to renovate existing facilities. Energy demand in the basin is expected to grow as economic development of the region intensifies and industrial production increases. However, thanks to the adoption of more energy efficient methods and processes, the growth in energy demand is not likely to be substantial. The hydropower plants on the Vuoksi River lack fish passages. To reduce their environmental impact, Finnish hydropower companies are obligated to release 1,125 kg of lake trout every year, mainly in the section of the river that lies between the two dams, but also in Lake Saimaa.

Water management and transboundary cooperation

As a member of the European Union, Finland bases its water resource policies on the Water Framework Directive. In the Russian Federation, the 2006 Water Code sets the framework for all water-related legislation.

The integrated water resources management approach has been adopted in both countries. Thus they consider the river basin as the basic unit in planning and management, while ensuring that different water uses are taken into consideration. Sustainability of water resources and stakeholder participation in decision-making are also viewed as important principles in water policy. While public participation in decision-making is well organized in Finland, there are implementation problems in the Russian Federation. In addition, overlap in the responsibilities of various Russian Federation administrative bodies has complicated the process by hindering inter-agency cooperation on environmental protection and natural resources management.

Regarding management of shared waters, since its establishment in 1964 the Finnish-Russian Commission on the use of transboundary watercourses has played a significant role in the Vuoksi River basin. The commission's co-chairs are representatives of the Finnish Ministry of Agriculture and Forestry and the Russian Federation Ministry of Natural Resources and Environment. With three working groups on the use of water resources, on fisheries and on water quality and monitoring the commission monitors activities that could affect transboundary waters and assesses the compensation required in the event of damage caused by either party.

The main challenges

Reducing water pollution: The pulp and paper industry is responsible for most of the organic and nutrient pollution in the Vuoksi River basin, whereas the mining, chemical and metal industries generally release considerable amounts of heavy metals into the river. Initial measures to treat industrial wastewater were taken in the 1960s and such action continued into the 1970s. As a result, industrial effluents have significantly decreased and water quality in the river has improved. For example, the loading of suspended solids and biochemical oxygen demand (BOD) in the Finnish part of the river has declined by 90% since the early 1970s (Figure 3.4). A major metal processing plant situated on the banks of the Vuoksi River on the Finnish side has adopted the ISO 14001 environmental management system (Ovako, 2008). Overall, while some minor industries and enterprises still do not treat their wastewater, most others have quite efficient wastewater treatment systems. As a result, not only has water quality improved, but valuable fish species have been observed returning to the river.

In the Russian Federation, the total point-source load into the Vuoksi River in 2006 was estimated at 1.4 tonnes/day (t/d) of suspended solids, 1.4 t/d of BOD,

Figure 3.4 Annual means of daily industrial and municipal point-source loading in the Vuoksi-Saimaa area in Finland

Notes The industrial loading is from pulp and paper mills Results are from an area 8 km from the border with the Russian Federation BOD7 BOD demand of a wastewater sample, measured over seven days' exposure CODCr chemical oxygen demand
Source Mitikka et al , 2004

0.47 t/d of nitrogen and 0.12 t/d of phosphorus (Finnish-Russian Commission, 2007). In general, for Russia, the sharpest decrease in Vuoksi River pollution came during the 1990s recession. In recent years the pollution load has started to increase again.

In the Russian part of the basin, about 73 million m^3 of wastewater is produced per year. Of this, 13 million m^3 is cooling water. The rest is treated in the wastewater treatment plants of large industrial enterprises (VUOKSIAGAIN, 2006). The Russian Federation requires permits and environmental impact assessments for actions that could negatively affect water resources or ecosystems. In addition, one objective in the Long Term Development Strategy for Water Economics is to rationalize industrial water use over a 20 year period.

Mitigating floods and droughts through joint action:
The natural discharge in the Vuoksi River is usually large enough to provide water for all users. If exceptionally high floods or intense droughts are forecast, however, the flow is regulated, under the Discharge Rule for Lake Saimaa and the Vuoksi River, to alleviate socio-economic damage.

Administered by the Finnish-Russian Commission, the Discharge Rule is an effective allocation mechanism that takes the interest of both countries into account. Decisions about changes in the discharge are jointly taken, and the damage one country may suffer as a result is compensated by the other. The Discharge Rule has been successfully applied since it came into force in 1991. Flood peaks have been lowered six times since then and low water levels in Lake Saimaa normalized three times. The key reason for these adjustments is to prevent flood damage to industrial facilities situated on the shores of Lake Saimaa. During two of the floods, discharge control caused a deficit in hydropower production on the Russian side. In accordance with the Discharge Rule, Finland paid the Russian Federation the agreed compensation for this damage.

Conclusions

Even in years when rainfall is below average, the water potential of the Vuoksi River basin is large enough to meet all water demand without significant problems. The main concerns have been the increasing human impact on water quality and the need to regulate the flow regime. Water quality has improved remarkably since the 1970s, creating better conditions for the use and protection of the water resources. In cases of severe floods and droughts, the flow regime can be (and has been) adjusted through cooperation based on the needs of all communities involved. Since the end of the 1990s recession, the region's economy has been improving. It will be critical for sustainable practices to be adopted, especially in the part of the basin that lies in the Russian Federation: such action can crucially affect overall water quality in the basin in the years to come.

References

Carter, T. R. (ed.). 2007. *Assessing the Adaptive Capacity of the Finnish Environment and Society under a Changing Climate: FINADAPT, Summary for Policy Makers/Suomen kyky sopeutua ilmastonmuutokseen: FINADAPT, Yhteenveto päättäjille*. Finnish Environment Institute, Helsinki. http://www.ymparisto.fi/download.asp?contentid=64914&lan=EN (Finnish Environment 1/2007, in Finnish and English, accessed December 2008.)

Federal Service of Hydrometeorology and Environmental Monitoring (Roshydromet). 2005. Strategic prediction for the period of up to 2010-2015 of climate change expected in Russia and its impact on sectors of the Russian national economy. Moscow, Roshydromet. wmc.meteoinfo.ru/media/climate/Strategic%20prediction_2015.pdf (Accessed December 2008.)

Finnish Environment Institute/Center for Transboundary Cooperation. 2008. *Vuoksi River Basin Case Study Report.* Helsinki/St Petersburg, Finnish Environment Institute/Center for Transboundary Cooperation. (Draft).

Finnish Meteorological Institute. 2006. Climatological statistics for the normal period 1971-2000. http://www.fmi.fi/weather/climate_6.html (Accessed December 2008.)

Finnish Ministry of Agriculture and Forestry. 2005. *Finland's National Strategy for Adaptation to Climate Change*. Helsinki, Ministry of Agriculture and Forestry. http://www.mmm.fi/attachments/5enfdAPe1/5kghLfz0d/Files/CurrentFile/MMMjulkaisu2005_1a.pdf). (Accessed December 2008.)

Finnish-Russian Commission. 2007. *Venäjän ryhmän ilmoitus vuonna 2006-2007 suoritetuista toimenpiteistä rajavesistöjen veden laadun suojelemiseksi likaantumiselta*. [Official report of the Russian group concerning water protection measurements made in 2006-2007.] Helsinki, Joint Finnish-Russian Commission on the Utilization of Frontier Waters. (Minutes of 45. meeting, appendix 5. 28.-29.8.2007.)

Kondratyev, S., Ignatyeva, N., Grineva, E., Smirnova, L. and Wirkkala, R.-S. 2007. Phosphorus load on the Vuoksi River and its catchment – preliminary analysis. Laita, M. (ed.), *Water Management and Assessment of Ecological Status in Transboundary River Basins.* (Reports of the Finnish Environment Institute 32/2007.)

Ministry of Economic Development and Trade of the Russian Federation. 2006. Complex Plan of Actions to Implement in the Russian Federation of the Kyoto Protocol to the UN Framework Convention on Climate Change. http://www.economy.gov.ru/wps/wcm/connect/economylib/mert/welcome_eng/pressservice/eventschronicle/doc1116234296469 (Accessed December 2008.)

Mitikka. S., Wirkkala, R.-S. and Räike, A. 2004. Transboundary waters between Finland and Russia – key issues in water protection. Timmerman, J. G., Behrens, H. W. A., Bernardini, F., Daler, D., Ross, Ph. and van Ruiten, C. J. M. (eds.), *Proceedings: Monitoring Tailor-Made IV. International workshop on information on sustainable water management, from local to global levels*. St Michielsgestel, Netherlands, September.

Ovako. 2008. Environment certificates. http://www.ovako.com/index.asp?r=578 (Accessed December 2008.)

Pöyry, J. and Toivonen, H. 2005. *Climate change adaptation and biological diversity*. Helsinki, Finnish Environment Institute. www.ymparisto.fi/download.asp?contentid=45300&lan=en (Finnish Environment Institute Mimeographs 333/FINADAPT Working Paper 3, accessed December 2008.)

Silander, J., Vehviläinen, B., Niemi, J., Arosilta, A., Dubrovin, T., Jormola, J., Keskisarja, V., Keto, A., Lepistö, A., Mäkinen, R., Ollila, M., Pajula, H., Pitkänen, H., Sammalkorpi, I., Suomalainen, M. and Veijalainen, N. 2006. Climate change adaptation for hydrology and water resources. Helsinki, Finnish Environment Institute. http://www.ymparisto.fi/download.asp?contentid=53794&lan=en (Finnish Environment Institute Mimeographs 336/FINADAPT Working Paper 6, accessed December 2008.)

Veijalainen, N. 2006. Ilmastonmuutoksen vaikutus kerran 250 vuodessa toistuviin tulviin Vuoksen vesistössä. [Effect of climate change on the floods with a recurrence period of 250 years in the Vuoksi drainage basin.]. (Draft.)

VIVATVUOKSIA. 2003. *The Sustainable Use of the Water Resources and Shore Areas of the River Vuoksi: Tacis CBC Small Project Facility* TSP/RL/0103/039. Wirkkala, R.-S., et al. (eds.) (Final report.)

VUOKSIAGAIN. 2006. *Guidance for the Land Use of the Shore Areas and the Water Protection of the River Vuoksi: Finnish-Russian Cross Border Co-operation Project of the Finnish Ministry of the Environment*. Smirnova, L. J., Gutman, N. S., Tshikidovskaja, N. D. and Wirkkala, R.-S. (Final report.)

Italy: the Po River basin

Although national regulations for water use and protection of the environment and water resources are in place, their local implementation and enforcement are generally insufficient. This poses many risks for the Po River basin, which generates nearly 40% of national GDP through intensive industry and other economic activities.

Setting the scene

The Po River basin extends from the Alps in the west to the Adriatic Sea in the east (Map 3.3) and covers an area of 74,000 km[2]. While 5% of the basin lies in Switzerland and France, most of it is situated in northern Italy. This is where the basin is the largest, its main channel the longest (650 km), and its discharge the biggest.[1] The Po basin is home to some 16 million people (2001), and extends over 24% of Italy's territory. The regions of Piedmont, Aosta Valley, Liguria, Lombardy, Veneto, Emilia Romagna and Tuscany lie partially or completely within it, as does the Autonomous Province of Trento. The climate is variable, ranging from Alpine in the mountainous north to cool temperate in the Apennines in the south. The flat central region is characterized by a continental climate. Average precipitation varies from a maximum of 2,000 mm in the Alpine range to slightly less than 700 mm in the eastern plains, with an annual average of 1,100 mm.

Climate change and variability: raining less and getting warmer

Meteorological records indicate that the total number of rainy days in Italy decreased by 14% from 1951 to 1996. The decrease was most pronounced in winter. The amount of rainfall also declined, especially in central and southern Italy. In addition, during the same period, persistent droughts grew more frequent.

Similar trends have been observed in the Po River basin. Average annual rainfall has diminished there by 20% since 1975 (Figure 3.5), and the average yearly discharge at Pontelagoscuro, near the lower end of the river, has fallen by between 20% and 25%.

Analysis of data covering 130 years (1865 1996) reveals that declining rainfall was accompanied by increases in both minimum winter and maximum summer temperatures. In northern Italy, where the

Map 3.3 The Po River basin

[1] The maximum discharge measured to date at Pontelagoscuro, at the lower end of the Po River basin, was 10,300 m[3] per second, during the flood of 1951.

[2] Except where otherwise noted, information in this case study is adapted from the draft *Po River Basin Case Study*, prepared in 2008 by the Po River Basin Authority.

Figure 3.5 Yearly cumulated rainfall in the Po River basin, 1975 2006

Note Excludes the area lying beyond Pontelagoscuro
Source Tibaldi et al , unpublished

Po River basin lies, maximum temperatures increased by nearly 0.6°C and minimum temperatures by 0.4°C. The warming effect was 0.2 to 0.3°C higher in central and southern Italy.

The change in average temperatures has accelerated the melting of glaciers in the Alps. In 2005, at 2,500 metres of altitude, the spring snow-melt period started 15 days earlier than in 1990 (Caracciolo, 2007). The overall extent of glaciers in the range as a whole shrank by 49% between 1850 and 2000, from 4,474 km^2 to 2,272 km^2 (CGI, 2006), and glaciers in the northern Italian Alps decreased from 525 km^2 in 1961 to 482 km^2 in 1989, a decline of 8% (Biancotti and Motta, 2000). The increase in temperatures has also accelerated desertification, especially in central and southern Italy.

State of the resource

The amount of available freshwater resources in the Po River basin is estimated at 77.7 billion m^3. Table 3.1 provides the breakdown of water use by sector. The basin is economically important for Italy, as 38% of the country's GDP is generated there, thanks to extensive industrial activity complemented by farming, animal husbandry and tourism (Figure 3.6).

Agriculture in the Po River basin is highly developed, accounting for more than half of the land use in the basin. In fact, at 30,000 km^2 it is the largest cultivated area in Italy, and accounts for 36% of the country's agricultural production. Accordingly, agriculture has the highest water demand of any sector in the basin, withdrawing nearly 17 billion m^3 per year. About 11,000 km^2 of the cultivated area is irrigated, almost exclusively (87%) from surface watercourses. Irrigation networks are mainly composed of open channels, though pressurized systems are also used, chiefly for high value crops. Overland flow is commonly practised in almost half the irrigated areas. Rice, which has high water demand, is grown on over 20% of the irrigated land. Nationwide, about 40% of agricultural production and more than 60% of agricultural exports depend on irrigation (Bazzani et al., 2002, citing ANBI, 1992).

The Po River basin is also urbanized, and home to 28% of Italy's population. Lombardy, Piedmont and Emilia Romagna are the most populated regions and have a concentration of economic activities (Table 3.2).

Milan and Turin are the main urban and industrial agglomerations. The basin's residents enjoy universal water supply and sanitation coverage. However, some

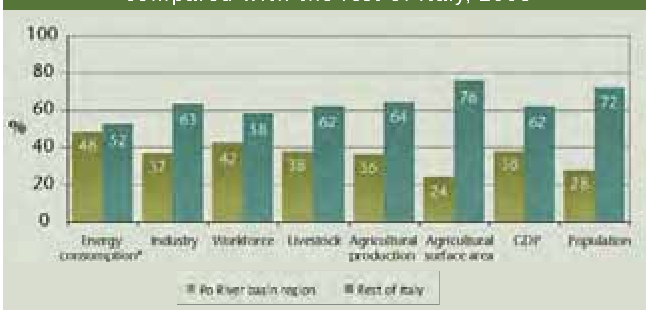
30% of the water in the drinking water network goes unaccounted for, and steps are being taken to minimize leakage from the water supply and sanitation infrastructure.

Meeting growing energy needs is one of the most important requirements for assuring sustainable socio-economic development in the Po River basin. To harness the hydroelectric potential of the basin, 890 dams have been built. The Po basin accounted for 46% of national hydroelectric production in 2004, and 48% of total national electricity consumption as of 1994.

Policy framework and decision-making: delayed implementation of the EU Water Framework Directive

At national level, the Royal Decree of 1933 recognized water resources as a public good. In 1989, Law 183 established the river basin as the basic unit within which all regulatory actions concerning water resource management, water pollution control and soil protection are to be coordinated for economic and social development and for environmental protection. The law also established major basin authorities and entrusted them with planning responsibilities (Box 3.2). In 1994, Law 36 introduced a reform under which municipal

Figure 3.6 Socio-economic indicators of the Po River basin compared with the rest of Italy, 2003



* 1994 value

Table 3.1 Annual water consumption by sector, 2006

Type of use	Volume withdrawn (billion m^3/year)	% from surface water	% from groundwater
Municipal	2.5	20	80
Industry*	1.5	20	80
Farming and livestock	16.5	83	17
Overall	20.5	71	29

* Excludes electricity generation

Table 3.2 Regional population distribution by number of inhabitants and share within the Po River basin

Region	Resident population	% of basin population
Emilia Romagna	2,193,177	13.78
Liguria	107,459	0.68
Lombardy (capital: Milan)	9,014,287	56.63
Piedmont (capital: Turin)	4,211,128	26.46
Autonomous Province of Trento	97,861	0.61
Tuscany	1,504	0.01
Aosta Valley	119,548	0.75
Veneto	15,916,707	1.08
Total		100.00

Source Adapted from Istat, 2001

utilities were aggregated into Optimal Territorial Areas (OTAs), which are responsible for the management and supply of water services such as wastewater treatment, sanitation and drinking water provision. OTAs also have to draft Optimal Territory Plans (OTPs), which analyse the availability of water resources and plan for their current and future use. Basin authorities have the responsibility of verifying that the OTP is coherent with basin plans and objectives.

Legislative Decree 152 was introduced in 1999 to protect water resources by preventing and reducing pollution and improving water quality. It also required regions to classify water bodies (i.e. surface, ground and coastal waters) and establish limits for the pollution loads that can be discharged into the environment. The Water Protection Plan, which directly complements the basin plan required by Law 183, is the main instrument for implementing the laws enacted by Legislative Decree 152. This decree is considered a forerunner of the EU Water Framework Directive of 2000, as it also aims for a comprehensive action framework for water resources protection by introducing measures for specific uses (e.g. drinking water, bathing water) and for specific sources of pollution, such as agricultural and industrial effluents.

In 2006, a consolidated text on environmental protection, Decree 152, was approved. It includes rules for waste management, strategic environmental assessment and environmental impact assessment procedures, and water resources protection and management, as well as for dealing with environmental damage. The part concerning water resources protection and management formally adopts the contents of the EU Water Framework Directive, for example by creating river district authorities and assigning them the task of producing river basin management plans. As of October 2008, however, Legislative Decree 152 of 1999 was still in effect because the 2006 decree had not yet been implemented.

The main challenges

Quality and quantity issues: The Po River is subject to extensive regulation. In some stretches, its flow is reduced to a trickle during the months of high consumption. The deficit in water availability creates tension among users and aggravates quality-related problems. However, in spite of these water quantity and quality issues, there are no national or regional plans for reducing high water consumption in agriculture. Although technological improvements have been introduced, low efficiency

Box 3.3 Role and structure of the Po River Basin Authority

National river basin authorities, whose members include representatives of the central and regional administrations, have as their main role the preparation of basin plans, which aim to protect water resources, mitigate hydrogeological risks (such as floods, landslides and erosion, including that of river banks) and promote sustainable use of water resources in an environmentally conscious way. The Po River Basin Authority and five other national river basin authorities (along with a pilot basin authority) were created by Law 183 in 1989.

The Po authority is composed of the secretary general, an institutional committee, a technical committee and a technical-operational secretariat. As the main decision-making body, the institutional committee comprises representatives of several ministries (Public Works/Environment, Territory/Agriculture, Forestry/ Cultural Assets), the presidents of the regional councils in the basin, and the secretary general. The institutional committee supervises the implementation of the basin plan. The technical committee, chaired by the secretary general and formed of experts and regional representatives, is the consultative body of the institutional committee.

The secretary general, who is elected by the institutional committee, plays a central role in the basin authority by overseeing and coordinating its activities and directing the secretariat. The secretariat drafts the basin plan in cooperation with the technical committee. The institutional committee then adopts it as a project proposal. The proposal is published in the official gazette and regional newspapers so all stakeholders may comment.
The regions analyze all comments collected within their jurisdiction and send a revised basin plan to the institutional committee for adoption. Some experts have criticized the public consultation stage as a weak link, since the regions do not have to make an analytical evaluation of the comments, the period for comments is limited, and the entity doing the review is usually the one that helped design the project plan (CABRI-Volga, n.d.). After a second approval by the institutional committee, the basin plan is passed to the national level for final validation by the National Council of Ministers. Although the basin plan has an implementation period of three years, there is no fixed schedule for reviewing progress or outcomes.

irrigation methods are still widely used, particularly in rice farming (Zucaro and Pontrandolfi, 2005).

Pollution: Surface and groundwater quality is affected by industrial, agricultural and household pollutants. Excessive organic content in surface water causes eutrophication in rivers with low flow rates and in lakes. Although a network of wastewater treatment facilities has stopped further degradation of water quality, it has not been sufficient to reverse the process. Groundwater resources continue to contain high concentrations of nitrates due to fertilizer use in agriculture, while excessive exploitation has caused salt intrusion into coastal aquifers and, in some places, ground subsidence.

Disconnect between planning and implementation: For the most part, these problems stem from the current management approach in the Po River basin. Although only the Po River Basin Authority is responsible for basin-wide planning (Box 3.3), other institutions (regions, provinces, city councils, etc.) are in charge of implementing the authority's plans. Their actions, however, have been fragmented and mainly focused on local interests (WWF, 2003). At national level, water issues are still regulated mostly by Legislative Decree 152 (1999), which delegates government responsibilities to regions. Each region has the right to make its own laws, and shares the responsibility for local implementation with the provinces (subunits of the regions). The 2006 decree incorporating the EU Water Framework Directive has yet to be implemented.

Overall, regulations for water use and for protection of the environment and water resources are in place, but implementation is weak and enforcement is generally lacking.

Conclusions

The Po River basin is a strategic region for the Italian economy, with significant agriculture, industry and tourism sectors, employing 42% of the national workforce and generating 38% of the national GDP. However, the high level of regional development has put heavy pressure on water resources and led to degradation of surface and groundwater quality. Increasing efficiency in agriculture is an issue that still needs to be addressed. Although policy tools for managing and safeguarding water resources are in place at national level, there are problems with the implementation and enforcement of rules and regulations at regional level. Installing a legal framework for application of the EU Water Framework Directive, and making greater efforts to develop a basin-wide vision agreed by all stakeholders, are among available options for safeguarding the resources of the Po River basin for future generations.

References

Associazione Nazionale delle bonifiche, delle irrigazioni e dei miglioramenti (ANBI). 1992. *L'uso irriguo delle acquae*. Rome, ANBI.

Bazzani, G., Di Pasquale, S., Gallerani, V. and Viaggi, D. 2002. *Water Policy and the Sustainability of Irrigated Systems in Italy*. St. Paul, Minn., Center for International Food and Agricultural Policy (CIFAP). www.ageconsearch.umn.edu/bitstream/14401/1/wp02-10.pdf (CIFAP Working Paper WP02-10, accessed November 2008.)

Biancotti, A. and Motta, L. 2000. L'evoluzione recente ed attuale dei ghiacciai italiani. Atti conv. Su: L'evoluzione del clima in epoca storica. Società Italiana di Geofisica, Roma, 5–6 December.

CABRI-Volga. No date. *The Po Basin Water Board, Italy: Case Study*. http://cabri-volga.org/DOC/D3-CaseStudies/CaseStudyPoBasin.doc (Accessed December 2008.)

Istat. 2001. 14° Censimento della popolazione e delle abitazioni 2001. http://www.istat.it/censimenti/popolazione (Accessed December 2008.)

Zucaro, R. and Pontrandolfi, A. 2005. Italian Policy Framework for Water in Agriculture. Presented at OECD Workshop on Agriculture and Water: Sustainability, Markets and Policies, 14–18 November, Adelaide and Barmera, South Australia. www.oecd.org/secure/docDocument/0,2827,en_21571361_34281952_35584805_1_1_1_1,00.doc (Accessed November 2008.)

Po River Basin Authority. Forthcoming. *Po River Basin Case Study.* (Draft.)

Caracciolo, R. 2007. Presentation at National Conference on Climatic Changes, Rome, 12–13 September.

Comitato Glaciologico Italiano (CGI). 2006. http://www.disat.unimib.it/comiglacio/comitatoglaciologico.htm (Accessed December 2008.)

Tibaldi, S., Agnetti, A. Alessandrini, C. Cacciamani, C. Pavan, V. Pecora, S. Tomozeiu, R. and Zenoni, E. Unpublished. Data presented at the conference Il cambiamento climatico nel bacino del Po: variabilità e trend (climatic changes in the Po River basin: variability and trends), Parma, Italy, 16 July 2007.

WWF. 2003. WWF Water and Wetland Index: Critical Issues in Water Policy across Europe. Results overview for the Po River Basin (Italy). http://assets.panda.org/downloads/wwipoitaly.pdf (Accessed November 2008.)

The Netherlands

Adapting to the reality of climate change and increased risk from floods has meant overturning centuries of reliance on big engineering solutions, returning land to nature and integrating risk management into policies based on stakeholder participation.

The Netherlands is located in western Europe, bordered by Belgium to the south, Germany to the east and the North Sea to the north and west (Map 3.4). Geographically, the Netherlands is a flat, low lying country formed by the estuary of four important European rivers: the Rhine, the Meuse, the Ems and the Scheldt. Two-thirds of the country is threatened by flooding. Through history, the country has defended itself against threats posed by water, building dikes and dams, canalizing rivers and reclaiming land from the sea. Today, about 9.6 million of its inhabitants (60% of the population) live below sea level, and about 70% of the country's GDP is generated below sea level (Netherlands Water Partnership, 2006), thanks to a 3,500 km primary flood defence system composed of dikes and sand dunes.[1]

Climate change: the danger of floods and a rising sea

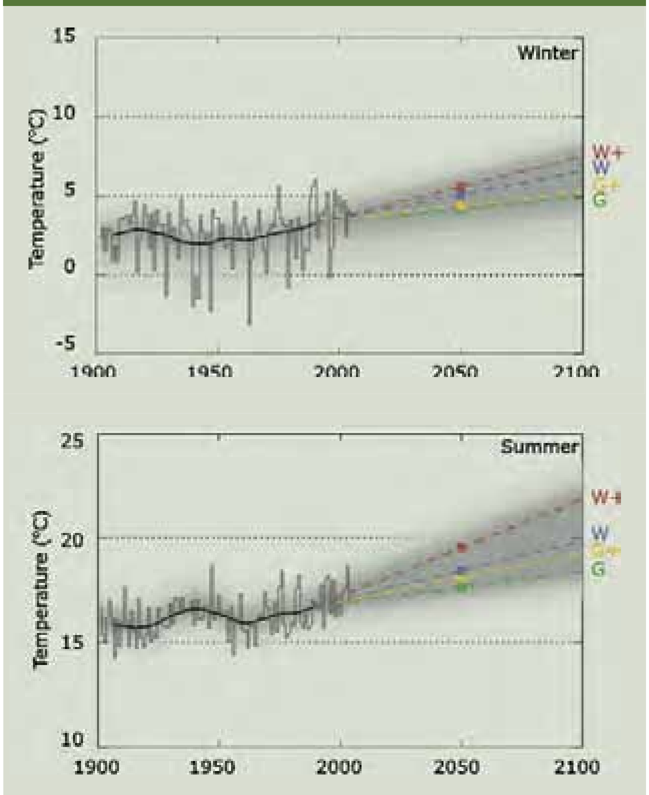
In 2006, the Royal Netherlands Meteorological Institute (KNMI) announced the results of a new study based on four climate change scenarios from the Intergovernmental Panel on Climate Change (Figure 3.7). The projections for 2050 include temperature increases of up to 2.9°C, the possibility of as much as 14% more precipitation in winter, and hotter summers with fewer rainy days but up to 27% more extreme rainfall events. These changes are likely to increase the flow of rivers in winter and the probability of longer dry periods in summer.

Besides a currently projected absolute rise in sea level of 35 to 85 cm by 2100, allowance needs to be made for land subsidence in the west, which will make the relative sea level rise even greater. Accordingly, the Governmental Delta Committee advised in 2008 that the Netherlands should prepare for an overall sea level rise of 0.65 to 1.30 metres by 2100.

These changes will have a definite impact on flood protection measures, water resource availability, the

Map 3.4 The Netherlands

Figure 3.7 Temperature variation in De Bilt, 1900 2005, and the four climate scenarios for 2050



Notes The thick black line represents the 30-year moving average of observed temperatures Coloured dashed lines connect each climate change scenario with the baseline year, 1990 The grey band represents year-to-year variation derived from the observations G denotes a scenario with moderate temperature change and W a scenario with higher temperatures De Bilt, a municipality in Utrecht province, is where KNMI is based

Source van den Hurk et al , 2006

[1] Except where otherwise noted, information in this case study is adapted from the draft *Netherlands Case Study Report*, prepared in 2008 by the Unie van Waterschappen.

Table 3.3 Water use by sector, 2005

	Water abstraction (million m³)			Water use (million m³)			
	Total	Groundwater	Surface water	Total	Groundwater	Surface water	Tap water
Tap water companies	1,256	766	490	0	0	0	0
Agriculture	52	37	15	99	37	15	47
Industry and refineries	3,375	220	3,155*	3,616	220	3,155	241
Power plants	9,771	1	9,770*	9,773	1	9,770	2
Other companies and households	481	1	480	1,279	1	480	799

* Cooling water

Source Statistics Netherlands

environment and the economy. The Delta Committee has drawn up an integrated vision, including risk management and investment components, to help the country cope better with climate change.

State of the resource and water use

Although there are some local water shortages, the presence of large rivers such as the Rhine and its tributaries, as well as the Meuse, ensures that water quantity and water allocation to various sectors are not generally an issue in the Netherlands (Table 3.3). Only 9% of the total annual renewable water resources is used. In recent years, however, periods of low river flow have become more frequent and tended to last longer. Recent studies indicate that water level and water quality and control may be most severely affected during the summer, when longer dry spells are expected. Water shortages and decreasing quality would affect agriculture, navigation, the energy sector (cooling water), nature and tourism. Consequently, the Dutch water management system could face a new challenge of having to allocate freshwater to priority areas. Current national priorities for freshwater allocation are based on minimizing irreversible damage and economic losses.

Policy framework and decision-making

Responsibility for the management of natural water systems in the Netherlands and for protecting residents from flooding is largely allocated to the *Waterschappen* (regional water authorities or water boards) (Box 3.4). The 26 current *Waterschappen* constitute a fourth form of government body in the Netherlands, alongside the central, provincial and municipal governments.

These decentralized public authorities focus on water quality and quantity, water management and flood protection, and wastewater treatment. They are also active in environmental development. (Issues concerning spatial planning and the environment are first vetted by provinces and municipalities.) Sanitation is the joint responsibility of municipalities, which deal with the sewage systems, and the *Waterschappen*, which focus on wastewater treatment. In addition, water supply companies are responsible for delivering safe drinking water. Groundwater is the responsibility of the provinces.

The main challenges

Floods: Floods have always been a major threat in the Netherlands. They can come from storm surges from the sea, high river discharges after heavy rain or snow-melt upstream, or intense local rainfall.

One of the worst floods in Dutch history took place in 1953. A combination of a high tide and a severe windstorm overwhelmed the sea defence structures on the North Sea coast. The extensive flooding caused major

Box 3.4 History and functions of the ***Waterschappen*** (water boards)

The history of the *Waterschappen* goes back to the 13th century. People, mostly farmers, living in the low lying areas of the Netherlands felt the need to organize to improve their living conditions. Over time the *Waterschappen* merged, usually because of extreme circumstances and disasters such as floods. For example, in 1950 there were around 2,500 *Waterschappen*. After a major flood in 1953 and high river levels in 1993 and 1995, the number went down, and is currently 26. The mergers are a response to the increased efficiency and professionalism needed to deal with the growing complexity of water management.

The *Waterschappen* are based on stakeholder participation. They allow local communities to play a direct role in development. The *Waterschappen* function around the three principles 'interest, pay, say': that is, the more benefit an interest group gets from work the *Waterschap* is doing, the larger its contribution to the budget and the more seats it has on the *Waterschap*.

In 2007, the 26 *Waterschappen* together had some 11,000 employees and a combined budget of €2.4 billion to manage about 3,450 km of primary dikes, 55,000 km of watercourses, 7,000 km of roads and 390 treatment plants.

socio-economic losses. More recently, flooding on the Rhine and Meuse rivers in 1993 and 1995 caused hundreds of thousands of people to evacuate homes in low lying areas. Similarly, excessive rainfall in 1998, 2001 and 2002 caused problems in certain areas. These events served as a warning that future floods could have even more disastrous results due to their increasing frequency, magnitude and intensity combined with the very dense land use and population behind the embankments.

Such considerations led the government to take a new approach and make spatial planning an integral part of water management. One significant result was a programme to make more 'room for the river'. In this context, a set of measures was adopted, including deepening the flood plains, moving dikes further from the river, lowering groynes and enlarging river beds. The aim is to create a 'comfort zone' for the river. Unfortunately, ever-increasing urbanization and likely climatic changes mean these measures by themselves will not fully address the problem.

Consequently, the Netherlands has also made substantial investments in real-time monitoring, scenario development, flood forecasting and data collection to increase preparedness and provide early warning. In addition, innovative and comprehensive risk management policies and strategies are being based on the key principles of resistance, resilience and adaptation. This approach, unlike previous practices, considers reinforcing dikes to be a viable option only when other measures are judged too expensive or inadequate.

To limit economic losses associated with floods, a risk-based cost-benefit analysis method is being developed to identify the most cost-effective measures. These include accepting a higher frequency of inundation or controlled inundation in certain areas, or even change in land use. The risk-based approach supports local decision-making while allowing for future spatial planning on a larger scale.

In addition to its national plans and legislation, as a European Union member the Netherlands is meeting its obligations under the Flood Directive and the overall Water Framework Directive.

Expanding and maintaining the water infrastructure

For centuries the Dutch have invested in building structures to mitigate extreme events and regulate water levels and supply in accordance with each sector's needs. Such structures are as expensive to maintain as to construct. Table 3.4 shows the annual costs covered by the Ministry of Transport, Public Works and Water Management, the *Waterschappen* and provincial and local government for flood defence and water management.

Although the country has these complex structures in place and keeps up with the cost of maintaining and expanding them, it is increasingly clear that complete safety and security can never be guaranteed. Faced with this reality, the government is implementing measures and strategies based on the principles of resistance, resilience and adaptation.

Table 3.4 Total cost of water management, 2007

	Cost (million euros)	% of total
Ministry of Transport, Public Works and Water Management	1,405	27
Provinces	165	3
Municipalities	1,100	21
Waterschappen	2,453	48
Total	5,123	100

Conclusions

Throughout the centuries, the Netherlands has defended itself against water-related threats through structural solutions that made it possible to live and work below sea level. However, the impact of climate change on national security, the economy, livelihoods and the environment is weakening the country's resilience against the increasing intensity of extreme events and calls for new responses. Rising sea level, land subsidence, more pronounced variation between wet and dry seasons, an increase in river levels due to intense rainfall, and increasing water demand during warmer summers are just some of the challenges requiring appropriate adaptation strategies. Acting on the advice of the Delta Committee, authorities are already taking measures relying on a mix of spatial planning, risk analysis and technical innovation. Stakeholder consultation and public participation remain the core of any solution.

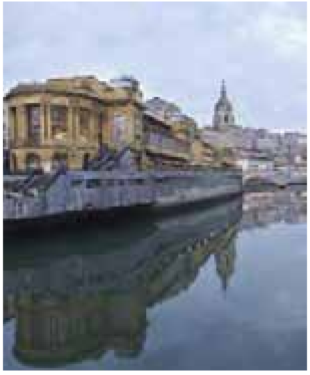
References

Netherlands Water Partnership. 2006. *Water in the Netherlands 2004 2005 and Riool in Cijfers [Sewerage Statistics]* 2005–2006. Waterland Water Information Network. www.waterland.net (Accessed December 2008.)

Unie van Waterschappen. Forthcoming. *Netherlands Case Study Report: Climate Change and Dutch Water Management*. The Hague, Unie van Waterschappen (Association of Water Boards).

Van den Hurk, B., Klein-Tank, A. et al.. 2006. *KNMI Climate Change Scenarios 2006 for the Netherlands*. De Bilt, Netherlands, Royal Netherlands Meteorological Institute. (Scientific Report WR-2006-01.)

Spain: the Autonomous Community of the Basque Country



With a long history of floods and a risk of drought, Basques know how important it is to plan ahead while protecting ecosystems and water quality. Building on a new regulatory framework in line with European Union directives, they are implementing strategies to anticipate, mitigate and manage these risks, along with new ones linked to climate change and variability.

Setting the scene

The Autonomous Community of the Basque Country is located in the northern part of the Iberian Peninsula along an Atlantic coastline of 209 km (Map 3.5). Its population of 2.1 million (2005) is dispersed over 7,234 km^2 of very mountainous territory. On the slopes facing the sea, an Atlantic climate brings moderate temperatures and abundant rainfall. In the interior, the climate is more Mediterranean, characterized by hot, dry summers and scant precipitation. The region has been enjoying steady economic growth and a per capita income that is higher than the European Union (EU) average.[1]

Climate change and variability: looking ahead

Although no statistically significant changes have been observed in the hydrological cycle so far, the Basque Sustainable Development Environmental Strategy 2002 2020 plans for and reflects the current understanding that the uncertainties introduced by climatic variation and climate change translate into a potential risk to the environment and socio-economic development. The Basque Climate Change Office was established to address this potential risk, and the Basque Plan to Combat Climate Change was drafted in 2006 (Box 3.5). As part of this effort, the Basque Water Agency has initiated an in-depth study to determine what measures related to water resources need to be taken in the event of variation from current climatic conditions over 2011 2040. The study will allow the agency to further improve its database on impacts and to align itself with the best international practices for adapting to climate change.

State of the resource and water use

Of the 24 major river basins in the Basque Country, 14 empty into the Atlantic Ocean and the rest flow towards the Mediterranean Sea, with the Cantabrian Mountains forming the Atlantic-Mediterranean divide. For the rivers that empty into the Atlantic, major industrial and urban development on the river banks and pollution caused by these activities are the main and most extensive pressures. The high topographical relief of the region, for example, makes it possible for effluents to spread easily.

Another major source of pollution is agriculture, including forestry. It is largely practised in the Mediterranean basins, which account for some 4,500 km^2 or 62.4% of the Basque Country territory. Of this area, about 850 km^2 is cultivated; meadows and pasture cover around 1,500 km^2 and the

The second edition of the *World Water Development Report* included a case study on the Basque Country (UNESCO-WWAP, 2006). The present case study builds upon the findings of the previous one. It emphasizes current policy development efforts, which include strategies to mitigate the effects of climatic variation and climate change and a legal and political framework for the full implementation of integrated water resources management with stakeholder involvement.

Map 3.5 The Basque Country

[1] Except where otherwise noted, information in this case study is adapted from the draft *Autonomous Community of the Basque Country Case Study Report*, prepared in 2008 by the Basque Water Agency and UNESCO-Etxea.

Box 3.5 Methodology for assessing the cost of climate change in the Basque Country

The Department of Environment and Territorial Management of the Basque Country Government has developed a methodology for analyzing the impact of climate change on the Bilbao metropolitan area. The methodology makes it possible to calculate the economic costs associated with climate change and to select cost-efficient adaptation measures.

The methodology contemplated three possible scenarios: a basic scenario (current situation), a reference scenario (a future projection not taking climate change into account) and a climate change scenario (basically, the reference scenario incorporating climate change criteria). Mean annual damage in the basic scenario was put at between €224.65 million and €275.09 million, with the bulk of the cost involving residential properties. It should be noted that the economic damage caused by floods in August 1983 was equivalent to around €930 million (in 2005 prices). Mean annual damage in the reference scenario ranged from €229.25 million to €281.27 million, and that in the climate change scenario from €358.46 million to €439.77 million (in 2005 prices).

Thus, the variation in costs attributable to climate change that is, the difference between the cost estimated in the climate change scenario and that in the reference scenario was between €129.21 million and €158.50 million. By anticipating the problem and taking appropriate adaptation measures, the city of Bilbao could reduce the cost of damage incurred by a hypothetical flood by more than 50%. This conclusion led to establishment of the interdepartmental Basque Climate Change Office in January 2006. The office was responsible for drafting and launching the Basque Plan to Combat Climate Change.

Source Ministry for Environment and Territorial Planning

remaining land is used for timber production. Current water demand for agriculture amounts to 34.94 million m^3 per year, which corresponds to 9.14% of total water consumption in the Basque Country. The agricultural sector is not a significant contributor to GDP, but its environmental impact is getting more pronounced through increasing pollution in both surface and groundwater, due especially to the nitrates in fertilizers. Furthermore, pesticide concentrations in water resources occasionally exceed standards.

Industry plays a dominant role in the Basque Country economy, accounting for some 28% of overall water withdrawals (91 million m^3) and, in 2007, 29.8% of GDP (Eustat, 2008). Initiatives under the 2002 2020 environmental strategy aim to reduce the high contaminant load in industrial effluents.

Overall, freshwater demand is much lower than the available supply. Nevertheless, interbasin water transfers are made to alleviate local water stress. For example, the Zadorra, Ullibarri and Urrunaga reservoirs in the Ebro region link to the Undurraga reservoir in the north and provide water to the Bilbao-Bizkaia Water Consortium, which supplies water to several municipalities, most notably Bilbao, the largest city in the Basque Country.

The hydroelectric sector comprises a little over 100 plants, most of them mini-hydropower stations with no significant regulation. There may be potential to develop hydropower further. In its 2010 Energy Outlook, issued in 2001, the Basque Country Government states its intent to improve energy efficiency to save energy, diversify sources of energy production, increase the level of self-sufficiency in energy production and substantially reduce the environmental impact of energy production.

With its climatic, geographical and topographical features, the Basque Country is very rich in flora and fauna: over 3,000 plant species and 400 vertebrate species. The 2006 Water Act of the Basque Country specifies that the minimum flow reserved for environmental purposes is not classified as water use and needs to be taken into account in basin planning. Some 20.3% of the territory (1,470 km^2) lies within the Network of Protected Natural Spaces, including natural parks and the Urdaibai Biosphere Reserve. The network includes many areas linked to aquatic environments that have been declared Sites of Community Importance under the European Council Habitats Directive.

Policy framework and decision-making: coming into line with EU directives

Spain’s 1985 Water Act defines water as a state owned asset. Under the Act, river basins crossing territories of multiple autonomous communities are managed by 15 river basin agencies known as hydrographic confederations. The Basque Country Government is mainly responsible for the basins that are confined to its territory. However, under a 1994 decision it also plays a functional role as regards the intercommunity basins on its territory, although the river basin confederations remain the principal decision-making bodies.

The Basque Country is obliged to comply with the EU Water Framework Directive, which sets priorities for the protection and improvement of all water resources and aquatic habitats. The 2006 Water Act aims to establish the mechanisms necessary to put relevant EU policies into practice, including the creation of a regulatory framework. The Act also led to the establishment of the Basque Water Agency, which began operating in January 2008 and is the central instrument for implementing water policy in the Basque Country.

The Basque Country Water Act also allows for a participatory approach in decision-making. The Basque Water Agency has initiated comprehensive consultation with sector representatives and the public to lay the foundation for an all-inclusive water management policy. Two advisory bodies, the Users’ Assembly and the Basque Country Water Council, work with the Basque Water Agency in this participatory process. The Users’ Assembly includes representatives of the Basque Parliament, the Basque Government, the Basque water operators and other local governments and institutions. The Water Council broadens the participation to other stakeholders, such as municipalities and representatives of environmental conservation groups.

The 2006 Water Act also deals with valuing water. Cost recovery is assured through the setting of tariffs differentiated by use. Because the management system in place is efficient, water services can recover a high percentage of their costs. In addition, an ecological tax is imposed to deter polluters, reduce water consumption and support the conservation, protection and restoration of the environment, including aquatic ecosystems. The tax is also aimed at funding measures to maintain environmental services and achieve good ecological conditions for water bodies, in compliance with the EU Water Framework Directive.

In July 2008, the Basque Country Government Council established a solidarity initiative supporting sub-Saharan countries' efforts to meet the water and sanitation targets of the Millennium Development Goals (MDGs). In so doing it agreed to allocate 5% of the ecological tax revenue for this purpose (see section 15.5 on sustainable financing in the third edition of the *World Water Development Report*).

The main challenges

Floods: Due to its topographic features and abundant rainfall, the Basque Country experiences frequent flood alerts. Bilbao alone has recorded 39 events classed as natural disasters. Early records of floods in the region date back to the 15th century. More recently, large-scale floods occurred in October 1953, June 1975, June 1977, August 1983, July 1988 and February 2003. The 1983 flood, in particular, claimed 34 lives and caused damage amounting to about €930 million.

To minimize socio-economic risks associated with floods, the Basque Water Agency has produced flood risk maps illustrating the extent of floods over the last 10, 100 and 500 years. They are used to establish land use criteria based on flood vulnerability. In 2007, the European Union passed a directive concerning the evaluation and management of flood risks. In support of this directive, a Spanish Royal Decree in 2008 incorporated risk management into public water management. Such policy measures are backed up by structural measures, including construction of drainage channels in highly urbanized areas, demolition of structures that cover rivers and obstruct flow (e.g. obsolete bridges and abandoned hydraulic structures such as water wheels and dams), rehabilitation of river beds and improvement of drainage capacity.

Drought: Although drought is unexpected and exceptional in the Basque Country, it is within the natural range of climatic variation. Two prominent drought periods took place from 1940 to 1950 and from 1989 to 1990. To minimize the environmental, economic and social effects of drought, a hydrological plan and the Special Action Plan in Situations of Urgency and Possible Drought, known as PES (Plan Especial de actuación en situaciones de alerta y eventual Sequía), were approved for the Ebro and Norte basins in 2007.

Basque Country administrative bodies are adopting various mechanisms to improve water supply and demand management under normal conditions and to deal with extreme episodes of drought with as little disruption to water supply as possible. These measures will be used to counterbalance the possible effects of climate change, especially in areas with the drier Mediterranean climate. To this end, the Basque Country Government has carried out research projects on increasing efficiency in the current use of water and harnessing additional resources, under both normal and extreme conditions. Examples include connecting intra- and intercommunity basins and modifying the use of reservoirs and groundwater abstraction in line with prevailing climatic conditions. Of particular note is a series of studies on improving water supply to the metropolitan areas of Bilbao and the Basque Country capital, Vitoria-Gasteiz.

Conclusions

As the second edition of the *World Water Development Report* concluded, the central challenge for the Basque Country is to define and successfully implement a series of case-specific and efficient programmes to protect and improve the status of valuable water resources and associated ecosystems. This is being done through the 2006 Water Act, which enforces relevant EU legislation while creating the legal framework for active involvement of all stakeholders. Basque Country authorities are also working on institutional development to plan for and mitigate potential risks associated with climate change and variability. The establishment of the ecological tax not only helps protect the environment but also, through the solidarity initiative, allows Basque officials to set a precedent for an innovative funding mechanism to support developing country achievement of the water and sanitation targets of the MDGs.

References

Basque Water Agency/UNESCO-Etxea. Forthcoming. *Autonomous Community of the Basque Country Case Study Report*. (Basque Water Agency: www.uragentzia.net)

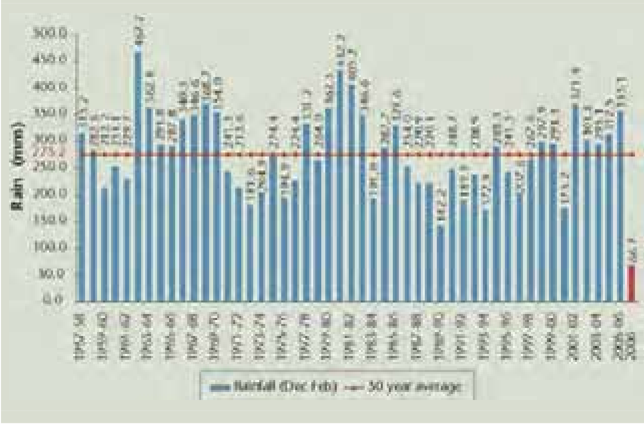
Euskal Estatistikar-Erakundea (Eustat). 2008. Press release on Basque Statistical Yearbook 2008. Vitoria-Gasteiz, Eustat.

UNESCO-World Water Assessment Programme (UNESCO-WWAP). 2006. The Autonomous Community of the Basque Country. *Water, a shared responsibility: The United Nations World Water Development Report 2*. Paris/Oxford, UNESCO/Berghan Books. www.unesco.org/water/wwap/wwdr2/case_studies/pdf/basque_country.pdf

Turkey: Istanbul

In coping with the challenges and demands of a megalopolis suffering the effects of an unplanned urban boom, officials are relying on significant infrastructure investment, public information campaigns and better enforcement of city planning regulations.

Figure 3.8 Combined rainfall in Istanbul for December, January and February, 50 year average



Background

Istanbul, located in north-western Turkey, has a population of over 12 million (Turkish Statistical Institute, 2007). Home to 17.6% of the country's population, it is the largest city in Turkey and one of the 25 largest in the world. Uniquely, by virtue of its situation straddling the Bosphorus strait, it has a presence on both the European and Asian continents (Map 3.6).[1]

Climate change and variability: anticipating problems

Although the data do not indicate a clear declining trend in rainfall in Istanbul and its surroundings (Figure 3.8), extreme events especially droughts seem more pronounced than in the past. In 2006, the measured rainfall of 66.7 mm was the record low for the previous 50 years, a period during which the average was 257.2 mm per year. Furthermore, the water level in reservoirs serving the city was just 45% in 2004, and plummeted to around 25% in 2007 and 2008 (ISKI, 2008). Officials at Istanbul Water and Sewerage Administration (ISKI), using the Inter-governmental Panel on Climate Control scenario of a 2°C temperature increase by 2030, have estimated the likely decrease in total reservoir capacity due to higher evaporation rates. Their calculations revealed that the water potential of the city might drop by as much as 14% over the next two decades. This projection, coupled with water demand scenarios, indicates that the onset of a water crisis is likely by 2030. In response, remedial actions are being taken, ranging from water saving campaigns (Box 3.6) to projects transferring water to Istanbul from as much as 150 km away.

State of the resource: monitoring, water transfer and expanded treatment facilities

Water to meet the needs of metropolitan Istanbul comes from the Marmara and Melen basins, whose combined water potential (including artificial storage) amounts to about 3.34 billion m^3. Groundwater resources are limited; their annual potential is around 0.175 billion m^3. To protect this precious resource, regulations prohibit the drilling and operation of wells without obtaining a permit. Depending on quality, some groundwater resources are mainly used for drinking water supply while others meet water needs in industry. However, uncontrolled settlement and over-abstraction have

Map 3.6 Istanbul

[1] Except where otherwise noted, information in this case study is adapted from the draft *Istanbul Case Study Report*, prepared in 2008 by ISKI and DSI.

Box 3.6 Water saving campaigns

Given climatic variation and the lower than average rainfall of recent years, water saving campaigns are now considered an important measure for raising awareness among Istanbul residents about climate change and its impact, and for promoting sustainable use of the limited freshwater resources.

For example, the 'Don't Waste Your Water' campaign, a joint effort of the Turkish Foundation for Combating Soil Erosion, for Reforestation and the Protection of Natural Habitats (TEMA) and the Istanbul Metropolitan Municipality, proved quite effective. It resulted in a decline in daily water consumption from 2.35 million m^3 to 1.9 million m^3 by promoting basic water saving methods that households can apply. ISKI estimated that 18 million m^3 of water was conserved during the course of the campaign.

Such campaigns also pave the way towards implementation of the EU Water Framework Directive, which focuses heavily on the need to keep the public well informed about water management issues and to devise participatory approaches for solving problems.

Source Istanbul Water and Sewerage Administration

diminished groundwater levels and led to saltwater intrusion in coastal areas. The decline in the water table due to unsustainable abstraction ranges from 30 metres to as much as 150 metres in some areas. Both surface and groundwater quality is monitored through 51 observation stations scattered throughout the two basins.

In 2007, the amount of water resources in use was 1.42 billion m^3. This means 40% of the water potential is being exploited, on average. However, geographic and seasonal disparities in the distribution of water resources, coupled in recent years with severe drought, have necessitated interbasin water transfer projects to provide more water where needed in Istanbul. For example, the Melen Project Phase I, which became operational in December 2007, supplies an additional 0.27 billion m^3 of water per year. With the full realization of similar projects, some 66% of the potential water resources would be made available for use.

As of 2007, ISKI operated six large water treatment plants and a number of smaller units. ISKI's master plan for water, which included construction of treatment plants, was based on projections of population growth and an accompanying increase in water demand. However, the projections proved to be overestimates, and the treatment plants currently operate at 61% of capacity. Although the existing plants can keep up with population growth in the near future, new facilities are being planned and constructed to assure the long term needs of the Istanbul metropolitan area.

Some 0.2 billion m^3 of treated wastewater is discharged from Istanbul into the sea every day. To make more efficient use of water resources and cope with periods of drought, water recycling plants are being planned, with the first one expected to be operational in 2009.

Institutional mechanisms for water and sanitation service provision

In its long history, Istanbul has served as the capital of many great civilizations. During the time of the Ottoman Empire (ca 1299 1922), water structures dating from Roman times were improved and extended, and aqueducts, reservoirs, wells and cisterns were added to improve freshwater supply to a growing population. After 1923, when the Republic of Turkey was founded, the Istanbul Water Administration (ISI) took over responsibility for managing the city's water resources.

Intensive internal migration to Istanbul resulted in a population boom and unplanned urbanization in the shape of shanty towns on the outskirts of the city. These conditions, which made it all but impossible for the ISI to meet everyone's water and sanitation needs in a city astride two continents, necessitated the establishment of institutions with the financial and human resources needed to cope with the challenges. Today, ISKI and the General Directorate of State Hydraulic Works (DSI) are the main institutions responsible for developing water resources for Istanbul. DSI was founded in 1954 and is responsible for planning, managing and developing all water resources in Turkey. ISKI, founded in 1982, is charged with setting up and maintaining water and sanitation infrastructure, managing surface and groundwater resources for domestic and industrial use, collecting, treating and disposing of wastewater, and protecting water resources from pollution. It is also responsible for river rehabilitation within greater Istanbul.

Although investment by both institutions has helped address water-related problems in Istanbul, a lack of coordination among various agencies dealing with water management in the city, combined with a complex and fragmented division of authority that makes it difficult to enforce regulations, is a critical issue that stands in the way of effective water governance.

The main challenges

Service coverage and expansion of the metropolitan area: In 1900, Istanbul was one of the few cities in the world with a population of 1 million, and it took almost 70 years for this number to double. However, with the onset of east to west migration in the mid-1970s, the population more than quadrupled in just 20 years' time, reaching some 6.6 million in 1990. Since then the population has again almost doubled, making Istanbul one of the world's 25 most populous cities. Most of its estimated 12 million people live on the European side. In 2004, the borders of the city were extended significantly, increasing ISKI's service area from 1,972 km^2 to 5,342 km^2 (or 6,500 km^2 if one includes the basin areas outside the provincial borders). These figures make clear the sheer magnitude of the challenge involved in providing basic water and sanitation services to the city.

However, thanks to significant investment, which especially gained momentum from the mid-1990s to total US$3.6 billion between 1994 and 2004, the water supply and sanitation infrastructure has improved considerably. Water storage capacity, for example, increased from 0.59 billion m^3 in 1994 to 1.17 billion m^3 in 2005. In addition, ISKI formulated the Water Master Plan in 2004 to address long term needs to 2040 by taking into account population estimates, water demand, water resources availability, water purification and sewerage work, etc. The plan includes new large water supply projects, such as pipelines to bring water from the Asian side to the European side (e.g. the Melen Project), to meet projected demand (Altınbilek, 2006).

River improvement and environmental protection: River improvement projects are necessary to ameliorate the quality of urban life and protect residents from socio-economic hazards associated with flooding. They become even more critical in densely populated settlements like Istanbul, where the rate of infrastructure expansion cannot keep up with the increase in demand stemming from continued internal migration. Such unplanned growth also creates serious problems with enforcement of urban planning rules and building codes.

Many projects have aimed to restore the quality of rivers that had turned into open sewers, especially during the 1990s. Unfortunately, due to a lack of financial resources, only 313 km of the 1,825 km of streams within the boundaries of the Istanbul Metropolitan Municipality have so far been improved.

The best example of environmental restoration in Istanbul concerns the Golden Horn. Once the pearl of Istanbul, the Golden Horn became an environmental disaster after its surroundings turned into an unplanned industrial zone housing docks, factories and warehouses. By 1985 around 700 industrial plants and 2,000 workshops had been opened along the Golden Horn. Hundreds of thousands of tonnes of waste were dumped directly into the waterway every year, gradually destroying all aquatic life. Finally, in the late 1980s, the Istanbul Metropolitan Municipality Government and ISKI joined forces to save the Golden Horn by constructing wastewater collectors, tunnels, pumping stations, wastewater treatment plants and related utilities, thus revitalizing the environment of the area. The Golden Horn Environmental Protection Project, with a total cost of some US$650 million, received first prize in 2002 from the World Association of the Major Metropolises (Altınbilek, 2006).

Unplanned urbanization: Unplanned urbanization through illegal construction is a serious problem in Istanbul. It entails risks of socio-economic losses, especially if structures are built in flood prone areas like those near river embankments. Such settlements are either not connected or illegally connected to water supply and sanitation infrastructure. Illegal connections can lead to water pollution, environmental degradation, and discontinuity in service provision due to resultant malfunctioning of local infrastructure. The combination of these factors often leads, in turn, to health problems. As part of an effort to prevent illegal urban development in protected water basins, ISKI uses remote sensing technology to run a basin information system for periodic monitoring of structural changes in its service area. The system has allowed municipal authorities to detect illegal construction in a relatively short time and to intervene accordingly.

Conclusions

Istanbul is one of the great metropolitan areas of the world, but it is suffering from unplanned and accelerating urbanization. Seasonal and geographic variations in water availability, coupled with pollution and wasteful water use, put the resource under ever-increasing pressure. The authorities are working seriously to address quality issues and improve the coverage of water supply and sanitation services. Nevertheless, there is still some progress to be made in terms of service provision, public awareness raising, implementation of laws and regulations, and the much needed political will to move forward.

References

Altınbilek, D. 2006. Water Management in Istanbul. *Water Resources Development*, Vol. 22, No. 2, pp. 241–53.

Istanbul Water and Sewerage Administration (ISKI). 2008. *Barajların Doluluk Oranları [Water level in reservoirs]*. http://www.iski.gov.tr/web/statik.aspx?KID=1000717 (Accessed December 2008.)

Istanbul Water and Sewerage Administration (ISKI)/General Directorate of State Hydraulic Works (DSI). 2008. *Istanbul Case Study Report*. (Draft.)

Turkish Statistical Institute. 2007. 2007 Nüfus Sayımı Sonuçları [2007 census results]. http://www.scribd.com/doc/1250825/TUK-Adrese-Dayal-Nufus-Kayt-Sistemi-2007-Nufus-Saym-Sonuclar (Accessed October 2008.)

4

Latin America and the Caribbean

Overall, Latin America is the richest region in terms of available freshwater resources per capita. The two transboundary case studies, involving Argentina, Bolivia, Brazil, Paraguay and Uruguay, were conducted in areas endowed with abundant water resources and spectacular biodiversity. Fertile land assures food security while waterways allow transport of goods to regional and international markets. The richness of the region is, however, under increasing human and climatic pressures. Progress towards reaching water- and sanitation-related Millennium Development Goals, wide recognition of the concept of integrated water resources management, and a decrease in poverty are a few of the encouraging signs that the region will be able to overcome these pressures.

Argentina, Bolivia, Brazil, Paraguay and Uruguay: La Plata River basin

The frequency and magnitude of extreme hydrological events have been increasing in the economic centre of South America over the last 40 years as a consequence of major land use changes and climatic variability, with significant social and economic costs.

Setting the scene

Extending over 3.1 million km^2, La Plata River basin is the second largest river system in South America and the fifth largest in the world. Shared by Argentina, Bolivia, Brazil, Paraguay and Uruguay, it covers about one-fifth of South America (Map 4.1). With over 100 million inhabitants, close to 50 big cities and 75 large dams, La Plata River basin is at the core of the region's socio-economic activities, which generate around 70% of the per capita GDP of the five basin countries.[1]

With its extensive geographic coverage, La Plata River basin is highly variable topographically, ranging from 4,000 metre high mountains in north-western Argentina and southern Bolivia to almost sea level southern plains in Argentina and Uruguay. Rainfall similarly varies, from less than 700 mm per year in the western Bolivian highlands to more than 1,800 mm per year along the Brazilian coast in the east.

The second edition of the *World Water Development Report* included a comprehensive assessment of the water resources of the basin (UNESCO-WWAP, 2006). The present case study builds upon those findings.

Climate change and variability

The regional climate is significantly affected by El Niño-Southern Oscillation (ENSO), which is accompanied by heavy rains, often resulting in catastrophic flooding. This large-scale global event produces complex variations that have a major impact on the climate and, consequently, on the basin's hydrology, and that greatly affect its population and economy.

An upward trend in rainfall has been observed in the south of subtropical Argentina since the 1960s and in southern Brazil and northern Argentina since the mid-1970s. Analysis of the mean discharge in the Paraná, Paraguay, Uruguay and La Plata sub-basins shows a similar trend. Measurements taken at Corrientes station on the Paraná River indicate increases of 16% in annual rainfall and 35% in discharge. The trend is thought to be linked partly to changes in land use, such as deforestation and increased soybean cultivation in Brazil, Paraguay and Argentina.

In addition, floods have been more frequent in La Plata River basin. Twelve of the 16 biggest monthly discharges ever recorded on the Paraná River have occurred since the 1970s; they included catastrophic ENSO events in 1982/1983, 1991/1992 and 1997/1998. Similar trends are observed for the Paraguay and Uruguay rivers. For example, two-thirds of the major floods in Paraguay's capital, Asunción, which is located near the Paraguay River, were recorded in the last quarter of the 20th century. For the Uruguay River, the 16 greatest daily discharge peaks were recorded after 1970. All these significant variations can be associated with climate change.

An important impact of climate change and climatic variation is expected to be on water availability for agriculture, with the effects varying considerably by location. For example, existing water supply problems in northern Argentina may worsen, necessitating changes in crop type and cultivation frequency, as well as better irrigation and drainage methods. Conversely, agricultural water supply in south-eastern Brazil is expected to increase (Magrin et al., 2007).

State of the resource and water use

In terms of freshwater potential, the Paraná River is the most important in La Plata River basin, with a mean annual flow of about 17,100 m^3 per second (m^3/s) at Corrientes. The Uruguay River has a mean annual flow of about 4,300 m^3/s, while the Paraguay River has the lowest capacity, with a mean annual flow of some 3,800 m^3/s at Puerto Pilcomayo (UNESCO-WWAP, 2006). The basin is also rich in groundwater resources. The Guaraní aquifer, shared by all five countries except Bolivia (Table 4.1), is one of the world's largest groundwater reservoirs, extending over 1.19 million km^2 and having an estimated capacity of 37,000 billion m^3. Of this, 40 billion m^3 to 80 billion m^3 per year is exploited, mainly in Brazil for consumption in over 300 cities.

Map 4.1 La Plata River basin

[1] Except where otherwise noted, information in this case study is adapted from the draft *La Plata River Basin Case Study Report*, prepared in 2008 by Víctor Pochat.

Table 4.1 Distribution of the Guaraní aquifer in La Plata basin

Country	Share of aquifer (%)
Argentina	19
Brazil	71
Paraguay	6
Uruguay	4

Of the overall agricultural area in La Plata River basin, the share of irrigated land is relatively low, varying from 2% in Paraguay to 15% in Uruguay. On the other hand, in all the basin countries agriculture holds the largest share of overall water consumption: from 62% in Brazil to 96% in Uruguay (FAO, 2004). Extensive rice production, and agricultural development projects undertaken since 1996, underlie this phenomenon; rice is one of the main irrigated crops in the basin. Moreover, increased average annual rainfall, coupled with the promotion of soybeans as the key crop, has resulted in expansion of agriculture, especially towards historically arid and semi-arid zones. Total combined soybean production in Argentina, Bolivia, Brazil and Paraguay is expected to rise by about 85% by 2020. Changes in land use and the potential effects of climate change could lead to salinization and desertification in the basin.

With regard to efforts under the Millennium Development Goals (MDGs) to halve the proportion of people suffering from hunger, Uruguay met this target in 2003, but the other basin countries have yet to do so (Table 4.2).

In general, poverty indicators are trending downwards in the basin countries (Table 4.3). From a reference year of 2002, Argentina has taken a significant leap forwards in alleviating poverty. The progress made by Brazil, although modest in appearance, represents some 6 million people lifted out of extreme poverty (ECLAC, 2007b).

Table 4.2 Progress towards halving hunger

	% of undernourished people in total population		Ratio 2001 2003/ 1990 1992*
Country	1990 1992	2001 2003	
Argentina	2	3	1.5
Bolivia	28	23	0.8
Brazil	12	8	0.7
Paraguay	18	15	0.8
Uruguay	7	3	0.4

* A ratio of 0 5 or lower signifies achievement of the MDG target

Source FAO, 2006

Table 4.3 Progress in alleviating poverty

	Poverty (%)			Extreme poverty (%)		
Country	2002	2005	2006	2002	2005	2006
Argentina	45.4	26.0	21.0	20.9	9.1	7.2
Bolivia	62.4	63.9	n.a.	37.1	34.7	n.a.
Brazil	37.2	36.3	33.3	13.2	10.6	9.0
Paraguay	61.0	60.5	n.a.	33.2	32.1	n.a.
Uruguay	15.4	18.8	18.5	2.5	4.1	3.2

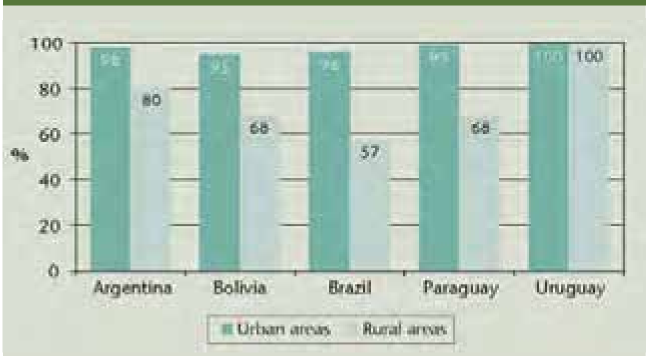
Note n a : not available

Source ECLAC, 2007b

Industrial water demand varies among the four main sub-basins. Demand is highest in the Paraná River sub-basin due to the major industrial areas in Brazil's São Paulo state and the Buenos Aires-Rosario region in Argentina. Although large rivers like the Paraná have a high self-cleaning potential, contamination by industrial, agricultural and household effluents is causing major environmental degradation, especially along the banks of the lower Paraná.

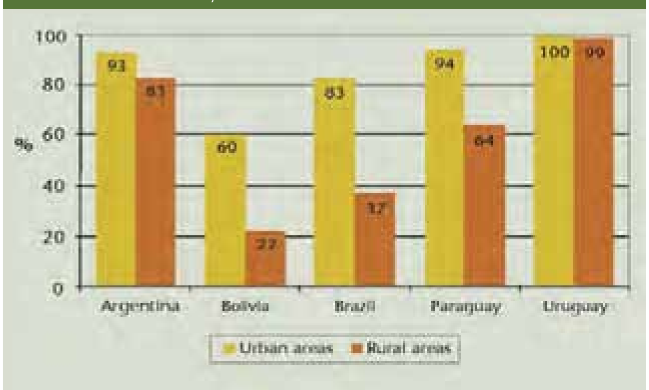
Urbanization is one of the biggest drivers of change in La Plata River basin. From the 1960s to the early 2000s, the share of urban dwellers in the region's population increased from about 45% to 86.6%, mainly through internal migration. In general, access to safe water coverage is better in urban than in rural areas (Figure 4.1). However, the data in the figure represent best case scenarios. Problems stemming from poorly maintained infrastructure and intermittence of service provision mean actual service is generally much poorer. In Uruguay, for example, water loss ranges from 46.2% to 54.4% (Gobierno de la República de Uruguay, 2001). Urban-rural discrepancies are also observed in access to improved sanitation. The gap in access to sanitation services in all basin countries except Uruguay varies from around 10 percentage points to more than 40 (Figure 4.2). Lack of

Figure 4.1 Population with access to safe drinking water, 2004



Source ECLAC, 2007a

Figure 4.2 Population with access to improved sanitation services, 2004



Source ECLAC, 2007b

Box 4.1 Meeting growing energy needs with biofuel production

Access to electricity, in terms of percentages of households and persons served, is high in La Plata River basin, varying from 64.4% in Bolivia to 96.5% in Brazil (IEA, 2006). Although non-renewable sources make up the bulk of energy production in the basin, oil use fell and natural gas consumption rose between 2002 and 2005. While the use of renewable energy sources decreased during the same period, biofuel use grew, thanks mainly to the strong development of the ethanol industry in Brazil (Ruiz Caro, 2007).

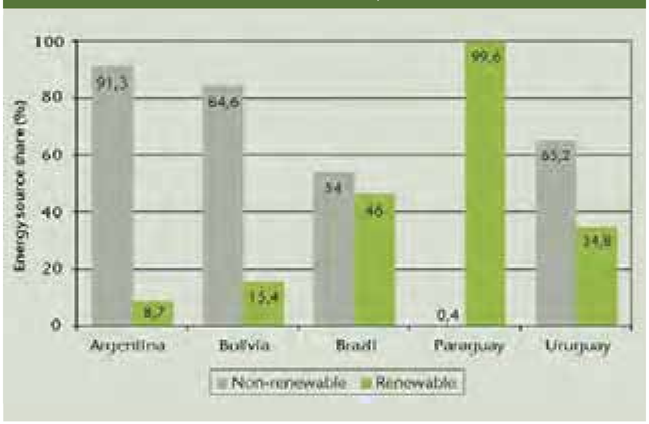
Brazil is one of the world's major biofuel producers, and the first to make ethanol from sugar cane. In 2005, Brazil accounted for 47.9% of world ethanol output (IEA, 2006). Producing ethanol from sugar cane generally puts less pressure on land and water resources than maize or other crops used for the purpose. Soil productivity in sugar cane fields is preserved by recycling the nutrients in sugar mill waste. In addition, most sugar cane production in Brazil does not require irrigation. Moreover, ethanol combustion emits 90% less CO_2 than the burning of conventional fuels such as gasoline (IEA, 2006).

sewage treatment facilities means effluents are often directly discharged into streams that are used as a water source downstream. Shanty towns in periurban areas suffer the most: water and sanitation coverage is lower or non-existent in these areas. This situation, in turn, increases the risk of water-related disease. Unfortunately, problems related to slums in the region are reported to have worsened since the 1980s (Von Cappeln, 2002).

Energy production in La Plata River basin is mainly based on non-renewable sources (Figure 4.3). However, hydropower, whose potential in the basin is huge, has a considerable share in electricity generation in all five countries. Indeed, Paraguay depends almost entirely on hydropower for its electricity generation, and dams on the Paraná River generate about 46% of the electricity used in Brazil (CIC, 2004*a*). Roughly 60% of the basin's hydropower potential is exploited. Among more than 100 hydropower plants in the basin (including those under construction), some are bilateral projects, such as Itaipú (Brazil and Paraguay), Yacyretá (Argentina and Paraguay) and Salto Grande (Argentina and Uruguay). Biofuel also plays a role in the energy supply, especially in Brazil (Box 4.1).

Waterways in La Plata River basin have been navigated since the 16th century. The Paraguay and Paraná rivers form a natural north-south transport corridor, connecting the five riparian countries to the Atlantic Ocean. The Hidrovía Paraguay-Paraná project, a waterway that would run from Puerto Cáceres in Brazil to Nueva Palmira in Uruguay, was proposed in the late 1980s because of the continuous maintenance requirements of the natural corridor.

Figure 4.3 Breakdown of energy supply: renewable and non-renewable sources, 2004



The Hidrovía would be a complex navigation system allowing year-round navigability by ships and barge trains. The aim is to promote regional development by reducing goods transport costs, improving links with commercial centres and providing landlocked Bolivia and Paraguay with a sea outlet (UNESCO-WWAP, 2006).

However, the project would entail extensive dredging, construction of dikes and levees, and channel straightening. The environmental impact of the work could prove to be extensive and diverse. In particular, the project could significantly modify the flow regime of the Pantanal, the world's largest freshwater wetland, risking serious damage to the site. Such a change would affect not only biodiversity, but also water levels at the confluence of the Paraná and Paraguay rivers. Other issues include the risk of alteration of natural aquifer systems and increased water contamination should the waterway lead to growth in the local population, in commercial and industrial activities and in irrigation (UNESCO-WWAP, 2006).

Another key navigation corridor in the region, which would be linked to the Hidrovía, is the 2,400 km Tietê-Paraná waterway in Brazil. It facilitates transport of up to 2 million tonnes per year of grain and other goods between states in Brazil and between Brazil and the other La Plata River basin countries.

Policy framework and decision-making

Since 2006, Argentina has progressed in its preparation of a national water resources plan, which involves collaboration between the central and provincial governments and that of the Autonomous City of Buenos Aires. The plan sets forth actions to improve water quality and quantity, to better manage demand from the various sectors and to mitigate the impact of extreme events. An important change in the water sector has been the renationalization of several water supply and sanitation services that were privatized in the 1990s. The move involved cancelling the contract of an international company serving the Buenos Aires metropolitan area, home to about one-third of the country's population. To maintain continuity of water and sanitation services, the government created another company, in which it holds 90% of the stock (NotiSur, 2006).

Bolivia created the Ministry of Water (Ministerio del Agua) in January 2006 with the overarching aim of protecting the inhabitants' right to water. The move came in response to strong popular reaction against private water companies in 2000 and 2005. Henceforth, all water companies operating in Bolivia are to be public companies, and are expected to follow an efficient and transparent public model. The ministry is in charge of (a) protecting and managing Bolivia's water resources, including monitoring the cumulative impact of mining and oil production; (b) improving irrigation; and (c) providing water supply, sanitation and solid waste management services. The ministry also aims to respect traditional knowledge and customs and to protect cultural diversity. Meanwhile, the government is considering a proposed law on water and sanitation services. Under the title 'Water for Life', this new legal framework would replace the current water regulating agency with a decentralized one. It would also reform water supply provision to better integrate municipalities and users and to prioritize social values (Alliance for Democracy, 2006).

In January 2006, the National Water Resources Council of Brazil approved the national water resources plan to establish guidelines and public policies aimed at increasing the quantity and quality of the water supply and improving demand management. The plan adopts a river basin approach and considers water to be a public good, a position essential in promoting sustainable socio-economic development. The plan, which is based on broad consultation with the public and water sector representatives, establishes guidelines, programmes and goals for the period to 2020 (MMA-SRH, 2006).

In June 2007, Paraguay passed a Water Resources Law defining water as a public good. It guarantees access to a minimum quantity of drinking water per day, holding this to be a human right. The exact amount is to be determined by the Ministry of Public Health. The Law exempts water use for households and small family-owned businesses from charges. Provision of water for other purposes will depend on the availability of resources and will be taxed accordingly. The Law promotes respect for indigenous customary rights and highlights the minimum volume of water required to sustain ecosystems (Arrieta, 2007).

Discussions about water privatization in Uruguay led to amendment of the Constitution in October 2004. The charter now guarantees public access to water supply and sanitation services as a fundamental right, and stipulates that social considerations should be given priority over economic factors in setting water policy. The Constitution prohibits for-profit corporations from supplying water for human consumption (Alliance for Democracy, 2006).

The main challenges

Health: Lack of proper sanitation infrastructure and inadequate wastewater treatment are the main causes of water-related infections in La Plata River basin. Among the major waterborne diseases in the basin (Table 4.4), diarrhoea is by far the most widespread. Yellow fever re-emerged in Paraguay during the summer of 2007/2008, affected Argentina and Brazil as well, and claimed 25 lives in a month's time (PAHO, 2008*a* and 2008*b*; Secretaria de Vigilãncia en Saúde, 2008). It was the most severe outbreak since the 1960s, leading the basin countries to agree on common action criteria (CC-RMS, 2008).

Environment: La Plata River basin is rich in terrestrial and aquatic biodiversity, but it is under increasing pressure. The initial World Water Assessment Programme case study (WWAP, 2007) identified population growth, road development, expansion of agricultural land, mining and large-scale water development projects (dams, waterways and irrigation projects) as particular sources of pressure. They have resulted in a decrease in the overall quality of the basin environment and created persistent problems, such as erosion of productive land, silting of waterways and reservoirs, soil and water pollution and loss of habitat for fish and wildlife.

Table 4.4 Cases of waterborne diseases by country, 1998 2005

	Argentina	Bolivia	Brazil*	Paraguay	Uruguay
Diarrhoea	951,480 (2003)	315,786 (2005)	260,000 (2002)	41,450 (1999)	n.a.
Cholera	12 (1998)	467 (1998)	753 (2000)	4 (1998)	0
Malaria	122 (2003)	23,552 (2005)	5,514 (2003)	1,392 (2003)	90 (2003)
Dengue	135 (2003)	4,095 (2005)	21,913 (2004)	148 (2005)	n.a.
Leptospiosis	201 (2004)	n.a.	1,353 (2003)	n.a.	20 (2002)
Leishmaniasis	748 (2002)	1,735 (2000)	7,633 (2003)	86 (2004)	n.a.
Yellow fever	n.a.	56 (2005)	62 (2003)	n.a.	n.a.

Notes * Data for states of La Plata River basin only
n a : not available

Sources PAHO, 2004; Ministerio de Salud y Ambiente de la Nación Argentina/OPS, 2005; Sistema Nacional de Vigilancia Epidemiológica de Argentina, 2003; Sistema Nacional de Información en Salud de Bolivia, 2005; Ministerio da Saúde, 2004; Ministerio de Salud Pública y Bienestar Social del Paraguay, 2005, Ministerio de Salud Pública de la República Oriental del Uruguay, 2002

Problems related to eutrophication have been observed in some reservoirs. At the Salto Grande dam, for example, a significant phosphorus load resulting from the use of agrochemicals promotes algae growth in summer when discharges are lower, affecting water quality and availability (Chalar, 2006). Another serious environmental problem is that some lotic ecosystems are becoming lentic[2], or almost lentic, leading to larger ecotones, the transition areas between adjacent ecosystems a change entailing destruction of terrestrial habitats and existing ecosystems. In general, all the basin countries have regulations on the protection of water resources and associated ecosystems, but the effectiveness of implementation and enforcement varies.

Risk management: The increase in the frequency and magnitude of extreme hydrological events in La Plata River basin since the mid-20th century, resulting from changes in large scale climatic systems and in land use at regional level, has had fundamental repercussions for risk prediction and mitigation (CIC, 2004*b*).

Floods have inflicted significant socio-economic costs on the basin. In Argentina, for example, flood-related damage associated with ENSO events in the 1980s and 1990s was estimated at US$2.6 billion, and 235,000 people were evacuated (CIC, 2004*d*). In the state of Santa Catarina in Brazil, ENSO-related flooding in 1983 caused significant damage along the Paraná River and led to an 8% drop in the state's GDP. Between 1983 and 1993, flood losses in União da Vitória, a city located on the Iguaçu River in Brazil, totalled over US$110 million (CIC, 2004*a*). The El Niño event of 1983/1984 in central Uruguay affected over 40,000 people in more than 70 cities and caused losses estimated at over US$1 billion for the entire La Plata River basin (CIC, 2004*c*).

Overall, measures addressing extreme hydrological events in the region are heavily biased towards structural solutions. Non-structural measures such as warning systems are not functioning effectively. The basin countries are still attempting to reach agreement on the definition of extreme hydrological events, including rainfall and river discharges; such a definition is important for reservoir operations, irrigation regimes and flood warnings. In addition, urban planning and basin management need to be integrated with extreme hydrological event management; otherwise it is difficult to limit socio-economic damage from such events.

Conclusions

La Plata River basin has become a regional centre of attraction, concentrating the socio-economic development of the five riparian countries. However, this development comes at the cost of spreading shanty towns and increasing problems with water supply, sanitation and health in urban areas, as well as degradation of water quality and ecosystems. At the same time, climate change and climate variability pose potential risks for an agricultural sector that serves the dual purpose of feeding a growing population and providing raw materials for biofuel. Given the increased frequency and magnitude of water-related hazards, cooperation among the basin countries is vital, as is the implementation of well-planned policies supporting both structural and non-structural measures to mitigate the hazards. New legislation across the region emphasizes the social dimension of water, defining it as a public good and guaranteeing access to it as a human right, while recognizing its central role in sustainable socio-economic development. Nevertheless, additional efforts are necessary, at national and basin level alike, to address other issues in the region, most notably poverty.

[2] 'Lotic' ecosystems are characteristic of fluvial water bodies, such as rivers, streams and springs. 'Lentic' refers to the ecosystems of still water bodies, such as lakes, ponds and swamps.

References

Alliance for Democracy. 2006. Looking South: Uruguay and Bolivia Lead the Way. *Justice Rising*, Vol. 2, No. 2, p. 13. http://www.thealliancefordemocracy.org/pdf/AfDJR22.pdf (Accessed November 2008.)

Arrieta Q., L. 2007. *Water Related Legislation in Latin America.* http://www.nahrim.gov.my/pdf/ToT/Conference%20Session%202/3.%20Water_Related_Legislation_in_Latin_America%20LLAVE.pdf (Accessed December 2008.)

Chalar, G. 2006. Dinámica de la eutrofización a diferentes escalas temporales: embalse Salto Grande (Argentina-Uruguay). Galizia Tundisi, J. et al. (eds.) *Eutrofização na América do Sul: Causas, conseqüências e tecnologias de gerenciamento e controle* [Eutrophication in South America: Causes, Consequences and Technologies for Management and Control]. São Carlos, Brazil, Instituto Internacional de Ecologia. http://limno.fcien.edu.uy/pdf/Chalar2006-EscalasTemporalesSaltoGrande.pdf (Accessed November 2008.)

Comité Coordinador de la Reunión de Ministros de Salud del Mercosur (CC-RMS). 2008. *Acta Nº 01/08: Reunión extraordinaria del Comité Coordinador preparatoria de la XXIV Reunión de Ministros de Salud del Mercosur*. Puerto Iguazú, Argentina, February. http://www.mspbs.gov.py/miscelaneas.php?codigo=2 (Accessed April 2008.)

Comité Intergubernamental Coordinador de los Países de la Cuenca del Plata (CIC). 2004*a*. *Bases conceituais para a visão dos recursos hídricos na porção brasileira da bacia do rio da Prata: termo de referência*. Buenos Aires, CIC. Technical document elaborated by Dias Coelho, M. (coord.), Souza Lima, G. and Petrelli, M. Jr. http://www.cicplata.org/marco/pdf/vision_3a/brasil/visao_brasil_01_a_04_final.pdf (Accessed November 2008.)

Comité Intergubernamental Coordinador de los Países de la Cuenca del Plata (CIC). 2004*b*. Eventos hidrometeorológicos extremos: Caracterización y evaluación de métodos de predicción de eventos extremos de clima e hidrología en la Cuenca del Plata. *Programa Marco para la Gestión Sostenible de los Recursos Hídricos de la Cuenca del Plata en relación a los efectos hidrológicos de la variabilidad y el cambio climático. Componente 2a: Definición del Sistema de Predicción Hidroclimática*. Buenos Aires, CIC. Technical document elaborated by Marengo, J. (coord.), Menéndez, A., Guetter, A., Hogue, T. and Mechoso, C. http://cicplata.org/marco/pdf/prediccion_hidroclimatica_2a/tema_3_eventos_hidrometeorologicos_extremos.pdf (Accessed November 2008.)

Comité Intergubernamental Coordinador de los Países de la Cuenca del Plata (CIC). 2004*c*. *Visão dos Recursos Hídricos da bacia do Rio da Prata. Visão regional*. Programa Marco para la Gestión Sostenible de los Recursos Hídricos en la Cuenca del Plata. Buenos Aires, CIC. Technical document elaborated by Tucci, C. http://cicplata.org/marco/pdf/vision_3a/vision_integrada.pdf (Accessed November 2008.)

Comité Intergubernamental Coordinador de los Países de la Cuenca del Plata (CIC). 2004*d*. *Visión para el desarrollo sostenible de la cuenca del Plata y su relación con los recursos hídricos. Informe Nacional de Argentina*. Buenos Aires, CIC. Technical document elaborated by Mugetti, A. (coord.). http://www.cicplata.org/marco/pdf/vision_3a/argentina/argentina_vision_01_a_03.pdf (Accessed December 2008.)

Economic Commission for Latin America and the Caribbean 2007a *Anuario Estadístico 2007*. Santiago de Chile, CEPAL/ECLAC. http://www.eclac.cl/cgi-bin/getProd.asp?xml=/publicaciones/xml/8/32598/P32598.xml&xsl=/deype/tpl/p9f.xsl&base=/tpl/top-bottom.xslt (Accessed December 2008.)

Economic Commission for Latin America and the Caribbean (ECLAC). 2007b. *Social Panorama of Latin America*. Santiago de Chile, ECLAC/CEPAL. http://www.eclac.cl/cgi-bin/getProd.asp?xml=/publicaciones/xml/9/30309/P30309.xml&xsl=/dds/tpl-i/p9f.xsl&base=/tpl/top-bottom.xslt (Accessed November 2008.)

International Energy Agency (IEA). 2006. *World Energy Outlook 2006*. Paris, IEA. http://www.iea.org/textbase/nppdf/free/2006/weo2006.pdf (Accessed November 2008.)

Food and Agriculture Organization (FAO). 2004. *FAO Statistical Yearbook 2004*. Rome, FAO. http://www.fao.org/es/ess/yearbook/vol_1_2/site_en.asp?page=cp (Accessed November 2008.)

Food and Agriculture Organization (FAO). 2006. FAOStat: *Food Security Country Profiles*. Rome, FAO. http://www.fao.org/countryProfiles/water/default.asp?lang=en (Accessed November 2008.)

Gobierno de la República Oriental del Uruguay. 2001. *Análisis sectorial de agua potable y saneamiento: Uruguay*. PIAS serie análisis sectoriales. Washington, DC, Organización Panamericana de la Salud. http://www.bvsde.paho.org/eswww/fulltext/analisis/uruguaya/uruguaya.pdf (Accessed December 2008.)

Magrin, G., Gay García, C., Cruz Choque, D., Giménez, J. C., Moreno, A. R., Nagy, G. J., Nobre, C. and Villamizar, A. 2007. Latin America. Parry, M., et al. (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*. Cambridge, UK, Cambridge University Press. http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter13.pdf (Accessed November 2008.)

Ministerio do Meio Ambiente, Secretaria de Recursos Hídricos (MMA-SRH). 2006. *Plano Nacional de Recursos Hídricos*. Brasilia, MMA-SRH.

Ministerio de Salud y Ambiente de la Nación Argentina/Organización Panamericana de la Salud (OPS). 2005. *Indicadores básicos: Argentina 2005*. Buenos Aires, Ministerio de Salud y Ambiente.

Ministerio da Saúde. 2004. *Plano Nacional de Saúde (PNS): Um Pacto pela Saúde no Brasil*. Brasilia, Ministerio da Saúde, Secretaría Ejecutiva, Subsecretaria de Planejamento e Orçamento.

Ministerio de Salud Pública y Bienestar Social del Paraguay. 2005. *Boletín epidemiológico semanal*. Asunción, Ministerio de Salud Pública y Bienestar Social, Dirección de Vigilancia de Enfermedades Transmisibles.

Ministerio de Salud Pública de la República Oriental del Uruguay. 2002. Situación de leptospirosis en Uruguay. *El diario médico*. Montevideo, Salud Hoy.

NotiSur. 2006. *Argentina: Government rescinds contract with Aguas Argentinas, renationalizes water service*. Albuquerque, NM, Latin America Data Base. http://www.thefreelibrary.com/ARGENTINA%3a+GOVERNMENT+RESCINDS+CONTRACT+WITH+AGUAS+ARGENTINAS%2c...-a0144164403 (Accessed May 2008.)

Panamerican Health Organization (PAHO). 2004. *Basic Country Health Profiles for the Americas 2002*. Washington, DC, PAHO/Organización Panamericana de la Salud. http://www.paho.org/English/DD/AIS/cp_index.htm

Panamerican Health Organization (PAHO). 2008*a*. Yellow fever in Argentina. *EID Updates: Emerging and Reemerging Infectious Diseases, Region of the Americas*. http://www.paho.org/english/AD/DPC/CD/eid-eer-2008-03-31.htm (Accessed April 2008.)

Panamerican Health Organization (PAHO). 2008*b*. Update of yellow fever in Paraguay and Argentina. *EID Updates: Emerging and Reemerging Infectious Diseases, Region of the Americas*. http://www.paho.org/english/AD/DPC/CD/eid-eer-2008-03-13.htm (Accessed April 2008.)

Pochat, V. Forthcoming. *La Plata River Basin Case Study Report*.

Ruiz Caro, A. 2007. *La seguridad energética de América Latina y el Caribe en el contexto mundial*. Santiago de Chile, Comisión Económica para América Latina y el Caribe. http://www.eclac.cl/publicaciones/xml/3/32123/lcl2828e.pdf (Serie Recursos Naturales e Infraestructura, Nº 128; accessed November 2008.)

Secretaria de Vigilãncia em Saúde. 2008. Situación de Fiebre Amarilla. Diciembre 2007 a marzo 2008. Reunión de Ministros de Salud del Mercosur. Simposio Mercosur Fiebre Amarilla. Puerto Iguazú, February. http://www.mspbs.gov.py/varios/simposio/Anexo%20III-B%20Brasil.ppt (Accessed December 2008.)

Sistema Nacional de Vigilancia Epidemiológica de Argentina. 2003. *Casos notificados de enfermedades epidemiológicas*. Buenos Aires, Dirección de Epidemiología.

Sistema Nacional de Información en Salud de Bolivia. 2005. *Boletín semanal de vigilancia*. La Paz, Ministerio de Salud y Deportes.

UNESCO-World Water Assessment Programme (UNESCO-WWAP). 2006. Case Studies: Moving towards an integrated approach. *Water, a shared responsibility: The United Nations World Water Development Report 2*. Paris/Oxford, UNESCO/Berghan Book. http://www.unesco.org/water/wwap/wwdr/wwdr2/pdf/wwdr2_ch_14.pdf (Accessed November 2008.)

Von Cappeln, J. 2002. *Documento sobre los recursos hídricos: Uruguay 2002*. Montevideo, Dirección Nacional de Hidrografía. (Technical document.)

World Water Assessment Programme (WWAP). 2007. *La Plata Basin Case Study. Final Report. April 2007*. http://unesdoc.unesco.org/images/0015/001512/151252E.pdf (Accessed November 2008.)

Brazil and Uruguay: Lake Merín basin

The ecological and economic riches of this region are under human and climatic pressure, while a deteriorating hydrological monitoring network makes accurate assessment complicated.

Setting the scene

Lake Merín is a freshwater body shared by Uruguay and Brazil. Covering an area of some 5,000 km² (Map 4.2), it is the second largest lake in South America, after Lake Titicaca in the Andes. The Lake Merín basin extends about 63,000 km² on the Atlantic coast of South America. It lies in the temperate zone, with a subtropical climate and annual rainfall of 1,200 to 1,500 mm. Much

Map 4.2 Lake Merín basin

of the rain falls from June to September, while November to December is usually the driest time of the year. The section of the basin that lies in Uruguay covers around 18% of the country. The part that lies in Brazil accounts for about 20% of the state of Rio Grande do Sul.[1]

The Lake Merín basin is part of a much broader region of pampas extensive flat plains typically covered by grasslands, wetlands and forests, forming an important part of the South American landscape. With an area of some 270,000 km^2, the pampas extend into Argentina, Brazil, Paraguay and Uruguay.

The western part of the basin includes five departments of Uruguay with a combined population of around 400,000. The eastern part is home to some 1.2 million people, representing 12% of the population of Rio Grande do Sul, in 15 municipalities.

Climate change and variability

Climatic data for Uruguay reveal an increasing trend in rainfall, especially in summer and spring. Also rising are minimum temperatures throughout the year, although the average temperature in summer is decreasing (AIACC, 2006). Studies of climate change scenarios for Uruguay point to likely increases in temperature, rainfall and sea level, as well as the frequency and intensity of extreme climatic events such as strong winds, heavy rains, hailstorms and other water-related hazards. The temperature could rise by as much as 0.5°C by 2020 and 2.5°C by 2050. The projected sea level rise of as much as 65 cm by 2100 would affect the lagoons and coastal wetlands of the Lake Merín basin and associated ecosystems that are vulnerable to related saltwater intrusion. The effects in the state of Rio Grande do Sul in Brazil would likely be quite similar.

From an economic perspective, Uruguay is more vulnerable than Brazil to problems induced by climate change because the region containing the Lake Merín basin generates 70% of the country's GDP. The economic activities there include extensive rice production, animal husbandry, forestry, tourism, maritime transport and various manufacturing industries. The Program of General Measures for Mitigation and Adaptation to Climate Change in Uruguay identifies agricultural production (food security), freshwater resources, ecosystems and public health as especially vulnerable to the effects of climate change (Ministry of Housing, Territorial Planning and Environment, 2007).

Research by the Brazilian Agricultural Research Corporation (EMBRAPA) and the Applied Meteorological and Climatic Centre of Investigation for Agriculture indicates a likely temperature increase of up to 1°C as early as 2020. This could have substantial implications for agricultural output in Brazil, as coffee production could fall by between 15% and 24%, soy bean production by 14%, rice by 4% and corn by 2% (Steinmetz et al., 2007).

[1] Except where otherwise noted, information in this case study is adapted from the draft *Lake Merín Basin Case Study*, prepared in 2008 by Carlos María Serrentino.

Aside from potential effects of climate change, existing climatic variation linked to El Niño and La Niña events have a significant impact on freshwater availability, as these cycles introduce considerable fluctuation in rainfall levels. Generally El Niño brings abundant rainfall while La Niña years are associated with drought, which affects not only crop and livestock production in the larger region where the Lake Merín basin lies, but also hydropower and wind energy generation. Here again, Uruguay is more exposed to these risks, as it relies almost entirely on hydropower for electricity generation.

State of the resource and water use: agriculture is dominant

In spite of climatic variability, the water resources in the Lake Merín basin are enough to meet demand in the near term. Making accurate long term water resources assessment is quite difficult, as the hydrometeorological monitoring network in the basin is of limited coverage and its quality has deteriorated since the 1970s because of declining funding and maintenance.

Consumption patterns can nevertheless be established sufficiently to identify agriculture as the sector dominating water use in both parts of the basin. On the Brazilian side, 97% of annual withdrawal is used for irrigation. During the summer months, especially in January, agricultural water use intensifies, reaching almost 99% of overall demand. Of this amount, 66% comes from the Merín-São Gonçalo basin, where vast paddy fields are common. The situation is quite similar on the Uruguayan side of the basin, where over 1,000 km^2 of paddies produce 70% of Uruguay's annual rice crop, and demand for irrigation water represents 99.8% of overall water consumption. Rice is the mainstay of the regional economy, generating far more revenue than livestock. It is grown not only to satisfy local needs but, in Uruguay, is among the top three exports by value.

Nationally, irrigation accounts for 59% of overall water withdrawal in Brazil, followed by households with 22% and industry with 19% (Netto, 2005). In Uruguay as a whole, the corresponding shares are 80%, 16% and 3.4% (adapted from Chao et al., 2007).

Inland waterways are an important and economical means of moving goods in the Lake Merín basin, and in the context of the Southern Common Market (Mercosur). For example, rice and forestry products from Uruguay are transported through the eastern part of the Mercosur Waterway from La Charqueada, in Uruguay's Treinta y Tres Department, to the Atlantic port of Rio Grande in the Brazilian state of Rio Grande do Sul for access to regional and international markets.

Further waterway development could help the regional economy not only by improving goods transport but also by increasing ecotourism, as waterways provide easy access to impressive wildlife habitats and other sites of environmental significance, although such development would itself have environmental implications.

Brazil and Uruguay have been successful to varying degrees in advancing water supply and sanitation coverage. Uruguay has achieved universal access to safe water and improved sanitation. In Brazil, however, sanitation coverage and, to a lesser degree, water supply continue to be problems, especially in rural areas (Figure 4.4). Thus, while the priority in Uruguay should be on allocating the funds necessary to maintain universal coverage, further steps are needed in Brazil to improve access to water supply and sanitation. A new federal water and sanitation law in Brazil (2007) aims at increasing investment so as to achieve universal access. Although no specific assessments are available for the Lake Merín basin, its water supply and sanitation coverage is believed to be similar to the national levels.

Figure 4.4 Access to safe water and improved sanitation in Brazil, 2006

Source WHO/UNICEF, 2008

Policy framework and decision-making

Brazil's 1934 Water Code provides the framework for all of the country's water-related legislation. Under the Federal Constitution of 1988, the states are responsible for all surface water resources except those lying in more than one state, which the federal government controls. This division results in implementation problems, as rivers under federal jurisdiction cannot be managed effectively without taking state-controlled rivers into consideration.

The National Water Law (Law 9.433) of 1997 established the National Water Resources Policy (NWRP) and the National Water Resources Management System (NWRMS). The Law identifies water as a public good, a limited natural resource with an economic value, and gives priority for water use in the event of drought to human and animal consumption. The NWRP takes the river basin as the basic unit for water resources planning and management. A key aspect of the policy document is that it requires decentralization of, and public participation in, water resources management (Aquastat, 2000).

The NWRMS, under the Ministry of the Environment, implements the NWRP. It is made up of the National Council on Water Resources, the National Water Agency, the River Basin Committees, the River Basin Water Agencies and relevant NGOs.

The National Council on Water Resources is the highest organization in the NWRMS hierarchy. It is responsible for formulating the National Water Resources Plan. The plan, which provides guidelines on how the NWRP is to be applied, is itself put into operation by the National Water Agency, ANA (Agência Nacional de Aguas). The ANA is an executive branch of the Ministry of the Environment but with administrative and financial autonomy.

The six national-level River Basin Committees include representatives of the federal, state and municipal governments, water users and civil society organizations. The committees promote and coordinate intersectoral actions regarding basin-related issues. The River Basin Agencies, which are still being formed, will function as the secretariats of the committees.

At state level, Rio Grande do Sul also applies the principles of access to information and a participatory approach in decision-making related to water resources. The State Water Resources System (Sistema Estadual de Recursos Hídricos), established in 1997, deals with water resources management in Rio Grande do Sul. It includes the formation of basin committees, which are involved in decision-making: one such committee deals with the Lake Merín basin and São Gonçalo channel. The system also requires the state to report regularly on the quantity and quality of freshwater resources.

In Uruguay, the Water Code of 1978 provides the general legal framework for water resources management. The code assigns responsibility for the management of surface and groundwater resources to the national government and departmental authorities. It is complemented by laws setting forth provisions specific to various sectors, such as agriculture and industry.

The Uruguayan Constitution was amended in October 2004 by national referendum to identify water resources as public property and recognize access to drinking water and improved sanitation as a fundamental human right. The constitutional reform also promoted integrated water resources management (IWRM), calling for public participation in planning and for management of water resources at basin level. A new Law on Access to Information (Law 18.381), promulgated in October 2008, is in line with this reform.

Institutions charged with elaborating and implementing water resources management policy, setting priorities for water use and establishing user fees in Uruguay include the National Water Authority and the National Water and Sanitation Administration (under the Ministry of Housing, Territorial Planning and Environment) in cooperation with the Ministry of Public Works and Transport. The National Water and Sanitation Policy, which is pending approval, is expected to include environmental preservation and protection among its aims. Like the similar policy document in Brazil, it will provide for all stakeholders, including local communities, to have a role in planning and decision-making.

Both Brazil and Uruguay are following up on the recommendations in the Johannesburg Plan of Implementation regarding IWRM and water efficiency plans. In Brazil, the 1997 National Water Law enshrined such IWRM principles as decentralized water resources

Box 4.2 Ecological importance of Lake Merín

The lake and surrounding wetlands comprise one of the major transboundary watersheds in the Americas, supporting a great diversity of flora and fauna, including a large proportion of the region's endemic species and many species of migratory birds. On the Uruguayan side, Bañados del Este is a Ramsar wetland and UNESCO biosphere reserve known for its rich biodiversity and wildlife. In addition, BirdLife International has identified the southern shore of the lake as a globally important endemic bird area. On the Brazilian side, the Taím ecological reserve is part of the UNESCO Atlantic Rainforest biosphere reserve.

In addition, the basin is the subject of a 1977 bilateral treaty on cooperation and resource use. It envisions 'harmonization ... of the studies, plans, programs and projects necessary for achievement of joint works designed to improve utilization of natural resources' (Article 3b), and 'the defense and suitable use of mineral, plant and animal resources' (Article 4e).

Since the 1970s, however, the dramatic expansion in rice cultivation has encroached on wildlife habitats. An expansion of plantation forests (pine and eucalyptus) and tourism development (on the Uruguayan side) have also had a significant impact on the ecosystems of the basin. To maintain healthy ecosystems and protect biodiversity, an integrated approach to conservation and development is urgently needed.

Source Adapted from de Sherbinin, 2005

management and stakeholder participation as a part of the National Water Resources Policy. Since then Brazil has taken concrete steps to ensure that these principles are applied in practice, and hence it has met the Johannesburg requirement. In Uruguay, although the Constitution provides for stakeholder participation, decentralization and the basin approach in water management, wide scale implementation is still lacking.

The main challenges

Environmental impact of economic development: Rio Grande do Sul is the fourth richest state in Brazil (SEMA, 2007), attracting both investment and labour with a diversified economy based on crops (chiefly soybeans, wheat, rice and corn), livestock, leather and food processing, textiles, lumber, metallurgy, chemicals, and, since the 1990s, petrochemical products and telecommunications. On the Uruguayan side of the Lake Merín basin, the major sources of income are rice, livestock and forest products. Both sides also have tourism activity thanks to the rich ecology and beach resorts in the basin.

Until recently, the pampas and other areas with rich biodiversity were relatively undisturbed, aside from livestock grazing. However, in the last 20 years the spread of irrigated and mechanized rice growing has caused extensive land transformation and led to conflicts over natural resources, while pollution from industry, agriculture and human settlements has degraded the water quality (Box 4.2). Many species of animals, especially birds, are threatened as the marshlands are increasingly converted to grazing and cultivation without any attempt to preserve wildlife. Among other species threatened with extinction are the otter, the coypu and the crocodile (UNESCO, 2008). Increased use of waterways and future waterway development plans might also have repercussions on ecosystems in the area.

Poverty and hunger: Brazil has one of the stronger economies in Latin America, yet poverty is still a socio-economic challenge: in 2006, over 30% of the population was poor (see Table 4.3 in La Plata River basin case study). Since 2002, Brazil has helped lift some 6 million people out of extreme poverty (ECLAC, 2007). Nevertheless, the incidence of poverty remains daunting, especially in rural areas, where a key factor is extreme inequality of land tenure, notably in the semi-arid north-east. In general almost 80% of the rural population about 30 million people lives in poverty. Poor rural communities face even harder challenges than the urban poor due to inferior water supply and sanitation coverage (IFAD, 2008). The situation in Uruguay stands in some contrast to that of Brazil, with poverty affecting 18.5% of the population as of 2006 (see Table 4.3 in La Plata River basin case study). Similarly, as regards the target in the Millennium Development Goals of reducing by half the share of the population suffering from hunger, Uruguay had met the target by 2003 while in Brazil that same year 8% of the population was undernourished (see Table 4.2 in La Plata River basin case study).

Thus, poverty and basic water supply and sanitation coverage are still of some concern in part of the Lake Merín basin, although rising income from rice cultivation, tourism and industry is alleviating the situation to some extent.

Conclusions

The Lake Merín basin is well endowed in freshwater resources. Agriculture, industry, ecotourism and waterway transport are helping boost the economy of the basin, creating job opportunities and improving the livelihoods of many, including the poor and disadvantaged. However, these activities also contribute to environmental degradation in the area, especially in the absence of measures to ensure that regulations are enforced. Climate change scenarios indicate risks to the socio-economic well-being of people living in the basin, mainly stemming from the likely impact on agriculture and tourism. Uruguay is more vulnerable than Brazil to the impact of climate change, as the area containing the Lake Merín basin generates 70% of its GDP. Stronger bilateral cooperation in the basin to improve integrated management of water resources, alleviate poverty and assure sustainability of ecosystems would be beneficial.

References

Aquastat. 2000. Brazil country profile. Rome, Food and Agriculture Organization. http://www.fao.org/nr/water/aquastat/countries/brazil/index.stm (Accessed December 2008.)

Assessment of Impacts and Adaptation to Climate Change in Multiple Regions and Sectors (AIACC). 2006. Adaptive responses for the mixed crop/livestock production systems in the Argentinean-Uruguayan Pampas (LA 27).

Chao, R., Macedo, E. and Batista, L. 2007. El Agua en Uruguay [Water in Uruguay]. *Asociación Cultivadores de Arroz: Revista [Rice Growers Association Review]*, No. 48. http://www.aca.com.uy/publicaciones/revista_48_agua_en_uruguay.htm (Accessed December 2008.)

de Sherbinin, A. 2005. *Remote Sensing in Support of Ecosystem Management Treaties and Transboundary Conservation*. Project on Remote Sensing Technologies for Ecosystem Management Treaties, US Department of State, Bureau of Oceans and International Environmental and Scientific Affairs Initiatives. http://sedac.ciesin.columbia.edu/rs-treaties/AIAA6thWorkshop.pdf (Accessed December 2008.)

Economic Commission for Latin America and the Caribbean (ECLAC). 2007. *Social Panorama of Latin America*. Santiago de Chile, ECLAC/CEPAL. http://www.eclac.cl/cgi-bin/getProd.asp?xml=/publicaciones/xml/9/30309/P30309.xml&xsl=/dds/tpl-i/p9f.xsl&base=/tpl/top-bottom.xslt (Accessed November 2008.)

IFAD. 2008. *Rural Poverty in Brazil*. Rural Poverty Portal, http://www.ruralpovertyportal.org/web/guest/country/home/tags/brazil (Accessed December 2008.)

Ministry of Housing, Territorial Planning and Environment. 2007. Program of General Measures for Mitigation and Adaptation to Climate Change in Uruguay. Montevideo, Unidad de Cambio Climático [Climate Change Unit], Dirección Nacional de Medio Ambiente [Environment Department], Ministerio de Vivienda Ordenamiento Territorial y Medio Ambiente.

Netto, O. 2005. Introduction of the Brazilian National Water Resources Plan. (Management of transboundary water resources in Brazil). Lima, International Symposium on Integrated Water Management in Transboundary River Basins.

Serrentino, C. M. Forthcoming. *Lake Merín Basin Case Study*.

State Environment Secretariat (SEMA). 2007. Annual Report. SEMA, Porto Alegre, Rio Grande do Sul, Brazil.

Steinmetz, S., Wrege, M. S., Herter, F. G. and Reisser Jr, C. 2007. *Impacto das mudanças climáticas na fruticultura de clima temperado e nas culturas anuais em Terras Baixas*. Paper presented at SEMA workshop on Rio Grande do Sul no contexto das Mudanças Climáticas.

UNESCO. 2008. *Station écologique de Taim (Rio Grande do Sul)*. World Heritage Tentative Lists Database. http://whc.unesco.org/en/tentativelists/42 (Accessed December 2008.)

World Health Organization (WHO)/United Nations Children's Fund (UNICEF). 2008. *Progress on Drinking Water and Sanitation: Special Focus on Sanitation*. New York/Geneva, Joint Monitoring Programme for Water Supply and Sanitation.

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