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Investing in Water for a Green Economy

Services, infrastructure, policies and management



Edited by
Mike D. Young and Christine Esau

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INVESTING IN WATER FOR A GREEN ECONOMY

In the context of the economies of the world becoming greener, this book provides a global and interdisciplinary overview of the condition of the world's water resources and the infrastructure used to manage it. It focuses on current social and economic costs of water provision, needs and opportunities for investment and for improving its management. It describes the large array of water policy challenges facing the world, including the Millennium Development Goals for clean water and sanitation, and shows how these might be met.

There is a mixture of global overviews, reviews of specific issues and an array of case studies. It is shown how accelerated investment in water-dependent ecosystems, in water infrastructure and in water management can be expected to expedite the transition to a green economy. The book provides a key source of information for people interested in understanding emerging water issues and approaches that are consistent with a world that takes greater responsibility for the environment.

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ABBREVIATIONS

AEZ	Agro Ecological Zone
AICD	Africa Infrastructure Country Diagnostic
AMCOW	African Regional Ministerial Conference on Water
ANC	African National Congress
BAU	business-as-usual
CAADP	Comprehensive Africa Agricultural Development Programme
CBA	cost–benefit analysis
CBD	Convention on Biological Diversity
CERES	Crop Environment Resource Synthesis
CES	constant elasticity of substitution
CEWH	Commonwealth Environmental Water Holder
CGE	computable general equilibrium
DALY	Disability Adjusted Life Year
DBSA	Development Bank of Southern Africa
DHS	Demographic and Health Surveys
DPLG	Department of Provincial and Local Government
DWAF	Department of Water Affairs and Forestry
ECOWAS-SWAC/OECD	Economic Community of West African States-The Sahel and West Africa Club/Organization for Economic Cooperation and Development
EPIC	Erosion-Productivity Impact Calculator
ESP	Environmental Service Program
FAO	Food and Agriculture Organization
FONAFIFO	National Forest Office and National Fund for Forest Financing (Costa Rica)
FONAG	Water Protection Fund (Ecuador)
FWGA	Financing Water for Growth in Africa
GDP	gross domestic product
GPOBA	Global Partnership on Output Based Aid
GSI	Genuine Savings Indicator
GWR	geographically weighted regression

HadGEM1-TRIP	Hadley Centre Global Environmental Model (including a dynamic river routing model)
HDI	Human Development Index
HIV/AIDS	human immunodeficiency virus/acquired immune deficiency syndrome
IDR	Indonesian rupiah
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade
IMT	irrigation management transfer
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
IWMI	International Water Management Institute
IWRM	Integrated Water Resource Management
kWh	kilowatt-hour
lcd	litres per capita per day
LHDA	Lesotho Highlands Development Authority
LISA	localized indicators of spatial autocorrelation
MDG	Millenium Development Goal
MEA	Millennium Ecosystem Assessment
MIDA	Malaysian Industrial Development Authority
MIGA	Multilateral Investment Guarantee Agency
NAPA	national adaptation programmes of action
NBA	Niger Basin Authority
NGO	non-governmental organization
NPV	net present value
OECD	Organization for Economic Cooperation and Development
OECD-DAC	Organization for Economic Cooperation and Development-Development Assistance Committee
OMVS	*l'Organization de Mise en Valeur du fleuve Sénégal*
PAM	Perusahan Air Minum
PES	payment for ecosystem services
PPP	purchasing power parity
PSP	private sector participation
RBO	river basin organization
SADC	Southern African Development Community
SIDA	Swedish International Development Agency
SODECI	*Société de Distribution d'Eau de la Côte d'Ivoire*
SOE	state-owned enterprise
SOYGRO	Soybean Growth Model
SRES	Special Report on Emissions Scenarios
SSA	sub-Saharan Africa
SVI	Social Vulnerability Index
TARWR	total available renewable water resource
TEEB	The Economics of Ecosystems and Biodiversity
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Program
UNDP/SEI	United Nations Development Program/Stockholm Environment Institute

UNECA	United Nations Economic Commission for Africa
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UN-ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations International Children's Emergency Fund
UPP	customer districts
WBCSD	World Business Council for Sustainable Development
WBI	World Bank Institute
WFD	Water Framework Directive
WHO	World Health Organization
WPI	Water Poverty Index
WSP-EAP	Water and Sanitation Program – East Asia and the Pacific
WUA	water user associations
WWF	World Wildlife Fund

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PART 1
Overview

1

INVESTING IN WATER SERVICES INFRASTRUCTURE POLICIES AND MANAGEMENT

Michael D. Young[1]

Key messages

Water, a basic necessity for sustaining life, goes undelivered to many of the world's poor. Nearly 1 billion people lack access to clean drinking water; 2.6 billion lack access to improved sanitation services; and 1.4 million children under 5 die every year as a result of lack of access to clean water and adequate sanitation services. At the current rate of investment progress, the Millennium Development Goal for sanitation will be missed by 1 billion people, mostly in sub-Saharan Africa and Asia.

The existing inadequacies in provision of water and sanitation services generate considerable social costs and economic inefficiencies. When people do not have access to water, either large amounts of their disposable income have to be spent on purchasing water from vendors or large amounts of time, in particular from women and children, have to be devoted to carting it. This erodes the capacity of the poor to engage in other activities. When sanitation services are inadequate, the costs of water-borne disease are high. Cambodia, Indonesia, the Philippines and Vietnam, for instance, together lose about US$9 billion a year because of poor sanitation – or approximately 2 per cent of combined GDP. Access to reliable, clean water and adequate sanitation services for all is a foundation of a green economy.

Continuing current practices will lead to a massive and unsustainable gap between global supply and demand for water withdrawal. This is exacerbated by failure to collect and treat used water to enable subsequent uses. With no improvement in the efficiency of water use, water demand is projected to overshoot supply by 40 per cent in 20 years time. Historical levels of improvement in water productivity, as well as increases in supply (such as through the construction of dams and desalination plants, as well as increased recycling) are expected to address 40 per cent of this gap, but the remaining 60 per cent needs to come from investment in infrastructure, in water-policy reform and in the development of new technology. The failure of such investment or policy reform to materialize will lead to the deepening of water crises.

The availability of an adequate quantity of water, of sufficient quality, is a service provided by ecosystems. The management of, and investment in, ecosystems is therefore essential to address water security for both people and ecosystems in terms of water scarcity, the over-abundance of water (flood risk) and its quality.

Accelerated investment in water-dependent ecosystems, in water infrastructure and in water management, can be expected to expedite the transition to a green economy. Modelling suggests that, under the green investment scenario, global water use can be kept within sustainable limits and all the MDGs for water achieved in 2015. With an annual investment of US$198 billion on average over the next 40 years, water use can be made more efficient, enabling increased agricultural, biofuel and industrial production. By 2030, the number of people living in a water-stressed region is 4 per cent less than under business-as-usual (BAU) and up to 7 per cent less by 2050.

When investment is coupled with improvements in institutional arrangements, entitlement and allocation system, the expansion of payments for ecosystem services (PES), and the improvement of water charging and finance arrangements, the amount that needs to be invested in water can be reduced significantly. Moreover, a significant proportion of water management policies and measures in other sectors such as input subsidies are undermining opportunities to improve water management. Resolving global water supply problems is heavily dependent upon the degree to which agricultural water use can be improved. Irrigated land produces 40 per cent of the world's food and, as populations grow, a significant proportion of this water will need to be transferred to urban, commercial and industrial uses.

Introduction

The aim of this chapter

Drawing upon the chapters presented in this book, this chapter has three broad aims. First, it highlights the need for providing all households with sufficient and affordable access to clean water supplies as well as adequate sanitation.

Second, it makes a case for early investment in water management and infrastructure, including ecological infrastructure. The potential to make greater use of biodiversity and ecosystem services in reducing water treatment costs and increasing productivity is emphasized.

Third, the chapter provides guidance on the suite of governance arrangements and policy reforms, which, if implemented, can sustain and increase the benefits associated with making such a transition.

Scope and definition

The scope of this chapter is restricted to freshwater ecosystems, the water supply and sanitation[2] sectors and the government and market processes that influence how and where this water is used.

The crucial contribution water makes to agriculture, fisheries, forestry, energy and industrial production is discussed in other chapters.

The perspective offered in this chapter is one that looks forward 20 years to 2030 and, where possible, to 2050. During the next 20 years, a considerable rise in demand for water of sufficient quantity and quality is expected and changes in local supply conditions are forecast.

Structure of the chapter

This chapter identifies the contribution that water can play in assisting a transition to a green economy. We first present a vision of the role that water ecosystems can play in the transition to a green economy and then provide an overview of the world's water resources and the services offered by the water supply and sanitation sector. After highlighting some of the more unique characteristics of water, we identify challenges and opportunities to make better use of water and water-dependent ecosystems. Building on this knowledge base, the benefits of investing in the water supply and sanitation sector, as a means to assist with a transition to a green economy, are quantified. The chapter closes by identifying institutional reforms, which, if implemented, would increase the returns that could be gained from a commitment to a transition to a green economy.

Water in a green economy – a vision

In a green economy, there is emphasis on the pursuit of opportunities to invest in sectors that rely upon and use natural resources and ecosystem services. At the same time, there is a transition to a suite of policy and administrative arrangements that neither degrade the environment nor impose costs on others. The interests of future generations are considered carefully. In the case of water, many of the potential gains are achieved simply by deciding to invest in the provision of water and sanitation services. Where water is scarce, this scarcity is acknowledged and managed carefully. Progress towards the pursuit of green objectives can be accelerated through the redesign of governance arrangements, the improved specification of property rights, the adoption of policies that reflect the full costs of use, including the costs of adverse impacts on the environment, and improved regulation to ensure that use is kept within sustainable limits.

In green economies, the role of water in both maintaining biodiversity and ecosystem services and in providing water is recognized, valued and paid for. The use of technologies that encourage efficient forms of recycling and reuse is encouraged.

Measuring progress towards a green economy

In many countries, there is a lack of reliable data on the water-storage capacities of river basins, the condition of built infrastructure and the performance of the water supply and sanitation sector. One of the more significant opportunities to improve investment and management is to assemble data in a manner that enables water to be managed effectively and the performance of one region to be accurately compared with other regions.

Signposts of success in terms of progress towards a greener set of economic arrangements include:

- recognition of the value of the benefits provided by good water management and costs (negative value) of not doing so;
- evidence of increased investment in the water supply and sanitation sector that gives consideration to the environment;
- the formal definition of rights to use water and its allocation to users and the environment;
- legislative recognition of the important role that ecosystem services can play in supporting an economy;
- investment in the development of institutional capacity to manage ecosystems, including water, on a sustainable basis or using an ecosystem approach;
- the removal of policies that discourage ecosystem conservation and/or have perverse effects on water use and investment;
- progress towards arrangements that reflect the full costs of resource use in ways that do not compromise the needs of disadvantaged people in a community; and
- addressing ecosystem degradation by increasing efforts for restoring and protecting ecosystems critical to supply of water quantity and quality.

Indicators to be tracked include data on:

- the number of people without access to reliable supplies of clean water and adequate sanitation;
- the volume of water available per person in a region;
- the efficiency of water supply in the urban sector and water use;
- the efficiency of water use in the agricultural and industrial sectors; and
- the water use and water-related impacts of companies and countries.

The world's water resources

Access to the world's water resources is heavily dependent upon the nature of the water cycle. While a massive amount of water reaches the earth's land surface, much less, around 40 per cent, makes its way into creeks, rivers, aquifers, wetlands, lakes and reservoirs, before cycling back into the atmosphere (see Plate 1.1). Of the water that is extracted for human purposes, on average, approximately:

- 70 per cent is used for agricultural purposes;
- 20 per cent is used by industry (including power generation); and
- 10 per cent is used for direct human consumption.

Given that the vast majority of usable fresh water is channelled towards agriculture, any global consideration of water allocation must consider the factors that determine the efficiency of water use in the sector. Irrigated land produces around 40 per cent of the world's food (Hansen and Bhatia 2004; Tropp Chapter 3). One of the biggest challenges facing water managers is to find a way to significantly increase the productivity of irrigated agriculture so that water can be transferred to other sectors without adversely affecting the environment or food security. In many parts of the world, there are few opportunities to enhance supplies at reasonable cost.

But general observations can be misleading. No two water bodies are the same. Managing large, complex, transboundary water systems typically requires a different approach to overseeing smaller water systems, where local issues are often all that need to be considered. In developing countries, water management and investment are typically geared towards reducing poverty and enabling economic development; the priority for developed nations tends to be maintaining infrastructure and supplying access to water at reasonable cost. In both cases, there is a need to focus more on long-term sustainability of the systems and services provided. Demand and supply also vary greatly. In Singapore, for example, almost all water is extracted for urban and industrial purposes, while in many other parts of the world the majority of water is extracted for agricultural or mining purposes (Cosgrove and Rijsberman 2000).

Water: a unique natural resource

Unlike most other natural resources, water flows readily across and through landscapes in complex ways that affect its availability and opportunities to manage it. Understanding these water flows is critical to the design of investment programmes and policies necessary to support a transition to a green economy.

Services from natural infrastructure

Water makes an irreplaceable contribution to ecosystem services that stem from the earth's "natural capital" and vice versa. Protecting the natural ecosystems of river basins and restoring degraded catchment areas is crucial to securing the world's water supplies, maintaining their quality, regulating floods and mitigating climate change (Khan Chapter 5; TEEB 2008, 2009a, 2009b, 2009c). The role of other ecosystems, such as forests, wetlands and floodplains in providing access to water also needs to be recognized and quantified. Gauging the true value that these ecosystems provide is a key part of charting a course to a green economy.

Recent analysis is showing a close global correlation between the threats to biodiversity and threats to water security. As shown in Plate 1.2, regions where threats to human water security are high, but the threat to biodiversity is low, are rare. When the threat to human water security is high, usually the threat to biodiversity is high. This suggests that there may be considerable opportunities for governments to improve biodiversity outcomes by investing in water security (Vörösmarty *et al.* 2010). Water-dependant ecosystems also play an important role in the provision of cultural benefits (Millennium Ecosystem Assessment 2005).

Water accounting

As water flows through and across land, it is used and reused. This makes information about water difficult to assemble and use for management. When, for example, a policy promotes a more efficient irrigation system, it is critical to decide whether or not the "savings" are to be used to expand irrigation or returned back to the river or aquifer from which the water was taken (Molden 1997). Gains in one area can be associated with losses in another area. When the savings are not returned back to the river or aquifer, the result can be a significant reduction in the quantity of water available to the environment and to other users (Independent Evaluation Group 2010).

Another common water accounting error is to assume that ground and surface water systems are not connected to one another and to administer them separately. Many rivers play an important role in replenishing aquifers, while aquifers can provide much of a river's base flow (Evans 2007). Failing to account for these interactions can result in the serious problems of over-use and degradation. One administrative solution is to reverse the onus of proof and require managers to assume that ground and surface water resources are linked and manage them as a single connected resource until such time as disconnection can be shown (NWC 2009).

Land-use changes can have similar effects on the volume of water available for use. For example, whenever a plantation forest is established, a hillside is terraced, or a farm dam is constructed, runoff is usually reduced. As a result, the quantity of water available for extraction from a river or aquifer is less than it otherwise would be. Accounting for water in a way that is consistent with the hydrological cycle and that avoids double counting of its potential is critical to developing the robust allocation and management systems that underpin a green economy (Young and McColl 2008).

Water and energy

The interdependence of water and energy demands also needs careful attention as arrangements are put in place for a transition to a green economy. There are at least two dimensions to this relationship.

First, water plays an important role in energy generation, notably as a coolant in power stations. In the USA, for example, 40 per cent of industrial water-use is for power-station cooling (National Research Council 2010), although water-use efficiency varies with the technology used (Figure 1.1). By 2030, it is expected that 31 per cent of all industrial water-use in China will be for cooling power plants (2030 Water Resources Group 2009). Generally, as countries become wealthier and more populous, industrial demand for water is expected to increase. In China, more than half of the increase in demand

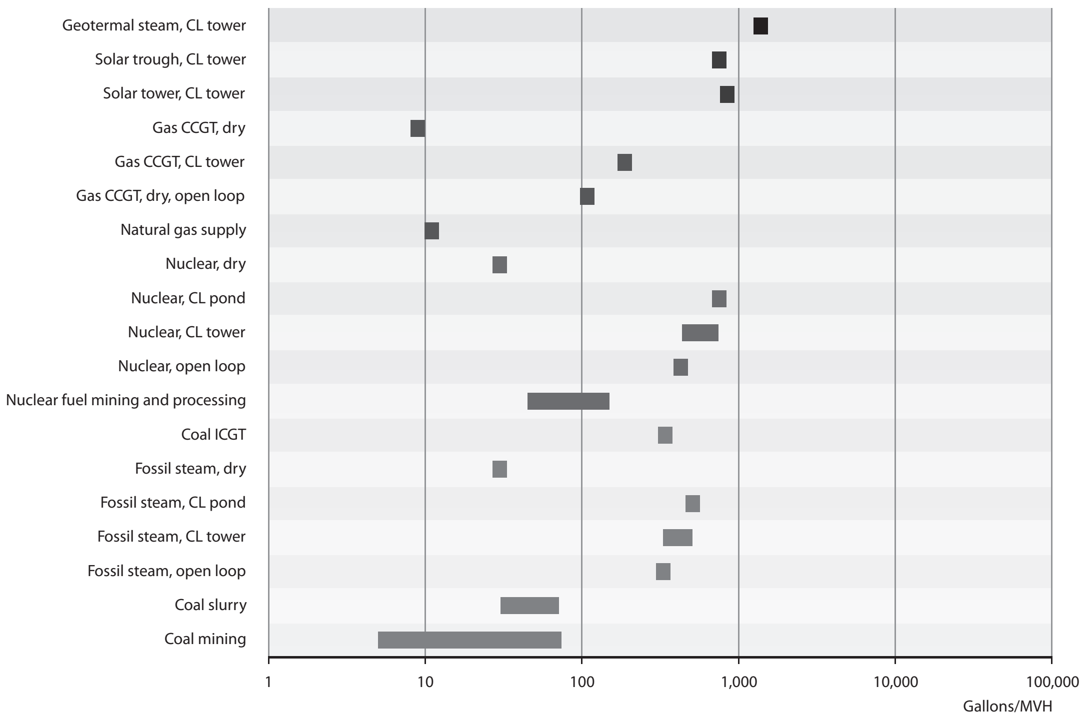


FIGURE 1.1 Water consumption for power generation, United States (2006).

Source: US Department of Energy (2006).

for water over the next 25 years is expected to result from a significant expansion in its industrial sector, which will need to be accommodated through a simultaneous reduction in the amount of water used for irrigation in the agricultural sector.

Second, the water supply and sanitation sector is a large consumer of energy. Relative to its value, water is heavy and in energy terms expensive both to pump over long distances and to lift. In California, USA, where large volumes of water are transported over long distances, the water sector consumes 19 per cent of the state's electricity and 30 per cent of its natural gas (Klein *et al.* 2005).

In developed countries, the relatively high energy costs of pumping and treating water for household, industrial or mining purposes are broadly accepted. In developing countries, great care must be taken to ensure that water treatment and distribution systems remain affordable. The relatively modest financial returns from food production in both developed and developing countries mean it rarely pays to pump water over long distances for agricultural purposes. In recognition of this, Saudi Arabia has recently shifted its food security policy from one that subsidizes water use at home to one that invests in the development of agriculture in other countries where water supplies are more abundant. This is enabling Saudi Arabia to access food at more affordable prices and use the revenue saved for other, more sustainable purposes (Lippman 2010).

Appreciation of the nexus between water and energy highlights a set of green investment opportunities that are starting to emerge. In Durham, Canada, for example, a water efficiency field trial[3] was able to reduce water use by 22 per cent, electricity by 13 per cent and gas by 9 per cent, with a resultant annual reduction in CO_2 emissions of 1.2 tonnes per household – an 11 per cent reduction (Veritec Consulting 2008).

Challenges and opportunities

This section identifies the challenges associated with water scarcity and declining water quality in many parts of the world. It outlines opportunities for societies to manage their water resources more efficiently and to make the transition to a green economy. In doing so, societies can achieve the Millennium Development Goals.

Challenges

Poverty, access to clean water and adequate sanitation services

Nearly 1 billion people lack access to clean drinking water and 2.6 billion lack access to improved sanitation services (WHO/UNICEF 2010).[4] As a direct result, every year, 1.4 million children (3,900 children per day) under the age of 5 die due to a lack of access to clean water and adequate sanitation services (UNICEF 2004). In east Nigeria and north Cameroon, every 1 per cent increase in the use of unprotected water sources for drinking purposes is directly associated with a 0.16 per cent increase in child mortality (Ward *et al.* Chapter 9).

Gleick (2004, 2009) argues that failure to provide people with affordable and reliable access to water and sanitation services is one of humankind's greatest failings. Lack of sanitation makes people sick. When water is unclean, water-borne diseases such as diarrhoea and water-washed diseases including scabies and trachoma are common (Bradley 1974). Diarrhoea is the third most common cause of child mortality in West Africa after malaria and respiratory infections (ECOWAS-SWAC/OECD 2008). New water-borne diseases such as Whipple's disease are still emerging (Fenollar *et al.* 2009).

The adverse impacts of water-borne disease on an economy can be large (Box 1.1). When people are sick, they cannot work and, among other costs, considerable expenditure on medical treatment is needed.

The adverse impacts of inadequate access to clean water, however, do not stop with water-borne disease. When water is not on tap, people (mainly women and children) must either spend a large amount of time fetching water or pay high prices for it to be carted to them. In Western Jakarta, Indonesia,

Box 1.1 ECONOMIC IMPACTS OF POOR SANITATION

Together, Cambodia, Indonesia, the Philippines and Vietnam lose an estimated US$9 billion a year because of poor sanitation (based on 2005 prices). This amounts to around 2 per cent of their combined GDP, varying from 1.3 per cent in Vietnam, 1.5 per cent in the Philippines, 2.3 per cent in Indonesia and 7.2 per cent in Cambodia.

The annual economic impact of inadequate sanitation is approximately US$6.3 billion in Indonesia, US$1.4 billion in the Philippines, US$780 million in Vietnam and US$450 million in Cambodia. In these four countries, the total value of this impact is US$8.9 billion per year.

In 1991, a cholera epidemic swept through most of Peru[5] and cost US$1 billion to control. If one tenth of this amount (US$100 million) had been spent on the provision of sanitation services, the epidemic would not have occurred.

Source: World Bank – Water and Sanitation Program (2008) and Tropp (2010).

the cost of water purchased from a water cart is ten to fifty times the full cost to a water utility of establishing a reliable mains water supply (Fournier *et al.* Chapter 10). In certain circumstances, it is challenging to find a way to convince governments and private investors to go ahead despite a widespread perception that poor people are not able to pay for water (services) and that it is not cost-efficient to supply water to informal settlements. A lack of easy access to clean water also erodes the capacity of the poorest to engage in other activities. When children, for example, spend a large proportion of their days fetching water, they have less opportunity to attend school and obtain the education necessary to escape from poverty. When women are forced to spend time carting water, they have little opportunity for gainful employment elsewhere. More than a quarter of the population of East Africa live in conditions where every trip to collect water takes more than half an hour (WHO/UNICEF 2010).

From a government perspective, when water supply and sanitation services are inadequate, large amounts of revenue are spent dealing with the impacts of disease, rather than generating wealth (Tropp Chapter 3).

In recognition of these fundamental and pressing challenges, governments have committed collectively to a set of MDGs, which, among other things, aim to halve the number of people without access to clean water and adequate sanitation services by 2015 (Box 1.2). By providing access to clean water and adequate sanitation services at an affordable price, people can begin to save, invest and take a longer-term view of their future.[6] A transition to greener approaches to resource use and investment becomes possible.

Water scarcity

Exploring opportunities to invest in the construction of dams, the International Water Management Institute (IWMI) has identified two types of water scarcity: physical scarcity and economic scarcity (Plate 1.3). In regions where there is physical scarcity, the sustainable supply limit has been reached and little opportunity to construct more dams remains. In regions where the scarcity is economic, however, it is possible to increase supplies if the financial resources necessary to build a new dam can be found. The International Water Management Institute is of the view that economic scarcity is widespread in sub-Saharan Africa and in parts of South and South-East Asia (Molden 2007).

Box 1.2 MILLENNIUM DEVELOPMENT GOALS AND WATER

In 2000, governments committed to a wide range of Millennium Development Goals (MDGs) that rely upon access to water and made a specific commitment to halve the number of people without access to clean water and adequate sanitation by 2015.

The 2010 update on progress towards the water-specific goals reports that 884 million – nearly 1 billion people – lack access to clean drinking water. When it comes to sanitation, 2.6 billion people do not have access to improved sanitation services. One in seven of those people without access to adequate sanitation services live in rural areas (WHO/UNICEF 2010).

At the current rate of investment progress, the Millennium Development Goals for sanitation will be missed by 1 billion people (Figure 1.2). Most of these people live in sub-Saharan Africa and Asia (Figure 1.3).

Significant progress has been made in India and China (WHO/UNICEF 2010).

continued

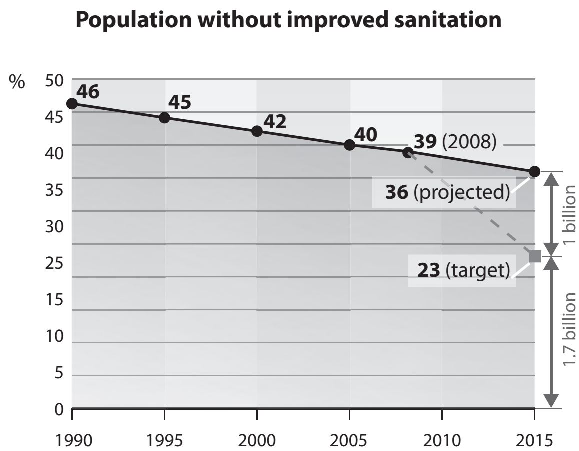


FIGURE 1.2 Global progress towards Millennium Development Goals' target to reduce the number of people without access to adequate sanitation services to 1.7 billion people by 2015.

Source: WHO/UNICEF (2010).

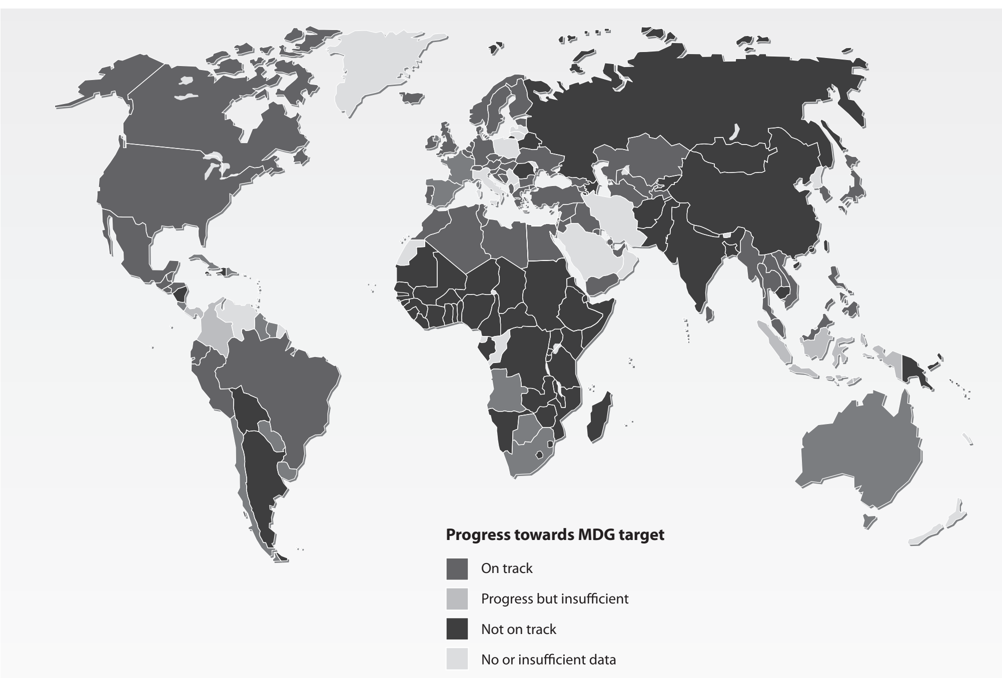


FIGURE 1.3 Progress towards attainment of the Millennium Development Goals' sanitation target to halve the number of people without adequate sanitation by 2015.

Source: WHO/UNICEF (2010).

There is general consensus that when people have access to less than 1,700 m^3 of water per year, a considerable proportion of them will be trapped in poverty (Falkenmark 1989). Taking a different approach, the Organization for Economic Cooperation and Development (OECD) defines water stress as "severe" when the ratio of total water use to renewable supply exceeds 40 per cent (OECD 2009). Using this measure, the OECD has estimated that by 2030 nearly half the world's population (3.9 billion people) will be living under conditions of severe water stress (Figure 1.4). The reasons for the emergence of this scarcity include:

- **Population increase**: by 2030, the world's population will have increased by 2.4 billion people. All of these people will demand access to water for basic needs, to supply industrial goods and grow food.
- **Increased living standards**: as countries develop and people become wealthier, they tend to consume more water and more water-intensive products such as meat.
- **Over-exploitation**: around the world, a considerable proportion of aquifers and river systems are over-used. It has been estimated that 15 per cent of India's total agricultural production is being delivered via groundwater depletion – the situation that occurs when extraction exceeds replenishment (Briscoe and Malik 2006).
- **Water pollution**: an increasing number of water supplies are becoming contaminated by pollutants, with the consequence that less water is available for use or it costs much more to make it usable.

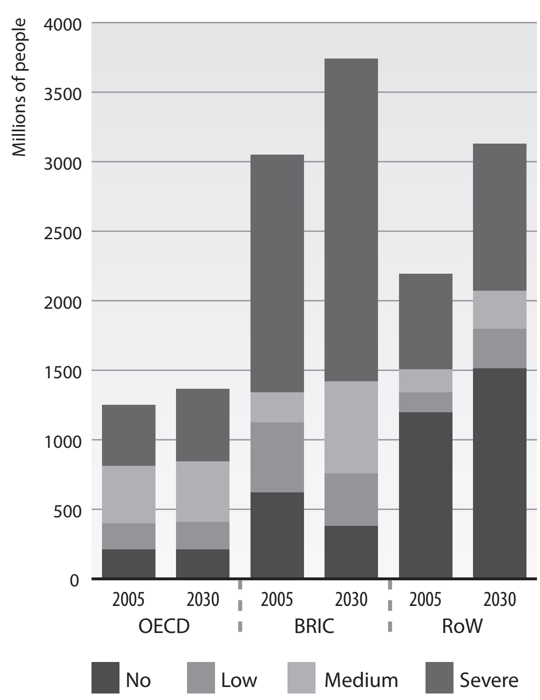


FIGURE 1.4 Number of people living in water-stressed areas in 2030 by country type.

Source: OECD (2009).

- **Ecosystem degradation**: Over the last 50 years, ecosystems have been degraded faster than ever before (Millennium Ecosystem Assessment 2005). Freshwater ecosystems, which provide critical services such as the purification of water by wetlands or forests, are the most threatened and have been among the hardest hit.
- **Adverse climate change**:[7] When combined with effects of climate change on dryland production systems, the International Food Policy Research Institute estimates that the aggregate effect of climate change is likely to be a significant reduction in total agricultural productivity. The greatest adverse impacts of climate change on people are expected in South Asia. In the next 40 years, child malnutrition is expected to increase by 20 per cent as a direct result of climate change (Nelson *et al*. 2009).

Balancing supply and demand

In an attempt to understand the magnitude of this emerging water-scarcity challenge, the 2030 Water Resources Group has projected global demand for water and, under different scenarios, compared it with likely supply. They concluded that if there is no improvement in the efficiency of water use, in 2030 demand for water could outstrip supply by 40 per cent (Figure 1.5). Clearly, a gap of this magnitude cannot (and will not) be sustained.

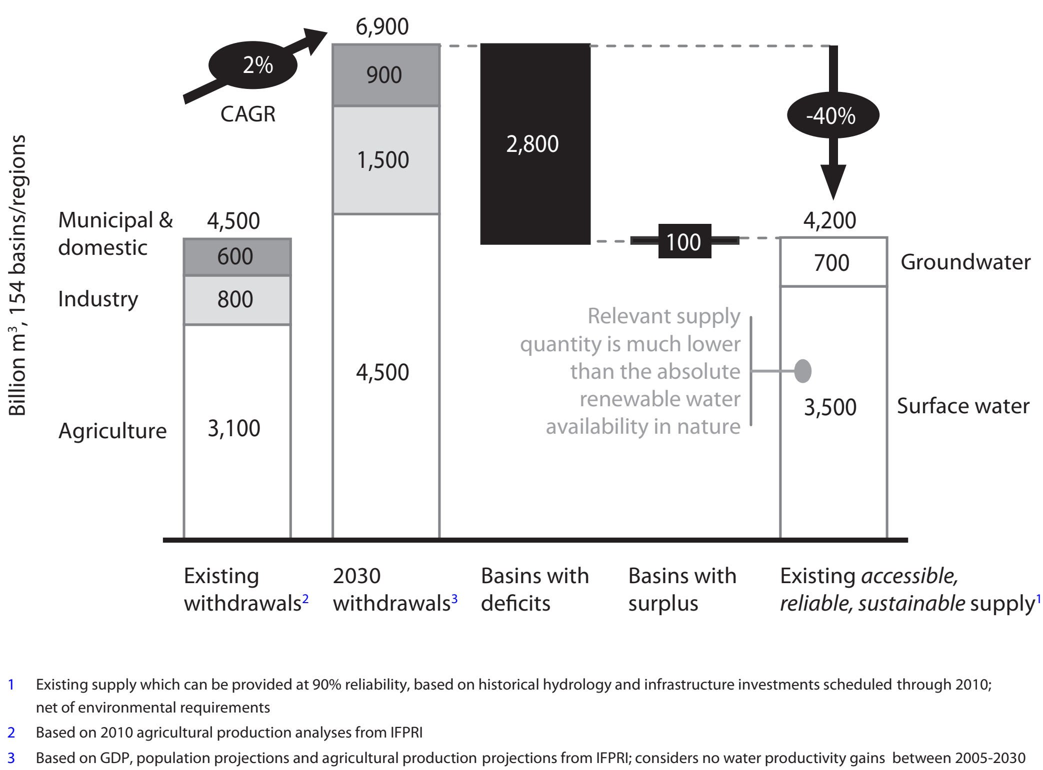
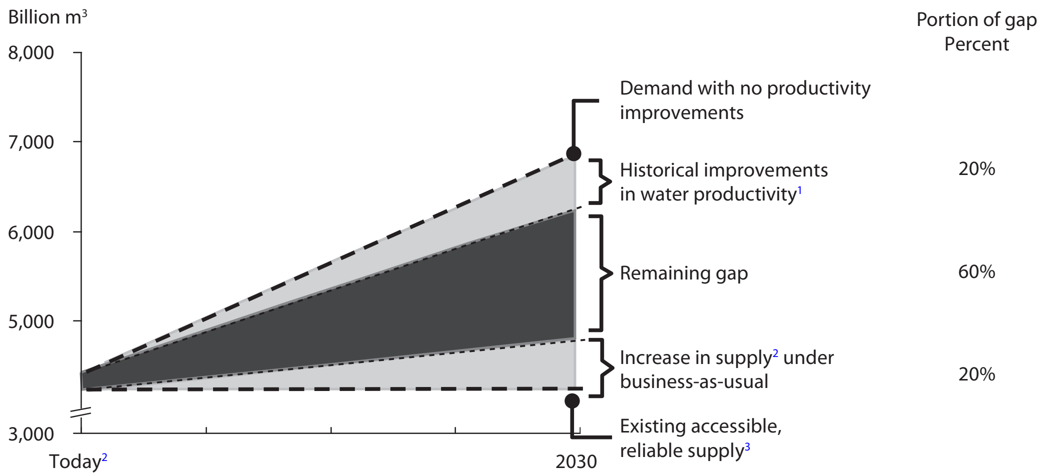


FIGURE 1.5 Aggregated global gap between existing accessible, reliable supply and 2030 water withdrawals, assuming no efficiency gains.

Source: 2030 Water Resources Group (2009).

Business-as-usual approaches will not meet demand for raw water



1 Based on historical agricultural yield growth rates from 1990-2004 from FAOSTAT, agricultural and industrial efficiency improvements from IFPRI
2 Total increased capture of raw water through infrastructure buildout, excluding unsustainable extraction
3 Supply shown at 90% reliability and includes infrastructure investments scheduled and funded through 2010. Current 90%-reliable supply does not meet average demand

FIGURE 1.6 Projection of the global demand for water and, under a business-as-usual scenario, the amount that can be expected to be met from supply augmentation and improvements in technical water-use efficiency (productivity).

Source: 2030 Water Resources Group (2009).

Figure 1.6 offers an alternative perspective on the magnitude of the emerging water-supply challenge. Under a business-as-usual scenario, improvements in water productivity can be expected to close around 20 per cent of the gap between global demand and supply. Increases in supply through the construction of dams and desalination plants, coupled with actions such as increased recycling, can be expected to close the gap by a similar amount. The remaining 60 per cent, however, must come from increased investment in infrastructure and water-policy reforms that improve the efficiency of water use. If the resources are not found to facilitate a significant increase in efficiency and if the water-policy reforms are not implemented, water crises must be expected to emerge. Figure 1.6 suggests that the average rate of improvement in water productivity and supply enhancement needs to increase at double the rate of improvement achieved in the past decade. Globally, the time for procrastination has passed.

Figure 1.7 shows the nature of expected increase in demand for water throughout the world. As discussed, one of the more significant challenges is to find ways to supply more water to the industrial sector while increasing agricultural production. Significant transfers of water from rural areas to the industrial sector can be expected, especially in China and in North America (2030 Working Group 2009). In anticipation of the pressure that these shortages will place on water-dependent business, a number of large companies are beginning to quantify and account for their water use and water-related impacts and the nature of the water-related risks they face (Lloyds 2010; United Nations 2010a).

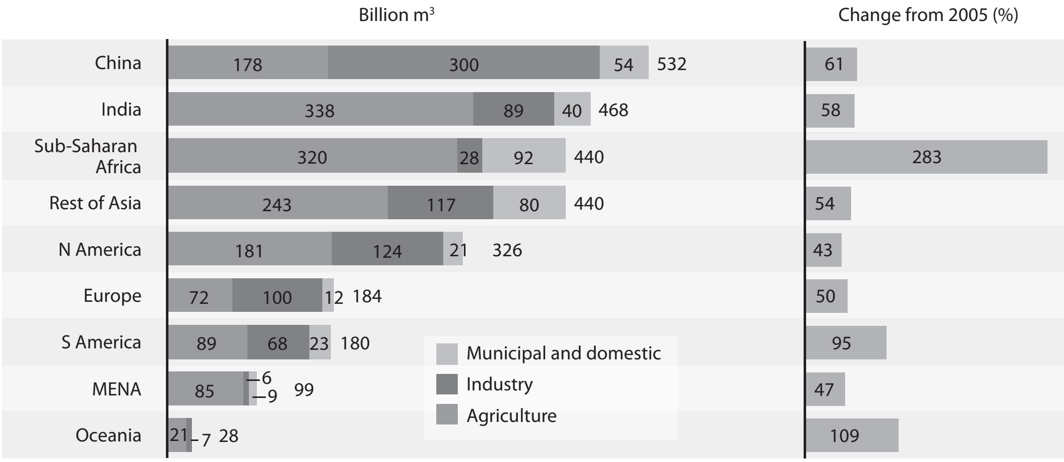


FIGURE 1.7 Assessment of expected increase in the annual global demands for water by country and by region (2005–2030).

Source: 2030 Water Resources Group (2009).

Opportunities

Investing in biodiversity and ecosystem services

In terms of ecosystem health and function, global assessments of the health of the world's water river systems and aquifers suggest that the aggregate trend is one of decline (Millennium Ecosystem Assessment Report 2005; WWF's Living Planet Report 2010; the UN World Water Development Report 2010b). Examples of this decline include:

- Barriers have been laid across China's Taihu Lake to stop regular algal blooms reaching the water treatment plant that supplies water to over 2 million people (Guo 2007).
- From October 2002 until October 2010, the absence of flow has meant that dredges have been used to keep the mouth of Australia's River Murray open to the sea.
- In Manila, the Philippines, groundwater extraction, primarily for industrial purposes, is lowering the water table at a rate of between 6 metres and 12 metres per year (Tropp Chapter 3).
- In 1997, China's Yellow River flowed all the way to the sea only for 35 days. For much of the year the river's last 400-plus miles were dry (Fu *et al*. 2004).

There is a new recognition of the positive synergy that emerges between healthy environments and healthy communities. As documented by Le Quesne *et al*. (2010), some countries are now investing large amounts of money in the restoration of degraded river systems and the development of policies and administrative arrangements designed to prevent degradation of these systems. Two examples are summarized in Box 1.3. Table 1.1 summarizes the general nature of returns to investment in the restoration of ecosystems. When astute investments in the restoration of ecosystems are made, internal rates of return in excess of 10 per cent are attainable.

Box 1.3 TWO EXAMPLES OF GOVERNMENTS INVESTING IN RIVER RESTORATION

Korea

In July 2009, the Republic of Korea announced a Five-Year Plan (2009–2013) for Green Growth in order to implement the National Strategy for Green Growth. This includes a 22.2 trillion Korean won (US$17.3 billion) investment in a Four Major Rivers Restoration Project.

The five key objectives of the project are as follows:

1 securing sufficient water resources against water scarcity;
2 implementing comprehensive flood control measures;
3 improving water quality while restoring the river-basin ecosystems;
4 developing the local regions around major rivers; and
5 developing the cultural and leisure space at rivers.

Overall, it is expected that the project will create 340,000 jobs and generate an estimated 40 trillion won (US$31.1 billion) of positive economic effects as rivers are restored to health.

Australia

In January 2007, the Australian government announced a AUS$10 billion (US$10 billion) commitment to restore health to the seriously over-allocated Murray-Darling basin and appoint an independent authority to prepare a new plan for the basin using the best available science. Some AUS$3.1 billion is being spent on the purchase of irrigation entitlements from irrigators and the transfer of these entitlements to a Commonwealth Environmental Water Holder, AUS$5.9 billion on the upgrade of infrastructure with half the water savings going to the environment, and AUS$1 billion on the collection of the information necessary to plan properly.

Sources: Office of National River Restoration (under the Ministry of Land, Transport and Maritime Affairs) (2009); Korean Ministry of Environment and Korea Environment Institute (2009); Murray-Darling Basin Authority (2010). Available at www.theaustralian.com.au/news/nation/prime-ministers-10-billion-water-plunge/story-e6frg6nf-1111112892512.

TABLE 1.1 Examples of the estimated costs and benefits of restoration projects in different biomes

Biome/ecosystem	*Typical cost of restoration (high-cost scenario)*	*Estimated annual benefits from restoration (average cost scenario)*	*Net present value of benefits over 40 years*	*Internal rate of return*	*Benefit:cost ratio*
		US$/ha	*US$/ha*	*%*	*Ratio*
Coastal	232,700	73,900	935,400	11	4.4
Mangroves	2,880	4,290	86,900	40	26.4
Inland wetlands	33,000	14,200	171,300	12	5.4
Lakes/rivers	4,000	3,800	69,700	27	15.5

Source: adapted from TEEB (2009a).

Investment in sanitation and drinking water supply

In many developing countries, one of the biggest opportunities to expedite a transition to a green economy is to invest in the provision of water and sanitation services to the poor.

A recent estimate puts the cost of achieving the 2015 Millennium Development Goals (MDGs) at US$142 billion per year for providing sanitation services and US$42 billion per year for drinking water supply to households (Hutton and Bartram 2008b). More investment is required for sanitation services than drinking water as the number of households without access to adequate sanitation services is much higher (WHO/UNICEF 2010; Tropp Chapter 3).

Although the amount of money needed to attain the Millennium Development Goals for water is considerable, when spread over a number of years and divided by the number of people expected to benefit from such expenditure, the investment case is strong. In Ghana, for example, the OECD estimates that investment of US$7.40 per person per year over a decade would enable the country to meet its MDG target (Sanctuary and Tropp 2005). Estimates of the required per capita expenditure in Bangladesh, Cambodia, Tanzania and Uganda range from US$4 to US$7 per capita per year (UN Millennium Project 2004; Tropp Chapter 3).

Taking a different approach, Grey (2004) has estimated the amount that each sub-Saharan country would need to spend to achieve water supply and sanitation standards now achieved in South Africa. Depending on the country, the amount needing to be spent varied from US$15 to US$70 per capita per year over the 10 years from 2005 to 2015.

As shown later in this chapter, returns to investment in the provision of these services can be high. In particular, Sachs (2001) has found that the average rate of economic growth in developing countries where most of the poor have affordable access to clean water and adequate sanitation is 2.7 per cent greater than that attained in countries where these services are not well supplied.[8] This observation, reinforced by other chapters in this book (Tropp Chapter 3; Ward *et al.* Chapter 9), suggests that failure to invest adequately in the provision of affordable access to clean water and adequate sanitation acts as a barrier to development and that early investment in these areas is a necessary precondition to progress. Grey and Sadoff (2007) argue that a minimum amount of investment in water infrastructure is a necessary precondition to development; using a range of case studies, they identify a close association between adequate investment in infrastructure and environmental degradation.

Investing in smaller, local water-supply systems

As observed by Schreiner *et al.* (Chapter 11), the presence of economic water scarcity should not be interpreted as a recommendation for the construction of large dams. In many cases, greater returns can be achieved from the construction of smaller storages that are built by and serve local communities. At this scale, community engagement and management of infrastructure is easier and adverse environmental impacts tend to be fewer in both urban and rural settings (Winpenny 2003).

In China's Gansu province, for example, investment in the collection of local rainwater at a cost of US$12 per capita was sufficient to enable a significant upgrade of domestic water supplies and to supplement irrigation. One project benefited almost 200,000 households (Gould 1999). At the micro-scale, it is possible to make much greater use of aid organizations and local knowledge. In Western Jakarta, for example, the local water utility is working with non-governmental organizations to provide water to people in informal settlements in a manner that would be impossible for a government utility to do so without being seen to sanction the presence of these settlements (Box 1.4).

Box 1.4 MICRO-SCALE INFRASTRUCTURE PROVISION IN WESTERN JAKARTA

In Jakarta, Indonesia, a significant proportion of the population lives in informal settlements. While the government does not want to legitimize the unlawful occupation of land, it realizes that the provision of access to safe water and sanitary conditions is necessary. A private water utility, Palyja, is responsible for water supply in Western Jakarta and it is expected to supply water to all residents, including those in informal settlements. To this end, Palyja has a water-supply contract with the government whereby they are paid for the cost of delivering water to users and for the cost of building and maintaining the necessary infrastructure.

As part of this process, Palyja is trialling the provision of access to groups of informal houses by establishing community-based organizations. Each organization is given access to a single master water meter and is responsible for the management of the community's water-supply infrastructure, as well as paying for the volume of water taken (Figure 1.8). MercyCorps has helped connect 38 households to a single meter, while USAID's Environmental Service Program (ESP) has brought 58 households together. Once established, the community signs a supply contract with Palyja, with a special tariff arrangement to account for the fact that many households are using a single meter. Under this arrangement, both sides benefit: the community gets reliable access to an affordable water supply, while Palyja supplies a large number of houses with water at much lower overhead and administrative costs.

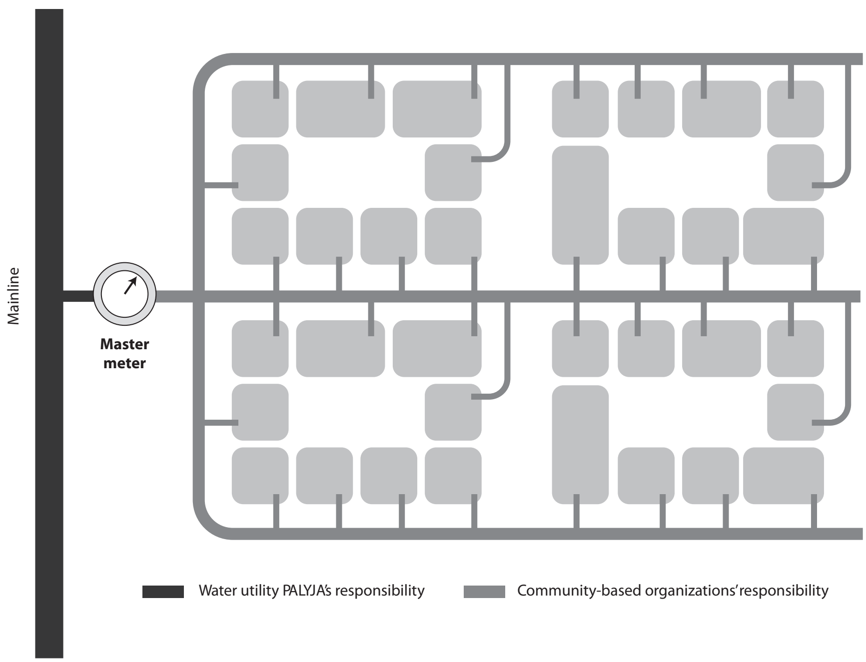


FIGURE 1.8 Schematic representation of a master meter system managed by a community-based organization.

Source: Fournier *et al.* (2010).

Accessing new (non-traditional) sources of water

One of the most common approaches to resolving water-supply problems is to build a large dam. Constructing them typically involves significant cost, the dislocation of many people and many adverse environmental problems.[9] Schreiner *et al.* (Chapter 11) observe that urban communities have historically relied on large dams for their water supplies. More recently, however, water-supply options have expanded to include the capture and storage of stormwater and desalination, fog interceptions in cloud forests (notably in the Andes mountains), transfers between islands, inter-basin water transfers and bulk transport such as by pipeline or Medusa bags (giant polyfibre bags holding up to 1.5 billion litres of potable water that are towed by ships). Other communities and countries are investing in sewage recycling. Singapore, for example, has invested in the development of systems that treat sewage to a standard allowing it to be used for drinking purposes. Most of these technologies, however, are reliant upon the use of increasing amounts of energy and, as a result, the costs of water provision are rising in most regions where there is physical water scarcity.

Desalination has the advantage that it is climate-independent but, as with most of these alternative sources of supply, is disadvantaged by the fact that it requires access to large amounts of energy. Usually, sewage recycling is cheaper than desalination as it uses the same reverse osmosis technology, but requires about half as much energy per unit of water treated (Côté *et al.* 2005). Public opposition to household use of recycled sewage water, however, is strong (Dolnicar and Schäfer 2006). A careful assessment of the costs of these alternative sources of supply often reveals that it is cheaper to invest in demand control (Beato and Vives Chapter 6; 2030 Water Resources Group Chapter 2). In a green economy, there is much more attention to the long-term costs and impacts of resource use on the environment.

Producing more food and energy with less water

As the world's population increases, more water will be needed for household and industrial purposes with the consequence that in many areas, either more food will have to be imported, or more food produced with less water. When asked, "Is there enough land, water, and human capacity to produce food for a growing population over the next 50 years – or will we 'run out' of water?", analysis undertaken by the International Water Management Institute (IWMI) reveals that, "It is possible to produce the food – but it is probable that today's food production and environmental trends, if continued, will lead to crises in many parts of the world" (Molden 2007).

For example, in many developing countries, typical irrigated maize yields are in the vicinity of 1 to 3 tonnes per hectare, while they could be as high as 8 tonnes per hectare. There is a significant opportunity to increase crop yields and avoid a global food security crisis. If this opportunity is realized, then not only will it also be possible to divert water to other uses, but it will also be possible for developing countries to produce a surplus for sale to others.

Institutional reform

When coupled with more traditional "hard" approaches to investment in built infrastructure, the "softer" approach of developing more effective administrative arrangements and policies that encourage private investment can significantly reduce the amount of money that governments need to invest in the water sector to achieve the same outcome. Opportunities to pursue this approach are developed below. Typically, soft approaches focus on incentives and the factors that motivate consumers to manage their water use.

The economics of greening water use

Research around the world suggests that there are no single-shot solutions to the world's mounting water access, sanitation and scarcity problems. Each circumstance has its own unique set of challenges and opportunities. At the most general level, it is becoming apparent that the best results come from the pursuit of mixed solutions. Simple, single-shot solutions tend to be prohibitively expensive and, in many cases, are insufficient to solve known supply problems (2030 Water Resources Group Chapter 2). In the Zambezi Basin, it has been estimated that even full development of the area's irrigation potential would benefit no more than 18 per cent of its rural poor (Björklund *et al*. 2009). A much more sophisticated investment strategy is needed (Ménard and Saleth Chapter 8).

The economics of investing in water and ecosystems

Under the global model developed for the Green Economy Report by the Millennium Institute, the green investment scenario assumed investment in the water supply and sanitation sector would equal that estimated by Hutton and Bartram (2008b) as necessary to achieve the MDGs for water by 2015. Once this is achieved, it is assumed that governments will decide, once again, to halve the number of people without access to a reliable mains water supply and adequate sanitation. This new goal is achieved in 2030. Any funds left over during this second period are allocated to other water-related investments. In areas where there is economic water scarcity, priority is given to the construction of dams. In other areas, investment is channelled into making water-use more efficient. Where possible, and economically appropriate, desalination plants are constructed. These are assumed to supply water into the urban sector at a cost of US\$0.11/m^3 – in constant US\$ 2010.

Under the business-as-usual scenario, water use remains unsustainable and stocks of both surface and groundwater decline. Under the green investment scenario, global water use is kept within sustainable limits and all the MDGs for water are achieved in 2015. Water use is more efficient, resulting in increased agricultural, biofuel and industrial production. The number of people living in a water-stressed region is 4 per cent less under the green investment scenario by 2030 compared to business-as-usual, up to 7 per cent by 2050.

The results from this modelling are encouraging in both economic terms and from the perspective of water management (see Table 1.2). For 2050, total employment and income is greater under the green investment scenario, whereas the number of people working in the water sector is lower. This counter-intuitive finding occurs because the sector becomes much more efficient. Labour and other resources, which, under BAU2 would have been retained in the water sector, are freed for use in other sectors. In addition, as water is used more efficiently, more is available for manufacturing and other purposes with the result that more people are gainfully employed.[10]

The overall conclusion from this assessment is that where there is water scarcity or when large proportions of a population do not have access to adequate water supply and sanitation services, early investment in water is a necessary precondition to progress.

Selecting projects and initiatives for investment

While it is useful and informative to examine the economics of investing in water at the global level, investments must be made primarily at the river-basin, catchment and local level.

In areas where the costs of enhancing water supplies from traditional sources are rising, the 2030 Water Resource Group (Chapter 2) is recommending the preparation of formal cost curves similar to

TABLE 1.2 Modelled results of the green investment scenario

		2% GDP invested in green sectors	
	Unit	*2030*	*2050*
Additional investment in water sector	US$ billion/year	191	311
Additional water from desalination	km^3	27	38
Water from efficiency improvements (driven by green investments)	km^3	604	1,322
Total employment in the water sector	million people	38	43
Change in total employment in the water sector relative to BAU2*	per cent	−13	−22

Note: * The water-related investments are part of an integrated green investment scenario, "G2", in which a total of 2 per cent of global GDP is allocated to a green transformation of a range of key sectors. The results of this scenario, in which the 2 per cent is additional to current GDP, is compared to a corresponding scenario in which an additional 2 per cent of global GDP is allocated following existing business-as-usual trends, "BAU2."

those shown in Plate 1.4. These cost curves rank each potential solution to a problem in terms of the relative cost per unit of desired outcome achieved and can be used to assess the likely costs and benefits of each solution. One of the most striking features of this approach is that one often finds solutions that both make more water available and cost less money. In China, for example, constructing water-availability cost curves identified 21 opportunities to make more water available for use and save money (Plate 1.4). These include increased paper recycling, investment in leakage reduction, waste-water reuse in power stations and commercial buildings and investment in water-efficient shower heads. All of these approaches are consistent with the development of a green economy, which seeks to minimize the impact of economic activity on the environment.

Flow of benefits from investment in the water-supply and sanitation sector

Many returns to investment in the water sector are indirect. Build a toilet for girls in a school and they are more likely to go to school. This simple statement highlights the fact that investment in water opens up other opportunities for development. Assessing the case for more investment in water infrastructure in the Niger Basin, Ward *et al.* (Chapter 9) report that investment in providing access to potable water and in education are the only two variables that are consistently related to poverty reduction across the whole Niger River Basin (Box 1.5).

Highlighting the complex spatial nature of responses to water investment, Plate 9.10 shows the predicted reductions in child mortality and morbidity from the protection of drinking-water supplies.

Enabling conditions – overcoming barriers and driving change

The first half of this chapter focuses on the case for investing in the provision of ecosystems services and in the water supply and sanitation sector. In the second half, we focus on the institutional conditions, "softer" approaches, which have the potential to speed the transition to increase the return on investment and reduce the amount of money that needs to be invested in the water sector.

Without significant water policy reform to enable the reallocation of water from one sector to another, financially reward those who make water use more efficient and so forth, a global analysis by the 2030 Water Resources Group 2010 (Chapter 2) suggests that some nations will not be able to avoid the emergence of a water crisis in many regions. If wide-ranging reforms are adopted, however, then the group's analysis suggests that most water crises can be averted. Investment in water policy reform and

Box 1.5 EMPIRICAL ANALYSIS OF THE RELATIONSHIP BETWEEN POVERTY AND THE PROVISION OF ACCESS TO WATER AND SANITATION IN THE NIGER RIVER BASIN

Ninety-four million people live in the Niger River Basin. The proportion living below the poverty line in Burkina Faso is 70.3 per cent, in Guinea 70.1 per cent and in Niger 65.9 per cent. Childhood mortality rates are up to 250 per 1,000 live births. In 2004, only 53 per cent of those living in the Niger River Basin were found to have access to a reliable and safe source of drinking water. Only 37 per cent had access to adequate sanitation facilities.

The quality of water used by households appears to be as important, or more so, than the total quantity of water available in the environment in predicting poverty levels. The use of unprotected well or surface water is generally positively correlated with increased child mortality and increased stunting.

In north-west Nigeria and east Nigeria, a 10 per cent decrease in the number of people using unprotected water is correlated with a decrease in child mortality of up to 2.4 per cent. Increased irrigation development is correlated with reductions in child stunting in central Mali, north-west Nigeria, central and eastern Nigeria and north Burkina Faso. Increased time spent in education is significantly correlated with a reduction in child mortality and child stunting. In much of the Mali Inner Delta, a 1-year rise in the average level of education is associated with an approximate 3 per cent fall in child mortality.

The area of irrigated land was associated with decreases in poverty in only two cases, north-west Nigeria and eastern Nigeria and northern Cameroon. This suggests that the contribution of irrigation to total rural welfare is low in the Niger River Basin and that the levels of irrigation potential are too small at present to offer a discernable improvement in livelihoods at this scale of analysis. This is in contrast to the general literature on development in this region that suggests irrigation will be crucial for the future economic well-being of the basin, along with improvements in the productivity of rain-fed agriculture. However, it may be that the benefits of irrigation do not yet accrue to the people engaged in its practice or that they do so at levels too small to register in these statistics.

The data suggest poverty reduction initiatives that rely solely on hydrologic probabilities or fail to account for the different causal relationships of spatially differentiated poverty are likely to be less effective than those that take a mixed approach.

Strong spatial patterning is evident. Education and access to improved water quality are the only variables that are consistently significant and relatively stationary across the Niger River Basin. At all jurisdictional scales, education is the most consistent non-water predictor of poverty. Access to protected water sources is the best water-related predictor of poverty.

Source: Ward *et al.* (2009).

governance enables greater engagement and use of local knowledge and for investments to be made at a multitude of scales. When such approaches are taken, the 2030 Water Resources Group (2009) estimates that the global amount of money that needs to be invested in the water sector can be reduced by a factor of four.

Improving general institutional arrangements

Arguably, the greatest impediment to investment in water infrastructure and management arrangements has been the difficulty in establishing high-level governance and political support for arrangements that support effective governance (Global Water Partnership 2009a). Problems range from a simple lack of institutional capacity to the presence of widespread corruption[11] and opportunities to gain political favour. Building upon these observations in a background paper prepared for this chapter, Ménard and Saleth (Chapter 8) report that governments are learning that improvement in arrangements for the administration of water resources offers one of the lowest-cost opportunities to resolve water management problems in a timely manner. Long-term solutions such as the establishment of reliable, stable governance arrangements for the supply of water are central to a green economy.

A parallel issue is the question of rights or entitlements to use land and water. When these rights are insecure, the incentive to take the long-term perspective necessary to encourage green approaches to investment is weak. When land tenure, water entitlements and other forms of property rights are well defined, far more sustainable forms of resource use can be expected. Early investment in the development of land registers and other similar processes are simple ways to expedite the transition to a green economy.

Increases in the capacity of a nation to collect taxes will clearly make it easier to move to full-cost pricing arrangements and, where appropriate, provide rebates and other forms of assistance to the most needy without having to resort to inefficient cross-subsidies.

Another example of an enabling condition is the use of education and information programmes designed to increase awareness of opportunities to act in an environmentally responsible manner. If members of a community feel obligated to look after the environment then they are more likely to do so.

International trade arrangements

Whether or not freer trading arrangements will ultimately be to the benefit of water users depends upon the degree of trade liberalization that occurs and what exceptions are made. As agriculture uses around 70 per cent of all water extracted for consumptive purposes, and large amounts of water are embodied in many of the agricultural products traded (Figure 1.9), this policy option deserves careful consideration. When trade is unrestricted and all inputs priced at full cost, communities have the opportunity to take advantage of the relatively abundant sources of water in other parts of the world. When trade in agricultural products is restricted, water use is likely to be less efficient. Fewer crops can be grown per drop of available water. As a whole, the world is generally worse off. However, some countries strive for "food sovereignty" for various reasons including security.

In an attempt to understand the likely impacts of freer trading arrangements on water use, a background paper to this chapter uses a model to estimate the likely effects of agricultural trade liberalization on water use (Calzadilla *et al.* Chapter 4). The model used differentiates between rain-fed and irrigated agriculture and includes functions that take into account the effects of climate change on the volume of water available for extraction. The trade-liberalization scenario is based on the proposals being

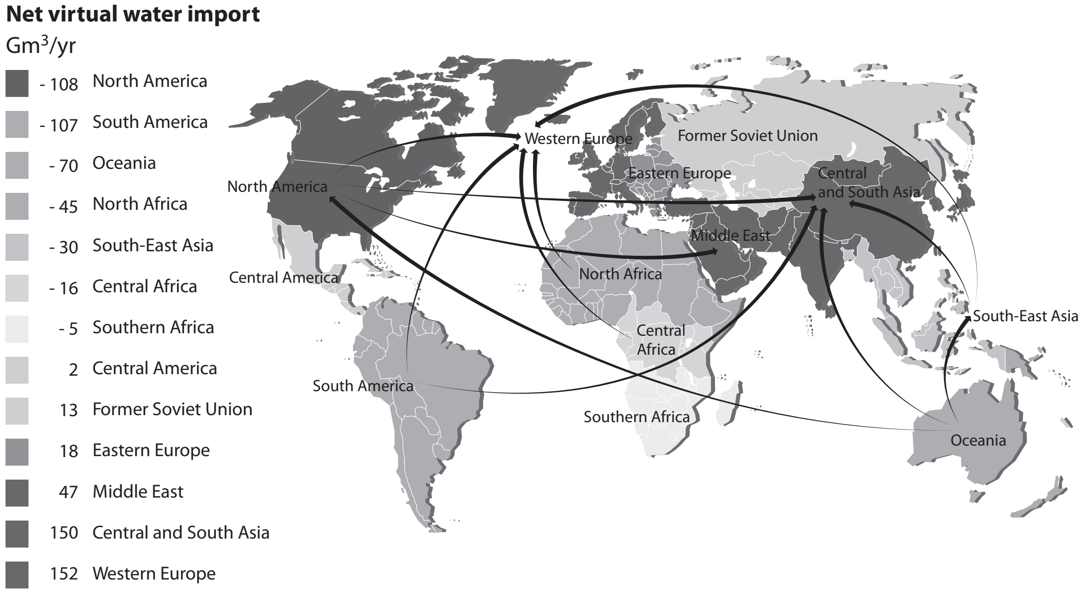


FIGURE 1.9 Regional virtual water balances and net interregional virtual water flows related to the trade in agricultural products, 1997–2001. The arrows show net virtual water flows between regions (>10 BCM/yr).

Source: Chapagain and Hoekstra (2008).

developed as part of the Doha round of negotiations, which seek to move the world towards a regime where agricultural trade is less restricted. In particular, the analysis assumes that there is a 50 per cent reduction in tariffs, a 50 per cent reduction in domestic support to agriculture and that all export subsidies are removed. Given that progress towards such a regime will take time to implement, the scenario is examined with and without climate change. The climate-change scenarios are based on those developed by the Intergovernmental Panel on Climate Change (IPCC) (2008).

Table 1.3 presents a summary of the findings of this modelling exercise, presented in more detail in the background paper. The introduction of "Doha-like" freer trading arrangements increases global welfare by US$36 billion. If strong climate change occurs, global welfare is reduced by US$18 billion. The model assumes no change to the policies that determine how the welfare benefits from increased trade are distributed. Calzadilla *et al.* (Chapter 4) conclude that trade liberalization:

- Increases the quantity of agricultural products traded and the capacity of nations to trade with one another with the consequence that global capacity to adjust to climate change is greater than it otherwise would be.
- Tends to reduce water use in water-scarce regions and increase water use in water-abundant regions, even though water markets do not exist in most countries.
- Makes each nation more responsive to changing conditions and, as a result, reduces the negative impacts of climate change on global welfare by 2 per cent. Regional changes, however, are much larger than this.

TABLE 1.3 Change in regional welfare over 20 years as a result of climate change and trade liberalization, US$ million (findings from a model developed by Calzadilla *et al.* 2010)

	50 per cent reduction in tariffs, no export subsidies and 50 per cent reduction in domestic support to agriculture	*Strong climate-change scenario*	*Both scenarios combined (free trade and strong climate change)*
United States	–1,069	–2,055	–3,263
Canada	–285	–20	–237
Western Europe	3,330	1,325	4,861
Japan and South Korea	11,099	–189	10,970
Australia and New Zealand	622	1,022	1,483
Eastern Europe	302	538	883
Former Soviet Union	748	–6,865	–6,488
Middle East	2,104	–3,344	–1,213
Central America	679	–240	444
South America	1,372	805	2,237
South Asia	3,579	–3,632	–28
South-East Asia	3,196	–3,813	–552
China	5,440	71	5,543
North Africa	4,120	–1,107	3,034
Sub-Saharan Africa	218	283	458
Rest of the World	285	–308	–17
Total	35,741	–17,530	18,116

In summary, the modelling suggests that freer international trading arrangements for agriculture will significantly reduce the costs of facilitating adjustment and attaining MDG targets. Trade liberalization can be expected to reduce water use in places where supplies are scarcest and increase water use in areas where they are abundant. Trade liberalization increases the capacity to adapt to climate change and reduces its negative effects.

Using market-based instruments

Market-based instruments that can be harnessed to foster a green economy include:

- payments for ecosystem services (PES);
- consumer-driven accreditation and certification schemes that create an opportunity for consumers to identify products that have been produced sustainably and pay a premium for access to them; and
- arrangements that send a scarcity signal including the development of offset schemes, the trading of pollution permits and the trading of access rights to water.

Each of these approaches has direct application to the water sector and the degree to which communities are likely to become interested in maintaining and investing in the provision of ecosystem services.

Payments for ecosystem services

From a water perspective, there are two main types of payments for ecosystem services – those financed by the user of a service and those financed by a government or donor (Pagiola and Platais 2007; Engel *et al.* 2008). In either case, such schemes can be successful only when a secure source of money for the scheme has been identified and committed. Arguably, the most efficient are operated by users who are able to identify which services they want and the price they are willing to pay for them. Most government-financed programmes depend on financing from general revenues and, because they typically cover large areas, they are likely to be less efficient. Moreover, because they are subject to political risk, they are less likely to be sustainable. When a government or financial conditions change, support for the scheme can collapse (Pagiola and Platais 2007; Wunder *et al.* 2008).

Payments for ecosystem services schemes are becoming common in Latin America and the Caribbean region. In Ecuador, Quito's water utility and electric power company pays local people to conserve the watersheds from which this company draws its water (Echavarría 2002a; Southgate and Wunder 2007). In Costa Rica, Heredia's public-service utility pays for watershed conservation using funds derived from a levy on consumers (Pagiola *et al.* 2010).

Many small Latin American towns have similar schemes, including Pimampiro in Ecuador, San Francisco de Menéndez in El Salvador and Jesús de Otoro in Honduras (Wunder and Albán 2008; Herrador *et al.* 2002; Mejía and Barrantes 2003). Hydroelectric producers are also becoming involved. In Costa Rica, for example, public-sector and private-sector hydroelectricity producers are paying for conservation of the watersheds from which they draw water. Pagiola (2008) reports that these companies now contribute around US$0.5 million per annum towards the conservation of about 18,000 ha. In Venezuela, CVG-Edelca pays 0.6 per cent of its revenue (about US$2 million annually) towards the conservation of the Río Caroní's watershed (World Bank 2007). Some irrigation systems, such as those in Colombia's Cauca Valley, have participated in schemes such as these (Echavarría 2002b).

More generally, and as explained by Khan (Chapter 5), as countries shift to a greener set of economic arrangements, the costs of more traditional hard engineering approaches to water management involving the construction of treatment plants, engineering works to control floods, etc. become more expensive. In contrast, the cost of operating an ecosystem payment scheme is much less likely to increase. For this to occur, however, parallel investments in the development of property rights and governance arrangements may be necessary to ensure water-supply utilities can enter into contracts that maintain access to ecosystem services and expect these contracts to be honoured. Well-defined land tenure systems, stable governance arrangements, low transaction costs and credible enforcement arrangements are essential (Khan Chapter 5).

As noted elsewhere in this chapter, early attention to governance arrangements is a necessary pre-condition to the inclusion of water in a transition strategy to a green economy.

Strengthening consumer-driven accreditation schemes

While rarely used in the water sector, in recent years there has been a rapid expansion in the use of a variety of product accreditation schemes that enable consumers to pay a premium for access to products produced without detriment to the environment including its capacity to supply water-dependent services. As observed by de Groot *et al.* (2007), these accreditation schemes rely on the self-organizing nature of private market arrangements to provide incentives for the beneficiaries of the improved service to pay for it. Once established, these arrangements can play an important role in encouraging the restoration of natural environments.

Arguably, one of the better-known examples is the labelling scheme developed by the Forest Stewardship Council (FSC). The Council guarantees that any timber purchased with its label attached has been harvested in a manner that, among other things, seeks to maintain ecological functions and the integrity of a forest. Where appropriate, this includes recognition of the essential role that forests play in water purification and in protecting communities from floods.[12]

Increasing the use of tradeable permit, off-set and banking schemes

A broad class of market-based instruments of relevance to a green economy are those that limit opportunity to pollute and/or use a resource. There are many variants of such schemes, but all work by using a market mechanism to reward people who are prepared to cease or reduce a water-affecting activity, thus allowing others to take up the same activity and thereby ensuring an overall controlled impact on the environment.

One such example is a mechanism whereby a water treatment plant can release more nutrients into a waterway by arranging for the reduction of nutrient pollution from a nearby dairy farm. In many cases, the result can be a significant improvement in water quality at a much lower cost if the water treatment plant is not allowed to increase its emissions. In rural areas, nitrate pollution charges and trading schemes are often suggested and are now operational in parts of the USA (Nguyen *et al.* 2006).

Another example, well developed in the USA, is the use of wetland banking schemes that require any person proposing to drain a wetland to first arrange for the construction, restoration or protection of another wetland of greater value (Robertson 2009). In these schemes, it is possible for a person to restore a wetland and then bank the credits until a third party wishes to use them. Three quarters of these wetland banking arrangements involve the use of third-party credits (U.S. Army Corps of Engineers 2006; Environmental Law Institute 2006).[13]

Improving entitlement and allocation systems

The last class of market-based instruments of particular relevance to water are those that use water entitlement and allocation systems to allow adjustment to changing economic and environmental conditions by allowing people to trade water entitlements and allocations.

In well-designed systems, water-resource plans are used to define rules for determining how much water is to be allocated to each part of a river or aquifer and a fully specified entitlement system is then used to distribute this water among users. Under such an arrangement, rapid changes in supply conditions can be managed efficiently (Young 2010). Australian experience in the development of fully specified entitlement systems is described in Box 1.6. Among other things, the approach enables people to use bottom-up market-based approaches to respond rapidly to changes in water supply. Consistent with the notion of increased returns from taking a green approach to the development of an economy, the introduction of water markets in Australia has produced an estimated internal rate of return in excess of 15 per cent per year over the last decade (see Figure 1.10). The result has been a considerable increase in the wealth and welfare of those involved.

In a green economy, the environment is given rights that are either equal or superior to those of other users of a water resource. In countries where property right systems are robust and users comply with entitlement and allocation conditions, environmental managers are beginning to purchase and hold water entitlements for environmental purposes. In Oregon, USA, for example, the Oregon Water Trust has been buying water entitlements from irrigators since 1993 (Neuman and Chapman 1999) and then using the water allocated to them to maintain and improve the function of streams and

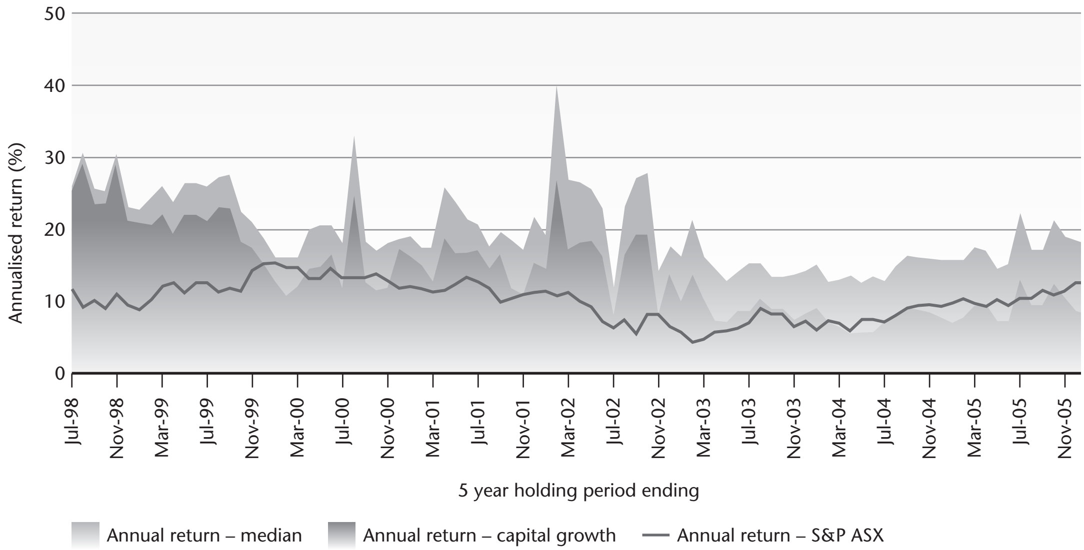


FIGURE 1.10 Annual returns from selling allocations (dark shading) and capital growth (light shading) in the value of a water entitlement compared with an index of the value of shares in the Australian Stock Exchange, Goulburn Murray System, Murray-Darling Basin.

Source: Bjornlund and Rossini (2007).

Box 1.6 AUSTRALIAN EXPERIENCE IN THE ROLE OF WATER MARKETS IN FACILITATING RAPID ADAPTION TO A SHIFT TO A DRIER CLIMATIC REGIME

Recently, Australia's Southern Connected River Murray System experienced a rapid shift to a drier regime that has demonstrated both how difficult and how important it is to specify water rights as an entitlement only to a share of the amount of water that is available for use and not an amount. At the time that this shift occurred, the plans that were in place assumed that inflows would continue to oscillate around a mean and that known water accounting errors in the entitlement system could be managed. As a result, when a long dry period emerged, stocks were run down and managers decided to use environmental water for consumptive purposes on the assumption that more water could be made available to the environment when it rained again.

After four years of drought, and as the drought moved into its fifth, sixth, seventh and eighth year, plans had to be suspended and new rules for the allocation of water developed (National Water Commission 2009). A new Basin Plan is now in the process of development and will seek, among other things, to deal with an acute over-allocation problem. In parallel with these changes, considerable investment has been made in the development of the scientific capability to assemble the knowledge necessary to prevent these problems from re-emerging.

Another key feature of the system now being used in all Basin States is the definition of entitlement shares in perpetuity and the use of water markets to facilitate change. All water users now understand that they will benefit personally if they can make water use more efficient.

continued

As a result, a vibrant water market has emerged and significant improvements in the technical efficiency of water use have occurred. In this regard, Australia was lucky its entitlement system and the associated administrative processes had been developed in a manner that facilitated the rapid development of the water market possible (see Figure 1.11). Among other things, this included a much earlier commitment to meter use and established governance arrangements that prevent people from using more water than that allocated to them and the unbundling of water licences so that equity, efficiency and environmental objectives can be managed using separate instruments.

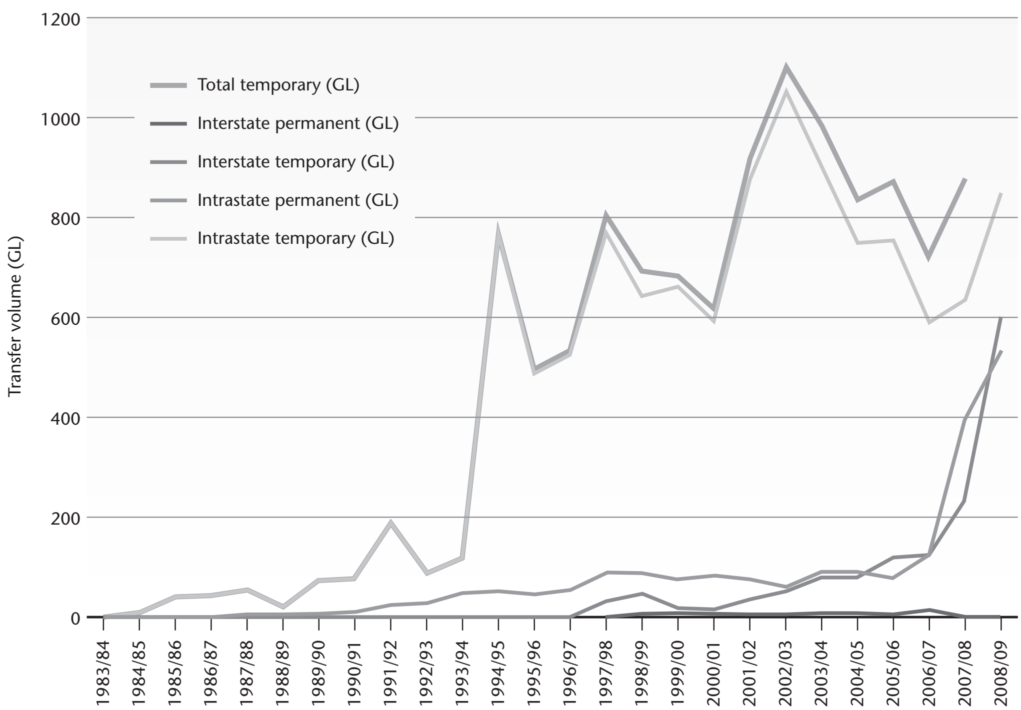


FIGURE 1.11 Development of Murray-Darling Basin water entitlement and allocation trading.

Source: Young (2010).

water-dependent ecosystems (Scarborough and Lund 2007). In Australia, the Commonwealth Environmental Water Holder (CEWH) has recently acquired 705 gigalitres of water entitlements from irrigators for similar purposes in the Murray-Darling Basin and has announced its intention to continue to do this until it holds in the vicinity of 3,000 to 4,000 gigalitres of water entitlements (Murray-Darling Basin Authority 2010). If this process is completed, the CEWH will hold between 27 per cent and 36 per cent of all the Basin's water entitlements.

Reducing input subsidies and charging for externalities

In some cases, subsidies can be justified but unless implemented with great care, they can have a perverse effect on progress towards the greening of an economy. In most cases, subsidies encourage the exploitation of water at unsustainable rates. In India's Punjab Province, for example, electricity for groundwater pumping is supplied to farmers either at a heavily subsidized price or for free. Experience is now showing that these subsidies encourage farmers to pump much more water than otherwise would be the case and, as a result, water levels in 18 of Punjab's 20 groundwater districts are falling rapidly. Officials are aware of the adverse effects of subsidizing electricity to this extent but have been unable to find a politically acceptable way of phasing them out (The Economist 2009).

Processes that attempt to reflect the full cost of electricity use include funding research on the adverse effects of providing these subsidies and stimulating public debate about the wisdom of continuing to do so. If this research is rigorous and the communication strategies well developed, it is hoped that ultimately there will be sufficient political pressure to enable these subsidies to be removed (Ménard and Saleth Chapter 8). As soon as this starts to happen, the money saved can be used to invest in other, more sustainable activities. An alternative, much more expensive approach is to build a separate rural power supply system so that access to electricity can be rationed.

Improving water charging and finance arrangements

As noted by the OECD (2010), water-supply pricing policies are used for a variety of economic, social and financial purposes. Ultimately, water policies need mechanisms that distribute water to where it is needed, generate revenue and channel additional sources of finance.

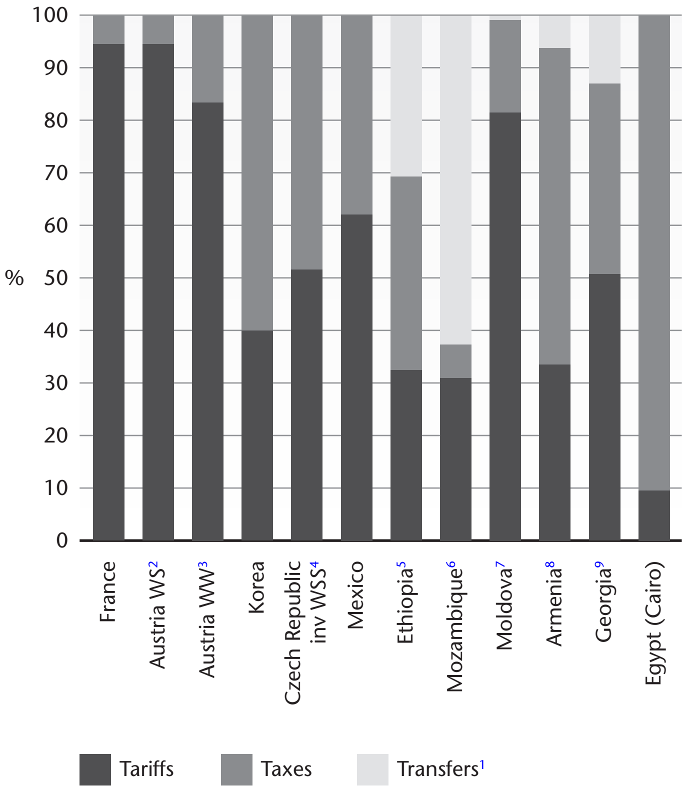
From a greening economy perspective, we recognize, however, that there is little agreement about the best way to charge for access to water and sanitation services. Three background papers were adapted to assist with preparation of this chapter – a primer on the economics of water use, a primer on financing and a paper on South African experience with the supply of free access to basic water (Beato and Vives Chapter 6; Muller Chapter 12). Relevant insights can also be gained from the background paper on Indonesian experience with the provision of water to Western Jakarta (Fournier *et al.* Chapter 10). The UK is pioneering various pricing arrangements that reflect the full costs of providing water. The approach emphasizes the role of pricing and charging in catalyzing innovation and in encouraging communities to share access to water resources.

Sources of revenue

Known as the "3 Ts", in essence, there are three ways to finance water infrastructure and the costs associated with operating that infrastructure (OECD 2009):

1 Users can be charged a *tariff* for the water provided to them.
2 *Tax revenue* can be used to subsidize operating costs and cover capital costs.
3 Grants and other forms of *transfer payment* can be sourced from other countries.

Figure 1.12 shows how different countries combine each of these approaches. Very few countries rely only upon tariffs to finance infrastructure investment, even though economic theory would suggest that charging people a tariff in proportion to the service provided is the most efficient option. Reliance on tax revenue is common and, when donors are willing, transfer payments (donations) can play a



1. Includes ODA grants as well as private grants, such as through non-governmental organizations
2. Water supply
3. Wastewater
4. Composition of capital investment for water supply and sanitation
5. 2005/06
6. Rural WS, 2006
7. 2006
8. 2005
9. 2007

FIGURE 1.12 Array of mixes of transfer, tax and tariff approaches to the provision of infrastructure finance.

Source: OECD (2009).

significant role. In OECD countries, it is now common for urban water-supply utilities to set a tariff that is sufficient to cover the full operating costs of supplying water (OECD 2010).

Charging for access to water

Shifting to a green economy usually involves a commitment to begin charging for the full costs of resource use. With regard to water, however, there is a dilemma as access to clean water and adequate sanitation services is a human right (United Nations 2010a). In a green economy, the efficient use of resources is encouraged, as is investment in built infrastructure. There is also an emphasis on equity.

When considering the most appropriate charge to set, from an efficiency perspective, it is useful to distinguish between:

- the capture, storage, treatment and supply of water for public rather than private purposes;
- situations where water supplies are abundant and when supplies are scarce;
- the supply of water to households, to industry and for irrigation;
- regions where institutional capacity to collect charges is strong and when it is weak; and
- the need to recover daily operating costs and the need to make an adequate return on capital so that the supplier (whether public or private) can afford to maintain both natural and built infrastructure.

Complicating the issue, there is also a need to consider the implications of charging people for the full cost of providing sanitation services. First, sanitation service provision generally requires access to water. Second, there are important public health issues to consider. When, for example, one person defecates in the open, health risks are imposed on all who live nearby. In an attempt to avoid the emergence of such problems, governments normally set building standards that require the provision of toilets and connection either to a sanitation service or an appropriate on-site treatment of the waste. When there is no effective building control and, especially when informal settlements are involved, a way to efficiently engage with communities needs to be found.

When water is used for public purposes, such as the maintenance of a wetland for biodiversity or recreational benefits, access is usually provided for free and funded by the government through taxation. Usually, this is efficient as the beneficiaries are numerous and not easily identified. Moreover, there is no congestion problem; many people can benefit without detracting from the benefit received by others.

When water supply (consumption) is for private benefit, however, use by one person typically excludes use by another. In such situations, the efficient strategy is to make water available to those who want it at – at least – the full cost of supply. Then, every water user has a greater incentive to use water efficiently. But this simple observation fails to consider important equity considerations that are discussed in the next section.

When water supplies are scarce, the efficient strategy is to price access to water at the marginal cost of supplying the next unit of water (Beato and Vives Chapter 6). Costs increase as more and more water is produced. The efficient charge is equal to marginal cost – the cost of producing the next unit of water. Typically, this cost rises as more and more water is supplied.

When water supplies are scarce and no more water can be accessed by, for example, more desalination or recycling, economic theory would suggest the need for a scarcity charge.

When water supply is abundant, however, water-pricing theorists face an interesting dilemma. As more and more water is supplied, the cost per unit of water supplied declines. Moreover, the cost of supplying the next unit of water is less than the average cost of supply. The result is a regime where, if water charges are set at marginal cost of supply, the revenue collected will not be sufficient to cover average costs – the water-supply business will go bankrupt unless the supply charge is set above average long-run cost of supply and/or a government makes up the shortfall (Beato and Vives Chapter 6).

The question of whether or not a government should fund any revenue shortfall experienced by a water utility depends upon its capacity to collect revenue from other sources. When institutional capacity to collect revenue is strong, the most efficient charge is one that charges all users in proportion to the metered volume of water taken. When institutional capacity is weak, however, it may not be possible to do this. Before volumetric charges can be introduced, meters must be installed and revenue collection procedures established.

Finally, it is necessary to differentiate between day-to-day operating costs and the cost of ensuring that sufficient money is set aside to fund infrastructure upgrades and maintenance, ecosystem restoration and to ensure an adequate return on capital. The former is sometimes known as the "lower bound cost" and the latter as the "upper bound cost."

As a general rule, the faster any system shifts to lower bound cost and then on to upper bound cost, the more efficient, the more sustainable and the more innovative water use will be. When institutional capacity is strong, the most efficient strategy is to set a price that is the greater of marginal cost and average cost. Mechanisms other than water-pricing policies should be used to transfer income to disadvantaged households and businesses.

Financing access for the poor

In an environment where a large number of children die as a result of lack of access to adequate water, what is the right tariff to set? Western Jakarta provides an illustrative case study. Some 37 per cent of the people living in Western Jakarta do not have access to a reliable mains water supply. Most of these people are poor and either buy water from carts operated by water vendors or collect it from an unhygienic source. Those forced to buy water from a cart pay up to 50 times the full cost of providing water access to a mains water supply. In addition, they incur the costs linked with poor quality and inadequate volumes of water. Government policy, however, requires the poor be provided access at a highly subsidized price so, in practice, those poor people who get access to mains water are supplied it at a price that is 70 times less than the price paid to water vendors. Since the government cannot afford to pay this subsidy, it is actively discouraging the water utility from making water available to these people (Fournier *et al.* Chapter 10). The poor who receive access to reliable subsidized water benefit, but this assistance is of no benefit to the 37 per cent of people who do not have access to a reliable mains water supply.

South Africa provides a different perspective on the question of what tariff to set. In 1996, South Africa devolved responsibility for water management to local government and then introduced a policy that required local governments to provide a basic amount of water to all people free of charge, using funds redirected from central government. As a result, the proportion of the population without access to a reliable water supply has dropped from 33 per cent to 8 per cent (Muller Chapter 12). Whether or not the same, or more, progress could have been made if users had been required to pay the full cost of supplying water to them is not known and probably cannot be determined reliably as water has played a central role in the political transformation of this country. Recently, the Constitutional Court of South Africa (2009) ruled that a local government could charge for access and use pre-paid meters as a means to do this.

Seeking empirical evidence in the Niger Basin, Ward *et al.* (Chapter 9) found that access to education and to clean water are the most consistent predictors of economic progress. Having analyzed the data and, particularly, the high costs of delaying access because of revenue shortfall, one can observe that if countries cannot afford to make drinking water available at less than full cost of supplying it to all poor people, then an alternative approach is to focus on the efficient provision of water to all poor people at the cost of supply. From a green economy perspective, the strategy of pricing to adopt is the one that most speeds the transition.

Cross-subsidizing (selectively taxing) water use

In many countries, the water tariff regimes are used to cross-subsidize the cost of supplying water to the poor. In Jakarta, this is achieved by charging wealthier households and/or those who use large volumes of water more than the cost of supply and then using the resultant revenue to enable water to be supplied to the poor at less than full cost (Table 1.4). As a transitional strategy in countries with

TABLE 1.4 Water tariff structure in Western Jakarta, US$ per m^3

Code	*Customer type*	*Volume of water used*		
		0–10 m^3 (US$)	*11–20 m^3 (US$)*	*>20 m^3 (US$)*
K2	Low-income domestic	0.105	0.105	0.158
K3A	Middle-income domestic	0.355	0.470	0.550
K313	High-income domestic and small business	0.490	0.600	0.745
K4A	High-income domestic and small business	0.683	0.815	0.980
K413	Non-domestic	1.255	1.255	1.255

Note: prices converted to US$ and rounded to 3 decimal places.

Source: adapted from Fournier *et al.* (Chapter 10).

little other capacity to transfer wealth from the rich to the poor, a case can be made for the use of cross-subsidies, even though this approach distorts investment in water use. In developed countries, however, the use of a water-charging regime to transfer income from one group of people or one region to another is extremely inefficient. For this reason alone, Beato and Vives (Chapter 6) conclude that subsidies should be targeted as tightly as possible and accompanied by a transparent strategy for their removal. The result is the emergence of a regime that encourages investment and innovation. Infrastructure is located in places where its use can be sustained. Sustainable jobs and more green growth follows.[14]

Increasing private-sector participation

As a transition to efficient supply of water at full cost occurs, opportunities for the involvement of private enterprise in the provision of water supply and sanitation services increase. The main reason for considering such arrangements is that research is showing that private-sector engagement can help to deliver benefits at less cost and thereby release revenue for green growth in other sectors. Once again, this opportunity is controversial. Several private-sector participation arrangements have failed. Nevertheless, there is little to suggest that the frequency with which these problems occur is less than that found among publicly run systems (Ménard and Saleth Chapter 8).

Closer analysis shows that when contractual arrangements are well developed, use of the private sector can offer a wide range of benefits and, when well-designed contractual arrangements are in place, the private sector can outperform the public sector. For example, Galani *et al.* (2002) show that Argentina's temporary privatization of approximately 30 per cent of its water supplies met with positive results. Child mortality was found to be 8 per cent lower in areas where water provision had been privatized. Moreover, this effect was largest (26 per cent) in the areas where people are poorest. The experience is equally positive in regions where businesses are allowed to supply water at full cost – operators are finding that many people are prepared to pay for the services they offer (Box 1.7).

Conclusions

Access to clean water and adequate sanitation services is critical to the future of each and every household. Water is clearly fundamental to food production and providing ecosystem services and vital for industrial production and energy generation.

Box 1.7 RECENT EXPERIENCE OF PRIVATE COMPANIES PROVIDING WATER TO HOUSEHOLDS

Phnom Penh Water Supply Authority in Cambodia has seen major transformations between 1993 and 2009. The number of connections increased seven-fold, non-revenue water fell from 73 per cent to 6 per cent, collection efficiency rose from 48 per cent to 99.9 per cent, and total revenues increased from US$300,000 to US$25 million, with a US$8 million operating surplus. After receiving initial grants and soft loans from international financial institutions, the utility is now self-financing. Tariffs increased steeply in the early years, but they have been held constant at around US$0.24/m^3 since 2001, because the combination of service expansion, reduced water losses and high collection rates has guaranteed a sufficient cash flow for debt repayment as well as capital expenditure.

Balibago Waterworks Systems serves around 70,000 customers in a rural area of the Philippines. The business has grown by going out to adjacent towns and villages and asking each community whether they would like the Balibago to build a network that would enable them to supply piped water to it. When Balibago does this, it begins by showing the community its regulated schedule of tariffs. The community is then asked if they want access to piped water and are prepared to pay the scheduled price for access to it. Balibago is finding that in many cases, the result is judged as an attractive proposition for communities that might previously have relied on hand pumps and wells, and it makes good money for the company's investors.

Source: adapted from Global Water Intelligence (2010).

Finding a way to use the world's water more efficiently and make it available to all at a reasonable cost, while leaving sufficient quantities to sustain the environment, are formidable challenges. In an increasing number of regions, affordable opportunities to access more water are limited. But progress has to be made to improve efficiency use and working within scientifically established and common practice limits. Direct benefits to society can be expected to flow both from increased investment in the water supply and sanitation sector, including investment in the conservation of ecosystems critical for water.

Research shows that by investing in green sectors, including the water sector, more jobs and greater prosperity can be created. Arguably, these opportunities are strongest in areas where people still do not have access to clean water and adequate sanitation services. Early investment in the provision of these services appears to be a precondition for progress. Once made, the rate of progress will be faster and more sustainable, thus making transition to a green economy possible.

Arrangements that encourage the increased conservation and sustainable use of ecosystem services can be expected to improve prospects for a transition to a green economy.

Ecosystem services play a critical role in the production of many goods and in many of the services needed by the world's human population but pressure on them is increasing. By investing in arrangements that protect these services and, where appropriate, enhance them, there is opportunity to ensure that the greatest advantage is taken of these services. Often the most effective way forward is to invest first in the development of supply and distribution infrastructure so that pressure is taken off the systems that supply ecosystem services.

Significant opportunities for improvement include the development of arrangements that pay people who provide and do the work necessary to maintain access to ecosystem services.

Another opportunity is the formal allocation of water rights to the environment. Where water resources have been over-allocated, there are significant opportunities to fund restoration at a reasonable cost before changes become irreversible.

The costs of achieving a transition will be much less if the increased investment is accompanied by improvements in governance arrangements, the reform of water policies and the development of partnerships with the private sector.

The opportunity to improve governance arrangements is one of the biggest opportunities to speed transition to a greener economy. In any area where there is water scarcity, it is critical that governance arrangements are put in place to prevent over-use and over-development of the available water resource. Building administrative regimes that are respected and trusted by local communities and industry takes time; however, this is essential in ensuring a return on the investments suggested in this chapter. These new arrangements, among others, will need to be able to facilitate the transfer of water from one sector to another.

Individual decisions about how to use resources and where to invest are influenced by policy. From a green economy perspective, there are significant opportunities to reform policies in ways that can be expected to significantly reduce the size of the investment needed to facilitate progress. Phasing out subsidies that have a perverse effect on water use and adopting freer trading arrangements brings direct benefits to many sectors. Other opportunities, such as the establishment of tradeable water entitlement and allocation systems, bring benefits initially to the water sector.

In green economies, there is a commitment to factoring social equity into the transition to arrangements, such as full cost accounting, that influence investment and decisions by people and industry. Ultimately, the question of how fast this transition should occur depends on a case-by-case assessment of the influence of the arrangement on the expected rate of progress. Where capacity exists, financial transfers and tax revenues collected from other sources can be used to fund the infrastructure necessary to provide households with access to services but, when this approach slows progress, tariffs should be raised to at least cover the full costs of service provision. Preference should go to the various pricing arrangements that enable most rapid progress.

Notes

1 This chapter was prepared in consultation with the International Reference Group listed in the preface to this book.

2 The World Health Organization (WHO) defines "sanitation" as "the provision of facilities and services for the safe disposal of human urine and faeces. Inadequate sanitation is a major cause of disease world-wide and improving sanitation is known to have a significant beneficial impact on health both in households and across communities. The word 'sanitation' also refers to the maintenance of hygienic conditions, through services such as garbage collection and wastewater disposal." Available at www.who.int/topics/sanitation/en/.

3 The field trial took a sample of 175 households in the region of Durham, east of Toronto. The sample homes were given upgrades in efficient clothes washers, dishwashers, toilets, showerheads, fridges and landscape packages to quantify the potential water, energy, gas, and CO_2 savings from efficient fixtures, appliances and landscape design. To control and measure demand for each of the resources, sub-meters and data loggers were installed on fixtures and appliances within the home. The savings in resources could be attributed to both efficient fixtures and appliances and efficient water and energy use habits of the homeowners. The annual utility cost savings are expected to be more than US$200 a year, which allows recovery of the additional installation cost in 3.4 years.

4 WHO (2010) notes that rapid urbanization between 1990 and 2008 has led to an increased (urban) population of 40 million not using water from improved sources and an increased (urban) population of 260 million not using improved sanitation.

5 The epidemic also spread into several other countries in South, Central and North America

6 In this context, Water, Sanitation and Hygiene (WaSH) initiatives, especially the teaching of basic sanitation and hygiene to communities and school children, will also prove critical.
7 The IPCC Fourth Assessment Report lists 32 examples of major projected impacts of climate change among eight regions (covering the whole earth). Of these: 25 include primary links to hydrological changes; of the other seven, water is implicated in four and two are general; only one refers to main impacts not obviously linked to the hydrological cycle: coral bleaching. The IPCC Technical Report (2008) underpinning this assessment report concludes unambiguously, inter alia, that: "the relationship between climate change and freshwater resources is of primary concern and interest." So far, "water resource issues have not been adequately addressed in climate change analyzes and climate policy formulations"; and, according to many experts, "water and its availability and quality will be the main pressures, and issues, on societies and the environment under climate change." The Scientific Expert Group Report on Climate Change and Sustainable Development (2007) prepared for the 15th Session of the Commission on Sustainable Development came to similar conclusions.
8 Sachs (2001) estimated that the rate of growth in GDP per capita in countries where most of the poor had access to clean water and adequate sanitation services was 3.7 per cent. When these services are not available, however, he found that the average annual rate of growth in GDP per capita was 1.0 per cent.
9 For an authoritative response to the controversies surrounding large dams, see World Commission on Dams (2000).
10 These findings are consistent with those of Hagos *et al.* (2008) who found that, as access to water improves, employment in other sectors expands.
11 The 2008 Global Corruption Report found that corruption in the water sector is likely to increase the cost of achieving the Millennium Development Goals by US$50 billion (Transparency International 2008). US$50 billion is about the same amount of money as the 2030 Water Resources Group's estimate of the annual cost of implementing the least-cost solution to the resolution of global water problems.
12 For more information, see www.fsc.org/pc.html.
13 In each of these schemes, banking and trading is possible only because they involve the development of indices that enable wetlands of differing value per hectare to be compared with one another.
14 When water is supplied to businesses at less than full cost, businesses tend to locate in places chosen on the assumption that subsidized access to water will continue. This, in turn, encourages people to live in and migrate to such places and locks an economy into a regime that becomes dependent upon the subsidy. As each of these steps occurs, opportunities for development are undermined.

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PART 2

The macro-economic case for investment in water

2

CHARTING OUR WATER FUTURE

Economic frameworks to inform decision-making[1]

2030 Water Resources Group

Introduction

Over the past 50 years the world's population has doubled and global GDP has grown ten-fold, agricultural and industrial output has boomed, and cities have burgeoned. This growth and these competing uses have put global water resources under ever-increasing strain.

Yet despite the depletion of watercourses, glaciers, and aquifers in many regions, the earth is not running out of water – in fact, most countries have more than enough water to supply their populations' growing needs and to sustain the flows needed to protect the natural environment. The problem, rather, is that our societies are doing a poor job of managing these water resources. The rate of innovation and productivity improvement in water-resource management lags that of many other sectors. It is this management challenge – a factor that we as human societies can control – that threatens our economies, human life and health, and natural ecosystems. We are not simply at the mercy of a scarce and variable natural resource.

Shining a light on water resource economics

Constraints on a valuable resource should draw new investment and prompt policies to increase productivity of demand and augment supply. However, for water, arguably one of the most constrained and valuable resources we have, this does not seem to be happening. Calls for action multiply and yet an abundance of evidence shows that the situation is getting worse. There is little indication that left to its own devices, the water sector will come to a sustainable, cost-effective solution to meet the growing water requirements implied by economic and population growth.

This study focuses on how, by 2030, competing demands for scarce water resources can be met and sustained. It is sponsored, written, and supported by a group of private-sector companies and institutions who are concerned about water scarcity as an increasing business risk, a major economic threat that cannot be ignored, and a global priority that affects human well-being.

Assuring sufficient raw or "upstream" water resources is a precondition for solving other water issues, such as those of clean water supply in municipal and rural systems, wastewater services, and sanitation – the "downstream" water services. Yet the institutions and practices common in the water sector have often failed to achieve such security. A lack of transparency on the economics of water resources makes it difficult to answer a series of fundamental questions: What will the total demand for water be in the coming decades? How much supply will there still be? What technical options for supply and water productivity exist to close the "water gap"? What resources are needed to implement them? Do users have the right incentives to change their behaviours and invest in water saving? What part of the investment backlog must be closed by private sector efforts, and what part does the public sector play in ensuring that water scarcity does not derail either economic or environmental health?

In the world of water resources, economic data is insufficient, management is often opaque, and stakeholders are insufficiently linked. As a result, many countries struggle to shape implementable, fact-based water policies. In addition, water resources face inefficient allocation and poor investment patterns because investors lack a consistent basis for economically rational decision-making. Even in countries with the most advanced water policies there is still some way to go before the water sector is managed with the degree of sophistication appropriate for our most essential resource. Without a step change improvement in water-resource management, it will be very difficult to meet related resource challenges such as providing sufficient food or sustainably generating energy for the world's population.

After careful quantitative analysis of the problem, this report provides some answers on the path to water-resource security. It first quantifies the situation and shows that in many regions, current supply will be inadequate to meet the water requirements. However, as a central thesis, it also shows that meeting all competing demands for water is in fact possible at reasonable cost. This outcome will not emerge naturally from existing market dynamics but will require a concerted effort by all stakeholders and the willingness to adopt a total resource view where water is seen as a key, cross-sectoral input for development and growth. It will also involve a mix of technical approaches, and the courage to undertake and fund water-sector reforms.

An upfront caveat is warranted. This work delivers – the authors believe – a mosaic of the solution by providing a comparative fact base on the economics of technical measures. We would therefore portray it as a starting point, not a comprehensive solution to all water problems. We fully recognize that water is a multi-faceted good differentiated by type of use, quality and delivery reliability, and therefore is a complex socio-political issue. We also acknowledge the vast body of economic and political economy literature that has elaborated on such topics. This chapter does not intend to substitute for that work.

To those familiar with the water challenge, our endeavour might appear daunting, as the quality of the data is highly variable and often uncertain. We fully acknowledge these uncertainties and welcome contributions that can improve this study's accuracy and usefulness through better data. Yet we are convinced that rigorous analysis built off existing data can provide a sufficiently robust fact base for meaningful stakeholder dialogue and action towards solutions.

By 2030, under an average economic growth scenario and if no efficiency gains are assumed, global water annual requirements would grow from 4,500 billion m^3 today (or 4,500 km^3) to 6,900 billion m^3. As Figure 1.6 shows, this is a full 40 per cent above current accessible, reliable supply (including return flows and taking into account that a portion of supply should be reserved for environmental requirements). This global figure is really the aggregation of a very large number of local gaps, some of which show an even worse situation: one-third of the population, concentrated in developing countries, will live in basins where this deficit is larger than 50 per cent. The quantity represented as accessible, reliable, environmentally sustainable supply – a much smaller quantity than the absolute raw water available in nature – is the amount that truly matters in sizing the water challenge.

The drivers of this resource challenge are fundamentally tied to economic growth and development. Agriculture accounts for approximately 3,100 billion m^3 or 71 per cent of global water withdrawals today, and without efficiency gains will increase to 4,500 billion m^3 by 2030 (a slight decline to 65 per cent of global water withdrawals). The water challenge is therefore closely tied to food provision and trade. Centres of agricultural demand, also where some of the poorest subsistence farmers live, are primarily in India (projected withdrawals of 1,195 billion m^3 in 2030), sub-Saharan Africa (820 billion m^3), and China (420 billion m^3). Industrial withdrawals account for 16 per cent of today's global demand, growing to a projected 22 per cent in 2030. The growth will come primarily from China (where industrial water demand in 2030 is projected at 265 billion m^3, driven mainly by power generation), which alone accounts for 40 per cent of the additional industrial demand worldwide. Demand for water for domestic use will decrease as a percentage of the total, from 14 per cent today to 12 per cent in 2030, although it will grow in specific basins, especially in emerging markets.

While the gap between supply and demand will be closed, the question is: How? Given past patterns of improvement, will the water sector settle on an efficient solution that is environmentally sustainable and economically viable? There is every reason to believe it will not. The annual rate of efficiency improvement in agricultural water use between 1990 and 2004 was approximately 1 per cent across both rain-fed and irrigated areas. A similar rate of improvement occurred in industry. Were agriculture and industry to sustain this rate to 2030, improvements in water efficiency would address only 20 per cent of the supply–demand gap, leaving a large deficit to be filled. Similarly, a business-as-usual supply build-out, assuming constraints in infrastructure rather than in the raw resource, will address only 20 per cent of the gap (see Figure 1.6). Even today, a gap between water demand and supply exists – even when some amount of supply that is currently unsustainably "borrowed" (from non-replenishable aquifers or from environmental requirements of rivers and wetlands) is excluded, or when supply is considered from the perspective of reliable rather than average availability.

If these "business-as-usual" trends are insufficient to close the water gap (see Figure 1.6), the result in many cases could be that fossil reserves are depleted, water reserved for environmental needs is drained, or – more simply – some of the demand will go unmet, so that the associated economic or social benefits will simply not occur. The impacts of global climate change on local water availability, although largely outside the scope of this study, could exacerbate the problem in many countries. While such impacts are still uncertain at the level of an individual river basin for the relatively short time horizon of 2030, the uncertainty itself places more urgency on addressing the status quo challenge.

The financial implications of this challenge are also clear. Historically, the focus for most countries in addressing the water challenge has been to consider additional supply, in many cases through energy-intensive measures such as desalination. However, in many cases desalination – even with expected efficiency improvements – is vastly more expensive than traditional surface water supply infrastructure, which in turn is often much more expensive than efficiency measures, such as irrigation scheduling in agriculture. These efficiency measures can result in a net increase in water availability and even net cost savings when operating savings of the measures outweigh annualized capital costs (Figure 2.1).

Closing the remaining gap through traditional supply measures would be costly: these face a steep marginal cost curve in many parts of the world, with many of the supply measures required to close the 2030 gap bearing a cost of more than $0.10/$m^3$, against current costs, in most cases, of under $0.10/$m^3$. The most expensive supply measures reach a cost of $0.50/$m^3$ or more. Without a new, balanced approach, these figures imply additional annual investment in upstream water infrastructure of up to $200 billion over and above current levels – more than four times current expenditure.

This picture is complicated by the fact that there is no single water crisis. Different countries, even in the same region, face very different problems and generalizations are of little help. We therefore conducted detailed case studies in three countries and in one region challenged by dramatically different water issues: China, India, South Africa, and the state of São Paulo in Brazil (Figure 2.2).

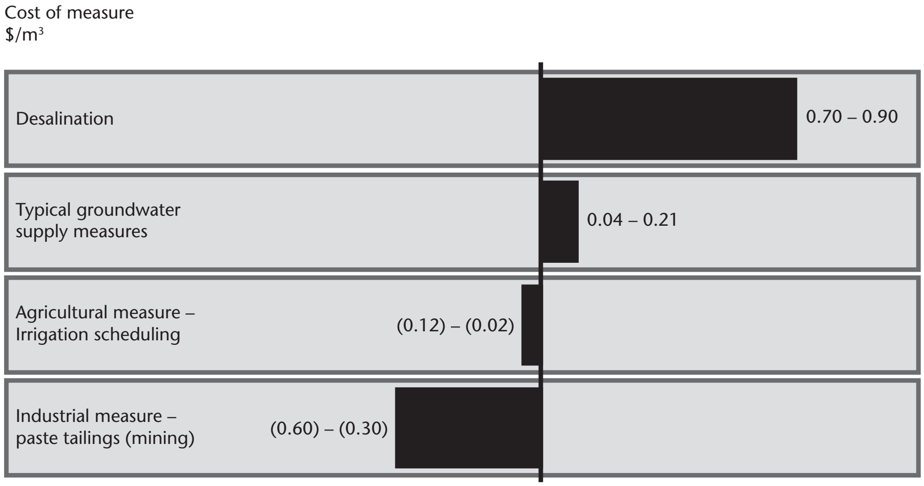

FIGURE 2.1 Representative demand- and supply-side measures.

Source: 2030 Water Resources Group.

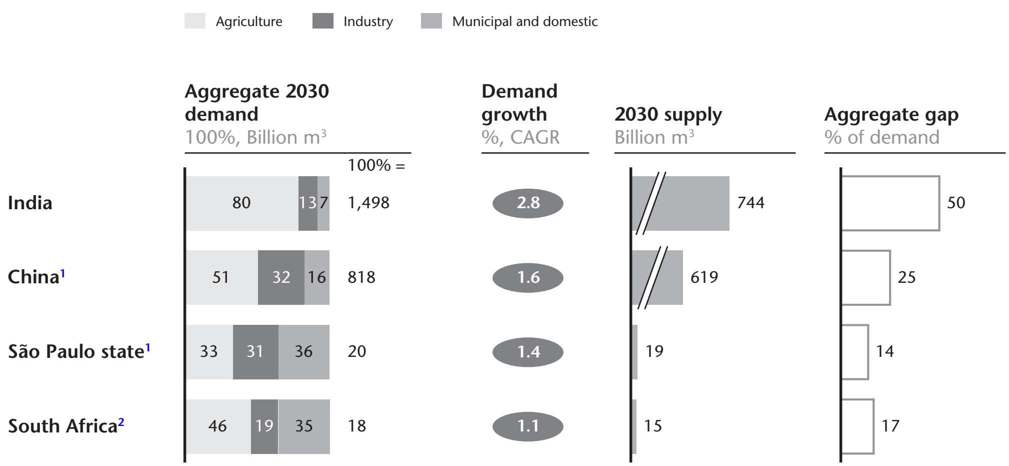

FIGURE 2.2 Base-case demand, supply, corresponding and gaps for the regional case studies.

Notes:

1 Gap greater than demand–supply difference due to mismatch between supply and demand at basin level.

2 South Africa agricultural demand includes a 3 per cent contribution from afforestation.

Source: Water 2030 Global Water Supply and Demand model; agricultural production based on IFPRI IMPACT-WATER base case.

These case studies reflect a significant fraction of the global water challenge. In 2030, these countries collectively will account for 30 per cent of world GDP and 42 per cent of projected global water demand. They also address some of the main themes of the global water challenge, including:

- competition for scarce water from multiple uses within a river basin;
- the role of agriculture for food, feed, fibre and bio-energy as a key demand driver for water;
- the nexus between water and energy;
- the role of urbanization in water-resource management; and
- sustainable growth in arid and semi-arid regions.

In each case study, we went to the highest level of granularity afforded by the accessible data, conducting analysis at the river basin or watershed level, and in many cases at the sub-basin level, as appropriate for each study. In each study we created a "base case" scenario for water demand and supply in 2030 by projecting the country's water demand to 2030; calculating the expected gap between this 2030 demand figure and currently planned supply; and analyzing the underlying drivers of that gap.

For the countries studied, these 2030 base cases illustrate the powerful impact of macro-economic trends on the water sector.

By 2030, demand in India will grow to almost 1.5 trillion m^3, driven by domestic demand for rice, wheat, and sugar for a growing population, a large proportion of which is moving toward a middle-class diet. Against this demand, India's current water supply is approximately 740 billion m^3. As a result, most of India's river basins could face severe deficit by 2030 unless concerted action is taken, with some of the most populated – including the Ganga, the Krishna, and the Indian portion of the Indus – facing the biggest absolute gap.

China's demand in 2030 is expected to reach 818 billion m^3, of which just over 50 per cent is from agriculture (of which almost half is for rice), 32 per cent is industrial demand driven by thermal power generation, and the remaining 18 per cent is domestic. Current supply amounts to just over 618 billion m^3. Significant industrial and domestic wastewater pollution makes the "quality-adjusted" supply–demand gap even larger than the quantity-only gap: 21 per cent of available surface water resources nationally are unfit even for agriculture. Thermal power generation is by far the largest industrial water user, despite the high penetration of water-efficient technology, and increasing water-supply limitations in rapidly urbanizing basins.

São Paulo state's projected demand in 2030 of 20.2 billion m^3 is evenly split between domestic, industrial, and agricultural requirements, against a current accessible, reliable supply of 18.7 billion m^3. Nearly 80 per cent of this demand is reflected in the São Paulo macro-metropolitan region, with a projected population of 35 million in 2030. This quantity challenge is compounded by severe quality issues, as even today low coverage of sanitation collection and treatment means that a significant proportion of São Paulo's water supply is polluted – requiring over 50 per cent of current supply to the region to be transferred from neighbouring basins.

Demand in South Africa is projected at 17.7 billion m^3 in 2030 with household demand accounting for 34 per cent of the total. Against this, current supply in South Africa amounts to 15 billion m^3 and it is severely constrained by low rainfall, limited underground aquifers, and reliance on significant water transfers from neighbouring countries. South Africa will have to resolve tough trade-offs between agriculture, key industrial activities such as mining and power generation, and large and growing urban centres.

In addition, we supplemented the detailed case studies with insights from other geographies to understand particular challenges (e.g. efficient water use in the arid countries of the Gulf Cooperation Council).

These regional water-resource challenges have been characterized, as a base case, by the water-resource availability and demand of historical climate conditions. Yet all regions are faced by increased uncertainty in water-resource availability as a result of the impact of global climate change. Without taking explicit scientific positions on how climate change will affect any one river basin, we do explore the major implications of climate change projections in some areas – for example, an "average" expectation of climate change for South Africa by 2030 shows a slight decrease in supply and a more pronounced increase in crop demand, increasing the 2030 supply–demand gap by 30 per cent.

Toward solutions: an integrated economic approach to water-resource management

Solutions to these challenges are in principle possible and need not be prohibitively expensive. A solution in a particular basin or country would utilize a combination of three fundamental ways to close the demand–supply gap. Two of these options involve no policy change and focus on technical improvements, increasing supply and improving water productivity under a constant set of economic activities. The third option is tied to the underlying economic choices a country faces and involves actively reducing withdrawals by changing the set of underlying economic activities. A well-managed sector would identify a sustainable and cost-effective mix of these three solutions.

In our case studies, we focused first on the two technical solutions and in all cases identified cost-effective solutions to close the gaps calculated in the base cases. Across the four regions under study, these solutions would require $19 billion per annum in incremental capital investment by 2030 – just 0.06 per cent of their combined forecast GDP for 2030. When scaled to total global water demand, this implies an annual capital requirement of approximately $50 billion to $60 billion to close the water-resource availability gap, if done in the least costly way available – almost 75 per cent less than a supply-only solution.

The challenge in linking these opportunities to close the water gap lies in finding a way of comparing the different options. As a key tool to support decision-making, this study developed a "water-marginal cost curve", which provides a micro-economic analysis of the cost and potential of a range of existing technical measures to close the projected gap between demand and supply in a basin (Plate 1.4 provides an example of the cost curve for China). For a given level of withdrawals, the cost curve lays out the technical options to maintain water-dependent economic activities and close the gap, comparing on a like-for-like basis efficiency and productivity measures with additional supply. Each of these technical measures is represented as a block on the curve. The width of the block represents the amount of additional water that becomes available from adoption of the measure. The height of the block represents its unit cost.

For each of the case studies, a basin-by-basin analysis of technical measures was conducted for the base case demand scenario. Then, departures from the base case in the form of alternative supply–demand scenarios were explored. The key findings for these cases are as follows.

Agricultural productivity is a fundamental part of the solution. In all of the case studies, agricultural water productivity measures contribute towards closing the water gap, increasing "crop per drop" through a mix of improved efficiency of water application and the net water gains through crop yield enhancement. These include the familiar technologies of improved water application, such as increased drip and sprinkler irrigation. The full suite of crop-productivity measures includes, among others, no-till farming and improved drainage, utilization of the best available germplasm, or other seed development. Other measures include optimizing fertilizer use and the application of crop-stress management regimes, including both improved practices (such as integrated pest management) and innovative crop-protection technologies.

In India, the least-cost set of levers – those on the left-hand side of the cost curve – is dominated by these agricultural measures, which can collectively close 80 per cent of the gap and include both irrigated and rain-fed crop production measures. In addition to the agricultural opportunity, lower-cost supply measures constitute the remaining 20 per cent required to close the gap, delivered mostly through the rehabilitation of existing irrigation districts and the "last-mile" completion of earlier projects such as canals. The total cost for the combined set of supply and agricultural levers is approximately $6 billion per annum, barely more than 0.1 per cent of India's projected 2030 GDP. This analysis does not take into account implementation and institutional barriers, nor the impact on labour markets, GDP, or other economic metrics, yet provides the starting point from which to consider approaches to overcome such barriers.

Efficiency in industry and municipal systems is similarly critical. In China, although agriculture still makes up more than 50 per cent of the total demand, industrial and urban water uses are the fastest growing (at ~3 per cent per annum). China can mitigate this rapid growth in a cost-effective way by instituting aggressive, water-conscious, "new build" programmes and enacting water-saving regulatory reforms. If it does so, the cost to fill the gap is negative, implying net annual savings of approximately $22 billion. Most of the cost-saving levers on the left of the cost curve for China are industrial efficiency measures. These have the potential to close one-quarter of the gap and result in net savings of some $24 billion. They are distributed among the thermal power, wastewater reuse, pulp and paper, textile, and steel industries. Their savings' potential derives from significant savings in energy and other operational expenditures, translating into overall productivity gains. The net capital expenditure to close the remainder of the gap amounts to $8 billion – less than 0.06 per cent of projected 2030 GDP.

Quality and quantity of water are tightly linked. The least-cost solution in São Paulo state has a net annual cost of $285 million (0.04 per cent of the state's projected 2030 GDP), a large part of which is in efficiency and productivity measures, while a supply infrastructure solution would nearly double the cost to $530 million per year, or 0.07 per cent of GDP. Any approach to solving the state's water management challenges must consider resolving quality issues, both for practical usage reasons and for environmental reasons. Industries can generate significant financial benefit by reducing their water use via levers such as spring-valve installation and sensitivity sensors. Utility leakage reduction can save nearly 300 million m^3. Wastewater reuse for greywater purposes (such as industrial processes and public works uses) offers roughly 80 million m^3 in new water.

Most solutions imply cross-sectoral trade-offs. South Africa has a balanced solution with cost-effective measures available across supply (which can close 50 per cent of the country's projected supply–demand gap in 2030), agricultural efficiency and productivity improvements (30 per cent), and industrial and domestic levers (20 per cent). Seven river sub-basins are almost entirely dependent on agricultural improvements, while the economic centres of Johannesburg and Cape Town are dominated by industrial and domestic solutions. Almost 50 per cent of the levers involve significant savings of input costs, effectively making half of the solution "cost-negative." In the case of industrial levers (such as paste-thickening and water-recycling in mining, and dry-cooling, and pulverized beds in power), up to $418 million in annual savings can be captured from the pursuit of efficiency.

Putting solutions into practice: new dialogue among stakeholders

Knowing the least-cost portfolio of technical solutions that will close a country's "base-case" water gap is a significant step forward. On the way towards real change, however, the technical options of new supply or better efficiency must be compared to additional options to shift the set of underlying economic activities away from the most water-intensive ones, recognizing that growth in energy, agriculture, and manufacturing have real implications for the water budgets of river basins and countries. The reverse is also true. Planning for water must be integrative with directions of the whole economy, whether explicitly constrained by water considerations or not. Using an iterative process, governments and other key stakeholders in a given country can create a matrix of options from which to chart pathways of development that balance water supply and demand.

The tools developed in this report, including the cost curve and gap models, can help provide critical insights for those engaged in transforming a national water agenda. In such a transformation effort, the first step in applying these tools is to construct a set of future scenarios that represent relevant choices facing the country. These might include, for example, the water-demand implications of rapid agricultural development or those of reduced water availability as a result of climate change. A scenario approach is chosen because it allows decision-makers to separate the problem of choosing an appropriate mix of economic activities, something that can only partly be planned and that is subject to large number of economic considerations, from ensuring that those economic activities in aggregate produce a sustainable outcome. For each scenario, a cost curve can then be constructed. Each cost curve can be used to define a set of technical solutions – a solution mix – such as the least-cost set of solutions, or the infrastructure-only set of solutions. A full suite of options, with the water costs associated with them, is therefore laid out for decision-makers to compare and discuss (Plate 2.1).

In choosing scenarios, and to some extent the technical measures to close the gap projected under any one of those scenarios, the trade-offs decision-makers will face go well beyond the issue of water. They will need to consider everything from the impacts on growth and jobs (including geographic distribution) to the implications for trade and geopolitics. A decision cannot be taken solely on the basis of the quantitative water calculations described in this report. The tools presented here will make the critical elements of those trade-offs more transparent and will define the boundaries of discussion well beyond the confines of the traditional water sector.

If all stakeholders are able to refer to the same set of facts, a more productive and inclusive process is possible in developing solutions. There are, of course, additional qualitative issues that need to be addressed, including institutional barriers (such as a lack of clear rights to water) and fragmentation of responsibility for water across agencies and levels of government, as well as gaps in capacity and information. While the quantitative tools discussed here will not in themselves address these challenges, they can help highlight those areas where institutional reform or capacity-building are most needed in order to close the water deficit cost-effectively.

Because this process weighs a broader set of benefits and policy decisions against the technical costs of closing the gaps, each stakeholder group will have different angles and interests to keep in mind. It is by balancing these interests that a shared solution can be developed.

Each group of stakeholders can derive specific planning benefits and insights from using this approach, addressed in turn below.

Tools for policymakers

Policymakers will want to assess whether the cost curve can reflect the difficulty of implementing a technical solution, which along with other secondary impacts will inform their policy choices.

They will want to understand the impact specific water policies may have on the adoption of measures and will want to understand which types of policies may change the adoption economics. Accordingly, three refinements of the cost-curve approach can help policymakers understand how to mobilize solutions.

First, the measures on the cost curve can be classified according to factors influencing their ease of implementation, such as low institutional capacity, policy and cultural barriers, and the high number of stakeholders from whom action would be needed (Plate 2.2). Solutions that are in principle technically feasible may face one or more of such barriers that, while not easily quantified in financial terms, are nevertheless very real for those charged with encouraging implementation. Policymakers can use the cost curve to understand the financial trade-offs implied by different levels of commitment to tackle such implementation barriers.

In China and India we grouped the levers independently of economic "sector" according to whether their adoption required few or many decision-makers, taking this as one illustration of "ease of implementation" from a public-policy perspective. The result of such an exercise can help to quantify the costs of not pursuing certain sets of measures. The exercise exposed the reality that a solution made up only of those measures that required the action of a few central decision-makers would come at significantly greater cost than a solution incorporating all available measures, including those whose adoption would require changed behaviour from millions of farmers and industrial or domestic water users. Avoiding these "more complex" levers and applying only the "less complex" levers would require an additional $17 billion a year in capital costs in India, while in China the full gap could not be filled at all using supply measures currently within reach – a high price for forestalling the institutional and organizational reforms needed to enable the least-cost solution. This is just one illustration. The real value of classifying levers in this way is as an aid to collaboration with the very policymakers who must make the difficult trade-offs on the path to water resource security, and who will have deeper and more nuanced views of what the barriers to implementation might be.

Second, policymakers can construct scenarios to assess the impact of policy decisions on water demand. A policymaker will want to know how a country's projected water supply–demand gap would change when specific policy measures are enacted or if greater-than-expected economic growth were achieved. The cost curve can reflect a range of different policy and growth scenarios. For example, a number of studies suggest that reducing energy subsidies in India – which currently allow farmers to pump groundwater at a very low cost – would reduce crop production, which would in turn lower irrigation water needs. An assumed five per cent decrease in irrigated crop production would reduce water demand by eight per cent – both straightforward calculations – but our analyses show the actual cost to close the resulting gap would be reduced by 10 per cent. This is to be weighed against the reduced output in crops and the corresponding reduction in economic activity. An ethanol boom in Brazil would double the demand for water for agriculture in São Paulo state and increase the size of the state's supply–demand gap from 2.6 to 6.7 billion m^3. As a consequence, the cost to close it would also double if relying upon the most efficient solution and increase even more if supply measures only are prioritized.

Third, a "payback curve" can be developed to quantify the economics of adoption for end-users. The costs of measures to close a country's water supply–demand gap as seen by the end-user can be quite different from those perceived by government. The payback curve, a variation of the cost curve, can help (Plate 2.3). It shows how long it will take for an investment to bear fruit, allowing comparison with the end user's expectations. For example, a low-income farmer might need his money back in less than three years whereas an industrial water user has more flexibility. Making financials more transparent can help policymakers distinguish between those measures that need an extra push, and those that, on paper at least, are financially attractive to the end-user. In India and China, for example, almost 75 per cent of the gap could be closed with measures offering payback time of three years or less. São Paulo state, on the other hand, relies heavily on supply and efficiency measures that are not yet sufficiently attractive to adopters – 86 per cent have payback times above five years.

Pathways for the private sector

Governments are not the only stakeholders that matter, nor are they the only ones that need help managing water decisions. We outline a path forward for five specific private-sector players who can contribute to water security solutions.

Agricultural producers and other agricultural value chain players

Food production and the water it requires form a key part of the water challenge. Food self-sufficiency in countries with rapid population and income growth will become an increasing challenge. Some 70 per cent of the world's water use is in agriculture – with the implication that farming plays a very important role in determining how much water is available for other uses. The agricultural water solutions shown in the cost curves address both the water challenge and the food challenge, and represent the full suite of existing techniques and technologies that can improve agricultural productivity. The magnitude of the potential impact of these solutions on both challenges should motivate farmers, other agricultural value-chain players (e.g. food processors), and policymakers to jointly address their implementation. In India, where agriculture plays the most important role in the least-cost solution, aggregate agricultural income could increase by $83 billion by 2030 from operational savings and increased revenues, if the full potential of agricultural measures is mobilized. In South Africa, where agriculture contributes 30 per cent to the least-cost solution, the aggregate potential is $2 billion. Though we have focused on measures that can be implemented geographically close to production, the opportunity exists to reduce losses and therefore "save" water and other inputs throughout the value chain.

Financial institutions

There is wide agreement that water has suffered from chronic under-investment. Financial institutions are likely to be an important factor in making up this shortfall. The cost curves provide such institutions with transparency on the financial costs and the technical potential of measures in the long run to close the water supply–demand gap, as well as on the barriers to their adoption, thus helping them construct credible investment theses – particularly important at a time when credit is hard to find. Investment opportunities span all sectors. The measures that in aggregate require the most capital in our study are municipal leakage reduction in China and water transfer schemes in São Paulo and South Africa. In India, drip irrigation offers potential for lending and equity investments alike. Our analysis implies that the penetration of this technology will grow by 11 per cent per year through to 2030, requiring increased manufacturing capacity and credit for farmers.

Large industrial water users

The nexus between water and energy and between water quantity and quality is at the heart of the water challenge, as we have seen in China and Brazil. Industry faces a potential spiralling challenge of decreasing water resources and increasing pollution, both requiring increasing energy. These issues are particularly relevant to large industrial users such as metals, mining, petroleum, and energy companies that face both a water and energy challenge. The transparency provided by the demand and supply analysis and by the cost curves on where such companies' exposure to the risk of water scarcity is greatest, and what their options are to mitigate the risk, will assist them in making the case for investing in water-efficiency solutions. In South Africa, for example, the basins with the largest gaps are also the centres of industrial water demand: in the Upper Vaal, where industry makes up 44 per cent of demand, the gap is 33 per cent; in Mvoti-Umzimkulu, where industry is 25 per cent of demand, 46 per cent. In such cases, the risk of water scarcity may affect the choice of technology, pointing towards potential measures such as dry cooling and fluidized bed combustion in power generation and paste tailings in mining.

Technology providers

Innovation in water technology – in everything from supply (such as desalination) to industrial efficiency (such as more efficient water reuse) to agricultural technologies (such as crop protection and irrigation controls) – could play a major role in closing the supply–demand gap. Also, many of the solutions on the cost curves developed for each country imply the scale-up of existing technologies, requiring expanded production on the part of technology providers. The cost curves provide a framework that technology providers can use to benchmark their products and services for an estimate of their market potential and cost-competitiveness with alternative solutions. Membrane technology, for example, is still two to three times more expensive in China than traditional treatment technologies. As the need for high-quality water treatment increases, specifically for potable or high-quality industrial use or reuse, low-pressure membrane technology could develop a market potential of up to 85 billion m^3 by 2030, 56 times its volume in 2005.

Construction sector

A renewed interest in efficiency and productivity does not mean that supply measures do not have an important role to play, as we have seen in Brazil and China. The construction sector will need to continue to deliver that large-scale infrastructure. The cost curves provide transparency on where such infrastructure is most needed and where alternative solutions may prevail. In South Africa and Brazil, for example, supply infrastructure makes up some 50 per cent of the gap. Even in India, where the share is only 14 per cent, the required annual investment still amounts to $1.4 billion per year.

Unlocking water-sector transformation

Business-as-usual in the water sector is no longer an option for most countries. The beginnings of change are underway and there is good reason to believe that water will be an important investment theme for public, multilateral, and private financial institutions in the coming decades. Although affordable solutions are in principle available to close the projected water supply–demand gaps for most countries and regions, institutional barriers, lack of awareness, and misaligned incentives may stand in the way of implementation across both the private and public sectors. Overcoming these barriers will require persistent action and, in many cases, an integrated agenda of water-sector transformation.

This report is founded on the belief that developing a fact-based vision for water resources at the country or state level is a critical first step in making a reform agenda possible. This vision will help identify metrics, such as the supply–demand gap, or the potential of different measures, that can help to measure progress. It will link cost and economic data to water-resource data – including environmental requirements – a step that is essential to manage the water challenge. Without such a vision, it will be difficult for leaders to gain support for more rational management decisions on water resources. Because of the cross-sectoral nature of the analysis, linking such a vision to action requires high-level energy and support and commitment from the most senior decision-makers in the country. In countries with sufficient resources, existing institutions can be empowered to produce the data needed to inform such visions. In countries with limited resources to manage their water sectors, developing this data should be a high priority for those seeking to assist.

Having created the fact base and gone through the process of describing the options available, policymakers, the private sector, and civil society will need to come together to put into practice a transformation towards sustainability. The fact base can provide crucial guidance for this process at several levels.

For example, an understanding of the economics of the chosen solution will help decision-makers come to a rational design of the economic regimes within which water is regulated. In this regard, there is considerable experience on the way market mechanisms can help efficient use of water by businesses and cities. Further, identifying the barriers to adoption, and the implementation challenges inherent in the measures described on the cost curve, will help leaders focus and improve the institutions needed to champion and implement reforms. The cost curve also provides a benchmark of existing technologies and their cost to deliver additional water, providing guidance for investment in technology hubs, research, and education to unlock future innovations in the water sector. Such innovation will be critical in generating new options and reducing costs of provision.

By demonstrating which measures have the greatest impact in delivering solutions, a robust fact base can also spur focused financial investments from the private sector as a key engine for reform. A number of approaches exist, from public and/or private water-financing facilities, to public projects that create the space for private financiers to scale up their investments, to innovative, micro-finance solutions for end-users. Policymakers, financiers, conservationists, farmers, and the private sector need to cooperate to develop and promote innovative financial tools to ensure those willing to improve their water footprint are given the opportunity – and capital – to do so.

In many cases, large individual water users have a big role to play in managing demand. Government policy can help align industrial behaviour with efficiency objectives, forming a key component of a reform programme. It is critical to ensure incentive design emphasizes the value of water productivity – for example through clearer ownership rights, appropriate tariffs, quotas, pricing, and standards – and at the same time recognizes the impacts such incentives can have on the companies' profitability. A fact base on the economics of adoption and on the real potential of efficiency measures in such sectors can help identify and prioritize the right regulatory tools for action.

The case for prioritizing countrywide changes in water-resource management has never been stronger. We have seen that the challenges that lie ahead are considerable for many countries but evidence suggests that none of these challenges are insurmountable.

The information presented in the full report[2] aims to further enrich the global debate, and provides policymakers, business stakeholders, civil society, and public users with the tools they need to unlock the full potential of a sustainable water economy.

Notes

1 This chapter is an edited reprint of the executive summary of a report by the 2030 Water Resources Working Group. The group was formed in 2008 to contribute new insights to the increasingly critical issue of water-resource scarcity. Its members are McKinsey & Company, the International Finance Corporation (World Bank

Group), and a consortium of business partners: the Barilla Group, the Coca Cola Company, Nestlé SA, New Holland Agriculture, SAB Miller PLC, Standard Chartered and Syngenta AG. In addition to the core sponsors, an expert advisory group, providing advice on the methodology and content of this study, was composed of:

Jamal Saghir, Director, Energy, Water and Transport, Abel Mejia, Water Anchor Lead, and Michael Jacobsen, Senior Water Resources Specialist, World Bank Group
Anders Berntell, Director General, and Jakob Granit, Program Director, Stockholm International Water Institute (SIWI)
Colin Chartres, Director General, International Water Management Institute (IWMI)
Dominic Waughray, Director of Environmental Initiatives, World Economic Forum (WEF)
James Leape, CEO, Stuart Orr, Freshwater Manager, WWF-International, and Tom LeQuesne, Freshwater Policy Officer, WWF-UK
John Briscoe, Gordon McKay Professor of the Practice of Environmental Engineering, Harvard University
Piet Klop, Acting Director, Markets and Enterprise Program, and Charles Iceland, Associate, People and Ecosystems Program, World Resources Institute (WRI)
Mark Rosegrant, Director of the Environment and Production Technology Division, International Food Policy Research Institute (IFPRI)
Michael Norton, Managing Director, Water and Power Group, Halcrow Group Ltd
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Peter Börkey and Roberto Martín-Hurtado, Water Team leaders, Organization for Economic Co-operation and Development (OECD)
Peter Gleick, President and Jason Morrison, Water Program Leader, Pacific Institute

2 The full report is available at mckinsey.com/clientservice/Water/Charting_our_water_future.aspx.

3

MAKING WATER A PART OF ECONOMIC DEVELOPMENT

The economic benefits of improved water management and services[1]

Håkan Tropp[2]

Introduction

Water is a basic requirement for human development. Water is a required input for a wide array of economic sectors including industry, agriculture and tourism. It is essential for human health and the survival of the ecosystems upon which people, especially the poor, depend. The prominence of water management in international discussions on poverty reduction and sustainable development has led to a high level of political support for water as an issue, but this is rarely translated into effective action or, in particular, increased investment. This is reflected, for instance, in the low priority water has in most national development strategies.

Many developing countries face severe shortages of water resources and water services. Often this is not due to lack of water per se, but lack of increased and sustained capital investment in both soft governance and management issues and hard infrastructure development.

In the water sector of developing countries, there has been chronic under-investment in infrastructure and the development of human and institutional capacity. One of the most recent cost estimates to attain the Millennium Development Goals (MDGs) target for sanitation and drinking water suggests that required annual spending in developing countries on new coverage to meet the MDG targets is US$14.2 billion for sanitation and US$4.2 billion for drinking water. New capital investment needs for sanitation are higher than for drinking water because of the larger number of people without access to improved sanitation, and because of the higher estimated cost per capita for sanitation for both piped and non-piped options. In addition, the cost of maintaining existing services was estimated at a further US$21.6 billion annually for sanitation and US$32.2 billion annually for drinking water (Hutton and Bartram 2008).

The above example only includes investment requirements to meet the MDGs on drinking-water supply and sanitation, and does not take into account investment requirements for universal water and sanitation coverage. Moreover, it neglects the costs of governance inefficiencies, such as corruption and mismanagement. Consequences of poor governance will include that it will take longer time, and cost more, to reach the MDGs. The Global Corruption Report (2008) suggests that due to corruption, it will cost an additional US$50 billion to reach the MDGs. While it is clear that the investment challenge is formidable for water and sanitation, the same holds true for improved management of water resources. The 2030 Water Resources Group (Chapter 2) suggests that to bridge the world's water resources gap between water supply and demand by 2030 requires massive investment. If only supply measures are considered, it will require annual investments of US$200 billion, but if a more balanced supply-and-demand approach is used, it will require investments around US$50–60 billion per year.

This paper focuses on how increased investments in water policies can make major contributions to economic and social development. It looks at the economic benefits and costs of improved water-resource management and access to water and sanitation services, particularly from a macro-economic perspective.

Conventional wisdom holds that countries need to grow economically before they can start to invest more heavily in improved water services and water management but the causality chain between development and investment is much more complex and dynamic. This chapter suggests that increased investment priority to improved water-resource management and water services can provide an important boost to economic and social development. In other words, the absence of improved water-resource management and water services put limitations on development, since large parts of the population find it increasingly difficult to live healthy and productive lives. Moreover, it will become increasingly difficult to meet increased water demands for production of food, industrials goods and biofuels, as well as maintaining ecosystem services. Looming climate change impacts on rainfall and other weather patterns make the challenge for increased water investments even more urgent.

This Chapter begins with with six important messages and concludes with prerequisites for action.

Six important messages

Investing in improved water, sanitation and water-resource management is beneficial for national economies, and in particular, the poorest in such communities.

Six urgent but realistic investment messages to public- and private-sector decision-makers are proposed that can help make water a much stronger part of economic development.

Message 1: improved water supply, sanitation and water-resource management boosts countries' economic growth and contributes greatly to poverty eradication

Among the world's poor countries, those with access to improved water and sanitation services experience greater economic growth. Poor countries with improved access to clean water and sanitation services enjoyed annual average growth of 3.7 per cent. Poor countries with the same per capita income but without improved access had an average annual per capita GDP growth of only 1.0 per cent (Sachs 2001).

Message 2: the economic benefits of improved water supply and, in particular, sanitation far outweighs the investment costs

Economic benefits ranging from US$3 to US$34 per US$1 invested (depending on the region and technologies applied) would be gained in the health, individual, household, agricultural and industrial sectors if the water and sanitation MDG targets were achieved. Furthermore, benefits of sanitation investments often are greater than those for water intervention. The integration of hygiene intervention produces even higher benefits (Hutton and Haller 2004).

In aggregate, the total annual economic benefits of meeting the MDG on water supply and sanitation accrue to US$84 billion (ibid.).

Message 3: national economies are more resilient to rainfall variability and climate change impacts, and economic growth is boosted when water storage capacity is improved

Disconnecting an economy from rainfall variability promotes gains in GDP. In Kenya, which has a water-dependent economy, the 1997–1998 floods and the 1999–2000 drought provide useful examples. The floods cost the country at least US$870 million, or 11 per cent of GDP, and the drought at least US$1.4 billion a year, or 16 per cent GDP. On average, the country experiences a flood that costs 5.5 per cent of GDP every seven years and a drought that costs it about 8 per cent of GDP every 5 years. This translates to a direct long-term fiscal liability of about 2.4 per cent GDP per annum. This means that Kenya's GDP annually should grow at a rate of at least 5–6 per cent in order to start reducing poverty. In 1996, a good year in Kenya, real GDP growth was 4.1 per cent (Republic of Kenya 1998).

Measures of improved water-resource management produce considerable economic gains, a US$15–30 billion investment in improved water-resource management in developing countries can result in direct annual income returns in the range of US$60 billion. Every US$1 invested in watershed protection can save anywhere from US$7.50 to nearly US$200 in costs for new water treatment and filtration facilities (Emerton and Bos 2004).

Message 4: investing in water is good business, improved water-resource management, water supply and sanitation contributes significantly to increased production and productivity within economic sectors

Meeting the MDG on water supply and sanitation will gain 322 million working days per year globally, valued at almost US$750 million. The biggest potential gains for increased productivity within both households and economic sectors are in the areas of time saved collecting water and improved access to sanitation, which has been valued at US$64 billion annually (Hutton and Haller 2004).

Providing reliable and sufficient water supplies is critical for business development and reduces investment risk. For example, a study in China points to the considerable gains that can be made by improved water quality. The industrial income lost due to water pollution amounted to US$1.7 billion in 1992 (Hansen and Bhatia 2004). What is now becoming increasingly clear to many governments is that reliable access to water resources is a competitive advantage and attracts business opportunities.

Industry faces increasing business risks due to water shortages and water quality problems. Eleven of the world's 14 largest semiconductor factories are based in the Asia-Pacific region, where water quality risks are severe. Semiconductor production requires vast amounts of very clean water. Intel and Texas Instruments alone used 11 billion gallons of water to make silicon chips in 2007. A water-related malfunction at a fabrication facility operated by these firms could result in $100–200 million in missed revenue during a quarter (Ceres and Pacific Institute 2009). Business risks can include higher costs for water, regulatory caps for water use and increasing conflicts with local communities and other large-scale water users. The regulatory and reputational risks that industry increasingly faces became evident when some of the major international beverage companies recently lost their operating licenses in parts of India due to water shortages (ibid.)

Message 5: the overall public and private investment needs for improved water supply, sanitation and water-resource management are considerable. However, at the national level, meeting such investment challenges is highly feasible and within the reach of most nations

Global World Health Organization (WHO 2004) estimates indicate that an annual additional investment of US$11.3 billion is required to meet the MDG on water supply and sanitation but the total accrued economic benefits of reaching the MDG are US$84 billion, a seven-fold return (Hutton and Haller 2004).

Broken down into country cost estimates, it is clear that meeting such investment challenges by 2015 is realistic. The annual per capita cost to meet the MDG on water supply and sanitation in Bangladesh, Cambodia, Ghana, Tanzania and Uganda ranges from US$4 to US$7 per capita annually (UN Millennium Project 2004).

Meeting public and private investment challenges related to improved water-resource management and infrastructure is feasible. For example, countries in sub-Saharan Africa need to invest between US$150 and US$700 per capita to reach a level of water storage infrastructure equivalent to that of South Africa (Grey 2004). If implemented over 10 years between 2005 and 2015, these investments would amount to US$15 to US$70 per capita on an annual basis.

Message 6: increased and more effective investments go hand-in-hand with improved governance. Poor governance constitutes an increased investment risk

Availability of water is certainly a concern for some countries but the global water and sanitation crisis is mainly rooted in poverty, power and inequality, not in physical water availability. While difficult to estimate the economic benefits of improved governance, or the costs of poor governance, it is clear that investments in soft governance and management issues plays a critical role in sustaining and expanding existing investments. For example, clear division of roles and responsibilities, clearly defined and enforced property rights, effective judiciary systems and access to information make significant contributions to improve quality of water-resource management and water services.

A particular case in point of the downside of poor governance is corruption. Bribes, kickbacks, collusion and substandard work can increase the cost of water provision by 20 to 30 per cent, raising the cost of meeting the water-related targets of the MDGs by almost US$50 billion (Transparency International and Water Integrity Network 2008).

Why the urgency? benefits for people, environment and business

In 2000, through the Millennium Development Goals (MDGs), the international community committed to halving the proportion of people without access to clean water and basic sanitation by 2015. Globally, almost 900 million people lack clean drinking water and 2.6 billion people have no access to hygienic sanitation facilities; 1.2 billion lack any sanitation facility at all. Each day, on average, 5,000 children die due to preventable water- and sanitation-related diseases (WHO 2010).

According to OECD (2012), water demand will increase by 55 per cent by 2050. New demands will be especially high in low- and middle-income countries, due to growth of manufacturing, electricity and domestic uses. As a consequence, more than 3.9 billion people are expected to live under water stress by 2050.

Meeting the MDG water and sanitation targets is more than just a health issue. The evidence is compelling that achievement of these water and sanitation goals would trigger a major leap forward in human and economic development.

Gains from improved water supply, sanitation and water-resource management benefit poor people most. Poor people are typically those that are worst affected by low-quality water and sanitation services. Water resources are critical to production processes, and worker health is critical for increased production and productivity. Targeting those who make the greatest economic gains will also achieve the highest marginal benefit of interventions. Interventions will be more effective in reducing poverty and increasing economic growth if they are targeted at improving health and resilience of agriculture to rainfall variability. Some of the aggregate gains that can be made in the area of sanitation are presented in Box 3.1. Only due to insufficient sanitation, Cambodia, Indonesia, the Philippines and Vietnam lose 1.3–7.2 per cent of their gross domestic product (GDP) (World Bank – Water and Sanitation Program 2008).

Box 3.1 ECONOMIC IMPACTS OF POOR SANITATION

Cambodia, Indonesia, the Philippines and Vietnam lose an estimated US$9 billion a year because of poor sanitation (based on 2005 prices). That is approximately 2 per cent of their combined gross domestic product, varying from 1.3 per cent in Vietnam, 1.5 per cent in the Philippines, 2.3 per cent in Indonesia and 7.2 per cent in Cambodia. The annual economic impact is approximately US$6.3 billion in Indonesia, US$1.4 billion in the Philippines, US$780 million in Vietnam and US$450 million in Cambodia. With the universal implementation of improved sanitation and hygiene, it is assumed that all the attributed impacts would be mitigated, except for health, for which 45 per cent of the losses would be mitigated. This would lead to an annual gain of US$6.3 billion in the four countries.

Source: World Bank – Water and Sanitation Program (2008).

For a poor household, the impacts of insufficient water services and water-resource management are considerable, for example:

- The health of poor men and women are disproportionately affected by unsafe drinking water and poor sanitation services.
- Poor people's livelihood systems, rural areas in particular, are directly dependent on environment and natural resources. The sustainable development of rural economies therefore becomes critical for long-term economic growth. More efficient and equitable management of common property resources including lakes, rivers, ground water and coastal areas translates directly into more food, income and time for the poor.
- Vulnerability is a critical dimension of poverty. Poor people are particularly at risk from environmental shocks and crises and are also disproportionately affected by water-service insufficiency. Natural disasters as well as rainfall variability, particularly for those in tropical and dry zones, or shifting agricultural zones affect developing countries, and the poor who live there, disproportionately.

- The performance of economic sectors, agriculture, industry and services relies on water resources, supply and sanitation services. The production capacity and productivity of economic sectors depend on people's health and reliable access to water.

Sustainable economic growth is vital to meeting the MDGs and the eradication of poverty. Meeting MDGs related to water will bring the international community closer to meeting a number of other MDG targets related to poverty reduction and equality. In fact, it is difficult to imagine how progress can be made without first ensuring that poor households have a safe, reliable water supply and adequate sanitation facilities. Water is clearly a key in the reduction of poverty in all its dimensions – income growth, improved health, gender equality, sanitation and water management. The achievement of the MDGs is challenged by population growth that will continue to drive the increased demands for resources, including water and related services. In real terms, the urban population of developing countries is expected to nearly double between 2000 and 2030 from 2 billion to almost 4 billion. Between 2015 and 2020, the urban population in developing countries will exceed the rural population for the first time. Continued economic progress and changing consumption patterns in combination with demographic dynamics will demand more water resources and services for productive uses and thus increase the challenge of sustainable water use.

Generating economic benefits with improved water-resource management and services

Society's economic sectors, including agriculture, industry and services, rely on water resources and related services. Improved access to water services and improved management of water resources contribute substantially to economic growth through increasing business productivity and development. It also improves human health, productivity and dignity considerably.

The UN Human Development Report (2006) points out that the costs of inadequate sanitation and water supply will be greatest in some of the poorest countries. Sub-Saharan Africa, for example, is losing 5 percent of GDP or some US$28.4 billion annually. This figure exceeds the total aid flows and debt relief to the region in 2003.

There is strong correlation between increased national income and the proportion of population with access to improved water supply. A 0.3 per cent increase in investment in household access to safe water is associated with a 1 per cent increase in GDP (World Bank 1994). Economic growth itself can also drive increasing investments in improved water management and services. It can be argued that the interaction between improved water supply and sanitation, and economic growth is mutually reinforcing and has the potential to start a virtuous cycle that improves the lives of poor people.

At the household level, enormous savings in time and increased livelihood opportunities for the poor are gained through improved access.

Improved water services and basic sanitation for economic development

Immediate benefits of improved human health

The lack of access to safe water, basic sanitation and good hygiene practices is the third most significant risk factor to poor health in developing countries with high mortality rates (WHO 2002a). Diarrhoeal disease, for example, is widely recognized as the principal result of inadequate water, sanitation and hygiene. Approximately 1.8 million people die every year from diarrhoeal diseases, of which almost

90 per cent are children under the age of five (WHO 2004). About 133 million people annually suffer from high-intensity intestinal worm diseases including Ascariasis, Trichuriasis and hookworm disease, which often lead to severe consequences such as cognitive impairment, massive dysentery or anaemia (WHO 2002b).

The benefits of preventive action provide another way to consider the immediate economic impacts of water quality and sanitation. Consider the cholera epidemic that swept Peru in 1991 that cost US$1 billion to treat. It is estimated that US$100 million, or a tenth of what was actually spent treating the disease, could have prevented the epidemic. In such circumstances, the cost:benefit ratio of preventative investments in water and sanitation are very high (WHO 2004).

Evidence shows that improved water supply and sanitation facilities and better hygiene behaviour will radically reduce population illness. Improved water supply can reduce diarrhoea morbidity by up to 25 per cent if severe outcomes are included. Hygiene interventions including hygiene education and promotion of hand-washing can reduce the number of diarrhoea cases by up to 45 per cent (Bartram *et al.* 2005). According to WHO, additional improvements to household drinking-water quality, such as point of use water treatment, can reduce diarrhoea episodes by up to 39 per cent.

Box 3.2 WHAT IS A DALY?

The Disability Adjusted Life Year is a summary measure of population health, and one DALY represents one year of healthy life lost. The DALY is used to estimate the gap between the current health status of a population and the ideal situation where everyone in that population would live to old age in full health.

Source: WHO (2002a).

Sub-Saharan Africa is a stark example of how water and sanitation has a very significant impact on the lives of poor people. In rural areas, girls and women can spend several hours per day collecting water. People also spend considerable time queuing for public toilets or finding a safe place to defecate. This is productive time lost, time that could be spent on a wide range of more productive activities such as childcare and food harvesting (Moss *et al.* 2003). WHO estimates that time and/or convenience savings of US$64 billion make up the majority of the benefits of reaching the MDG water and sanitation targets. The total benefits are estimated at US$84 billion.

A World Bank review provides empirical evidence of the effectiveness of simple measures outside the narrow definition of the "health sector" that nevertheless bring substantial health improvements and prevent the loss of DALYs (Lvovsky 2001). The report examined how much it cost to avoid one year of healthy life lost. For various interventions, the review concluded with the following estimated costs per DALY saved:

- Hygiene behaviour change: US$20 per DALY saved.
- Water connections in rural areas: US$35 per DALY saved.
- Malaria control: US$35–70 per DALY saved.
- Improving indoor air quality with better stoves: US$50–100 per DALY saved.

Long-term benefits of improved education and health

Improving health through investments in water supply and sanitation services has several immediate benefits for the economy and also delivers important long-term economic growth benefits.

Human capital theory and endogenous growth theory suggest that there are substantial economic benefits of education. At the most basic level, for example, a person without basic literacy and numeracy skills is not able to participate as effectively in political processes and higher levels of societal organization. Investing in water management and services provides people with the chance to spend more time in school, more effectively. With less time ill and less time spent fetching water, women and girls in particular are able to devote more time to learning. Furthermore, better health strengthens cognitive ability (Michaelowa 2000).

A study conducted on Jamaican school children aged 9–12 years showed that reducing the incidence of Trichuriasis, which is strongly related to inadequate sanitation, was followed by significant improvements in the results of tests of auditory short-term memory. The study also found that absenteeism was more frequent among infected children. Furthermore, there was a direct correlation between the intensity of the infection and the level of absenteeism (WHO 2002a).

Jamaica is just one example where improved water supply and services has had an impact. According to UNICEF (2003), millions of children around the world suffer from water-related parasites that consume nutrients, aggravate malnutrition, retard children's physical development and result in poor school attendance and performance. Schools themselves often have poor sanitary environments. They have no, or insufficient, water supply, sanitation and hand-washing facilities. If present, they are often not adapted to the needs of children, and are broken, dirty or unsafe. Under these conditions, schools become disease havens, with reinforcing negative impacts for the children, their families and the schools.

The China Council for International Cooperation on Environment and Development estimates that 1.5 per cent of all deaths in China, or 64,000 persons per year, can be attributed to water-related diseases (Warford and Yining 2002). The total welfare loss from the impact of water pollution on health alone is estimated at US$13.4 billion for the late 1990s. This is equal to 1.3 per cent of China's GDP (Hansen and Bhatia 2004).

High disease rates also affect the level of fertility and the subsequent reduction of parental investments in children. Societies with high rates of infant mortality (deaths under one year of age) and child mortality (deaths under five years of age) have higher rates of fertility, in part to compensate for the frequent deaths of children. Large numbers of children, in return, reduce the ability of poor families to invest heavily in the health and education of each child (Becker 1991).

An econometric study found that more than half of Africa's economic growth shortfall relative to the high-growth countries of East Asia could be explained statistically by disease burden, demography and geography, rather than by more traditional macro-economic policy variables and political governance (Bloom and Sachs 1998).

Widespread water-related disease and illness are also a concern with respect to investment at the macro-economic level. Where the level of such disease is chronic, entire sectors of the economy suffer. High rates of disease and/or illness introduce a new source of business risk that defers investment (Hansen and Bhatia 2004).

The losses in productivity due to poor health and missed opportunities caused by lack of improved water management and services impede long-term growth. Jeffery Sachs (2001) has demonstrated empirically the significance of water and sanitation mismanagement on health and education, and more generally on economic welfare and growth. Sachs argues that across the world's poor countries, it is the countries that experience improved access to water and sanitation services that experience higher economic growth. As an illustration, consider the poorest countries with per capita annual income below US$750 in purchasing power parity. Those with improved access to clean water and sanitation services enjoyed annual average growth of 3.7 per cent, while those without improved access had an annual average per capita GDP growth of only 0.1 per cent.[3]

Sachs (2001) provides an upper-limit estimate of how many annual deaths due to disease could be avoided if actions to eradicate water-related diseases throughout developing countries were realized. He estimates that the equivalent of 330 million DALYs could be averted by 2015.[4] Making the conservative assumption that each DALY is valued at one year of low-income country per capita income in 2015 (i.e. US$563), the direct economic savings would be US$186 billion per year in 2015. Sachs argues that lost benefits would actually be much higher because this valuation is much more conservative than what is conventionally used and it does not take into account the missed economic growth opportunities.

Water-resource management for economic development

The management of water resources for growth and increased productivity in the agricultural and food sector faces two distinct challenges. On the one hand, sustainable agricultural growth demands improving water use efficiency and matching water use with what local and regional water resources are able to provide. On the other hand, sustainable growth will demand protecting farmers, ranchers and fishermen from rainfall variability and extreme events such as floods and droughts. Agriculture and food production is by far the largest user of water, particularly in developing countries.[5] For the majority of people living in low-income countries, agriculture is the most important sector in terms of employment but lags in terms of productivity, contributing only 23 per cent of GDP (World Bank 2003). Any poverty-reduction strategy must therefore consider food production together with water management if it is to be effective. Reducing the strain on water systems will require a matching of what is farmed and what water resources can provide on a sustainable basis.

Increases in the demand for food over the next 25 years will be met mainly by increasing the yield from land already under cultivation. Irrigated land currently produces 40 per cent of the world's food on 17 per cent of the world's agricultural land. A broadening of irrigation and more effective rain-fed agriculture will be necessary to meet the demand for food. This will require significant investments in irrigation, water storage, water distribution and drainage, well coordinated with the demand for water resources from other sectors (Hansen and Bhatia 2004).

Vulnerability to rainfall variability: adapting to climate change

Improving water management makes national economies more resilient to hydrological variability and is vitally important for sustainable economic growth and development. Though this is an issue that impacts all sectors, it is most acute in the agricultural and food sector, which is highly susceptible to hydrological variability and associated landscape vulnerability. While attention is typically focused on extreme weather conditions, without adequate water-resource management, even regular annual hydrological cycles threaten livelihoods and can slow, or even reverse, economic development.

Climate change will have significant impact on hydrological variability and intensity. The effects of climate change will require economic safeguards for poor people and the development of a capacity to adapt for climate change, as they are the most vulnerable and also those least able to pay for safeguards, such as insurance.

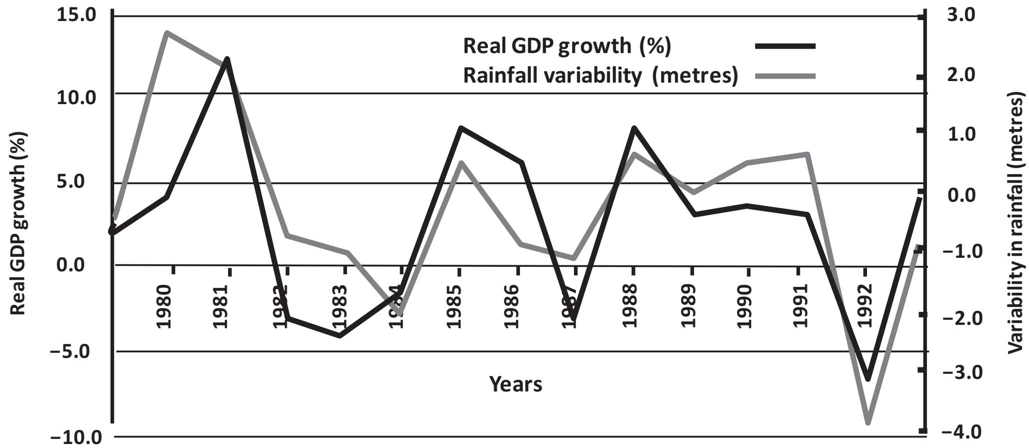

FIGURE 3.1 The dependency of the Zimbabwe economy on rainfall (1970–1990).

Source: Grey and Sadoff (2002).

There are a number of reports that estimate the cost of adapting to climate change.[6] One conclusion from the Stern Report (Stern 2007) is that if we do not act forcefully now, the effects of climate change could equal a 5 per cent annual reduction of global GDP. Pre-emptive action will cost only 1 per cent of global GDP. The costs of taking immediate action to avoid worst-case scenarios can be limited to 1 per cent of global GDP on an annual basis.

A World Bank (2009) study suggests that between 2010 and 2050 the global cost of adapting to an approximately 2°C-warmer world by 2050 is in the range of US$75 billion to US$100 billion annually. This sum is of the same order of magnitude as the foreign aid that developed countries now give developing countries each year, but it is still a very low percentage of the wealth of countries as measured by their GDP. How this will play out in countries will, among other things, depend on expected effects of climate change and choice of technology. Governments in developing countries need better information to cost, prioritize, sequence and integrate robust adaptation strategies into their development plans and budgets in contexts of high uncertainty, competing needs and limited financial resources.

Figure 3.1 illustrates how normal rainfall variability, as well as events such as floods and droughts, has an impact on economic growth. The Zimbabwean economy is closely tied to rainfall variability. Improved water-resource management is critical to the stability and security that is required to enable economic development. There is ample evidence that irrigation, for example, has contributed significantly to poverty reduction. Across Asia, regions with high irrigation density consistently have significantly fewer households below the poverty line than areas relying on rain-fed agriculture (Thakur *et al.* 2000; Garcia *et al.* 2000; Hossain *et al.* 2000).

Improved water management provides benefits to farmers' livelihoods, making them more competitive in a globalizing world,[7] thereby improving the structure and performance of national economies.[8] These benefits can be viewed as a means to smooth seasonal and intra-seasonal water availability, thus reducing the economy's vulnerability. Another measure to make the economy more resilient to rainfall variability is found in shifting trade strategies. Trade in food and other goods imply indirect trade in water. The total amount of water that is used to produce a product is referred to as virtual water. Trade in virtual water can reduce consumptive water use in agriculture, as well as industry, provided that exporters achieve higher water productivity than importers.

Fisheries

For the people of Africa, Asia and Latin America, the fisheries of inland lakes, rivers and other freshwater ecosystems are an important source of food and income. Fish are also the principal source of animal protein for many. Over-fishing and degradation of the ecosystem through the mismanagement of water resources pose a threat to the livelihoods of hundreds of millions of people. Though the value of these fisheries is undeniable, the sustainable use and maintenance of them is often overlooked in favour of short-term interests.

The productivity and value of freshwater fisheries is highly dependent upon quantity and quality of the water supply as well as access to markets. In sub-Saharan Africa, the larger floodplains of the inner delta of the Niger, the Sudd of the Nile and the Lake Chad Basin each yield up to 100,000 tonnes per year, generating US$20–25 million income in each area (Mekong River Commission 2001). Poorer households are more vulnerable to losses in fisheries and degradation of wetland resources, particularly because they are less able to deal with shocks such as health problems, drought and livestock death. Households in the village of Veun Sean, Cambodia, depend on the Stung Treng wetland for their fish, water supply and transport. The total benefits of the wetland amount to US$3,200 per household per year. Poorer households are most dependent on wetland resources for providing food security and income. They make an average 77 per cent of their income from fisheries, compared to 56 per cent for less poor households (WHO 2000).

Industrial development

Reliable and sufficient water supplies are critical for business development and a better investment climate. Industrial facilities use water for a variety of purposes such as cooling and transportation, producing steam or electricity, sanitation and as a critical component of a firm's output (such as paper products). Similar to the food sector, the average virtual water content of industrial products varies significantly. On average, each $1 worth of product uses 80 litres of water (Chapagain and Hoekstra 2004).

Industry faces increasing business risks due to water shortages and water-quality problems. A report by Ceres – a US-based coalition of investors and environmental groups – and the Pacific Institute points out that 11 of the world's 14 largest semiconductor factories are based in the Asia-Pacific region, where water-quality risks are severe. Semiconductor production requires vast amounts of very clean water. Intel and Texas Instruments alone used 11 billion gallons of water to make silicon chips in 2007. A water-related malfunction at a fabrication facility operated by these firms could result in $100–$200 million in missed revenue during a quarter (Ceres and Pacific Institute 2009). Other impacts on the business sector can include higher costs for water, regulatory caps for water use and increasing conflicts with local communities and other large-scale water users. Industry thus encounters increasing water-quality and water-quantity risks, regulatory risks as well as reputational risks. For example, some of the major international beverage companies recently lost their operating licenses in parts of India due to water shortages (ibid.)

Many businesses in different regions are now increasingly aware of the need for improved water management and that reliable water access implies business opportunities. The Malaysian Industrial Development Authority (MIDA) is the government's principle agency for promoting and coordinating industrial development. It is marketing reliable access to water as a key advantage to investing in the Malaysian economy.[9]

In contrast, recent industrial development in Manila has led to a rapid increase in the demand for water and water-supply shortages have forced many businesses to dig their own wells. About 80 per cent of Manila's industries rely on private wells as their main source with only about 20 per cent getting water from the Metro Manila Waterworks and Sewage system. As a result, groundwater extraction is lowering the water table by 6–12 metres per year and increased salinity and pollution threaten groundwater services.

The unsustainable water withdrawals of groundwater pose a significant and ever-increasing cost to businesses as they compete for a dwindling supply of poor-quality water (International Development Research Centre 1998).[10] Consequently, there are huge economic gains that can be made through improved water-resource management and storage capacity.

Water storage and hydropower infrastructure

As one Indian Finance Minister said, "every one of my budgets was largely a gamble on rain" (Grey and Sadoff 2007). The development of a sound, well-planned and maintained water infrastructure is a critical component of water-resource management, improving access to water and sanitation and boosting economic growth. Dams and reservoirs, both large and small, provide services such as power generation, flood control and water supply to agricultural and domestic users. These facilities can provide opportunities to improve livelihoods, increase incomes and reduce vulnerability.

Other important assets include canals, drains and irrigation systems. These assets can smooth out seasonal and inter-seasonal variations of water supply. This is particularly important in monsoon climates or other climate zones characterized by big monthly rainfall variations, typical in many low-income tropical countries. Sub-Saharan Africa is subject to more climatic variability than most other regions, but has the least per capita water storage and buffer capacity to deal with extreme natural events. Without adequate water-control infrastructure, the economy is more susceptible to water-related shocks.

In India, water-infrastructure development has evened out the seasonal demand for labour, resulting in major gains for the poor. Furthermore, recent analyses in India have shown that irrigation infrastructure has a major impact on the returns to investments in education (World Bank 2004).

Water-storage capacity per person is often cited as a proxy to water security and a measure of large- and small-scale water-infrastructure development. Figure 3.2 illustrates the disparity between different regions. Australia and Ethiopia have similar degrees of climate variability, but whereas Australia has

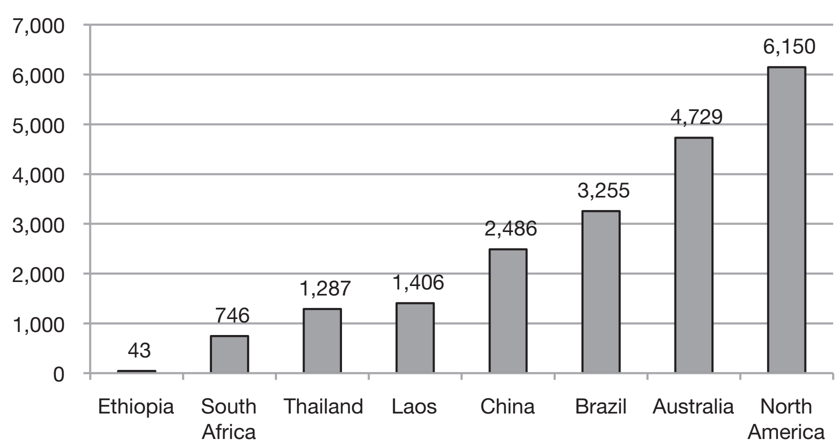

FIGURE 3.2 Africa's infrastructure gap: water storage per person in cubic metres.

Source: Grey and Sadoff (2002).

over 4,700 m^3 of water-storage capacity per person, Ethiopia has 43 m^3 (World Bank 2004). The breakdown of dams per geographical region shows that in Africa there is a large scope for water-infrastructure development. Statistics from the International Commission on Large Dams show that only 5 per cent of the world's dams are located in Africa, whereas 33 per cent are located in Asia. This does not, however, take into account local rainwater harvesting technologies.

Development of hydropower capacity, in particular, is one strategy that will reduce economic dependence on fossil fuels and limit greenhouse gas emissions. The World Energy Outlook 2004 points out that the world will need almost 60 per cent more energy in 2030 than in 2002, with economic growth in the developing world driving most of the increase (OECD and IEA 2004). Thus, developing hydropower resources, particularly in the developing world, is necessary.

There are several economic benefits of electrical power in terms of economic growth and poverty alleviation. Energy services that allow for heating, cooking and illumination are not only a boon to the activities of daily life; they are also critical inputs to agriculture and the types of small-scale productive activities that are a significant component of rural and urban economies.

Dam projects are often a catalyst for economic growth and development and provide many indirect benefits that are difficult to measure, but nonetheless significant. In the Punjab district of India, a multipurpose dam (hydropower and irrigation) was found to generate almost as much indirect value added via inter-industry linkages and consumption-induced effects as direct value added through agriculture and electricity.

A comparison of levels of economic development was carried out in China comparing districts with and without rural hydropower (Chinese Ministry of Water Resources 2003). From 1995 to 2000, the GDP of 335 districts with completed primary electrification doubled with an annual growth rate of 15.3 per cent, which is twice that of the national average. The annual average income per farmer increased 8.1 per cent per year, which is 2.7 per cent more than the national average. In these communities about 30 million people changed their mode of living from marginalized farming to off-farm labourers in industry or the services sector.

Both large- and small-scale investments in water storage and water-resource management enhances resilience and helps communities cope better with erratic rainfalls. Proper implementation of these installations provides opportunities for the poor as well as substantial benefits to broader society. Well-planned water-storage infrastructure is critical for the provision of safe and secure water supply to households, agriculture and food production and for industry. Hydropower is a renewable source of energy that has not yet been fully developed. The benefits of renewable electric power are clear not only for the economy but for sustainable development as well. Development of the water-infrastructure assets, together with effective water management, provides a basis for economic stability, growth and poverty eradication strategies.

While large-scale dam construction has had many positive impacts on economic development, there have also been many associated environmental and social costs. The full cost of such effects is normally not adequately factored into economic benefits derived from large-scale dams. Critical concerns regarding social and environmental impacts of poorly planned water-infrastructure development continue. Ecosystems provide multiple economic benefits and can be an alternative to and/or complement infrastructure development.

Ecosystem goods and services

Water, and how it is managed, contributes to the production and consumption of ecosystem services and goods. Ecosystems including lakes, rivers, forests and wetlands generate vast and important economic benefits.[11]

There are rarely any assessments made of the value of wider ecosystem services – not just the high-profile issues surrounding carbon sequestration and storage but also issues including soil-erosion control, water purification, maintenance of genetic diversity (for crops and medicines) and air pollution control. The reality is that ecosystem services have high economic value. If this dimension is ignored, decision-makers only hear one part of the story (The Economics of Ecosystems and Biodiversity, TEEB 2009).

Typically, however, ecosystems are not respected and their productivity falls as they are degraded. The economic costs of environmental degradation have been estimated at 4 per cent to 8 per cent of GDP in many developing countries (World Bank 2000). How this can play out in a particular locality in a developing country is illustrated by the case of Waza Logone Floodplain in Cameroon. In this area, the socio-economic effects of flood loss have been significant, incurring livelihood costs of close to \$50 million over the last two decades since the scheme was constructed. Up to 8,000 households have suffered direct economic losses totaling more than US\$2 million a year through reduction in dry-season grazing, fishing, natural-resource harvesting and surface-water supplies. The affected population, mainly pastoralists, fisherfolk and dryland farmers, represent some of the poorest and most vulnerable groups in the area. The return of waters to these areas has the potential to restore up to 90 per cent of the floodplain area, at a capital cost of approximately US\$10 million. The economic value of floodplain restoration would be immense. It could add more than \$2.5 million a year to the regional economy, or US\$3000 per km^2 of flooded area, recovering the initial investment costs in less than 5 years. Ecological and hydrological restoration will also have significant impacts on local poverty alleviation, food security and financial well-being. Releases of floodwater will rehabilitate vital pasture, fisheries and farmland areas used by nearly one-third of the population, to a value of almost US\$250 per capita. Similarly in Vientiane, the capital of Lao, wetlands offer flood control and wastewater treatment services valued at US\$2 million per year. It has been estimated that these ecosystem services constitute investment savings of more than US\$18 million in damage costs avoided and US\$1.5 million in the artificial technologies that would be required to fulfil the same functions (Emerton and Bos 2004).

The importance of upstream management of water is well illustrated in the Catskill watershed near New York, USA. The city of New York paid US\$1–1.5 billion to farmers and other land owners to maintain water-purification services in upstream parts of the watershed. This was considerably less than the estimated cost of constructing (US\$6–8 billion) and operating (US\$300–500 billion) annually a filtration plant (TEEB 2009).

A wetland is a water-related ecosystem that provides many direct and indirect benefits. A study of Muthurajawela Marsh, a coastal wetland in a densely populated area in North Sri Lanka, illustrates several of these ecosystem benefits. Emerton and Kekulandala (2003) estimate the economic significance of conserving the wetland, which is under increasing pressure from industrial and urban development. Several direct services (agriculture, fishing and firewood) contribute to local incomes (total value US\$150 per hectare per year) but the most substantial indirect benefits, which accrue to a wider group of the population and to economic actors, are related to flood relief (US\$1,907 per hectare) and industrial and domestic wastewater treatment (US\$654 per hectare). The value of carbon sequestration, in this case as in most existing valuation studies, was estimated using conservative assumptions (a damage cost of US\$10 per tonne of carbon).

In Uganda alone, the use of inland water resources is worth almost US\$300 million a year in terms of forest catchment protection, erosion control and water purification services. Almost 1 million urban dwellers rely on natural wetlands for wastewater-purification services (Emerton and Muramira 1999). Work carried out in the Zambezi Basin in South Africa shows that natural wetlands have a net value of more than US\$64 million, comprising US\$16 million in terms of groundwater recharge,

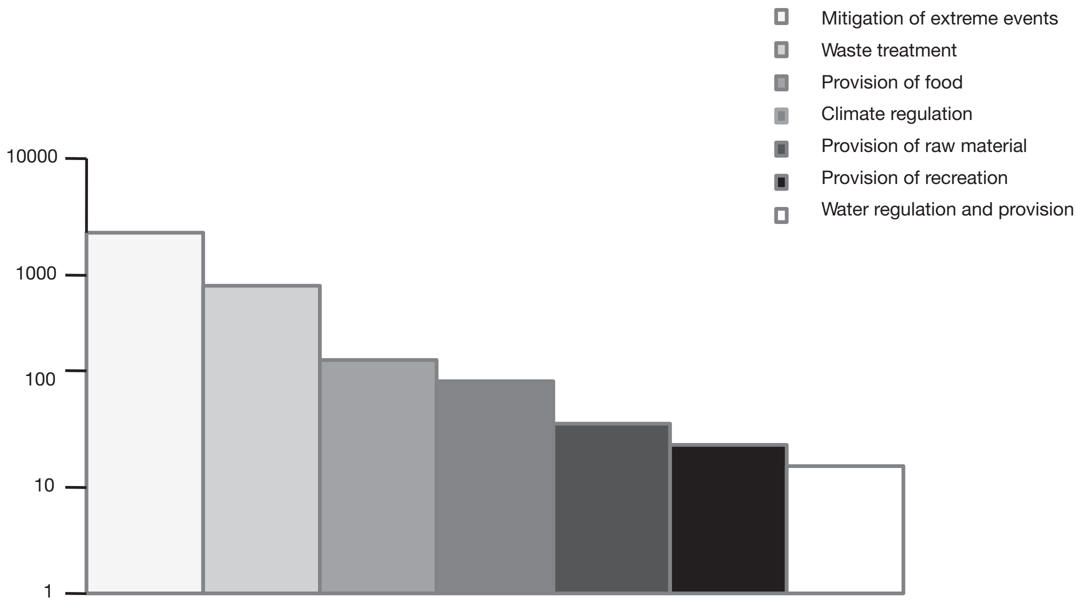

FIGURE 3.3 Values of seven ecosystem services in wetlands, Muthurajawela Marsh, Sri Lanka, in US$/ha/year.

Source: Emerton and Kekulandala (2003).

US$45 million in terms of water purification and treatment services and US$3 million in reducing flood-related damage costs (Turpie *et al*. 1999).

The improvement of water-resource management has several productive benefits. To date, the effect of ecosystem-service degradation caused by the over-use of water has been offset by the expansion of cultivation into new areas. However, cumulative global productivity loss due to land degradation has been roughly estimated at 12 per cent of total productivity. This translates to an average annual rate of productivity loss of 0.4 per cent (Crosson 1995; World Bank 2003).

Floods, droughts and the economy

The poor in low-income countries remain acutely vulnerable to external shocks. Natural disasters can have significant adverse consequences on growth prospects in these countries, particularly in agricultural communities that lack sufficient water-resource management. Furthermore, providing access to water and sanitation services to these communities as well as better water-resource management (better irrigation practices, protection of freshwater ecosystems) would be an enormous step towards lifting these groups out of poverty, reducing their vulnerability and promoting equitable growth in the longer term. Flooding alone cost the world economy US$27.3 billion in 2002 (Munich Re 2002).[12] Floods in Asia resulted in economic losses of approximately US$6 billion and 3,500 fatalities in 2002.

- The drought in Zimbabwe in the early 1990s brought a 45 per cent decline in agricultural production, an 11 per cent decline in GDP and a 60 per cent decline in stock markets.
- The 1997–1998 El Nino floods in Kenya caused an economic loss exceeding US$1.7 billion; the 2000 floods in Mozambique led to a 23 per cent reduction in GDP; the drought of 2000 in Brazil

halved projected economic growth; in 1998, El Nino, Peru, suffered US$2.6 billion in damages to public infrastructure, equivalent to 5 per cent of GDP.

- Losses due to landslides in Venezuela in 1999 cost US$10 billion, equivalent to 10 per cent of GDP.

Improving access to water supply and sanitation: how much will it cost to act?

Global-level cost estimates

WHO has prepared estimates based on several different levels of service, reaching beyond the MDG targets (Hutton and Haller 2004). They estimate that halving the proportion of people without sustainable access to both improved water supply and improved sanitation (i.e. meeting the MDG target) would cost around US$22.6 billion per year. Another US$2 billion would provide water treatment using chlorine and safe storage, taking the global cost to US$24.6 billion. Access for all, to regulated in-house piped water supply with quality monitoring and in-house sewage connection with partial treatment of sewage, would require a total investment of US$136.5 billion per year.

Some of the most recent cost estimates of reaching the MDGs on water and sanitation suggests new annual investments of US$14.2 billion for sanitation and US$4.2 billion for drinking water. New capital investment needs for sanitation are higher than for drinking water because of the larger number of people without access to improved sanitation, and because of the higher estimated cost per capita for sanitation for both piped and non-piped options. The cost of maintaining existing services was estimated at a further US$21.6 annually for sanitation and US$32.2 billion annually for drinking water (Hutton and Bartram 2008).

The World Bank (2003) estimated in 2003 that an additional investment of US$15 billion per year is required to reach the MDGs on water and sanitation. Other global financing forecasts range from US$30 billion to US$102 billion for water supply, and from US$24 billion to US$42 billion for sanitation for the period 2001–2015 (UN MDG Taskforce No. 7 2005). Much will depend upon the technologies adopted and country-specific preferences and conditions. Taking an average of the extremes would provide a conservative cost estimate of US$68 billion for water and US$33 billion for sanitation, or a total cost of US$101 billion and an annual average of US$6.7 billion (over 15 years). Although these are considerable sums, the cost per capita is in fact moderate. The Organization for Economic Cooperation and Development-Development Assistance Committee (OECD-DAC 2004) calculates that meeting the MDG target for sanitation and water services in Ghana would cost on average US$7.40 per person on an annual basis between 2006 and 2015.

Country- and local-level cost estimates

Investment needs at the national level are able to reflect "how much would it cost" with a higher degree of accuracy. The UN Millennium Project provides a snapshot of a few countries in terms of what is needed at the national level. Table 3.1 presents a summary of some of the figures that have been prepared (UN Millennium Project 2004).

Tanzania, for example, is one of the poorest countries in the world, with an annual per capita income estimated at US$257. Tanzania receives US$27 per capita in development assistance, of which only an estimated US$5 goes towards MDGs (World Bank 2003). Forty-eight percent of the rural and 86 per

TABLE 3.1 Resource requirements for reaching MDG water and sanitation target in five low-income countries, 2005–2015

Total cost estimates in 2003 (US$ million)					
Period	*Bangladesh*	*Cambodia*	*Ghana*	*Tanzania*	*Uganda*
2006	689	50	133	160	63
2010	829	77	166	223	106
2015	1,178	151	263	545	336
2006–2015					
Overall	8,719	882	1,797	2,764	1,467
Average per year	872	88	180	276	147
Average annual percentage of GDP, 2006–2015	1.0	1.3	2.0	1.6	1.2
Per capita total cost estimates in 2003 (US$)					
2006	4.4	3.3	6.0	4.1	2.2
2010	5.0	4.6	6.9	5.3	3.2
2015	6.5	8.2	10.0	11.9	8.6
2006–2015 average per year	5.2	5.3	7.4	6.5	4.3

Source: UN Millennium Project (2004).[13]

cent of the urban population had access to safe water in 2000. Likewise, 41 per cent of the rural and 53 per cent of the urban population had improved access to sanitation. In order for Tanzania to reach its MDG target for sanitation and water, it is estimated that per capita spending on these services will have to increase from US$4.10 in 2006 to US$11.90 in 2015. At the country level, this implies an average annual investment of US$276 million (UN Millennium Project 2004). The lack of domestic resources means that between one-third and one-sixth of this funding will have to come from outside Tanzania.

Cambodia is recovering from prolonged conflict where the foundations for human development and economic growth are being restored. In 2006, it was estimated that 36 per cent of the population was below the national poverty line. Water and sanitation were major challenges for Cambodia, especially in rural areas, where 30 per cent had access to improved water services and 8 per cent had access to improved sanitation. In Urban areas, the statistics were better (but daunting nonetheless) at 58 per cent and 53 per cent respectively. Cambodia is off-track to meeting the MDG water and sanitation target. The investment required to meet the MDG in 2006 stood at US$3.30, increasing to US$8.20 in 2015 – or an average annual investment of US$88 million. Approximately one-quarter of the total financing will have to come from outside Cambodia (UN Millennium Project 2004).

Further work is required to develop a more accurate understanding of both the global and local financial requirements to meeting the water supply and sanitation targets. One difficulty is the lack of knowledge in many developing countries on what can be rehabilitated and at what cost and what other technology choices exist. The cost–benefit analysis done by WHO and others is a significant step towards improving this lack of critical information. But, importantly, such information must also get the attention of decision-makers.

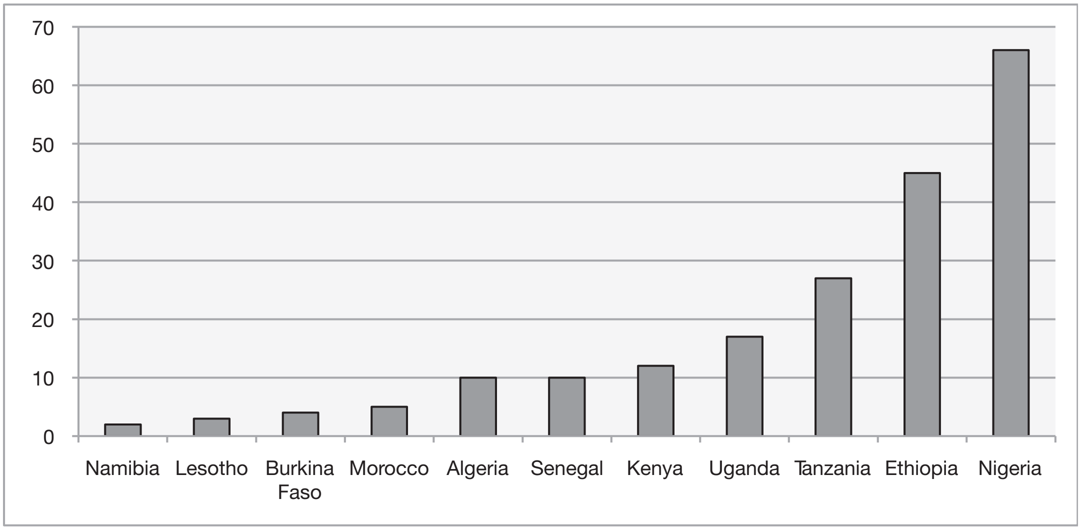

FIGURE 3.4 Water storage investments required in Africa (in US$ billion).

Source: Grey (2004).

Improving water-resource management and water infrastructure

Figure 3.4 provides a World Bank estimate of the water storage investments required in several African states. The costs are based on estimates of what level of water storage would be required in order to provide water security to the population. The total investment need for the listed countries tops US$200 billion. Nigeria, Ethiopia and Tanzania are the three countries where the required investments are highest.

The case of the Kenyan drought of 2000 illustrates the importance of such investment in water infrastructure and water-resource management. The manufacturing sector in Kenya was hit particularly hard from shortages of agricultural inputs, water supply for production and power supply. Real output in the manufacturing sector declined by 1.4 per cent in 2000. Kenya requires investments of approximately US$12–16 billion in order to develop the same per capita water storage as South Africa, another country faced with a similar climate (Republic of Kenya 1998).

The costs for improved water-resource management and infrastructure depend on technologies applied. An example from Gansu province, China, using rainwater harvesting technologies showed that investment of a mere US$12 per capita in rainwater harvesting was sufficient to upgrade domestic water supplies and supplement irrigation. One particular project benefited almost 200,000 households (Gould 1999).

However, infrastructure construction is not the only strategy available to reduce water vulnerability. The World Bank has found that there are often sharply declining returns on water-infrastructure investment once basic levels of service have been achieved (World Bank 1994). Their studies showed that when water resources are scarce, the cost of a cubic metre of water could rise by as much as two to three times.

In developing local and national financing and adaptive strategies for climate shocks, the role of virtual water should also be taken into account. Alternatively, or as a supplementary measure, countries can strive to diversify economies and shift away from water-intensive agriculture and industries to reduce water scarcity as well as drastically reduce investment needs.

Economic cost–benefit analysis

Evaluating the economic costs and benefits of interventions is vital for using resources in the best way to achieve desired societal objectives within a community. It has been aptly observed that financial cost–benefit analysis (CBA) tends to look at financial returns for particular projects and individuals, whereas economic CBA examines costs and benefits to society as a whole (Emerton and Bos 2004).

Investments in improved access to water and sanitation services are one of the most effective ways of promoting the equitable economic growth that is a prerequisite for poverty alleviation. Unfortunately, many developing strategies neglect to mention water and its key role in poverty alleviation.

The situation is similar with many national adaptation programmes of action (NAPA) to climate change. Many policymakers remain unaware that most climate-change impacts (flooding, droughts and rises in sea level) are driven by changes in the water cycle, and that poor people will suffer disproportionately from these impacts.

It is acknowledged that the benefits and the costs of different interventions can vary considerably depending on the type of technology selected. Informed and rational decision-making requires sound economic evaluation of the various options available on a case-by-case basis. No matter how they are done, typically they involve very tough political trade-offs between economic, social and environmental interests.

Water and sanitation

WHO cost estimates are the most sophisticated currently available as they take into account existing levels of service and incremental improvements (Evans 2004). Their evaluation estimates the costs and benefits of a range of interventions including achieving the MDG target using basic technologies to providing universal access to in-house piped water and sewer connections. The costs of providing access to safe water and adequate sanitation vary from relatively expensive when high standards are applied and sophisticated technology used, to substantially cheaper when simple technology that demands low maintenance is used. Costs of water improvement vary from US$0.33 per person served per year in Africa for household water treatment using chlorine, to US$12.75 for household water connection, including both hardware and software components. For sanitation, the costs range from a cheap small pit latrine at US$4.88 to a more expensive option with household sewer connection and partial treatment of wastewaters at US$10.03 per year per person served (Hutton and Haller 2004).

The biggest potential gain for increased productivity and production within both households and economic sectors amounts to US$64 billion per year globally. For example, the relocation of a well or borehole to a site closer to user communities, the installation of piped water supply to households and closer access to latrines can save each individual many hours each day, translating into increased economic production and higher school attendance rates.

Meeting the MDG target implies an annual health sector cost saving of US$7 billion. An additional US$340 million is saved annually due to avoidance of costs of drugs, treatment and time lost.

Meeting the MDG target will gain 322 million working days per year and the annual global value of adult working days gained as a result of less illness would be almost US$750 million. More benefits will come from illness avoided and days lost in terms of formal or informal employment, productive activities in the household and/or school attendance. The school attendance days gained reaches a staggering 270 million days. It implies enormous long-term benefits for economic development.

As shown in Table 3.2, the total global economic benefits of reaching the MDG accrue to US$84 billion. Access for all will accrue US$263 billion in economic benefits. The economic benefits would

TABLE 3.2 Cost–benefit ratio and total economic benefits for four interventions (all costs and benefits included)

Region	*Cost–benefit ratios and total economic benefits by intervention*											
	Having the proportion of people without access to both improved water supply and improved sanitation. Meeting the MDG target			*Access for all to improved water and improved sanitation services*			*Access for all to improved water and sanitation services plus household water treatment at point of use*			*Access for all to regulated in-house piped water on sewage connection*		
Select countries within	*Cost–benefit*	*Annual costs in US$ millions*	*Annual benefits in US$ millions*	*Cost–benefit*	*Annual costs in US$ millions*	*Annual benefits in US$ millions*	*Cost–benefit*	*Annual costs in US$ millions*	*Annual benefits in US$ millions*	*Cost–benefit*	*Annual costs in US$ millions*	*Annual benefits in US$ millions*
Africa	11.33	2021	22,908	10.89	4,043	44,036	14.269	4,360	62,214	4.39	24,729	108,441
America	10.21	157	1,607	10.59	315	3,334	13.77	368	5,074	3.88	2,320	9,007
Europe	3.40	71	242	6.55	143	934	5.82	266	1,551	1.27	4,206	5,337
East Mediterranean	34.95	100	3,505	42.50	201	8,523	61.47	250	15,355	14.49	3,275	47,431
South-East Asia	3.16	3,628	11,457	7.88	7,257	57,155	9.41	7,704	72,478	2.90	35,074	101,643
Western Pacific	3.36	3,282	11,013	6.63	6,563	43,487	7.89	6,957	54,885	1.93	28,129	54,426
Rest of the world		2,046	33,668		4,087	105,410		4,744	132,549		38,782	229,616
Total	7.50	11,305	84,400	11.63	22,609	262,879	13.96	24,649	344,106	4.07	136,515	

Note: The countries included in each region are those with the highest adult and child mortality rates.

Source: Hutton and Haller (2004).

be greater in regions where the number of those without access is high and where the diarrhoeal disease burden is significant.

The results of this CBA illustrate that achieving the MDG target for both water supply and sanitation would bring substantial economic benefits. Each US$1 invested would bring an economic return of between US$3 and US$34, depending on the region and the level of intervention.

Many studies confirm the considerable economic benefits. OECD has prepared a cost–benefit analysis looking specifically at what is needed in order to meet the MDG sanitation target alone. The analysis provides figures in terms of the net present value (NPV).[14] With a discount rate of 5 per cent and 10 per cent, the NPV of meeting the MDG sanitation target is US$400–412 billion respectively. The results confirm again that the benefits far outweigh the costs (Rijsberman 2004). Similar economic benefits result from local water supply and sanitation interventions.

Improved access to water and sanitation services universally, including point-of-use water treatment, would lead to an economic benefit ranging from US$5–60 per dollar invested (Hutton and Haller 2004). Choosing more advanced types of technologies such as provision of regulated in-house piped water and sewer connections would lead to big overall gains, including an average global reduction of diarrhoeal episodes of around 70 per cent (Hutton and Haller 2004) but this type of intervention is also the most expensive. Implementing universal access to in-house piped water and sewer connection would cost more than US$130 billion annually.

The burden of disease associated with lack of access to safe water supply, adequate sanitation and a general lack of hygiene is concentrated among children under 5 years of age in developing countries. Accordingly, emphasis should be placed on interventions likely to yield an accelerated, affordable and sustainable health gain among this group. The present analysis points to household water treatment and safe storage as one option of particular potential as a good short-term approach to rapidly and effectively reducing diarrhoeal illness. This should be followed up with long-term improvements to water and sanitation services. In terms of convenience time saved, improved sanitation has the biggest gain.

Water-resource management

Decision-makers typically need to improve their awareness of the value of economic benefits of water resources and its management. Water managers also need to be better advocates. Improving water-resource management entails considerable costs but these are significantly outweighed by the economic benefits. For example, in Portland, Oregon, Maine, Seattle and Washington it has been found that every US$1 invested in watershed protection can save anywhere from US$7.50 to nearly US$200 in costs for new water treatment and filtration facilities. Such measures can be more challenging to apply in countries where water governance is weak and hence there can be additional costs involved to strengthen institutions and capacities.

Hansen and Bhatia (2004) venture to estimate that direct annual income lost due to land and water mismanagement in developing countries is in the magnitude of global foreign aid transfers (which currently stand at US$60–70 billion). Inevitably, it is difficult to quantify these losses, given the challenge of setting a monetary price to uncertain and intangible items. At the same time, they argue that measures that could prevent such damages would cost no more than 25–50 per cent of the annual losses. This means that a US$15–30 billion investment in improved water-resource management might have direct economic returns in the range of US$60 billion. For example, poor water-resources development and management approaches in Kenya cost the country more than US$48 million per year, about 0.6 per cent of GDP (Mogaka *et al.* 2001). Improved water-resource management is also beneficial for better health and the economy.

Intermediate technologies have the potential to provide massive productive gains. There has been an upsurge in the adoption of water technologies for poor farmers such as low-cost bucket and drip lines, sustainable land-management practices such as low- or zero-till agriculture, supplemental irrigation, groundwater recharge and water-harvesting systems. The evidence suggests that the promotion and adoption of these simple technologies has the potential to improve the livelihoods of the poorest farmers. For example drip irrigation systems minimize water losses and increase yields by delivering the right quantity of water at the right time, increasing yields between 20 per cent and 70 per cent, while using less water than traditional methods (Shah and Keller 2002).[15] For example, a farmer in Nepal can buy a drip irrigation kit for about US$13 per kit. The total net benefits, subtracting all costs except labour, obtained by each farm household were US$210 per thousand square metres and the total NPV for three years (10 per cent discounting rate) would be US$570 per farmer (Rijsberman 2004).

Drip irrigation is just one example of the benefits of providing poor farmers with access to small-scale water technology. There are in fact a wide variety of technologies available. The direct total net benefits of promoting these technologies have been estimated to be US$100–200 billion for the estimated 100 million farmers that could adopt these tools (Rijsberman 2004).[16] When including indirect benefits in the economy, the total net benefits (NPV) can increase to US$300–600 billion.

The potential benefits of investment in water-resource management is illustrated by a small-scale water resources development project in Bangladesh. The Asian Development Bank and the International Fund for Agricultural Development helped finance the US$51 million project that focused on increasing agricultural production and farmer incomes. The project includes several components, including the development of infrastructure for flood control, drainage improvement, water-conservation measures, introduction of integrated pest management and mitigating measures to reduce loss of floodplain fisheries. As a result of the project, some areas saw agricultural yield increase by 60 per cent. The overall rate of return of the project is estimated at around 30 per cent (Asian Development Bank 2004).

Though systematic empirical evidence on aggregated benefits is scant, the statistics to be found on the subject present a convincing case that the potential benefits of investment in improved water-resource management are real and considerable.

Good governance: fuelling growth and decreasing transaction costs

Governance is important for development. World Bank Institute (WBI) research suggests that countries that improve governance can increase their national income by two to three times in the long term. It also shows that additional short-term effects of improved governance are evident, including reduced child mortality and illiteracy (Kaufmann 2005). The causality between governance and economic growth is complex and it is true that improved governance can be a cause of growth and a consequence of growth. Kaufmann and Kraay (2002) make the point that there is a strong correlation between governance and economic growth, while growth may not necessarily lead to better governance.

Governance underpins increased and more effective investments. Poor governance constitutes an increased investment risk and affects the competitiveness of countries in global markets, as well as businesses in national, domestic and local markets. Figure 3.5 shows the results of a survey where a number of businesses ranked bureaucracy and corruption among the highest impediments to progress.

Conventional wisdom suggests that insufficient infrastructure constitutes a major business constraint with regard to accessing markets. It is therefore striking that some governance-related issues are ranking higher than infrastructure in regions such as sub-Saharan Africa and South Asia. It is acknowledged that there can be big variations between countries within a region and that results are relative and not suitable for regional comparison. The development of institutions and governance systems would, among

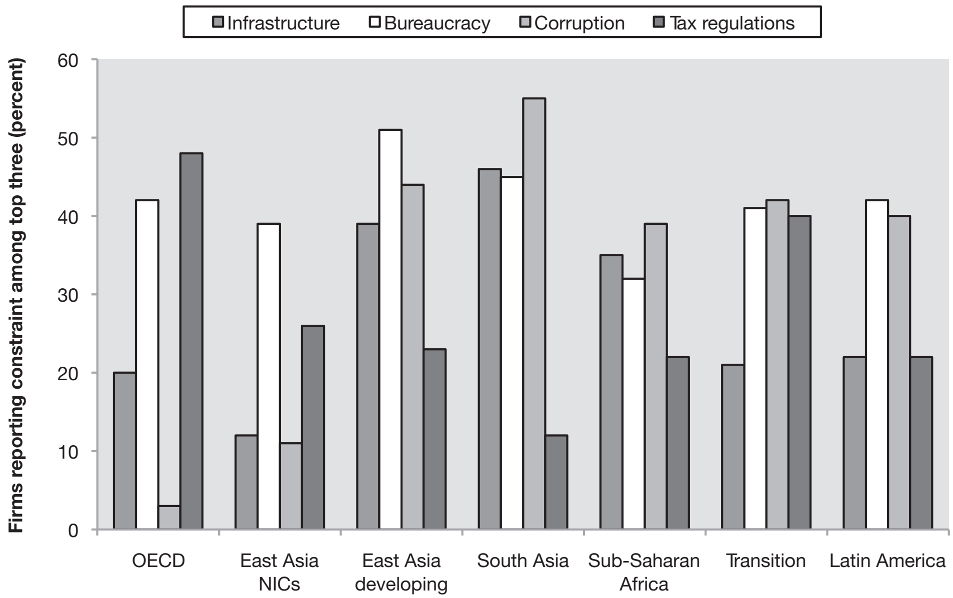

FIGURE 3.5 Some key business constraints.

Source: Kaufmann (2005).

other things, contribute towards lowering the transaction costs of firms. Simply put, a transaction cost is a cost incurred in making an economic exchange (i.e. the cost of participating in a market).

While difficult to estimate the economic benefits of improved governance, or the costs of poor governance, it is clear that investments in soft governance and management is critical to expanding and sustaining existing investments. For example, the clear division of roles and responsibilities, well-defined property rights, effective judiciary and enforcement systems, access to information and stakeholder participation all make significant contributions towards improved quality of water-resource management and water services. The application of participatory irrigation management in a number of schemes in India, Mexico and Turkey has yielded considerable gains. It is reported that increased participation, through water user associations and the like, can lead to increased collection of water tariffs, improved management and operation of irrigation facilities and higher agricultural productivity (World Water Assessment Programme 2009).

A particular case in point of the downside of poor governance is corruption. Corruption raises transaction costs, undermines economic development and makes it harder to attain development targets. More than US$1 trillion dollars (US$1,000 billion) is paid in bribes each year worldwide in both rich and developing countries, according to estimates by the WBI. This is approximately equal to the combined GDP of all low-income countries.

Bribes, kickbacks, collusion and substandard work can increase the cost of water provision by 20 to 30 per cent, raising the cost of meeting the water-related targets of the MDGs by almost US$50 billion (Transparency International and Water Integrity Network 2008). However, this does not reveal the complete story on costs associated with corruption, since it does not take into account costs in the form of alternative use of funding (or opportunity cost) to reduce poverty and inequalities, water provision, health and education and more. It also excludes costs of pollution and natural resource over-use that can follow in the trail of corrupt behaviour.

A growing body of local case studies indicate that corruption is a mounting problem within the water sector, costing the water sector millions of dollars every year. A study of the water supply and sanitation sector in a number of Indian cities indicated that:

- 41 per cent of the customer respondents had made more than one small payment (median payment US$0.45) in the past 6 months to falsify metre readings to lower bills;
- 30 per cent of the customer respondents had made more than one small payment (median payment US$1.90) in the past 6 months to expedite repair work; and
- 12 per cent of the customer respondents had made payments (median payment US$22) to expedite new water and sanitation connections.

The study also indicated the frequency of side payments from contractors to public officials. One-third of all public officials surveyed said that kickbacks take place commonly and an additional 17 per cent of those surveyed said that kickbacks take place every time. The value of the kickbacks to public officials normally ranged from 6 per cent to 11 per cent of the contract value (Davis 2004).

Poor governance misdirects considerable financial resources that might otherwise be used to strengthen national and local budgets and improve water, sanitation and other services. Conversely the reduction of corruption, bureaucratic red tape and other mismanagement practices bolsters the performance and effectiveness of both public and private sectors and contributes to a country's prospects for economic development.

What are the ways forward?

The macro-economic benefits of improved water supply, sanitation and water-resource management provide a compelling case for decision-makers to take immediate action to resolve the major water challenges. Improved water-resource management and services may not automatically benefit the poor and it is therefore important to target investments that provide better opportunities for poor people to thrive and break out of the vicious cycle of poverty. Actions that target poor people have the highest marginal benefit.

Investing in the health of people, ecosystems and more efficient and sustainable water use is an investment that not only provides immediate economic benefit but also safeguards previous and future economic gains. National figures suggest that the investments required are within reach for most countries.

Six critical guiding principles to action are suggested. These prerequisites provide a starting point for the development of national and local action strategies that target case-specific investment challenges and priorities.

Resolving water challenges boosts countries' GDP and reduces poverty. It is critical that the economic benefits of improved water supply and sanitation and water-resource management are understood, clearly articulated and included in national strategic macro-economic decision-making. Investments in the water sector – sanitation in particular – must be promoted for the economic benefits they generate, which considerably outweigh costs. Below are proposed ways forward and snapshots of previously referred-to economic benefits that can derive from their implementation.

Prerequisite 1: *donors must increase and refocus their development assistance and target sufficient aid to those poorest low-income countries that are most off-track to meet the water and sanitation MDGs.*

Example: aid interventions must, to a greater extent, focus on improved water supply, sanitation and water-resource management. As has been shown, interventions have considerable impacts that go far beyond immediate project benefits. Every US$1 invested in water supply and sanitation has benefits ranging from US$3 to US$34.

Prerequisite 2: *governments of middle-income countries that do not depend on aid must re-allocate their resources so that they target funding to those without access.*

Example: the targeting of improved and extended water supply, sanitation and water-resource management constitutes a pro-poor investment strategy. Consider the cholera epidemic that swept Peru in 1991 that cost US$1 billion to treat and hit the poorest the hardest. It is estimated that an investment in water interventions of US$100 million, a tenth of what was actually spent treating the epidemic, could have prevented the outbreak in the first place. Add to this the monetary expenses, the value of lost working days and the lives lost, the cost–benefit ratio of preventative investments in water and sanitation become astronomical.

Prerequisite 3: *decision-makers must involve both men and women in the development of water supply and sanitation initiatives, especially when poor communities are involved.*

Example: community ownership and participation are required for successful interventions. Over the last two decades, India has implemented major investment programmes in rural water supply and sanitation. Karnataka was the site of a US$200 million project that was completed in 2001, providing direct benefits to approximately 5.5 million people. The economic and social benefits were substantial, and women, who are invariably in charge of water for home use, household cleanliness and sanitation, were the main beneficiaries. Different technologies were implemented, including pit latrines, hand pumps, open wells and roofwater harvesting schemes. Up to 50 per cent of the households opted for private household systems. The NPV of the project is estimated at US$85 million, and the economic internal rate of return is more than 20 per cent.

Prerequisite 4: *there must be recognition among decision-makers that basic sanitation and hygiene requires an approach that centres on community mobilization and actions that support and encourage that mobilization.*

Example: community involvement and ownership are key strategies for successful interventions. Estimates indicate that sanitation and hygiene interventions often have a higher economic impact per dollar invested than water-supply interventions. Integrated approaches that implement water sanitation and hygiene together fare even better. An OECD cost–benefit analysis looking specifically at what is needed in order to meet the MDG sanitation target concluded: with a discount rate of 5 per cent and 10 per cent, the NPV of meeting the MDG sanitation target is US$400 to US$312 billion, respectively.

Prerequisite 5: *decision-makers must do proper planning of sound water-resource management and infrastructure and apply safeguards for social and environmental impacts.*

Example: interventions of improved water management and infrastructure must target poor sections of society. Targeting those with lowest capacities and levels of access to water for various productive uses is sound investment strategy. For example, there are huge economic benefits of interventions that provide access to small-scale water technology to poor farmers. The direct total net benefits of promoting these technologies have been estimated to be between US$100–200 billion for the estimated 100 million farmers that could adopt these tools. When including indirect benefits to the economy, with a multiplier of 3, the total net benefits can increase to US$300–600 billion.

Prerequisite 6: *decision-makers must invest in soft issues, such as improved governance and capacity. Poor governance constitutes an increased investment risk.*

Example: improved governance is critical for increasing the quality and quantity of investments and infrastructure development. Bribes, kickbacks, collusion and substandard work can increase the cost of water provision by 20 to 30 per cent, raising the cost of meeting the water-related targets of the Millennium Development Goals by almost US$50 billion.

It is paramount that governments and decision-makers are aware of the leadership and commitment that must accompany the resolution of these issues. Only then can they set priorities and instigate the reforms necessary to improve institutional performance and attract investment. Even though there remain many challenges to increases public and private investments in water supply, sanitation and water-resource management, the obstacles pale in comparison to the economic and social difference that such investments will make to poor people and to the entire economy.

Notes

1 The chapter is a shortened and updated version of H. Tropp and M. Sanctuary (2005) Making Water a Part of Economic Development: The economic benefits of improved water management and services, Stockholm International Water Institute, Stockholm.

2 Dr. Håkan Tropp, Stockholm International Water Institute (SIWI). The inputs and comments from Alastair Morrison, SIWI, are acknowledged.

3 In this study, low infant mortality rates lie between 50 and 100 deaths per 1,000 live births whereas high infant mortality is defined as greater than 150 deaths per 1,000 live births. Data range between the period of 1965 to 1994.

4 This estimate is based on comparison with a business-as-usual baseline.

5 Worldwide, agriculture uses 69 per cent of water, compared with 23 per cent by industry and only 8 per cent by households. In contrast, agriculture's share of GDP in 2001 was only 5 per cent globally, while industry's share was 31 per cent and that of services 64 per cent. In developing countries, however, the water proportion used by agriculture is very much higher (e.g. 97 per cent in Pakistan, 93 per cent in India, 87 per cent in China, 86 per cent in Egypt, and 76 per cent in Indonesia, to list a few of the most populated developing countries) (World Bank 2003).

6 For example, Oxfam has used a bottom-up approach and estimates an annual cost of US$50 billion. See World Bank (2009) for a summary of alternative cost estimates.

7 In developing countries, 80 per cent of export earnings come from the agricultural sector.

8 Securing food sources is seen by many as a precursor to development of a more advanced economy.

9 See the official website of MIDA: www.mida.gov.my/en_v2/index.php?page=infrastructure-support-2

10 Policy brief on "Manila's Water Supply: Getting Water to Work" (1998). Avilable at www.idrc.ca/.

11 Such benefits can be divided into use values and non-use values. Use values refer to direct, indirect and option values. Direct values: food, fodder, timber, fuel, etc. Indirect values: various ecological services, such as flood control, water purification, nutrient retention, etc. Option values: future possible direct and indirect economic gains. Finally, the non-use values refer to intrinsic moral, cultural, aesthetic, etc. values of ecosystems.

12 Most of these economic losses occurred in the developed countries of Europe as a result of the 2002 floods.

13 These costs consider rural and urban differences in capital and operating costs for water and sanitation provision. They also consider the cost of rural and urban wastewater treatment and hygiene education.

14 Net present value (NPV) is the present value of future cash flows in relation to a particular investment. NPV compares the value of one dollar today with its future value, taking into account inflation and profit margins. If NPV is positive for a particular project it is considered well worth investing in; if negative, stay away from investing.

15 Water savings are reported to be around 60 per cent over flood irrigation (e.g. see Shah and Keller 2002).

16 Assuming an NPV discount rate of 10 and 5 percent, respectively, see Rijsberman (2004). A multiplier of three is used to estimate indirect benefits.

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4

THE IMPACTS OF CLIMATE CHANGE AND TRADE LIBERALIZATION ON GLOBAL ARCHITECTURE

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Introduction

Water is one of our basic resources, but it is often in short supply. Surface water and groundwater are both important sources not only for human use but also for ecological systems. While in some countries groundwater resources are abundant (still) and readily available for development, in others depletion due to over-use, water logging, salinity and pollution cause severe problems. In addition, the uneven distribution of water (and population) among regions has made the issue of adequate supply critical for a growing number of countries. Rapid population growth and an increasing consumption of water per capita have aggravated the problem. This tendency is likely to continue as water consumption for most uses is projected to increase by at least 50 per cent by 2025 compared to the 1995 level (Rosegrant *et al.* 2002). One additional reason for concern is (anthropogenic) climate change, which may lead to increased droughts in many places (IPCC 2001).

Climate model simulations suggest that global average precipitation will increase as global temperature rises. As a result, global water availability is expected to increase with climate change. However, large regional differences are expected. At high latitudes and in some wet tropical areas, river flow and water availability are expected to increase. An opposite trend is projected for some dry regions at mid-latitudes and in the dry tropics (Bates *et al.* 2008). In many regions, the positive effects of higher annual runoff and total water supply are likely to be offset by the negative effects of changes in precipitation patterns, intensity and extremes, as well as shifts in seasonal runoff. The overall global impacts of climate change on freshwater systems are expected to be negative (Bates *et al.* 2008).

While many studies have focussed on the natural science aspects of water availability, the economic response is crucially important as well. Economies, and in particular agricultural sectors, of some developing countries might be hit particularly hard by a changing climate and changes in water availability. The agricultural sector is by far the largest consumer of water and farmers operate, directly or indirectly, at the world market for agricultural products.

Method

This study assesses the potential impacts of climate change on global agriculture, and its interactions with trade liberalization as proposed for the Doha Development Round (Ferguson 2008). The analysis is implemented using version 2 of the GTAP-W model, which distinguishes between rain-fed and irrigated agriculture. We consider the effects of climate change on crop yield through runoff, precipitation, temperature and CO_2 fertilization. The analysis relies upon the International Panel for Climate Change's Special Report on Emissions Scenarios (SRES) A1B and A2 scenarios and data derived from Calzadilla *et al.* (2010) that enables assessment of predicted changes from Falloon and Betts (2006).

> **Scenario A1B** can be described as a low to intermediate climate change scenario[2] with rapid economic growth, global population that peaks at 8.7 billion mid-century and then goes into decline. Income levels converge. The mix of fossil and non-fossil fuel sources of energy is balanced. Global surface temperature rises to 2.8°C somewhere between 2090–2099.
>
> **Scenario A2** can be described as a severe climate change scenario with a diverse range of economic and population growth patterns around the world. Mid-century global population is 11.3 billion and rises to 15.1 billion at the end of the century. Coal remains the main source of energy with some reduction in oil use. Global surface temperature rises to 3.4°C by 2090–2099 and then continues to increase.
>
> (IPCC 2007)

To alleviate the negative effect of climate change, trade could be liberalized to stimulate economic growth, reduce poverty and expand market access. Agricultural trade liberalization is supposed to be beneficial, if developing countries' comparative advantages are located in agriculture. Depending on the scenario chosen, most studies find a positive economic effect of agricultural trade liberalization for developing countries.[3]

Changes in tariffs or subsidies for agricultural goods involve regional as well as global adjustments in the production of the goods in question but have effects on other markets, such as factor-input markets, as well. Water is one production factor in agriculture. It is not known whether trade liberalization might increase or alleviate problems related to water use and water availability. To our knowledge, the effect of trade liberalization based on a future scenario of climate change has not been investigated in a multi-region, multi-sector general equilibrium model.

Most of the current analyses on agricultural trade liberalization ignore the impact on water use and problems related to water availability. Some authors have looked at the potential impact on sustainable development in developing countries including water as an environmental service. George and Kirkpatrick (2004) argue that further trade liberalization would lead to improved overall availability of water through increased efficiency in all developing countries.[4] Their study does not distinguish between different developing countries, nor is a quantitative assessment provided. Other studies related to water issues investigate the implications of the GATS negotiations on service trade liberalization on water management and the ability of governments to regulate water services.[5] All these analyses are qualitative assessments not based on economic models. The analysis by Berrittella *et al.* (2008) is an exception. They use a *global* CGE model including water resources (GTAP-W) to analyze the economic impact of hypothetical Doha-like liberalization of agricultural trade on water use. The Doha Development Agenda, launched in 2001, is meant to improve the situation for developing countries, but is subject to seemingly interminable delays.

This chapter differs from previous work in three ways. First, we use version 2 of the GTAP-W model (for a detailed description of the model, see Calzadilla *et al.* 2008). Second, we base our analysis on future scenarios of climate change for two time periods (2020 and 2050) as described in Calzadilla *et al.* (2010). They investigate the effect of climate change on water use and water availability but ignore the impact that trade liberalization could have on the economy. Based on their results we, third, investigate how trade patterns would change if trade of agricultural products were liberalized. Similar to Berrittella *et al.* (2008), we assume a hypothetical Doha-like liberalization.

The GTAP-W model (version 2)

Economic models of water use have generally been applied to look at the direct effects of water policies, such as water pricing or quantity regulations, on the allocation of water resources. In order to obtain insights from alternative water-policy scenarios on the allocation of water resources, partial and general equilibrium models have been used. While partial equilibrium analyses focus on the sector affected by a policy measure assuming that the rest of the economy is not affected, general equilibrium models consider other sectors or regions as well to determine the economy-wide effect; partial equilibrium models tend to have more detail. Most studies analyze pricing of irrigation water only.[6] Rosegrant *et al.* (2002) use the IMPACT model to estimate demand and supply of food and water to 2025. Fraiture *et al.* (2004) extend this to include virtual water trade, using cereals as an indicator. Their results suggest that the role of virtual-water trade is modest. While the IMPACT model covers a wide range of agricultural products and regions, other sectors are excluded; it is a partial equilibrium model.

Studies of water use employing general equilibrium approaches are generally based on data for a single country or region, assuming no effects for the rest of the world of the implemented policy.[7] All of these CGE studies have a limited geographical scope. Berrittella *et al.* (2007) and Calzadilla *et al.* (2008) are an exception. Both are based on GTAP-W, a multi-region world CGE model.

Based on GTAP-W, it is possible to assess the systemic general equilibrium effects of climate change impacts and trade liberalization on global agriculture. The model is a further refinement of the GTAP model[8] (Hertel 1997) and is based on the version modified by Burniaux and Truong[9] (2002) as well as on the previous GTAP-W model introduced by Berrittella *et al.* (2007). For a more detailed description of the model, see Calzadilla *et al.* (2008).

Unlike version 1 (Berrittella *et al.* 2007), version 2 of the GTAP-W model (Calzadilla *et al.* 2008), used here, distinguishes between rain-fed and irrigated agriculture. In the previous version of the GTAP-W model (version 1), substitution between intermediate inputs and value added for the production function of tradeable goods and services was not possible. As a consequence, a price-induced drop in water demand did not imply an increase in any other input. The new production structure of the model introduces water as an explicit factor of production and accounts for substitution possibilities between water and other primary factors.

The GTAP-W model uses the GTAP6 database, which represents the global economy in 2001, and the IMPACT 2000 baseline data. The model has 16 regions and 22 sectors, seven of which are in agriculture.[10] The most significant change and principal characteristic of version 2 of the GTAP-W model is the new production structure, in which the original land endowment in the value-added nest has been split into pasture land (grazing land used by livestock) and land for rain-fed and irrigated agriculture. The last two types of land differ, as rainfall is free but irrigation development is costly. As a result, land equipped for irrigation is generally more valuable, as yields per hectare are higher. To account for this difference, we split irrigated agriculture further into the value of land and the value of irrigation. The value of irrigation includes the equipment but also the water necessary for agricultural production. In the short run, irrigation equipment is fixed, and yields in irrigated agriculture depend mainly on water availability. The tree diagram in Figure 4.1 represents the new production structure.

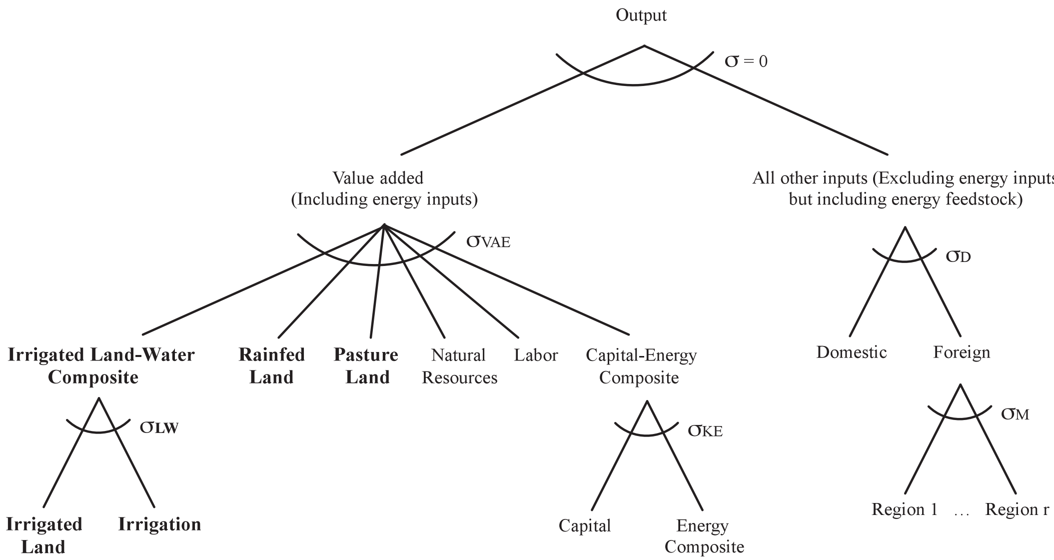

FIGURE 4.1 Nested tree structure for industrial production process in GTAP-W (truncated).[11]

Land as a factor of production in national accounts represents "the ground, including the soil covering and any associated surface waters, over which ownership rights are enforced" (United Nations 1993). In order to include water as a factor of production in the GTAP data and model for each region and each crop, the value of land in the GTAP social accounting matrix was split into the value of rain-fed land and the value of irrigated land in proportion to contribution to total production. The value of pasture land is derived from the value of land in the livestock-breeding sector.

In the next step, we split the value of irrigated land into the value of land and the value of irrigation using the ratio of irrigated yield to rain-fed yield. These ratios are based on IMPACT data. The numbers indicate how valuable irrigated agriculture is compared to rain-fed agriculture. The magnitude of additional yield differs not only with respect to the region but also to the crop. On average, producing rice using irrigation is relatively more productive than using irrigation for growing oil seeds, for example. On average, regions such as South America seem to grow relatively more using irrigation instead of rain-fed agriculture compared to countries in North Africa or sub-Saharan Africa.

The procedure we described above to introduce the four new endowments (pasture land, rain-fed land, irrigated land and irrigation) allows us to avoid problems related to model calibration. In fact, since the original database is only split and not altered, the original regions' social accounting matrices are balanced and can be used by the GTAP-W model to assign values to the shared parameters of the mathematical equations. For detailed information about the social accounting matrix representation of the GTAP database, see McDonald, Robinson and Thierfelder (2005).

As in all CGE models, the GTAP-W model makes use of the Walrasian perfect competition paradigm to simulate adjustment processes. Industries are modelled through a representative firm, which maximizes profits in perfectly competitive markets. The production functions are specified via a series of nested constant elasticity of substitution (CES) functions (Figure 4.1). Domestic and foreign inputs are not perfect substitutes, according to the "Armington assumption", which accounts for product heterogeneity.

Table 4.1 Aggregations in GTAP-W

A.	*Regional aggregation*	*B.*	*Sectoral aggregation*
1.	USA – United States	1.	Rice – Rice
2.	CAN – Canada	2.	Wheat – Wheat
3.	WEU – Western Europe	3.	CerCrops – Cereal grains (maize, millet, sorghum and other grains)
4.	JPK – Japan and South Korea	4.	VegFruits – Vegetable, fruits, nuts
5.	ANZ – Australia and New Zealand	5.	OilSeeds – Oil seeds
6.	EEU – Eastern Europe	6.	Sug_Can – Sugar cane, sugar beet
7.	FSU – Former Soviet Union	7.	Oth_Agr – Other agricultural products
8.	MDE – Middle East	8.	Animals – Animals
9.	CAM – Central America	9.	Meat – Meat
10.	SAM – South America	10.	Food_Prod – Food products
11.	SAS – South Asia	11.	Forestry – Forestry
12.	SEA – South-East Asia	12.	Fishing – Fishing
13.	CHI – China	13.	Coal – Coal
14.	NAF – North Africa	14.	Oil – Oil
15.	SSA – Sub-Saharan Africa	15.	Gas – Gas
16.	ROW – Rest of the world	16.	Oil_Pcts – Oil products
		17.	Electricity – Electricity
		C.	*Endowments*
Wtr – Irrigation		18.	Water – Water
Lnd – Irrigated land		19.	En_Int_Ind – Energy-intensive industries
RfLand – Rain-fed land		20.	Oth_Ind – Other industry and services
PsLand – Pasture land		21.	Mserv – Market services
Lab – Labour		22.	NMServ – Non-market services
Capital – Capital			
NatlRes – Natural resources			

A representative consumer in each region receives income, defined as the service value of national primary factors (natural resources, pasture land, rain-fed land, irrigated land, irrigation, labour and capital). Capital and labour are perfectly mobile domestically, but immobile internationally. Pasture land, rain-fed land, irrigated land, irrigation and natural resources are imperfectly mobile. While perfectly mobile factors earn the same market return regardless of where they are employed, market returns for imperfectly mobile factors may differ across sectors. The national income is allocated between aggregate household consumption, public consumption and savings. The expenditure shares are generally fixed, which amounts to saying that the top-level utility function has a Cobb-Douglas specification. Private consumption is split in a series of alternative composite Armington aggregates. The functional specification used at this level is the constant difference in elasticity form: a non-homothetic function, which is used to account for possible differences in income elasticities for the various consumption goods. Hicksian equivalent variation is used as the measure of economic welfare and is computed from the model output.

In the original GTAP-E model, land is combined with natural resources, labour and the capital-energy composite in a value-added nest. In our modelling framework, we incorporate the possibility of substitution between land and irrigation in irrigated agricultural production by using a nested constant elasticity of substitution function (Figure 4.1). The procedure of how the elasticity of factor substitution between land and irrigation (LW) was obtained is explained in detail in Calzadilla *et al.* (2008). Next, the irrigated land-water composite is combined with pasture land, rain-fed land, natural resources, labour and the capital-energy composite in a value-added nest through a CES structure.

The IMPACT model provides detailed information on green water use in rain-fed production (defined as effective rainfall), and both green and blue water use in irrigated production (blue water or irrigation is defined as the water diverted from water systems).[12] In the GTAP-W benchmark equilibrium, water used for irrigation is supposed to be identical to the volume of blue water used for irrigated agriculture in the IMPACT model. An initial sector- and region-specific shadow price for irrigation water can be obtained by combining the social accounting matrix information about payments to factors of production with the volume of water used in irrigation provided by the IMPACT model. In the GTAP-W model, only irrigation water has a price. In contrast, rain that falls directly on a crop, whether rain-fed or irrigated, is not priced. Instead, the amount of rain that falls on a crop is modelled exogenously using information from IMPACT.

The distinction between rain-fed and irrigated agriculture within the production structure of the GTAP-W model allows us to study expected physical constraints on water supply due to, for example, climate change. In fact, changes in rainfall patterns can be exogenously modelled in GTAP-W by changes in the productivity of rain-fed and irrigated land. In the same way, water excess or shortages in irrigated agriculture can be modelled by exogenous changes to the initial irrigation-water endowment.

Design of model experiments

Our model experiments are based on future impacts of climate change on agriculture at two time periods: 2020 and 2050 covering the years 2006–2035 and 2036–2065 respectively. In a first step, information on the future benchmark equilibria under normal climate conditions (omitting climate change) is needed. How to find a hypothetical general equilibrium state in the future imposing forecasted values for some key economic variables in the initial calibration dataset is described in Calzadilla *et al.* (2010).

The current baseline data and future baseline simulations under normal climate conditions are shown in Tables 4.2, 4.3 and 4.4. These baselines are based on the IMPACT model (Rosegrant *et al.* 2002). Compared to the 2000 baseline data (Table 4.2), a growth in both crop harvested area as well as crop productivity under normal climate conditions is projected for 2020 (Table 4.3) and 2050 (Table 4.4). For 2020 and 2050 respectively, global agricultural area increases by 1.1 per cent and 2.8 per cent while production rises by 32.8 per cent and 91.7 per cent.

To investigate the impact of climate change on global agriculture, Calzadilla *et al.* (2010) use information on key climate variables, which includes temperature and precipitation, as well as river flow. Their analysis also includes the CO_2 fertilization effect. Predicted changes in the magnitude and distribution of global temperature, precipitation and river flow are based on Falloon and Betts (2006). They used the Hadley Centre Global Environmental Model, including a dynamic river routing model (HadGEM1-TRIP), to simulate changes in temperature, precipitation and river flow over the next century and under the IPCC SRES A1B and A2 scenarios (see Figure 4.2). Crop-yield response to temperature and precipitation are taken from Rosenzweig and Iglesias (1992). They used the CERES and SOYGRO crop models to analyze crop-yield responses to arbitrary incremental changes in temperature (+2°C and +4°C) and precipitation (± 20 per cent). The study was carried out in 18 countries worldwide and uses common crop-growth models and methodology.

River flow is a useful indicator of freshwater availability for agricultural production. Irrigated agriculture relies on the availability of irrigation water from surface and groundwater sources, which depend on the seasonality and inter-annual variability of river flow. Therefore, river flow limits a region's

TABLE 4.2 2000 baseline data: Crop harvested area and production by region and crop[13]

Description	*Rain-fed agriculture*		*Irrigated agriculture*		*Total*		*Share of irrigated agriculture in total*	
Regions	*Area (000 ha)*	*Production (000 m)*	*Area (000 ha)*	*Production (000 m)*	*Area (000 ha)*	*Production (000 m)*	*Area (%)*	*Production (%)*
United States	35,391	209,833	67,112	440,470	102,503	650,303	65.5	67.7
Canada	27,267	65,253	717	6,065	27,984	71,318	2.6	8.5
Western Europe	59,494	462,341	10,130	146,768	69,624	609,108	14.5	24.1
Japan and South Korea	1,553	23,080	4,909	71,056	6,462	94,136	76.0	75.5
Australia and New Zealand	21,196	67,204	2,237	27,353	23,433	94,557	9.5	28.9
Eastern Europe	37,977	187,468	5,958	40,470	43,935	227,939	13.6	17.8
Former Soviet Union	85,794	235,095	16,793	74,762	102,587	309,857	16.4	24.1
Middle East	29,839	135,151	21,450	118,989	51,289	254,140	41.8	46.8
Central America	12,970	111,615	8,745	89,637	21,715	201,252	40.3	44.5
South America	79,244	649,419	9,897	184,304	89,141	833,723	11.1	22.1
South Asia	137,533	491,527	114,425	560,349	251,958	1,051,877	45.4	53.3
South-East Asia	69,135	331,698	27,336	191,846	96,471	523,543	28.3	36.6
China	64,236	615,196	123,018	907,302	187,254	1,522,498	65.7	59.6
North Africa	15,587	51,056	7,352	78,787	22,938	129,843	32.0	60.7
Sub-Saharan Africa	171,356	439,492	5,994	43,283	177,349	482,775	3.4	9.0
Rest of the World	3,810	47,466	1,093	23,931	4,903	71,397	22.3	33.5
Total	852,381	4,122,894	427,164	3,005,371	1,279,545	7,128,265	33.4	42.2
Crops								
Rice	59,678	108,179	93,053	294,934	152,730	403,113	60.9	73.2
Wheat	124,147	303,638	90,492	285,080	214,639	588,718	42.2	48.4
Cereal grains	225,603	504,028	69,402	369,526	295,005	873,554	23.5	42.3
Vegetables, fruits, nuts	133,756	1,374,128	36,275	537,730	170,031	1,911,858	21.3	28.1
Oil seeds	68,847	125,480	29,578	73,898	98,425	199,379	30.1	37.1
Sugar cane, sugar beet	16,457	846,137	9,241	664,023	25,699	1,510,161	36.0	44.0
Other agricultural products	223,894	861,303	99,122	780,180	323,017	1,641,483	30.7	47.5
Total	852,381	4,122,894	427,164	3,005,371	1,279,545	7,128,265	33.4	42.2

Source: IMPACT, 2000 baseline data (April 2008).

water supply and hence constrains its ability to irrigate crops. Regional changes in river flow are related to regional changes in water supply by the runoff elasticities of water supply estimated by Darwin *et al.* (1995).

The CO_2 fertilization effect on crop yields is based on information presented by Tubiello *et al.* (2006). They report yield response ratios for C3 and C4 crops to elevated CO_2 concentrations in the three major crop models (CERES, EPIC and AEZ). In this analysis, we use the average crop-yield response of the three crop models to the CO_2 concentrations in 2020 and 2050 for the IPCC SRES A1B and A2 scenarios.

Future climate change would modify regional water endowments and soil moisture, and in response, the distribution of harvested land would change. Therefore, we include a land-use scenario that explores possible shifts in the geographical distribution of irrigated agriculture. It assumes that irrigated areas could expand in regions with higher water supply. Vice versa, irrigated farming could become unsustainable in regions subject to increased water shortages.

Going one step further, based on the impact of climate change on agricultural production, we examine whether trade-liberalization policies would help to alleviate the negative effect of climate change. To better be able to single out the effect of trade liberalization on agricultural production, we also analyze

TABLE 4.3 2020 no climate change simulation: Crop harvested area and production by region and crop[14]

Description	*Rain-fed agriculture*		*Irrigated agriculture*		*Total*		*Share of irrigated agriculture in total*	
Regions	*Area (000 ha)*	*Production (000 m)*	*Area (000 ha)*	*Production (000 m)*	*Area (000 ha)*	*Production (000 m)*	*Area (%)*	*Production (%)*
United States	33,927	267,740	68,072	606,204	101,999	873,944	66.7	69.4
Canada	25,091	81,239	678	7,460	25,769	88,699	2.6	8.4
Western Europe	51,622	472,176	9,391	166,310	61,013	638,485	15.4	26.0
Japan and South Korea	1,375	25,068	4,453	72,230	5,828	97,299	76.4	74.2
Australia and New Zealand	20,698	83,292	2,216	35,441	22,915	118,733	9.7	29.8
Eastern Europe	34,492	210,311	5,520	53,325	40,012	263,636	13.8	20.2
Former Soviet Union	83,591	309,682	16,838	100,534	100,430	410,215	16.8	24.5
Middle East	30,232	163,563	22,561	176,977	52,793	340,539	42.7	52.0
Central America	13,152	163,265	9,383	136,479	22,535	299,744	41.6	45.5
South America	87,571	1,152,723	11,360	344,208	98,931	1,496,931	11.5	23.0
South Asia	121,508	551,783	126,468	822,052	247,977	1,373,835	51.0	59.8
South-East Asia	72,405	431,084	27,457	282,402	99,863	713,486	27.5	39.6
China	61,761	691,581	120,838	1,014,241	182,600	1,705,822	66.2	59.5
North Africa	16,011	73,390	7,726	106,969	23,737	180,359	32.5	59.3
Sub-Saharan Africa	194,346	665,335	7,847	85,687	202,193	751,022	3.9	11.4
Rest of the World	4,060	71,744	1,227	42,107	5,287	113,851	23.2	37.0
Total	851,843	5,413,975	442,036	4,052,625	1,293,880	9,466,600	34.2	42.8
Crops								
Rice	53,799	107,477	91,696	327,822	145,495	435,299	63.0	75.3
Wheat	117,231	358,153	89,017	375,312	206,248	733,466	43.2	51.2
Cereal grains	222,513	646,828	73,584	524,949	296,097	1,171,777	24.9	44.8
Vegetables, fruits, nuts	140,559	1,742,380	40,067	748,817	180,625	2,491,196	22.2	30.1
Oil seeds	70,829	135,312	30,504	94,146	101,333	229,458	30.1	41.0
Sugar cane, sugar beet	20,753	1,473,872	11,446	1,080,858	32,198	2,554,730	35.5	42.3
Other agricultural products	226,160	949,953	105,723	900,721	331,883	1,850,674	31.9	48.7
Total	851,843	5,413,975	442,036	4,052,625	1,293,880	9,466,600	34.2	42.8

Source: IMPACT (April 2008).

the impact of reductions in trade barriers ignoring the effect of climate change. As indicated above, the scenarios are based on a hypothetical Doha-like liberalization of agricultural trade.

As the Doha negotiations are still ongoing (at a very slow pace), the modalities of the possible agreement are uncertain. It is clear that the parties involved have very different interests. Agricultural exporters aim for open foreign markets and reductions in distorting subsidies elsewhere. Industrial exporters in emerging economies want to remain protected. In contrast, countries with a comparative advantage in service provision hope the General Agreement on Trade in Services negotiations will result in the reduction of restrictions on the provision of services to other countries. Therefore, any

TABLE 4.4 2050 no climate change simulation: Crop harvested area and production by region and crop

Description	*Rain-fed agriculture*		*Irrigated agriculture*		*Total*		*Share of irrigated agriculture in total*	
Regions	*Area (000 ha)*	*Production (000 m)*	*Area (000 ha)*	*Production (000 m)*	*Area (000 ha)*	*Production (000 m)*	*Area (%)*	*Production (%)*
United States	31,731	359,608	69,511	872,566	101,243	1,232,174	68.7	70.8
Canada	21,827	97,335	620	9,640	22,447	106,975	2.8	9.0
Western Europe	39,815	452,254	8,282	188,597	48,097	640,851	17.2	29.4
Japan and South Korea	1,107	27,348	3,770	72,337	4,876	99,685	77.3	72.6
Australia and New Zealand	19,952	109,152	2,186	49,047	22,137	158,200	9.9	31.0
Eastern Europe	29,264	232,260	4,864	69,807	34,127	302,068	14.3	23.1
Former Soviet Union	80,287	412,791	16,906	142,725	97,194	555,515	17.4	25.7
Middle East	30,822	210,882	24,227	279,714	55,049	490,596	44.0	57.0
Central America	13,425	259,733	10,341	221,277	23,766	481,010	43.5	46.0
South America	100,062	2,230,050	13,553	675,050	113,615	2,905,101	11.9	23.2
South Asia	97,471	645,050	144,534	1,287,136	242,005	1,932,186	59.7	66.6
South-East Asia	77,311	602,597	27,640	451,659	104,951	1,054,256	26.3	42.8
China	58,049	808,747	117,569	1,183,716	175,619	1,992,463	66.9	59.4
North Africa	16,647	113,839	8,288	159,094	24,935	272,933	33.2	58.3
Sub-Saharan Africa	228,831	1,070,839	10,628	174,781	239,459	1,245,619	4.4	14.0
Rest of the World	4,435	117,189	1,427	78,062	5,862	195,251	24.3	40.0
Total	851,036	7,749,674	464,345	5,915,210	1,315,381	13,664,884	35.3	43.3
Crops								
Rice	44,981	105,044	89,661	373,142	134,642	478,186	66.6	78.0
Wheat	106,856	427,710	86,806	500,301	193,662	928,011	44.8	53.9
Cereal grains	217,878	860,509	79,858	788,785	297,735	1,649,294	26.8	47.8
Vegetables, fruits, nuts	150,763	2,346,842	45,754	1,124,570	196,517	3,471,412	23.3	32.4
Oil seeds	73,803	148,761	31,892	127,020	105,696	275,782	30.2	46.1
Sugar cane, sugar beet	27,197	2,799,190	14,752	1,914,327	41,948	4,713,517	35.2	40.6
Other agricultural products	229,558	1,061,618	115,623	1,087,064	345,182	2,148,682	33.5	50.6
Total	851,036	7,749,674	464,345	5,915,210	1,315,381	13,664,884	35.3	43.3

Source: IMPACT, 2050 simulation without climate change (April 2008).

analysis investigating scenarios of trade liberalization must take all three aspects into account. However, as our study focuses on trade liberalization in agriculture, we account for liberalization in non-agricultural sectors, but vary the levels of liberalization for the agricultural sectors only. The cut in tariffs for products in the non-agricultural sectors is 25 per cent.

In scenario 1, a 25 per cent tariff reduction is chosen for all agricultural sectors (TL1). In addition, we assume zero export subsidies and a 50 per cent reduction in domestic farm support. Scenario 2 is a variant of scenario 1 in that tariffs are reduced by 50 per cent (TL2). According to the negotiations so far, export subsidies will be phased out over the next few years. Tariff reductions will also be phased in and not implemented all at once. To account for this procedure, we designed our above-described scenarios for the years 2020 and 2050.

As shown in Figure 4.2, in total we have 16 different scenarios, including two climate scenarios (A1B and A2), for two future time periods (2020 and 2050) and two trade liberalization scenarios (TL1 and TL2).

Simulation results

Trade liberalization only (TL1 and TL2) would have a limited effect on global production of agricultural goods (Tables 4.5 and 4.6). On the regional level, the effect is different but the numbers are small. Some regions expand production (particularly Canada, Australia and New Zealand),[15] while others reduce production (particularly Western Europe, Japan and South Korea). The relationship between trade liberalization and agricultural production is complex. Current tariffs vary widely between crops and between regions, also relative to the costs of production. Uniform cuts in nominal tariffs, as investigated here, would therefore have a non-uniform impact.

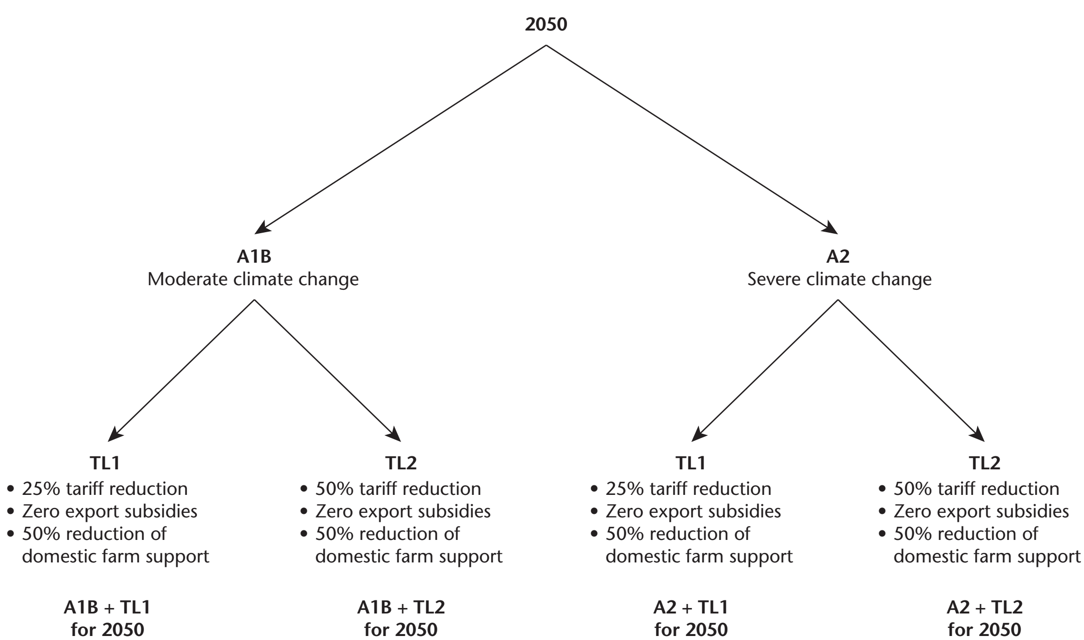

FIGURE 4.2 Structure of scenarios used to analyze the effects of climate change and trade liberalization on agricultural production for 2050.

TABLE 4.5 Change in agricultural production in 2020 (in per cent) relative to the baseline

	2020 scenario							
Regions	*TL1*	*TL2*	*A1B*	*A2*	*A1B+ TL1*	*A1B+ TL2*	*A2+ TL1*	*A2+ TL2*
United States	–0.97	–0.75	–1.61	–3.73	–2.39	–2.20	–4.31	–4.15
Canada	2.19	4.25	–2.02	–0.05	0.14	2.08	2.13	4.11
Western Europe	–1.26	–2.21	2.09	2.72	0.68	–0.25	1.30	0.40
Japan and South Korea	–1.34	–2.11	1.08	1.31	–0.29	–1.06	–0.06	–0.80
Australia and New Zealand	2.03	2.20	7.16	10.76	8.13	8.35	11.18	11.43
Eastern Europe	–0.24	–0.49	1.41	1.38	1.11	0.86	1.08	0.83
Former Soviet Union	–0.20	–0.23	–4.19	–4.95	–4.05	–4.10	–4.77	–4.82
Middle East	0.75	0.68	–1.83	–3.62	–1.12	–1.18	–2.91	–2.97
Central America	–0.08	–0.02	0.42	–0.75	0.33	0.38	–0.83	–0.80
South America	0.72	0.95	–0.12	0.19	0.54	0.73	0.83	1.03
South Asia	–0.61	–0.72	–1.87	–0.92	–2.39	–2.50	–1.49	–1.59
South-East Asia	0.10	0.12	–5.48	–6.41	–5.38	–5.35	–6.31	–6.28
China	0.46	0.59	1.86	1.77	2.27	2.47	2.16	2.36
North Africa	–0.07	–0.68	–0.29	–0.42	–0.41	–0.98	–0.54	–1.10
Sub-Saharan Africa	0.20	0.25	0.79	1.29	0.95	1.02	1.44	1.52
Rest of the World	1.11	1.10	–1.41	–1.09	–0.41	–0.42	–0.07	–0.08
Total	0.01	0.01	–0.45	–0.53	–0.44	–0.44	–0.53	–0.52
Crops								
Rice	–0.19	–0.12	–1.27	–1.28	–1.44	–1.37	–1.45	–1.38
Wheat	0.15	0.26	–0.47	–0.60	–0.39	–0.29	–0.57	–0.45
Cereal grains	0.01	–0.01	–0.29	–0.64	–0.28	–0.31	–0.63	–0.65
Vegetables, fruits, nuts	0.08	0.10	–0.42	–0.36	–0.34	–0.31	–0.27	–0.25
Oil seeds	–0.98	–1.15	–0.57	–1.29	–1.40	–1.60	–2.01	–2.23
Sugar cane, sugar beet	–0.04	–0.09	–0.54	–0.55	–0.60	–0.64	–0.60	–0.65
Other agricultural products	0.11	0.11	–0.24	–0.36	–0.15	–0.10	–0.28	–0.23
Total	0.01	0.01	–0.45	–0.53	–0.44	–0.44	–0.53	–0.52

The effect of climate change is a reduction in global agricultural production (A1B and A2). The decrease is more pronounced in 2050 and for the A2 scenario. While in 2020 only irrigated production decreases, rain-fed production falls as well in 2050.[16] On a regional level, the drop in production is particularly pronounced in South-East Asia, the former Soviet Union and the USA, while in other regions including Australia and New Zealand, Western Europe and China, irrigated and rain-fed agricultural production expands.

Climate change plus trade liberalization changes this pattern for some countries. In 2020, the impact on production is negative for Western Europe, the USA, South Asia, Japan and South Korea. The impact is positive (or less negative) for Canada, South America, China and sub-Saharan Africa. In 2050 the situation is different again with respect to the two climate scenarios.

Tables 4.7 and 4.8 show the effect of the different scenarios on water use. Comparing the results to those presented in Tables 4.5 and 4.6, the pattern is the same for both climate-change scenarios (A1B and A2). Trade liberalization only (TL1 and TL2) would imply an increase in water use in Canada, Australia and New Zealand; and a reduction in the USA, Western and Eastern Europe, Japan and South Korea, and the former Soviet Union. In developing regions, trade liberalization would mainly lead to

TABLE 4.6 Change in agricultural production in 2050 (in per cent) relative to the baseline

	2020 scenario							
Regions	*TL1*	*TL2*	*A1B*	*A2*	*A1B+ TL1*	*A1B+ TL2*	*A2+ TL1*	*A2+ TL2*
United States	−0.41	−0.35	−9.20	−10.12	−9.40	−9.36	−10.31	−10.28
Canada	0.66	1.76	−10.04	−8.53	−9.53	−8.78	−7.99	−7.21
Western Europe	0.21	−0.41	4.30	4.83	4.73	4.19	5.27	4.72
Japan and South Korea	−0.26	0.22	6.47	6.86	6.61	7.52	7.01	7.85
Australia and New Zealand	1.48	1.49	6.95	9.49	8.40	8.41	10.90	10.93
Eastern Europe	−0.14	−0.24	2.59	2.29	2.49	2.43	2.18	2.12
Former Soviet Union	−0.15	−0.18	−21.28	−20.42	−21.30	−21.28	−20.41	−20.39
Middle East	0.11	0.08	−23.24	−16.81	−23.23	−23.22	−16.76	−16.75
Central America	−0.12	−0.19	−1.70	−2.70	−1.81	−1.89	−2.80	−2.88
South America	0.21	0.16	−1.77	−1.81	−1.65	−1.76	−1.70	−1.80
South Asia	−0.73	−0.76	−3.16	−2.17	−3.89	−3.84	−2.97	−2.93
South-East Asia	0.01	0.04	−11.63	−12.28	−11.74	−11.68	−12.40	−12.34
China	0.20	0.37	11.18	9.04	11.54	11.88	9.36	9.68
North Africa	0.12	−0.17	−8.90	−13.73	−8.91	−9.00	−13.73	−13.81
Sub-Saharan Africa	−0.29	−0.39	3.54	3.69	3.24	3.13	3.39	3.28
Rest of the World	0.91	0.93	−3.58	−3.64	−2.82	−2.79	−2.89	−2.86
Total	−0.06	−0.08	−2.28	−2.38	−2.31	−2.29	−2.43	−2.42
Crops								
Rice	−0.50	−0.49	−4.09	−4.17	−4.53	−4.50	−4.60	−4.57
Wheat	−0.16	−0.23	−4.97	−3.72	−5.39	−5.38	−4.24	−4.21
Cereal grains	0.09	0.07	−3.32	−3.41	−3.23	−3.24	−3.34	−3.34
Vegetables, fruits, nuts	0.02	0.03	−1.36	−1.41	−1.28	−1.23	−1.35	−1.29
Oil seeds	−1.79	−2.19	−3.71	−4.28	−4.89	−5.36	−5.41	−5.87
Sugar cane, sugar beet	−0.04	−0.10	−3.37	−3.31	−3.43	−3.48	−3.37	−3.42
Other agricultural products	0.04	0.12	1.19	0.10	1.35	1.52	0.23	0.38
Total	−0.06	−0.08	−2.28	−2.38	−2.31	−2.29	−2.43	−2.42

higher levels of water use. However, in later years some of these regions would see an increase in water use for a partial liberalization, but a decrease for a more complete liberalization. In all cases, changes in water use due to trade liberalization are less than 10 per cent.

Climate change leads to a reduction in worldwide water use of between 77 km^3 (scenario A1B in 2020) and 187 km^3 (scenario A2 in 2050). This amounts to a decrease of 1.27 to 2.31 per cent as displayed in Tables 4.7 and 4.8. At the regional level, water use increases by up to 17 per cent for Australia and New Zealand and declines by up to 27 per cent in the Middle East. For most countries that experience a decline in water availability, the effect in later years and of the A2 scenario is generally more pronounced.

There are differences between the trade-liberalization scenarios and the climate-change scenarios. While regions such as the Middle East and South-East Asia would increase their use with trade liberalization they would reduce it under climate change. Other regions, including Eastern and Western Europe, Japan and Korea, would use more water. Climate change plus trade liberalization leads to smaller decrease in 2020 but a slightly more pronounced decrease in 2050.

TABLE 4.7 Change of agricultural water use in 2020 (in per cent) relative to the baseline

Regions	*2020 scenario* *TL1*	*TL2*	*A1B*	*A2*	*A1B+ TL1*	*A1B+ TL2*	*A2+ TL1*	*A2+ TL2*
United States	−2.24	−1.98	−2.65	−5.82	−4.60	−4.38	−7.53	−7.34
Canada	2.13	3.95	−2.27	−0.23	−0.19	1.51	1.85	3.60
Western Europe	−1.80	−2.98	2.60	3.32	0.47	−0.69	1.17	0.05
Japan and South Korea	−3.88	−7.60	1.35	1.76	−2.72	−6.42	−2.31	−6.05
Australia and New Zealand	1.36	1.61	11.76	16.85	11.32	11.65	15.49	15.85
Eastern Europe	−0.13	−0.37	1.22	1.30	1.00	0.77	1.08	0.86
Former Soviet Union	−0.12	−0.08	−6.21	−7.21	−5.89	−5.88	−6.83	−6.83
Middle East	1.86	2.02	−3.94	−8.81	−2.17	−2.01	−7.03	−6.89
Central America	−0.81	−1.55	0.81	−1.96	−0.01	−0.76	−2.74	−3.46
South America	2.46	2.99	−0.13	0.57	2.20	2.70	2.87	3.38
South Asia	−0.35	−0.33	−3.26	−1.88	−3.51	−3.48	−2.20	−2.17
South-East Asia	0.27	0.21	−5.33	−6.23	−5.01	−5.07	−5.90	−5.96
China	0.33	0.29	2.00	1.75	2.27	2.29	2.00	2.01
North Africa	0.14	−0.48	−2.85	−2.41	−2.78	−3.39	−2.35	−2.94
Sub-Saharan Africa	0.46	0.45	0.87	1.48	1.27	1.28	1.85	1.87
Rest of the World	0.75	0.72	−3.03	−2.55	−2.35	−2.39	−1.88	−1.92
Total	0.11	0.13	−1.27	−1.33	−1.15	−1.13	−1.22	−1.20

TABLE 4.8 Change of agricultural water use in 2050 (in per cent) relative to the baseline

Regions	*2020 scenario* *TL1*	*TL2*	*A1B*	*A2*	*A1B+ TL1*	*A1B+ TL2*	*A2+ TL1*	*A2+ TL2*
United States	−1.57	−1.53	−11.69	−12.62	−12.69	−12.69	−13.61	−13.61
Canada	0.52	1.33	−9.70	−8.25	−9.31	−8.75	−7.84	−7.25
Western Europe	−0.21	−1.04	4.83	5.53	4.80	4.08	5.49	4.76
Japan and South Korea	−1.93	−3.99	6.69	7.28	4.56	2.45	5.11	3.07
Australia and New Zealand	0.86	0.90	11.86	15.46	12.73	12.78	16.23	16.30
Eastern Europe	−0.07	−0.22	2.69	2.17	2.65	2.56	2.13	2.04
Former Soviet Union	−0.11	−0.12	−23.52	−22.55	−23.49	−23.47	−22.47	−22.45
Middle East	0.84	0.80	−26.50	−19.74	−25.90	−25.87	−19.05	−19.01
Central America	−0.76	−1.46	−2.20	−3.93	−2.92	−3.60	−4.63	−5.29
South America	1.08	1.27	−0.65	−0.67	0.21	0.33	0.19	0.31
South Asia	−0.53	−0.47	−3.46	−2.49	−4.07	−3.93	−3.19	−3.06
South-East Asia	0.03	−0.08	−12.42	−13.13	−12.36	−12.46	−13.07	−13.15
China	0.02	−0.05	12.16	9.46	12.27	12.31	9.55	9.57
North Africa	0.10	−0.09	−8.76	−10.89	−8.89	−8.93	−10.78	−10.81
Sub-Saharan Africa	0.01	−0.05	3.26	3.60	3.23	3.15	3.57	3.50
Rest of the World	0.56	0.59	−5.09	−5.78	−4.61	−4.59	−5.30	−5.29
Total	−0.13	−0.16	−2.19	−2.31	−2.31	−2.31	−2.45	−2.45

Tables 4.9 and 4.10 show the impact of climate change and trade liberalization on welfare. Trade liberalization has a positive effect on welfare of US$31 billion in 2020 and US$67 billion in 2050 for the 25 per cent cut in tariffs (TL1). An extra 25 per cent tariff cut further increases welfare by US$4 billion in 2020 and US$10 billion in 2050 (TL2). As expected, the first cuts have the greatest benefit. The impact of climate change on welfare is negative, valued at up to US$18 billion in 2020 and US$283 billion in 2050.

The impact of trade liberalization varies with climate change, as regions are affected differently. In 2020, the impact of climate change is small; the global difference in welfare is less than US$0.1 billion. However, in 2050 trade liberalization increases welfare by a further US$2 billion (TL1) or US$4 billion in the scenarios with climate change, when viewed in comparison to the scenario without. The intuition is as follows: trade liberalization would make it easier to substitute domestic food production for import and hence make it easier to adapt to climate change.

The results presented in Tables 4.9 and 4.10 indicate that regions are affected very differently. In the USA, climate change has a negative impact on welfare in the first time period but the effect of trade liberalization is worse irrespective of the climate scenario. For the Former Soviet Union, the situation is more severe. The opposite is true for Western Europe, and in particular for China, Japan and South Korea as well as for Northern Africa. However, differences exist with respect to time. In 2050, the impact of climate change dominates and the effect of trade liberalization on welfare is minor for all regions.

TABLE 4.9 Change in welfare for 2020 (in US$ millions) relative to the baseline

	2020 scenario							
Regions	*TL1*	*TL2*	*A1B*	*A2*	*A1B+ TL1*	*A1B+ TL2*	*A2+ TL1*	*A2+ TL2*
United States	−999	−1,069	−606	−2,055	−1,650	−1,741	−3,154	−3,263
Canada	−285	−285	−60	−20	−288	−284	−241	−237
Western Europe	3,127	3,330	1,248	1,325	4,554	4,727	4,707	4,861
Japan and South Korea	8,278	11,099	55	−189	8,367	11,168	8,149	10,970
Australia and New Zealand	692	622	756	1,022	1,352	1,277	1,563	1,483
Eastern Europe	230	302	618	538	892	954	822	883
Former Soviet Union	715	748	−5,654	−6,865	−5,261	−5,206	−6,548	−6,488
Middle East	1,995	2,104	−2,353	−3,344	−351	−233	−1,332	−1,213
Central America	575	679	46	−240	611	722	337	444
South America	1,044	1,372	332	805	1,401	1,747	1,874	2,237
South Asia	3,492	3,579	−5,948	−3,632	−2,396	−2,298	−121	−28
South-East Asia	3,018	3,196	−3,137	−3,813	−71	111	−735	−552
China	4,940	5,440	441	71	5,379	5,886	5,032	5,543
North Africa	4,137	4,120	−859	−1,107	3,290	3,279	3,043	3,034
Sub-Saharan Africa	180	218	129	283	277	325	410	458
Rest of the World	298	285	−340	−308	−37	−49	−5	−17
Total	31,437	35,741	−15,333	−17,530	16,068	20,384	13,802	18,116

TABLE 4.10 Change in welfare for 2050 (in US$ millions) relative to the baseline

Regions	*2020 scenario* *TL1*	*TL2*	*A1B*	*A2*	*A1B+ TL1*	*A1B+ TL2*	*A2+ TL1*	*A2+ TL2*
United States	−2,703	−3,235	−29,695	−34,251	−33,392	−34,496	−37,970	−39,077
Canada	−161	−161	22	462	−131	−92	327	366
Western Europe	8,176	8,373	13,627	11,767	22,655	22,142	20,929	20,420
Japan and South Korea	13,001	18,051	9,265	8,012	22,394	27,995	21,183	26,615
Australia and New Zealand	1,298	1,062	15,560	16,912	16,720	16,402	18,014	17,669
Eastern Europe	823	1,363	−7,011	−7,797	−6,326	−5,815	−7,084	−6,565
Former Soviet Union	1,778	1,987	−179,459	−169,498	−175,466	−174,159	−165,701	−164,448
Middle East	3,721	4,158	−66,360	−49,479	−62,554	−62,010	−45,742	−45,175
Central America	1,220	1,512	8,535	6,188	9,702	10,076	7,341	7,695
South America	2,560	3,833	49,634	48,800	52,458	54,160	51,663	53,363
South Asia	9,466	10,340	−86,006	−72,555	−75,955	−74,846	−62,709	−61,639
South-East Asia	6,988	7,876	−38,809	−41,028	−31,650	−30,538	−33,847	−32,732
China	11,424	12,581	20,873	14,920	32,459	34,091	26,502	28,088
North Africa	8,913	8,752	−17,871	−26,039	−9,472	−9,573	−17,560	−17,599
Sub-Saharan Africa	158	467	27,964	28,202	27,963	28,310	28,186	28,514
Rest of the World	238	172	−3,197	−3,405	−2,972	−3,052	−3,183	−3,261
Total	66,901	77,133	−282,929	−268,788	−213,565	−201,407	−199,650	−187,765

Discussion and conclusion

We use a global computable general equilibrium model including water resources (GTAP-W version 2) to assess impacts of climate change and trade liberalization on global agriculture. We find that trade liberalization has a small effect on agricultural production and on water use. Water use for some crops and some regions goes up, and it goes down for other crops and regions. Signs may switch between a modest liberalization and more substantial trade liberalization (e.g. for China and South-East Asia). Trade liberalization reduces water use in places where it is scarce (including, for example, the Middle East and Northern Africa) and increases water use in places where it is more abundant. Overall, and for most regions of the world, the effect of trade liberalization on welfare is positive.

The impact of climate change on global agriculture is much more pronounced. Agricultural production and water use decrease, as does global welfare. On a regional level, the drop in production is particularly pronounced in the Middle East, North Africa and South-East Asia, as well as the USA and Canada. Production increases in China, Japan and South Korea, Western Europe, and Australia and New Zealand. The net effect of these positive and negative changes is negative: global welfare decreases by up to US$283 billion.

Trade liberalization increases the depth of the market and therefore the capacity to adapt to climate change. As a result, trade liberalization reduces the negative impact of climate change on welfare, albeit by less than 2 per cent.

In summary, significant reductions in agricultural tariffs lead to modest changes in regional water use. Patterns are non-linear. On the regional level, water use may go up for partial liberalization, and down for more complete liberalization. This is because different crops respond differently to tariff reductions, and because trade and competition matter too. Moreover, trade liberalization tends to reduce water use in water-scarce regions, and increase water use in water-abundant regions, even though water markets do not exist in most countries. The welfare impact of climate change is substantially larger than the welfare impact of tariff cuts. Trade liberalization reduces the negative impacts of climate change, but only slightly.

Several limitations apply to the above results. The model is static. A dynamic model may find larger effects of trade liberalization and climate change with further specialization through capital stock adjustments. The limited disaggregation of crops and regions may hide larger shifts in agricultural production and water use due to trade liberalization. The importance of these factors will need to be tested with future versions of the current model and with other models. Our scenarios on climate change use information on temperature, precipitation and river flow based on regional averages. We do not take into account that precipitation and river flow might increase in some water basins and decrease in others within the same region. These local effects are averaged out. Also, we use annual average temperature, precipitation and river flow data; we do not consider changes in the seasonality of river flow nor extreme events. We do not take into account the effects of groundwater depletion. These issues are deferred to future research.

Notes

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2 The assumed rise in global temperature is 2.4°C by 2090–2099 relative to the global temperature during 1980 to 1999.
3 See Anderson *et al.* (2006) or Francois *et al.* (2005).
4 They mention that regulatory and subsidy frameworks are critical.
5 See Watson (2004) or Kirkpatrick and Parker (2005).
6 For an overview of this literature, see Johannson *et al.* (2002).
7 For an overview of this literature, see Calzadilla *et al.* (2008) and Dudu and Chumi (2008).
8 The GTAP model is a standard CGE static model distributed with the GTAP database of the world economy (www.gtap.org). For detailed information, see Hertel (1997) and the technical references and papers available on the GTAP website.
9 Burniaux and Truong (2002) developed a special variant of the model, called GTAP-E. The model is best suited for the analysis of energy markets and environmental policies. There are two main changes in the basic structure. First, energy factors are separated from the set of intermediate inputs and inserted in a nested level of substitution with capital. This allows for more substitution possibilities. Second, database and model are extended to account for CO2 emissions related to energy consumption.
10 See Table 4.1 for the regional, sectoral and factoral aggregation used in GTAP-W.
11 The original land endowment has been split into *pasture land*, *rain-fed land*, *irrigated land* and *irrigation*. (is the elasticity of substitution between value added and intermediate inputs, (VAE is the elasticity of substitution between primary factors, (LW is the elasticity of substitution between irrigated land and irrigation, (KE is the elasticity of substitution between capital and the energy composite, (D is the elasticity of substitution between domestic and imported inputs and (M is the elasticity of substitution between imported inputs.
12 Green water used in crop production or effective rainfall is part of the rainfall that is stored in the root zone and can be used by the plants. The effective rainfall depends on the climate, the soil texture, the soil structure and the depth of the root zone. The blue water used in crop production or irrigation is the applied irrigation water diverted from water systems. The blue water used in irrigated areas contributes additionally to the freshwater provided by rainfall (Rosegrant *et al.* 2002).
13 2000 data are three-year average for 1999–2001.

14 Linear interpolation between 2000 baseline data and 2050 simulation without climate change.
15 We do not differentiate between Australia and New Zealand.
16 The data are available from the corresponding author.

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5

BENEFITS AND COSTS OF INVESTING IN ECOSYSTEM SERVICES FOR CLEAN WATER SUPPLY AND FLOOD PROTECTION

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Introduction

The benefits of investing in ecosystem services for clean water supply and flood protection are understood to be great. Evidence shows the tremendous value of wetlands, forests and estuaries and the critical services they provide for water purification, groundwater recharge, carbon sequestration, and to buffer against storm surges. It is worth protecting these ecosystems. Furthermore, restoration of wetlands, reported to show great returns on investment, offer critically needed jobs that can realistically contribute to the rescue of our global economy and climate.

The public benefits from investment in ecosystem services are significant. Evidence shows that it can be more cost-effective to invest in wetlands for water treatment and flood protection than in built infrastructure. Private investments in watershed services are growing more popular as businesses come to realize their dependence on healthy water resources not only for social but also for productivity benefits.

This chapter presents information from some of the best available examples of the values, benefits and costs of investing in watershed services and draws on the reams of literature readily available on the topic. The literature, including recently released and extensively researched reports and chapters from The Economics of Ecosystems and Biodiversity (TEEB), a major international initiative that began in 2007, calls attention to the fact that, even though it is understood that the benefits of investing in ecosystem services are great, better science-based evidence is required. This information will help to increase voluntary investment in the promising market for ecosystem services, and assist forward-looking governments to not only support private investment but also protect their citizens' natural heritage. With the global economic, climate and water crises that we currently face, governments have every incentive to improve the governance and institutional arrangements necessary to support investment in ecosystem services.

Investing in water-related ecosystems: The time is now

In 2008, the world economy suffered financial losses of US$1–1.5 trillion because of a global financial crisis (DW-World.DE 2008). Governments around the world have allocated enormous sums of money to financial bailout packages and economic stimulus plans in an effort to save jobs and livelihoods.

The global community has been suffering far greater human welfare losses for decades, US$2–4.5 trillion *per year* due to the degradation of life-sustaining services that are normally provided by the natural environment (TEEB 2008). The earth's natural infrastructure, including forests, wetlands, and coral reefs, provide humankind with valuable services such as water supply, flood protection, and climate regulation. Yet approximately 60 per cent of the earth's ecosystem services have been degraded or destroyed by humans in the past 50 years (Millennium Ecosystem Assessment (MEA) 2005a). Due to the destruction of critical habitat to make way for residential, commercial, and industrial development for burgeoning populations, the global community has lost approximately 40 per cent of global forest area, about 50 per cent of wetlands, and an estimated 35 per cent of mangroves. About 30 per cent of coral reefs, with their ability to moderate extreme weather events, have been seriously damaged (TEEB 2008). Furthermore, about 29 per cent of sea grass meadows, which provide an estimated US$1.9 trillion per year in nutrient cycling, have disappeared and continue to suffer from the impacts of the billion or more people who live within 50 kilometres of them (Waycott *et al.* 2009).

Losses in ecosystem services are not simply environmental or economic. There is also a human dimension, especially for people in low-income countries where the financing and long-term maintenance of major technological solutions are not readily available. More than 1.1 billion people lack access to safe water and 2.6 billion lack access to basic sanitation, risking lives and livelihoods. More than 1.2 billion people have suffered losses from floods, which accounted for 43 per cent of all recorded disasters from 1992 to 2001 (MEA 2005a). The number of people affected by floods is expected to rise to 2 billion by 2050 (United Nations University 2004). Demand for water-related ecosystem services, hereafter called watershed services, such as water purification and flood protection, is also expected to increase (MEA 2005b).

The achievement of some Millennium Development Goals (MDGs) is at risk, particularly the one aimed at reducing the number of people afflicted by hunger and malnutrition. This goal depends on the performance of the agriculture sector, which accounts for more than 70 per cent of water withdrawals from an increasingly dwindling world supply. This is due not only to inefficient irrigation systems made worse by wasteful water and energy subsidies, but also from dwindling groundwater resources that are not being adequately recharged because of deforestation, degradation of wetlands, development, and compounded by climate-induced drought.

> In a context of abundant supply of water, and with little understanding of environmental implication, irrigated agriculture increased practically unconstrained in the second part of the twentieth century. As a result, the environmental limits of hydraulic systems are being reached in an increasing number of places. Increasing water scarcity and concern for environmental sustainability now constrain further development of water for agriculture, and in places, competition from other sectors leads to a reduction of volumes allocated to agriculture. The key to ensuring continuous supply of food and other agricultural commodities therefore lies in increased productivity of water.
>
> (World Water Assessment Programme 2009)

Even before the current global financial crisis, both developed and developing countries were finding it difficult to meet the costs of constructing and repairing the infrastructure necessary to meet water supply and regulation needs. The World Business Council for Sustainable Development (WBCSD) estimated that the total costs of replacing ageing water supply and sanitation infrastructure in developed countries might be as high as $200 billion a year (WBCSD 2005). The current estimated investment of US$15 billion per year towards the Water Supply and Sanitation Millennium Development Goal is only half what is needed to meet the target (World Bank 2009). Since the global financial crisis, the financing necessary to meet these needs has become even more elusive. However, there exists a readily available, cost-effective, and cost-beneficial solution to our water crisis – investment in watershed services. Investment in protection of forests and wetlands, for example, not only offers a cost-effective, sustainable solution to agricultural water supply needs but also offers great benefits from carbon sequestration.

Despite this, relatively little has been invested in maintaining ecosystems and sustaining the services they provide. In 2007 it was reported that governments worldwide had spent US$2 billion in payments for ecosystem services (WWF 2007a). But it has been estimated that investments of US$45 billion in protected areas alone could generate nature-based services worth some US$5 trillion a year (TEEB 2009a).

> Too often, human-built infrastructure (e.g. water filtration plants) is adopted as the solution to problems that ecosystems have been addressing for millennia. While the costs of setting up a water treatment facility can run into billions of dollars, the opportunity cost of having the same filtration services provided by ecosystems are often considerably lower. As a result, it is becoming increasingly recognized that the preservation and maintenance of ecosystems and the services that they provide often makes good economic sense.
>
> (UNEP IUCN CBD 2008)

Ecosystems provide valuable clean water supplies and flood protection services

Water-related ecosystems such as forests and wetlands provide vital "provisioning" services to humankind, including food, fibre and water. They also provide "regulating" services such as improving the quality of surface water and groundwater; withholding pollutants and sediments; reducing erosion; stabilizing river banks and shorelines; controlling runoff and water supply and preventing, controlling, and mitigating floods. Watersheds also provide valuable recreational, cultural, and aesthetic services. In 2007 it was reported that the world's coastal ecosystems provided up to US$25,783 billion per year in ecosystem services and products. We also know that coral reefs alone provide us with US$172 billion worth of services per year (TEEB 2009a).

Yet poorly managed ecosystems, exacerbated by competing demands for water, have resulted in the global water crisis that we currently face (UNEP IUCN CBD 2008). Competing demands include water for human consumption, domestic, agricultural, and industrial use, and even for maintaining healthy ecosystems. The main causes of water-related ecosystem degradation and loss include infrastructure development, land conversion, excessive water withdrawal, and excessive nutrient loading. The nitrogen load to coastal ecosystems is predicted to increase a further 10 to 20 per cent by 2030, with almost all of the increase occurring in developing countries (MEA 2005b).

A large number of studies have concluded that returns from investment in ecosystems services can be significant.

- Wetlands in the Zambezi Basin in Southern Africa are estimated to have a net present value of more than US$64 million, including US$16 million in terms of groundwater recharge, US$45 million in terms of water purification and treatment services, and US$3 million in reducing flood-related damage costs (Turpie *et al.* 1999).

- In Sri Lanka, the Muthurajawela wetlands are estimated to have an annual economic value of US$8.1 million, including US$5.4 million for flood protection, US$1.8 million for industrial wastewater treatment, US$48,000 for domestic sewage treatment, US$42,000 for freshwater supplies for local population, and US$8,700 for carbon sequestration (Emerton and Kekulandala 2003).
- Coastal wetlands in the USA are estimated to provide US$23.2 billion per year in storm protection services (Costanza *et al*. 2008).
- The water storage function of China's forests is estimated to be approximately US$1 trillion, three times the value of the wood in those forests (Stolton and Dudley 2007).

It is clearly worth protecting these ecosystems. Plus, with the outrageous damage costs, including loss of health, life, productivity, and GDP, which is incurred from the loss of watershed services, it is worth restoring wetlands that have been destroyed in the name of development. Water-related ecosystem restoration costs in the USA are currently estimated at US$60 billion and are expected to rise (World Water Assessment Programme 2009). Yet as costly as it may appear to be, restoration is found to be highly beneficial. In a review of more than 2,000 case studies,[2] it was reported that water-related ecosystem restoration projects offer significant returns, as shown in Table 5.1 (TEEB 2009a). The consensus remains, however, that maintenance and conservation are almost always cheaper than destruction and subsequent restoration.

Water-related ecosystems suffer tremendous losses because of non-native invasive species.

The costs of invasive species in the USA, UK, Australia, South Africa, India, and Brazil have been estimated to be over US$314 billion per year, equivalent to US$240 per capita. Assuming similar costs worldwide, invasive species damage would cost more than US$1.4 trillion per year, representing nearly 5 per cent of world GDP (TEEB 2009c).

In South Africa, the government-funded Working for Water public works programme invests in protection of water resources to eliminate the spread of invasive plants and restore hydrological functioning. With more than 300 projects in all nine South African provinces, the programme has provided, *each year*, jobs and training for approximately 20,000 people. Workers are recruited from among the most marginalized sectors of society and 52 per cent of them are women. Costs of the programme range from €200–700 per hectare while it is estimated that benefits could reach a net present value (calculated over 40 years and using a discount rate of one per cent) of €47,000 per hectare (TEEB 2009c).

TABLE 5.1 Estimates of costs and benefits of restoration projects in different biomes

Biome/ecosystem	*Typical cost of restoration (high scenario)*	*Estimated annual benefits from restoration (average scenario)*	*Net present value of benefits over 40 years*	*Internal rate of return (per cent)*	*Benefit/cost ratio*
Coral reefs	542,500	129,200	1,166,000	7	2.8
Coastal	232,700	73,900	935,400	11	4.4
Mangroves	2,880	4,290	86,900	40	26.4
Inland wetlands	33,000	14,200	171,300	12	5.4
Lakes/rivers	4,000	3,800	69,700	27	15.5
Tropical forests	3,450	7,000	158,700	50	37.3

Source: TEEB Climate Issues Update, Table 3 (2009).

Even investment in the construction of wetlands can be more cost-effective than building water-treatment systems, as reported by Zhang *et al.* (2009).

- The total capital cost of an ecosystem comprising integrated ponds and constructed wetland system in Dongying City, Shandong Province, China, was US\$82 per m^3 per day, which is about half the cost of the conventional system based on activated sludge process; the operation and maintenance cost is US\$0.012 per m^3, about one-fifth the cost of conventional treatment systems
- The capital investment and operation cost of a large-scale reed bed in Weifang City, Shandong Province, China were 35 per cent and 14 per cent respectively of that of A2O (anaerobic/anoxic/oxic) treatment systems
- With the treatment capacity of 200 m^3 per day, the construction cost in the Longdao River constructed wetland in Beijing was calculated to be US\$0.02 per m^3, and average treatment cost totalled US\$0.03 per m^3, which is equal to one-fifth the cost of that in a traditional wastewater treatment plant.

Adaptation efforts, including investment in wetland conservation, are also found to be less costly than built infrastructure for protection from a rise in sea level caused by climate change, storm surges, and flooding. In 1990, the Intergovernmental Panel on Climate Change (IPCC) reported that globally it would cost at least US\$500 billion to build coastal defences to protect against a one-metre rise in sea level. This amount was qualified as a considerable underestimate, as it did not include costs necessary to meet existing needs for coastal defence. The estimate did not include the value of the unprotected dry land or ecosystems that would be lost, nor did it consider the cost of responding to saltwater intrusion or the impacts of a possible increase in storm frequency. The report noted that many small island states would be unable to bear the costs of protection (IPCC 1990). A 1995 study from Nigeria concluded that relocation of the population and villages at risk from a one-metre rise in sea level would be more practical than spending US\$558 million to US\$1.8 billion in protection measures such as seawalls (UNEP Grid Arendal 2001).

By anticipating the impacts of sea-level rises with proactive responses that include wetland preservation and restoration, reactive responses would cost less. To illustrate, in northern Vietnam, the Vietnam Red Cross (VNRC) has been planting and protecting 12,000 hectares of mangrove forests since 1994. The programme has cost around US\$1 million, but has helped reduce the cost of dyke maintenance by US\$7.3 million per year (UNEP Grid Arendal 2005).

With the loss of wetlands, including forests and estuaries, comes the loss of their carbon-sequestration services and a cost-effective strategy for climate-change mitigation. The ocean's near-shore vegetated habitats, such as mangroves, salt marshes, and sea grass, rank among the most intensive carbon sinks on the planet, accounting for approximately 50–71 per cent of all carbon storage in ocean sediment. Halting their loss and degradation as well as that of tropical forests could result in global-emissions mitigation of up to 25 per cent (TEEB 2009a).

Investment in ecosystems for protection from devastating climate-induced floods cannot only be more cost-effective than building new infrastructure but also safer for the environment and human populations. Hard infrastructure such as dams and dykes have, in many cases, ruined the ecological health of rivers and estuaries and have often failed to protect vulnerable and poor communities who, with a false sense of security, live in floodplains.

Now, efforts are being made the world over to restore wetlands for flood protection. For example, China is restoring 20,000 square kilometres of Yangtze wetlands to act as flood absorption areas. Communities along France's longest river, the Loire, persuaded the government to scrap a planned flood control dam in favour of river restoration and a new flood warning system (Mongabay 2007). In Nepal, a community-led initiative employing bioengineering techniques has been found to be most appropriate and effective not only in mitigating annually recurring floods, but also in turning these risks into rewards. With local knowledge of their environment, the community planted the river bank with commercially valuable plants chosen to withstand the forces of river water. The project was funded by several national and international donors totalling about US$40,000 and mobilized a substantial amount of local resources in the form of cash, labour, and material assistance. The project is expected to generate hundreds of thousands of US dollars annually from the sale of forestry products (World Water Assessment Programme 2009).

Investing in watershed services provides great benefits at relatively low cost

- Forty-nine per cent of US GDP comes from estuary counties. Coastal areas generate more than 28 million jobs in the USA. Healthy coasts and estuaries are essential for protecting more than US$800 billion of trade each year, and more than 45 per cent of the nation's petroleum-refining capacity. Seventy-five per cent of all US commercial fisheries depend at some stage on estuaries. Commercial and recreational fishing employs 1.5 million people and contributes US$111 billion to the nation's economy. Recreational fishing is estimated to contribute between US$10 billion and US$26 billion per year and coastal wildlife viewing may generate between US$4.9 billion and US$49 billion each year. Beach going may contribute between US$6 billion and nearly US$30 billion annually to economic well-being (Pendleton 2008).
- Healthy coastal habitats are critical to the recovery and sustainability of the USA's economy. Under the American Recovery and Reinvestment Act (2009), the National Oceanic and Atmospheric Administration was provided US$167 million for marine and coastal habitat restoration. When complete, the projects will have restored more than 3,600 hectares of habitat and removed obsolete and unsafe dams that open more than 1,100 stream kilometres where fish migrate and spawn. The projects will also remove more than 850 metric tonnes of debris, rebuild oyster and other shellfish habitat, and reduce threats to 4,760 hectares of coral reefs (Recovery at Commerce 2009).

It is understood that investments in watershed services are cost-beneficial, with most of the measured benefits accruing to the public sector. Yet more investment is required, especially from the private sector that increasingly recognizes not only the value of being socially responsible, but also the value of improved access to healthy water resources for safe and sustainable business productivity and growth.

The services that wetlands provide in water purification, groundwater recharge, and flood protection are technically available for free. Sadly, as these ecosystems have been degraded and destroyed, it has been found that replacing such services with built infrastructure can be prohibitively expensive. Both the public and private sectors understand more and more the importance of investing in water-related ecosystems for these services, especially in light of our global economic and climate crises.

One of the most popular approaches to financing environmental protection and conservation is through payment for ecosystem services (PES), where markets are being created for environmental services in the same manner as for other commodities. For example, money is collected from users, both public and private, of watershed services and payments made directly to those in the community safeguarding the resources and providing the services. However, well-functioning markets require, among other things, a well-defined system of rights and transparent information that allows buyers and sellers to decide for themselves whether or not to enter the market.

Payments for ecosystem services, and specifically for watershed services, have gained in popularity over the past decade, and many examples from across the globe have been analyzed in numerous and substantial reports (TEEB 2009; TEEB 2008; Porras *et al.* 2008; USAID 2007; Smith *et al.* 2006). Most schemes have depended on government funding, even if only for start-up costs. However, for what is meant to be a market mechanism, payments for ecosystem services are not optimal without private and voluntary investments. The private sector has been slow to commit to PES schemes, largely because of the lack of scientific monitoring and measurement to prove the direct links between investments and economic benefits.

The following two sections shed insight into improving and increasing payments from watershed services with key information regarding costs and benefits from some of the best available examples.

Learning from costs and payments for watershed services

- In Costa Rica, approximately US$200 million was invested from 1997 to 2004 in the country's national PES programme. The main source of funding comes from 3.5 per cent of a 15 per cent tax on fuels. The programme protects over 460,000 hectares of forests and forestry plantations and contributes to the well-being of more than 8,000 people (Porras *et al.* 2008).
- In Mexico, approximately US$18 million per year is allocated to payments for hydrological environmental services. Fees collected from charges to bulk water users are used to maintain ecosystem services and restore over-exploited aquifers in forest areas and provide water to more than 5,000 people (Porras *et al.* 2008).
- In Quito, Ecuador, the Water Protection Fund (FONAG) was created in 2000 with financial support from the local water utility that contributed over US$3 million. Other partners included the Nature Conservancy, the Swiss Development Agency, an electrical utility, and a brewery. The fund was designed to run as a non-declining endowment where only investment returns are distributed for watershed management and payments to landholders. By 2006, the fund's endowment had reached US$3.5 million and was expected to grow to US$7.4 million by 2010 (Smith *et al.* 2006).
- In the USA, fees from some 9 million users of the New York City water supply system have paid, since 1997, for the US$1.5 billion cost of protecting its drinking water supply from agricultural pollution and stormwater runoff. This cost is considerably less than the US$6–8 billion plus some US$300–500 million in yearly operating costs that would have been required at the time to build the necessary water filtration and treatment system. Currently the cost of filtration for New York City's water supply is estimated at US$8–12 billion for construction, with operating costs of about US$350 million a year. User fees continue to fund protection of this drinking water supply from the Catskill Watershed (TEEB 2009, Riverkeeper 2009).

Municipal and regional water utilities, especially in South America, are well represented in PES schemes (Mulder *et al.* 2005). However, in developing countries in particular, public water utilities are subject to political will, which can easily change with different administrations, threatening the long-term sustainability of PES initiatives. This specific issue was addressed by the Water Protection Fund in Quito, Ecuador, in 2000. The fund was designed to run for 80 years to ensure long-term institutional and political legitimacy (Porras *et al.* 2008).

Transaction costs have in general been high and thus a deterrent to investment, but with improved governance and institutional arrangements such costs can be reduced, especially with the use of intermediaries. In Costa Rica, the National Forest Office and National Fund for Forest Financing (FONAFIFO) helped to keep transactions costs to a "low" level of 7 per cent (Smith *et al.* 2006).[3]

TABLE 5.2 Examples of payments made for watershed services

Price paid (US$ ha/yr)	*Activities compensated*	*Watershed services provided*	*Service buyer*	*Service seller*	*Location*
45	Reforestation	– Salinity control – Freshwater supply association	Downstream farmers landowners	Government and upstream	Murray-Darling Basin, Australia
45–116	Protecting, sustainably managing and replanting forests	– Freshwater supply – Wildlife habitat – Cultural heritage and identity Financing – FONAFIFO	National Forest Office and National Fund for Forest	Private upstream landowners	Costa Rica
125	Soil conservation	– Soil protection – Sedimentation control – Water quality control – Regulation of flow	US Department of Agriculture	Farmers	United States
170	Watershed restoration	– Freshwater supply – Wildlife habitat landowners	State of Parana and private	Municipalities	State of Parana, Brazil

Source: Smith *et al.* (2006: Table 3.1).

Transaction costs can be reduced by "bundling" services. For example, water-related services of forested land can be bundled with carbon sequestration; flood protection services of wetlands and flood plains can be bundled with those of biodiversity. Bundling can help sellers gain greater access to financing. On the other hand, especially at a more local level, transaction costs can be reduced by "unbundling" services, making it easier to identify and measure benefits, target service providers and beneficiaries, and define payments. In this way, it is possible to attract more investment, particularly by the private sector (UNECE 2007).

The above examples present costs at the programme level. It is also possible to examine the costs, or payments, per hectare of watershed protection and restoration and the related watershed services provided, as shown in Table 5.2. The payments range from US$45–170 per hectare per year. By comparing these costs with corresponding watershed service values that range from US$200–1,000 per hectare per year (TEEB 2008), it becomes clear that the benefits of these PES schemes are substantial.

Understanding the benefits of investing in watershed services

Investment in watershed services offers great public benefits, particularly as they provide a cost-effective alternative to built infrastructure for water supply and flood protection. After decades of scientific research, we now have significant data on the values of these watershed services. Wetlands-restoration projects offer significant returns on investment and they are labour intensive, providing critically needed shovel-ready jobs to the poor and unemployed, as shown in South Africa's Working for Water programme. This additional source of employment contributes to poverty reduction and increased GDP, as does the increased productivity that results in communities that are dependent on healthy water resources, especially in coastal communities where approximately half of the world's population currently live and work.

The water supply and treatment services of wetlands are particularly valuable. We know that investments in watersheds for water treatment services are cost-effective, and we know that improved water supply and sanitation is cost-beneficial. In 2007, the World Health Organization reported that water and sanitation improvements are cost-beneficial in all developing world sub-regions (African, the Americas, Eastern Mediterranean, European, South-East Asia, and the Western Pacific regions). Improved water supply in this study generally referred to low-technology improvements that involve better physical access and the protection of water sources from contamination. In developing regions, the return on a US$1 investment was in the range US$5–46, depending on the intervention. For the least developed regions, every US$1 investment to meet the combined water supply and sanitation Millennium Development Goal led to an estimated return of at least US$5 (in African and South-East Asian regions) or US$12 (in Americas, Eastern Mediterranean, and Western Pacific regions). The main contributor to economic benefits was time savings associated with better access to water and sanitation services, contributing at least 80 per cent to overall economic benefits (Hutton *et al.* 2007).

Not only public but also private investors can benefit from investments in ecosystems for their water supply and treatment services. Businesses benefit from improved relationships if they act responsibly towards communities and their environments, as well as from increased productivity due to improved access to healthy water resources for input, output, and for the health of employees and their children.

Most PES schemes are still relatively young and their full effects have not yet been realized. Many benefits of such investments accrue over long periods of time. In a review of 100 cases of private PES, most of the initiatives, especially related to water services, were lacking in hard scientific evidence that supported the notion that ecosystems deliver the services that a buyer has paid for (Mulder *et al.* 2005). In Costa Rica's PES scheme, although the overall benefits of the project are undisputed, its efficiency with respect to environmental benefits and improvements in biodiversity and water quality remain unqualified, mainly because of lack of funding for scientific monitoring of outcomes (WWF 2007b).

> Thousands of projects are carried out each year to improve the ecological status of damaged ecosystems. Unfortunately and surprisingly, cost–benefit analyses of those projects are scarce. Even simple records of restoration costs are rare in the peer-reviewed literature, let alone a full discussion of the benefits to society.
>
> (TEEB 2009c)

The benefits of investments in watershed services are understood to be great. They often include non-monetary benefits that include strengthening of property rights, capacity building, and associated improvements in social organization and in quality of life.

- In Mexico's payments for hydrological environmental services, 80 per cent of members of *ejidos* (peasant communities) and 73 per cent of small private landowners considered payments important for annual income (Porras *et al.* 2008).
- In Pimampiro, Ecuador, the 30 per cent of household income received from cash payments were used for school fees and health care (Porras *et al.* 2008).
- In north-eastern France, the Vittel (Nestlé Waters) PES scheme to protect its industrial water supply from polluting agricultural practices resulted in elimination of risk to its business while offering benefits to farmers that included debt cancellation, additional land, and secured long-term farming (Perrot-Maître 2006).

Private investors have participated in PES schemes mainly for public relations reasons, but even that has economic value that could be measured. With more investment in scientific monitoring and measurement of the benefits of payments for watershed services, accompanied by stronger governance and institutional arrangements to support private investment in PES, governments can increase success in the market for protection of water-related ecosystem services.

Improving governance and institutional arrangements for more successful investments in watershed services

> Where favourable conditions exist – such as an active civil society, a well-functioning legal and judicial system, stable funding flows and strong complementary policies for maintaining the public nature of goods – ecosystem services markets have the potential to provide significant additional income to local stewards of nature.
>
> (TEEB 2009b)

> The key ingredients [for payment schemes] are effective institutions, reliable contract law, enabled by good governance, capacity for transaction governance and credible enforcement. [The institutional framework] includes the clarification of rights, agreement of obligations among parties, establishment of contractual arrangements and mechanisms for ensuring compliance and enforcement.
>
> (Smith *et al.* 2006)

A number of substantial reports discuss in detail the governance and institutional arrangements necessary for efficient and productive investments in water-related ecosystems (TEEB 2009b; Porras *et al.* 2008; and in particular, Smith *et al.* 2006). Some of the key arrangements, presented below, include the need for a well-designed system of rights, rules and regulations, the elimination of water-wasteful subsidies, the use of intermediaries, and improved monitoring and measurement of benefits.

Ensure a well-defined system of rights

For suppliers of watershed services to enter into market transactions, their property, access, land tenure, and use rights need to be clearly established. If payments for ecosystem services are to address the needs of the poor and landless, recognition must be given to their informal access to resources.

> . . . property rights must provide for more than the regulation of land ownership and include the natural resources that the land provides. Ensuring that property rights are clearly designated, whether through formal or customary law, is essential if payment schemes are to result in the anticipated incentives for watershed management. Effective registration and administration of tenure rights is an instrument for clarifying rights among stakeholders.
>
> (Smith *et al.* 2006)

Improve rules and regulations

> Many threats to biodiversity and ecosystem services can be tackled through robust regulatory frameworks that establish environmental standards and liability regimes. These are already tried and tested and can perform even better when linked to pricing and compensation mechanisms

> based on the "polluter pays" and "full cost recovery" principles – to alter the status quo which often leaves society to pay the price.
>
> (TEEB 2009b)

Key aspects of the 1997 New York City Watershed Memorandum of Agreement include a land acquisition programme and new watershed regulations issued with the intent of limiting certain land use that threatened water quality. Activities affected by the regulations include septic system installation, wastewater treatment plant operation, and construction activities (Riverkeeper 2009). This type of regulatory and legal framework is important to ensure compliance and fulfilment of obligations undertaken in exchange for payments for watershed services.

Eliminate water-wasteful subsidies

It has been strongly suggested that water-wasteful subsidies, particularly those in the agricultural sector, be eliminated and, furthermore, that they could be redirected into funding for watershed services.

> Subsidies paid to the agricultural sectors of OECD countries between 2001 and 2003 averaged over $324 billion annually, or one-third the global value of agricultural products in 2000. A significant proportion of this total involved production subsidies that led to overproduction, reduced the profitability of agriculture in developing countries, and promoted overuse of fertilizers and pesticides. Many countries outside the OECD also have inappropriate input and production subsidies. These subsidies could instead be directed to payments to farmers to produce non-marketed ecosystem services through the maintenance of forest cover or wetlands or to protect biodiversity, thereby helping to establish economic incentives to provide these public goods.
>
> (MEA 2005b)

Use intermediaries

The use of social intermediaries can help strengthen the arrangements necessary to build capacity among ecosystem service providers and keep transaction costs down. Vittel (Nestlé Waters) used an intermediary to foster a successful relationship with the French farming community. It was found that the primary reasons for the programme's success were not financial but came from trust-building through the creation of a locally based intermediary institution that was sympathetic to the farmers' cause. Other reasons for success, facilitated by the use of the intermediary, included the development of a long-term participatory process to identify alternative practices and a mutually acceptable set of incentives, the ability to link incentives to land tenure and debt cycle issues, and the substitution of old technical and social support networks with new ones (Perrot-Maître 2006).

Improve monitoring and measurement of benefits

Throughout this report, the need for improved scientific monitoring and measurement of the benefits of investments in ecosystem services has been made clear. It is because of decades of research into the economic values of watershed services that we are aware of the outrageous costs that the public pays for degradation and loss of wetlands and the life-supporting services that they provide.

With scientific research, we have been able to show that investment in our natural infrastructure, which includes forests and wetlands, can cost-effectively provide us with clean water supply and flood protection. However, more science-based evidence is required to prove the economic returns on these investments. Benefits are known qualitatively but they need to be better quantified. More data is required, particularly from developing countries, and international efforts are required to obtain measurements that are uniform in scale and scope. Ultimately, this research will enable more successful investments into the national and international markets for ecosystem services, improving the links between supply and demand, reducing transaction costs, and facilitating critical public–private partnerships.

The time to invest for our future is now

With greatly increased and increasing demands for safe water resources, made worse by climate-induced drought and floods, we are presented with a critical opportunity to invest in ecosystems for improved clean water supply and flood protection. The costs of meeting demands for watershed services with traditional built infrastructure such as water treatment plants and flood control dams are often prohibitively expensive, especially in developing countries, and especially when finance is difficult to source from donors. However, investment in watershed services, including forests and wetlands, offers cost-effective and readily available solutions to our global water, climate, and economic crises.

The tremendous economic value of watershed services has been proven over the past few decades because of significant investment in scientific research. However, more effort is required to mainstream this information into our market economy in order to correct the failures that result in ecosystem loss.

It is clear that investments in watershed services, especially for improved water supply, are tremendously beneficial for human and environmental health and productivity. However, more investment is required to prove the returns on investments in ecosystem services so as to convince investors to voluntarily increase participation in what appears to be a promising market. Governments can achieve their clean water supply and flood protection goals by supporting private investors with improved governance and institutional arrangements. Market-based protection measures need to be fully explored because the needs for investment, as well as the rewards, are understood to be truly great.

We cannot neglect the costs of inaction. Ultimately, the choice that we will face is whether to pay enormous restoration costs in the future or employ protection costs now, which are substantially less costly. The decision is not simply financial – human lives and livelihoods are increasingly at risk because of the loss of water-related ecosystems and the life-supporting services that they provide. The time to invest in ecosystem services is now.

Notes

1 Sharon Khan is an independent consultant. Since 2004, she has provided economic evidence for watershed protection to Waterkeeper Alliance, an international clean-water advocacy organization. The views expressed by the author in this chapter do not necessarily reflect the views of Waterkeeper Alliance.

2 Out of the 2000 studies, only 95 studies provided meaningful cost data and none provided values or detailed analysis of the achieved or projected benefits.

3 Conversely, Porras *et al.* (2008) reported that transaction costs in Costa Rica are high, with 11 separate requirements identified and an average transaction cost for the farmer estimated by the 12 to 18 per cent fee that facilitators charge.

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PART 3

Policy guidelines for investment in water

6

A PRIMER ON WATER ECONOMICS

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Increasing efficiency and availability of water investments

Water is essential for survival. It has been estimated that human beings need at least 18 to 23 litres of water a day to survive. While there is enough water in the world for everyone, access to that water is a considerable problem. Recent studies forecast that, under current water management conditions, 35 per cent of the world's population will run short of water in the next 25 years. Even in areas where water is not scarce, many people do not have access to it. More than 1 billion people lack access to safe drinking water (two-thirds of them live on less than US$2 a day) and more than 2.6 billion lack access to improved sanitation.

Recent United Nations estimates show that there are more than 100 million people that still lack access to safe drinking water in Europe, contributing to the deaths from diarrhoea of nearly 40 children across the region every day. At the world level, current evidence shows that 1.7 million deaths a year could be avoided by providing access to safe drinking water and sanitation. These gaps have been recognized in the Millennium Development Goals (MDGs), where Target 10 of Goal 7 calls for halving, by 2015, the proportion of people without sustainable access to safe drinking water. It is also dealt with indirectly in Target 5 of Goal 4, which calls for reducing by two-thirds, between 1990 and 2015, the mortality rate of children under the age of 5.

The Food and Agriculture Organization (FAO) estimates that by 2030, food production needs to grow at 1.4 per cent a year to satisfy demand. About half of this increase would have to be generated from irrigated fields. The key to meeting this need is water availability because more than half of the world's population live in regions where water is scarce. On a global scale, agriculture accounts for more than 70 per cent of worldwide water consumption, while industry accounts for 20 per cent, with only 10 per cent devoted to domestic consumption. In low-income countries, the figures are 88 per cent for agriculture and 6 per cent each for industry and domestic consumption. This means that this growth in food production needs to be achieved without increasing the share of water consumed by agriculture.

Needs for investment and water scarcity coexist with water waste, inefficient management, weak institutions, indiscriminate subsidies for both agricultural use and human consumption, and continuous increases in water investment costs. Assessments of water-use efficiency in irrigation show that only 40–50 per cent of the water delivered at various levels is actually used. In urban water systems, unaccounted-for water can reach 40 per cent. Expanding water supply through groundwater and reservoir storage implies huge environmental and economic costs. For example, in some parts of the world, the cost of tapping new groundwater supplies has tripled because aquifers have been drawn down, and as a result water now has to be pumped from much greater depths. The drawdown is also causing pollution problems, further driving up the cost of treating water. Some users are turning to desalination to meet rising demand but even with recent technological advances, desalination is expensive and, as a general rule, prohibitively expensive to be used for agricultural production.

It has been estimated that simply to achieve the water and sanitation MDGs, it will be necessary to undertake investments of US$30 billion a year. This is more than double the current level of expenditure and does not include an allocation for water for industry and agriculture, the major water users by far. It has also been estimated that, on average, developing countries should be investing at least two per cent of gross domestic product (GDP) in the water sector (with large variations by country income), but they are in fact, investing significantly less. Most research indicates that while all sectors of national economies receive water subsidies, industrial and agricultural water users receive the largest ones. Most users in developed countries, as well as wealthy consumers in developing countries, do not pay the true cost of water. However, the poorest sometimes have to pay up to 500 times the price paid by their better-off fellow citizens because their only options are to buy bottled water or purchase from local carriers.

New mechanisms for allocating resources must be put in place in order to bring demand and supply into balance. The Dublin Principles, which were agreed to at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil, in 1992, establish, among other recommendations, that "water has an economic value in all its competing uses, and should be recognized as an economic good" (Global Water Partnership 1992). Although underlying concepts and theoretical foundations for the use of economic incentives in water management are well understood, their application is complicated by the fact that practical experience in water management and investment is limited.

The problem of access to drinking water and sanitation is a complex one. Water is a capital-intensive sector and significant investments are required to collect and distribute the resource. Nevertheless, many people consider water access a right and, as such, there is resistance to paying a price that is concomitant to its full delivered value. The matter is further complicated by the fact that water is indispensable for human health and for food production. As a result, access to water is a highly charged political issue that clouds decision-making regarding investments and control of the resource. Furthermore, many of the responsibilities for production and delivery are in the hands of sub-national entities, adding another layer of political risks that stem out of shorter planning horizons and potential differences in political outlook with national governments. Both issues increase the politicization of decision-making.

The goal of this chapter is to present a schematic discussion of the issues involved in increasing the economic and financial efficiency and availability of resources for improving access to water. For more information, the reader is referred to the extensive bibliography at the end of the chapter.

Mechanisms for assigning raw water

This section uses simple economic principles to guide the application of incentive-based measures for improving efficiency in the use of raw water.

Water has been traditionally viewed as an inexhaustible resource that should be available to everyone at little or no charge. The high cost of expanding the supply of water is not reflected in its price because pricing and allocation have been historically determined without reference to basic economic principles of supply and demand. Indeed, if the price of water were to reflect the actual cost of supply, demand would decrease. Efficient mechanisms for allocating resources must be put in place in order to bring demand and supply into balance.

Trading and efficiency

In order to achieve the efficient allocation of water from a given river basin among the different uses and users, the marginal social benefit from each form of water use should be equal. If this is not the case, then water can be reallocated so that at least one person is made better off and all those adversely affected by this reallocation compensated so that no one is made worse off. One way of doing this is to allow people to equalize users' marginal benefits by voluntarily trading water. Trading unambiguously improves efficiency when externalities are not present and supply costs are fully accounted for. This pursuit of individual well-being by firms and households will draw on all the available information to equate marginal private benefits (which will also equal marginal social benefits) with the market price across the different uses and users of water.

Although trade would improve efficiency, government intervention is still necessary for several reasons. First, if externalities such as pollution costs are not included explicitly in the prices paid by water users, trade may still increase efficiency but the allocation will not reach its most efficient point. In this case, measures such as taxes, pollution permits and regulation can be used to correct for the failure of the market. Second, government intervention may also be necessary to provide the public goods associated with water. For example, water that is allocated to environmental uses supports biodiversity for the benefit of current and future generations. Since public goods are characterized by non-rival consumption, the sum of individual marginal benefits yields the marginal social benefit. As a result, voluntary trade will generate allocations that are below the most efficient allocation. A third reason for government intervention is that property rights to water must be defined and protected in order to make trade possible. In fact, the cornerstone of water trade is water rights. A fourth reason is that infrastructure maintenance and delivery arrangements associated with infrastructure operation are often poorly costed. A common mistake is to fail to account for the supply infrastructure that may become obsolete.

Water rights

A water right is a legal authorization to use a nominated quantity or share of water in a system that is a public resource. Authorization allows access or use for a designated purpose or for any other purpose that qualifies as a beneficial use. Beneficial use involves the allocation of a reasonable amount of water to a non-wasteful use such as irrigation, domestic water supply or power generation. Transferable water rights are those that can be freely transferred or traded between the owner of the right and other potential users for the same or for other uses. However, water-rights markets need a well-defined system of property rights in order to facilitate the buying and selling of the resource.

There are four major issues associated with the proper definition of property rights that are independent of its transferability. The first of these issues has to do with the cost associated with a right, which varies across users and uses. The use of water involves at least three stages: delivery of the water to the user, the actual use of the water and wastewater disposal. These stages involve very different activities for different users and uses, and frequently different costs. Transferable water rights must take into account the different costs associated with different users of water. One way to approach this multiple-characteristics issue is to unbundle them by establishing separate property rights for the primary water product (at the dam or aquifer), a delivery right, and a use licence to internalize the pollution costs associated with wastewater. This means that water use would require holding a water entitlement or allocation, as well as a delivery right and a use licence, which may involve different prices or costs. In Australia, the cost of administering a water trading system has been reduced by unbundling a water right and establishing separate registers for entitlements, allocations, delivery rights, use approvals and pollution permits (Young and McColl 2005). In some Australian administrative systems, allocation registers are managed like bank accounts in a manner that allows irrigators to transfer volumes of water from one person's account to another over the Internet (Young and McColl 2005).

The second major issue regarding the proper definition of property rights to water refers to the establishment of rules for resolving conflicts that may arise if the real flow of water is less than the assigned water rights. There are two basic models for establishing such rules. One is the *Prior Appropriation System* under which rights are expressed quantitatively (for instance, in cubic metres per hour). If the real flow of water is less than the assigned water, any conflicts that may arise are resolved through seniority. As will be discussed later, when these water rights are transferable and there are markets for them, the price of water rights will vary with the risks of shortages so that it is possible to establish a price for water shortage risks. The other system for establishing conflict resolution rules is the *Correlatives Shares System*. Under this system, rights are expressed as a portion of available water. This avoids conflicts because water is appropriated after the real flow is known and, as a result, water rights with similar risks have uniform prices.

The third problem surrounding the definition of water rights has to do with the period of time for which the water entitlement is given. Most uses of water require complementary investments with effective lives of many years (often decades). As a result, water entitlements with a long tenure are preferable because they provide the assurance necessary to make these investment decisions. Provided future changes in water rights are explicit, property rights remain clear and markets can work. In systems that are fully unbundled, the incentive to plan on a long-term basis can be maximized by defining the entitlement as a share in perpetuity. Arrangements to alter use conditions, delivery arrangements and other rights may need to be changed.

The final problem is whether the water entitlements should be assigned for gross or net water diversions (that is, once account is taken for the return of quality water). In principle, net use is the appropriate measure. Under a net diversion entitlement regime, as the water-use efficiency increases the gross volume of water that may be diverted by an entitlement holder is decreased so that the net amount of water used remains the same. As net diversion entitlement regimes can be more expensive to administer, it is common for administrators to prefer to implement a gross entitlement regime. If this is accompanied by an arrangement that periodically decreases every entitlement holder's expected allocation as system-wide water-use efficiency increases, then the case for implementation of a net rather than gross entitlement is reduced.

Payment and fees for water rights

Water rights usually include a charge for variable costs that are generally defined as the operating costs. Sometimes the rights also include the annuity value of investments and major refurbishment extensions. However, in many cases, local and central governments and water-supply associations face fixed costs associated with water delivery. From an economic perspective, it can be argued that past capital costs are sunk and, as such, should not be taken into account when calculating efficiency prices. However, if water is scarce and the water-entitlement regime reflects the value of that scarcity, prices should be sufficient to produce an adequate return on investment.

An area of contention is that of how to charge for the cost of delivering water when a large portion of the operating costs (such as maintenance expenses) are fixed. If potential users (who may not be actually using water) do not pay for the fixed costs of system management, remaining users have to pay a relatively higher share of the total operating costs. One good option for dealing with this problem is to require that owners of water-delivery rights pay for their share of fixed costs regardless of whether or not they use water.

Another issue regarding fees and payment associated with water rights is that of how to charge for pollution costs, such as sewage, industrial waste and irrigation runoff into rivers. As mentioned earlier, one way to internalize pollution costs is to issue licences to use water. Licensing can take the form of regulation; for example, by requiring that sewage be treated or certain practices not be adopted. Another option is to block the transfer of irrigation water from low-environmental impact regions to high-environmental impact regions. Licensing can also take the form of a pollution tax. In some cases, pollution levels are relatively easy to measure (for example, most household and industrial wastewater). By contrast, much of the water pollution related to irrigation is difficult to measure. Indirect methods are the only measurement option in such cases but can be cost-effective substitutes.

Market institutions

Effective water markets will require registries that record ownership and transfer of water entitlements, delivery rights and use licences that are transparent, accessible to the public at a relatively low cost and have the full backing of the law. One option is to set up a publicly operated register similar to that used to register land titles. Another option is to set up a register similar to that used to register ownership of shares in a public company. A key feature of both of these systems is the fact that ownership is defined by the entry on the register and trades are completed by amending the register. The trade is executed at the point in time that the register is amended. A system of water market trading could be administered by a public institution or by a regulated private organization. Electronic markets could be used to bring buyers and sellers together to negotiate mutually beneficial transfers and prices. Again, information on transfer prices and quantities should be made readily available to the public.

When full transferability of water rights is possible, a water trade can take a number of different forms. For example, a sale contract can take the form of a permanent exchange of a water right or it can take the form of a lease contract where the owner keeps the water right but allows someone else to use it for a specified period of time. Another example is that of an option contract between a buyer and a seller, which specifies the circumstances under which the buyer can use the water right. Under an option contract, when the buyer uses the water right, an additional payment is made (a striking or exercise price). Notice that transferability of water rights does not mean that all types of contracts can be entered into. Some systems only allow for the full sale of rights, while other systems allow some or all types of contracts to be recorded.

Final remarks

Under a trading system, efficiency is achieved by enabling water to be transferred between individual users so that the expected marginal social benefit from water use can be equalized. In theory, trade occurs because at least one water user can be made better off by increasing his or her allocation without making the other users worse off. Given that different water users (such as irrigators of a particular crop or different households) tend to have different costs and benefits, equalizing users' marginal benefits requires either voluntary trade or a mechanism for ensuring equal marginal benefits across all users. The presence of externalities such as pollution and the possibility of adverse impacts on human health and/or biodiversity values means that the existence of a water market is not a sufficient condition for optimal allocation and use of water. In practice, some form of government intervention is necessary to prevent trade causing adverse environmental or social impacts. Although there are no simple rules to find the right balance between water trade and public-sector intervention, both are needed.

Challenges facing the use of water for agriculture

The challenge of agriculture

This section reviews issues associated with establishing incentive-based regimes that discourage inefficient water use.

The Food and Agriculture Organization (FAO) estimates that by 2030, food production needs to grow by 1.4 per cent a year, and that about half of this growth will have to be generated by irrigated agriculture. The challenge to meet this need is to improve water efficiency because more than half of the world's population live in regions where water is scarce. Furthermore, the agricultural sector needs to increase food production without increasing agriculture's share of water consumption, which is already over 70 per cent.[2] This challenge requires the development of regimes that discourage people from squandering water and ensuring that water flows toward the highest economic priorities.

Prices and water efficiency

Water demand for irrigation is a derived demand; that is, it is derived from the demand for agricultural products. As a consequence, the sensitivity of water consumption to the cost of accessing water (i.e. its price elasticity) is an increasing function of the share of water in total production costs, a decreasing function of the price elasticity of the final product and an increasing function of the elasticity of substitution between water and other inputs.

In most cases, an increase in the supply charge for irrigation water would reduce its consumption without necessarily reducing agricultural output on a farm. The reason for this is two-fold. First, higher prices reduce water squandering by creating an incentive for irrigators to use less water. Second, higher prices promote the adoption of technologies that consume less water and make greater use of other inputs.

In general, an increase in the supply charge would have a smaller impact on water consumption in developed than in developing countries. This is true for two reasons. One reason is that the share of water in total costs is larger in developing countries (where land and labour are relatively cheaper) than in more industrialized countries. The second reason is that the price elasticity of the demand for food and other agricultural products declines as income increases. In low-income households, which are more common in developing countries, the amount of income spent on food as a share of total spending is proportionately larger.

Introduction of opportunities to trade water has a similar effect to an increase in the supply charge with the key difference. Revenue from the sale of a water entitlement or allocation can be used to fund investment in the equipment, infrastructure and land improvements necessary to enable water efficiency to be improved.

Enhancing agricultural markets

Constraints to agricultural trade reduce the value-added component of agricultural products in most countries but particularly in developing countries. Compared to other water and land uses, agriculture commonly generates the lowest value-added product per unit of water and/or per unit of land. Therefore, as demand increases and competition mounts, farmers will progressively give up land and water to domestic, municipal and industrial uses.

Open trade in agricultural products would help establish incentives for investments in agriculture in developing as well as developed countries to the extent that new investment will embody new and more water-efficient technologies. The liberalization of agricultural trade can be expected to promote more efficient and less water-intensive crop practices. However, policies that distort agricultural trade remain much more pervasive and substantial around the world than policies that distort trade in other goods. High agricultural tariffs are prevalent in East Asian countries, while the USA and the EU rely on subsidies.

Land intensification and new technologies

Given that agricultural inputs are limited, trade-driven changes in water use are typically accompanied by an intensification[3] in the use of land and the adoption of new technologies. Although research on the adoption of improved irrigation technologies is relatively new, there is evidence suggesting that trade liberalization does not always result in the adoption of new technologies and increased water consumption.

First, the incentive to introduce new technologies appears lower in industrialized countries than in developing countries. Empirical studies show that investing in irrigation technology is not the unique response to an increase in the value of irrigation water. Other responses include expansion of rain-fed agriculture or selling a portion of land for other, more profitable uses. The challenge is to find incentives to increase food production while promoting efficient water use. Second, studies show that subsidies designed to encourage adoption of new technologies do not always encourage water saving, especially where water rights are not transferable and/or water supply charges are low. Indeed, simulations indicate that such subsidies may increase water consumption.

According to the economic literature, the higher the level of capital subsidy, the more probable the adoption of new irrigation technologies is but, where the amount of water available for use is not limited, there is evidence that improvements in water-use efficiency can increase water consumption. Third, the maximum technical efficiency of water utilization is usually not economically efficient. That is, profit-maximizing farmers do not choose irrigation technologies that are technically most efficient because water has a cost. Therefore, water-resource managers who are considering saving water by subsidizing the adoption of efficient technology need to be careful. The result can be an increase in total water use. In some cases, the increase in the total quantity of water used as a result of the subsidy can be large.

Investments in irrigation

While there is a case for public investment in irrigation, drainage and other agricultural water management projects, there has been a general worldwide decline in investment over recent times. Two economic issues must be addressed in order to increase investments in efficient irrigation. First, there is a need to identify and evaluate the costs and benefits from investment in irrigation infrastructure.

Second, an institutional framework for allocating costs efficiently among water users needs to be present so that investment is financially attractive. These issues also rely on transparency and are not independent because the true benefits and costs to farmers will only be revealed if the real benefits of doing so are higher than those of revealing false benefits and costs. Either way, it is not easy to attain an optimal level of investment, even with public intervention, as the evidence below shows.

In particular, individual decisions by farmers do not result in optimal irrigation investments. The reason for this is that each farmer invests in irrigation by taking only his or her own benefits into account. Yet, the irrigation investments also benefit others. Each consumer has an incentive to benefit from the irrigation investments of others, and invest insufficiently himself or herself. This is referred to as "the free-rider problem." One way of overcoming this free-rider problem is to use public sector funds to invest in irrigation and then recover costs from irrigators, whether or not they use the water.

The Lindahl equilibrium provides a guide for authorities to select an optimal level of investment in different situations. The idea behind this concept is that each farmer should be given the opportunity to pay a different price for water as is the case when water markets are introduced. Each farmer then has the opportunity to maximize profits; that is, the revenue received from crop production minus the cost of water and other inputs. When markets are in place, this is the natural result.

When markets are not in place, the government has to select the level of irrigation investment that maximizes the benefit of investment and satisfies existing demand. The problem is how to determine individual supply charges. One option is to set prices according to each farmer's willingness to pay. Nevertheless, as information is asymmetrical, farmers could report a lower willingness to pay in order to minimize their own payments. Another option is to establish individual prices for water based on estimated benefits. This option may lead to the selection of inefficient agricultural products and technologies (another major shortcoming, as it promotes discrimination among farmers). Many communities reject price discrimination, especially when it is promoted by a public sector authority.

Third, a general lesson from the literature on public-goods mechanisms is that, under asymmetric information, the optimal mechanism generally calls for deviations from the first-best allocations. The reason for this is that under asymmetric information, a farmer may report a willingness to pay for a public good that is lower than his or her actual willingness to pay, thus minimizing his or her own payments and letting other farmers bear the bulk of the investment. In order to remove those negative incentives, the authorities should undertake a lower level of investment than would have been undertaken with more complete information.

Concluding remarks

An economic policy that aims to ensure that a sector can meet its increasing demand for food by providing that water is not a barrier for agricultural production must simultaneously set appropriate incentives in four areas. First, farmers should face institutional incentives for the efficient use of water. Increasing water charges to the marginal cost of supply is a necessary condition for this, but it is not a sufficient one. Moreover, increasing water charges without introducing additional measures may cause farmers to reduce agricultural production. The introduction of water markets may avoid this problem. Second, governments should create institutional incentives for farming that discourage the transfer of land and water to other uses. This could imply temporarily higher prices for some agricultural products. Policy efforts, however, should not artificially restrict prices but should focus on promoting an increase in supply. Third, technical change in the way that irrigation water is managed is a must if food production is to be increased. If internal agricultural cash flows are not initially sufficient to finance investment, economic policy should create incentives to ensure that the appropriate investment is undertaken.

The introduction of water markets is one way of doing this in a cost-effective manner. Fourth, where more infrastructure investment is needed to increase the availability of water, in most cases, some sort of public sector intervention is required to bring investment as near as possible to its optimal level.

Pricing drinking water and sanitation

Overview of pricing issues

In most cases, drinking water is provided by a utility that is managed by a public or private entity, which operates within a sub-national or national authority (such as a ministry). Water and sanitation services are generally provided together, although this is not always the case. When water and sanitation services are unbundled from one another and delivered separately, sanitation is usually provided by a relatively autonomous municipal agency and financed through municipal charges.[4] The reason for this is that sanitation services are required to ensure the proper disposal of wastewater, leaving no room for individual choice in the matter. If it is not feasible to enact municipal charges to pay for sanitation, then water and sanitation services should be bundled, and provided and billed together to ensure that sanitation charges are actually paid by consumers. When billing is collected by one agency but part of the service delivered by another, there is a moral-hazard risk that one of the services may be compromised.

As is the case in all segments of infrastructure services, pricing water and sanitation services is the central regulatory issue of monopoly providers. The reason for this is that while in competitive environments, firms may not set prices higher than marginal costs without experiencing a large reduction of their market share. In contrast, monopoly firms are able to increase prices without losing market share or income. Moreover, given that the short-run demand elasticity of water is low, an unregulated monopoly will yield prices that are well above marginal costs. There are two different dimensions that must be taken into account when pricing water and sanitation utilities; namely, average prices and the price structure.

Operator revenues are a function of prices, the quantity of water consumed, sanitation services and also the degree to which accounts are collected. In many systems, operator revenues are supplemented with public-sector transfer and financed from tax revenue in a manner that does not pass costs on to consumers in the form of higher prices. In less-developed countries, it is common for some infrastructure to be paid for via donations from other countries.

Another issue is the question of how best to distribute charges among various services and consumers. For example, drinking-water service provision may be divided into two distinct services: access to the network and the actual provision of water for consumption. Usually, water users pay a charge for access to the delivery network – whether or not they take water from it. Access charges may include a fixed periodic (e.g. monthly or quarterly) access fee as well as an initial charge when they first connect to the supply system. Connection fees may or may not be the same for all consumers. This is a function of the maximum water flow, user revenues and the location of the connecting unit.

There are two main schemes for computing the charges associated with water usage. One is based on setting a *constant rate per unit of water consumption;* that is, each consumer is charged the same price for each unit of water. If charges are set equal to marginal cost and there are no externalities, this system results in the optimal use of water (to the extent that it allows for the equalization of marginal utility among all consumers, which, in turn, is a necessary condition of optimal allocation). The other scheme *increases the rate as the volume consumed increases*. This is done by varying the charge according to the volume of water consumed in a series of steps or blocks. Typically, the first block of water is supplied at a very low price. The second and third block of water used within a period is then supplied at a higher price. Under this alternative approach, charges per unit of water increase as water consumption increases. This system makes it possible to correct for externalities associated with the use of large volumes of water and can be a second best solution especially when externalities are an increasing function of the volume used. In some cases, particularly in those services where it is not feasible to meter consumption, *flat rates* are charged that are more or less independent of the amount of water consumed. Rates *may* be linked to the projected level of use using proxy measures such as the number of persons in a household or the size of the pipe connection. Although proxy methods such as this have many shortcomings, they can be the only feasible way of collecting revenues in a system characterized by lack of meters or poor management.

Care needs to be taken not to confuse the case for the use of proxy measures and the use of these measures to facilitate the introduction of cross-subsidies. Issues associated with the use of cross-subsidies as a means to transfer benefits from one group of users to another are discussed below.

Marginal-cost pricing

Most economists would accept that maximizing net social benefits implies that water delivery and treatment charges should be set so that they are equal to marginal costs. However, marginal-cost pricing is only a necessary condition for welfare maximization, not a sufficient one. It is a sufficient condition only if average costs of water supply are not decreasing, there is no surplus infrastructure, there is no water scarcity and there are no externalities. Given that, the main reason for having only one firm provide water and sanitation services is that the underlying technology tends to yield increasing returns to scale when operated by a single entity. That is, as the size of the distribution system and treatment system increases, average costs tend to decrease. In such an environment, the marginal cost-pricing rule does not have much theoretical support. In other words, marginal cost pricing works as a rule to ensure optimality only when decreasing returns exist – that is, average costs increase as more water is supplied. Most specialists agree that this (decreasing returns) is not the case of water and sanitation services.

Unfortunately, when increasing returns are present, the marginal cost-pricing rule generates financial losses for the utility because average operating costs are higher than marginal cost. That is, returns the revenue gained from setting charges at the marginal cost of supply is insufficient to recover the total cost of building, maintaining and operating the supply system. In this situation, some sort of government payment can be used to cover the difference between average and marginal cost. The alternative approach is to set price equal to average cost even when this is greater than marginal cost on the understanding that this may not bring full efficiency but will guarantee cost coverage.

When water and sanitation services show non-increasing returns to scale (as could be the case with services that are used at full capacity) and the cost of new connections is above the average cost paid by existing users, marginal-cost pricing could be theoretically an option. However, there are practical difficulties that would advise against such an approach. Two additional points must be raised. The first is that when marginal costs are increasing very fast, applying such a rule raises prices for consumers and increases the utility's profits, which could in turn trigger social condemnation of the utility and make payment unaffordable for a significant proportion of the population. The second point refers to the difficulty in defining and calculating marginal costs. This is especially the case when historical accounting data has to be used, external costs have to be imputed and joint costs of service distributed arbitrarily among users. The American Water Works Association (1991) contends, "the application of the theory of marginal cost pricing to water rates lacks considerable practicality."

In most cases, as most water and sanitation systems are characterized by increasing returns to scale, it is necessary to accept the fact that there will always be a lack of mechanisms to generate efficient water allocations that are, at the same time, decentralized with respect to information and compatible with the incentives facing consumers and managers. The advice for politicians and regulators that stems from this powerful result emphasizes the importance of finding a market-like mechanism and showing some trade-offs between adequate incentives and information requirements. Nevertheless, the primary goal is to find a way to maximize welfare while taking into account the limitations of the marginal cost-pricing rule. An important criterion is the financial sustainability of the service, which requires sufficient revenues to meet the present and future financial obligations of the utility (that is, operating costs as well as the capital costs of facilities and infrastructure). Another criterion is that users should bear the cost of the service (that is, consumers should pay an amount equivalent to the burden of their consumption on society). This implies that charges should be high enough to recover the full costs, including not only operation, maintenance and capital replacement, but also positive and negative externalities. The third criterion is that water should be affordable for all. This means that prices should be set in such a way that low-income groups are able to pay for their efficient and rational consumption. Unfortunately, these criteria are often conflicting. For example, assuring that low-income groups are charged an affordable rate is likely to clash with the criteria of recovering full costs and ensuring financial sustainability.

Other criteria for structuring user charges are simplicity, transparency and predictability. Simplicity means that tariffs should be understandable and straightforward for all social groups. This also allows consumers to understand how consumption patterns affect the amount they pay. Transparency enables consumers to understand how their own tariffs and those of other users are arrived at. Finally, predictability permits customers to reasonably anticipate and plan for their water-related expenses.

In some water and sanitation services, there are decreasing returns to scale because of the need to use more expensive sources of water as use increases. Examples of these more expensive users include desalination, wastewater reuse and reduction of leakages in networks. This raises public concerns about the possibility that the water companies may profit unfairly if services are priced at their marginal cost. To balance sustainability of service and consumer affordability, in cases where operator revenues stem from regulated prices, one option is to set average prices at average costs and have cost pricing guide the higher blocks in the block tariff structures.

For an efficient outcome, the institutional regime should also reflect the marginal cost of environmental impacts – either as part of the tariff regime or, preferably, using separate policy instruments so that those whose actions seek to reduce adverse environmental impacts are rewarded. When water supplies are scarce, a scarcity charge should be set.

Price cap versus cost-plus charging regimes

There are several options available to assist governments to determine the charging regime that a water utility may set. One option is to use a complex incentive-based regime such as the setting of a cap on the maximum revenue per user that the utility may collect. This encourages cost-minimizing behaviour, requires less data to be collected from each utility and can yield more profits to those that are most efficient. An alternative approach is to regulate costs and control profits. This alternative approach requires a price regulator to collect much internal information from the utility and reduces the incentive for them to minimize costs. Under this alternative "cost-plus" approach, a mixed mechanism is used in which charges are calculated using firms' real costs for some inputs and standard cost values for others. This is usually the most appropriate option.

However, in order to analyze the relative advantages of each regime, it is useful to consider the case of a pure price-cap regime and pure cost-plus regime. A first recommendation is that cost-plus regimes tend to be more appropriate in developing countries as well as in other cases where the willingness and capacity to pay for the services are low.

A second recommendation is that if there are large average cost differences among water utilities within a country, cost-plus schemes should be favoured. If cost differences across units are large, setting average prices equivalent to those of the most inefficient utility, as is the case with a price cap, can result in large losses to society.

Cross-subsidies and the provision of water and sanitation services

In many water supply and sanitation regimes, it is common for the charging regime to include cross-subsidies. Typically, these take the form of an arrangement where one group of users are charged well above the cost of supplying water to them so that the utility can operate at a profit while supplying water to others at less than the cost of supply. When the high charge is less than the cost of supply from alternative sources, cross-subsidy charging regimes can be maintained. When a monopoly supplier sets a charge that is greater than the cost of supply from alternative sources revenue streams can be quickly eroded because competitors are able to enter the system and destroy the monopoly.

When trying to establish whether or not a cross-subsidy is present, four criteria can be identified.

1 *Marginal cost criterion*. Under this criterion, a price scheme is said to have cross-subsidies if some consumer prices are lower than the marginal cost. Otherwise, if all consumer prices are equal or above marginal costs, then the price scheme is subsidy-free.
2 *Average cost criterion*. Under this criterion, a price scheme is said to have cross-subsidies if some consumer prices are below average costs and others are above. Notice that when some costs are shared among different products, the average cost schedule cannot be precisely defined.
3 *Incremental cost criterion*. Under this criterion, a price scheme is said to have cross-subsidies if revenues from a consumer or a group of consumers are less than the incremental cost of providing services to that consumer or group of consumers.
4 *Stand-alone criterion*. Under this criterion, a price scheme is said to have cross-subsidies if the revenues from a consumer or group of consumers are larger than the cost of providing service alone to this consumer or group of consumers.

Market efficiency and cross-subsidies

A well-known theoretical result states that any uniform price schedule different from marginal cost can be welfare-dominated by a non-uniform price schedule if consumers have different price elasticities. These findings are relevant for setting discriminatory prices in water and sanitation services because marginal cost pricing does not cover total cost in the presence of increasing returns to scale, which is a common feature of these services. Therefore, if revenues from water and sanitation services cover total costs, then prices must diverge from marginal cost. In other words, from a welfare standpoint, price-discrimination schedules may be better than a uniform price when the uniform prices do not equal marginal cost and price elasticity differs among consumers.

However, price discrimination may or may not imply cross-subsidies. If regulators set prices so that they just cover costs without yielding extraordinary profits, then any price-discrimination scheme has implicit cross-subsidies according to the average cost criterion. The reason is that consumers who pay higher prices are paying more than average costs, while consumers who pay lower prices are paying less than average costs. In these cases, the allocations resulting from pricing with cross-subsidies according to the average cost criterion may dominate, from an efficiency standpoint, allocations resulting from uniform prices. It may occur that a price scheme that increases welfare with respect to uniform prices has cross subsidies according to the average cost criterion and does not have them according to the standalone or the incremental criterion. However, it may also be the case that a price scheme appropriate for welfare purposes has cross-subsidies according to the average cost, the standalone and the incremental cost definitions. Nevertheless, as discussed in the next section, prices must be free of cross-subsidy according to the marginal cost criterion for welfare goals.

Price should cover marginal costs

The previous sections have shown that price discrimination and cross-subsidies, in the increasing returns and a no-losses restriction, may increase social welfare. Yet, they are far from showing that all discriminatory schemes are appropriate for improving welfare. This section discusses three important considerations in analyzing the welfare implication of schemes with price discrimination and cross-subsidies.

Cross-subsidy schemes

Cross-subsidy schemes that set the charge paid by some users at less than marginal costs are not appropriate from the efficiency standpoint. The reason is simple: if the price paid by a consumer is lower than marginal cost, the social cost of this consumer service is larger than the benefit. Therefore, welfare is increased by simply reducing production in the amount corresponding to the underpriced consumer.

Schemes with cross-subsidies

Schemes with cross-subsidies and price discrimination increase welfare only if they increase aggregate consumption. If a cross-subsidy scheme is successful in increasing the consumption level, the welfare improvement from greater consumption may be larger than the welfare loss from the difference in marginal rates of substitution – a result that is possible because marginal rates of substitution can be different among consumers.

Under increasing returns

Under increasing returns and when a water utility is not allowed to run at a loss, a necessary condition for welfare maximization is that the deviation of prices from marginal cost in each market should be inversely related to the price elasticity of demand in each market.

Cross-subsidies may hinder water services

According to the average cost criterion, cross-subsidy schemes are a necessary condition for welfare maximization when increasing returns are present and losses are forbidden. Therefore, reasons other than welfare should be the cause for rejecting price schedules with cross-subsidies. One reason for rejecting cross-subsidies is that they may lead overpriced consumers to abandon the regulated firm or force the exclusion of underpriced consumers. The notion of voluntary sustainability is appropriate to analyze the extent to which cross-subsidies may destroy water and sanitation services.

A price discrimination scheme for a community is voluntarily sustainable if the following two conditions hold. First, each group of consumers pays less for the provision of the service than they would pay alone (*stand-alone criterion).* This condition sets an upper bound for revenues from a consumer. Second, revenues from each group cover the incremental to total cost that occurs when the service is provided to that group as opposed to not being provided at all (*incremental cost criterion).* This condition sets a lower bound for revenues from a group of consumers. When the first condition holds, no group will be willing to disband because doing so will increase their payments. However, if the second condition holds, no group is willing to exclude other groups.

Some observations on these conditions should be made. First, a price scheme is sustainable if, and only if, it is cross-subsidy-free according to both the standalone and the incremental criteria. Second, the incremental cost condition requires that prices should be above marginal costs. Therefore, price over marginal cost should hold for both welfare and sustainability reasons. Third, price schedules meeting the conditions for voluntary sustainability may have implicit cross-subsidies according to the average cost criterion. Fourth, the sustainability of a price scheme closely depends upon the alternatives for service provision of each consumer or group of consumers. That is, checking sustainability requires that information about alternative technologies be available to every group of consumers.

Three main conclusions

1 If a uniform price schedule is established and charges diverge from marginal cost, then social welfare can be increased by establishing appropriate price discrimination schemes that may have cross-subsidies. This does not mean that all schemes with cross-subsidies increase welfare, but some do.
2 From a voluntary sustainability standpoint, some cross-subsidy schemes are not appropriate, whereas others are.
3 Sometimes, optimal and voluntarily sustainable price schedules are not compatible. In these cases, a trade-off between economic optimality and sustainability is often necessary. In summary, cross-subsidies are good for increasing welfare, but inappropriate use may bring separation of overpriced consumers and large costs for all.

Notes

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2 Globally, cereal yields will have to increase from the current average of about 3 tonnes per hectare to 4 tonnes per hectare by 2030. Agricultural water management will thus have to provide more efficient and equitable solutions for intensification at the basin level to increase water and land productivity.
3 Agricultural intensification has been defined as the use of "increased average inputs of labour or capital on smallholding, either cultivated land alone or on cultivated and grazing land, for the purpose of increasing the value of output per ha."
4 Drinking water is generally provided in Europe by a utility, while sanitation and water treatment is provided by the municipality. In many Latin American municipalities, water and sanitation services are provided by one organization.

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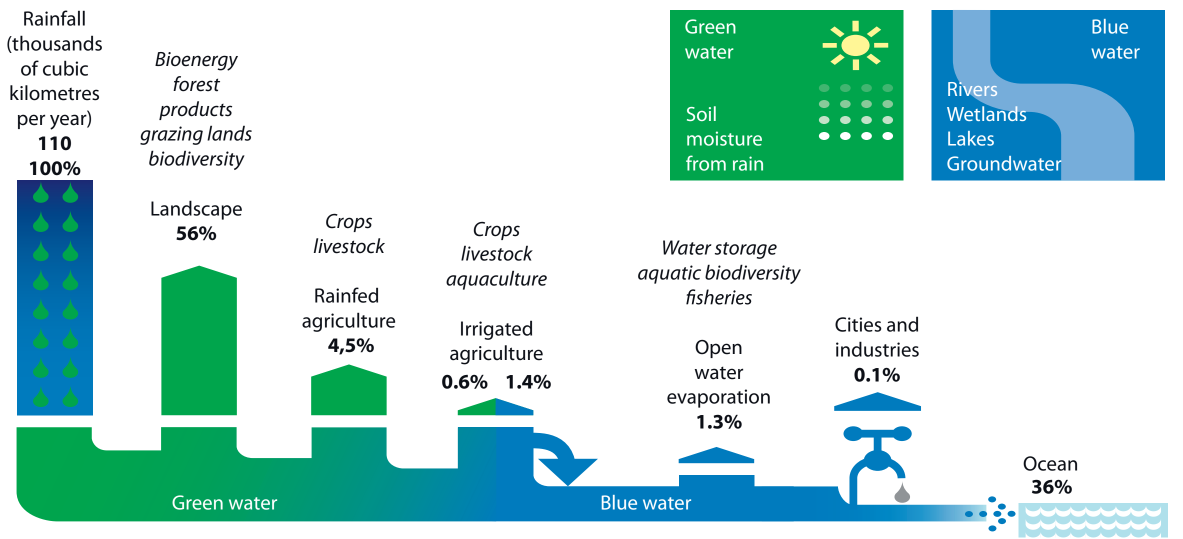


PLATE 1.1 "Green water" refers to rainwater stored in the soil or on vegetation, which cannot be diverted to a different use. "Blue water" is surface and groundwater, which can be stored and diverted for a specific purpose

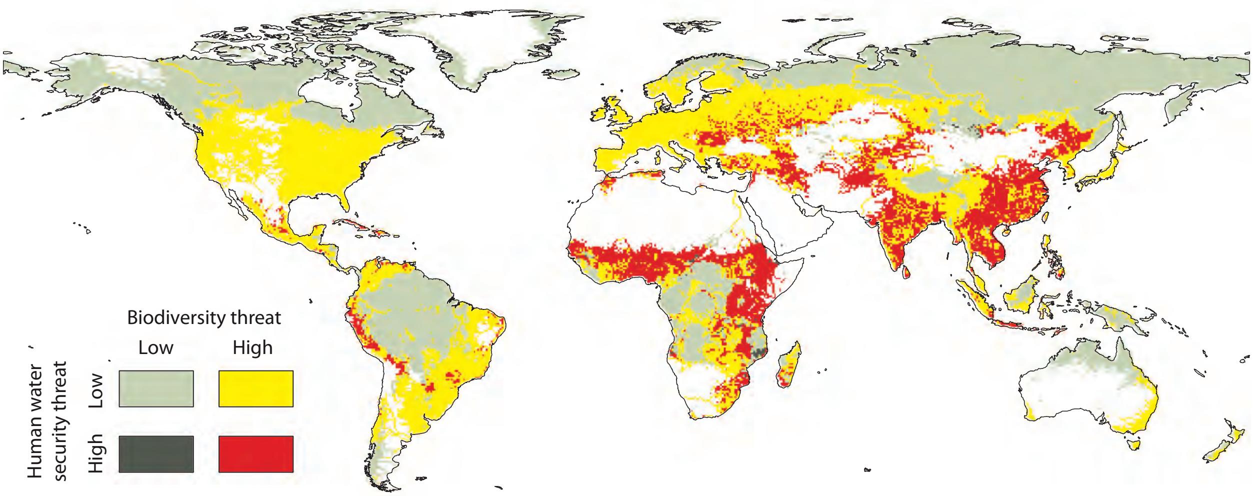
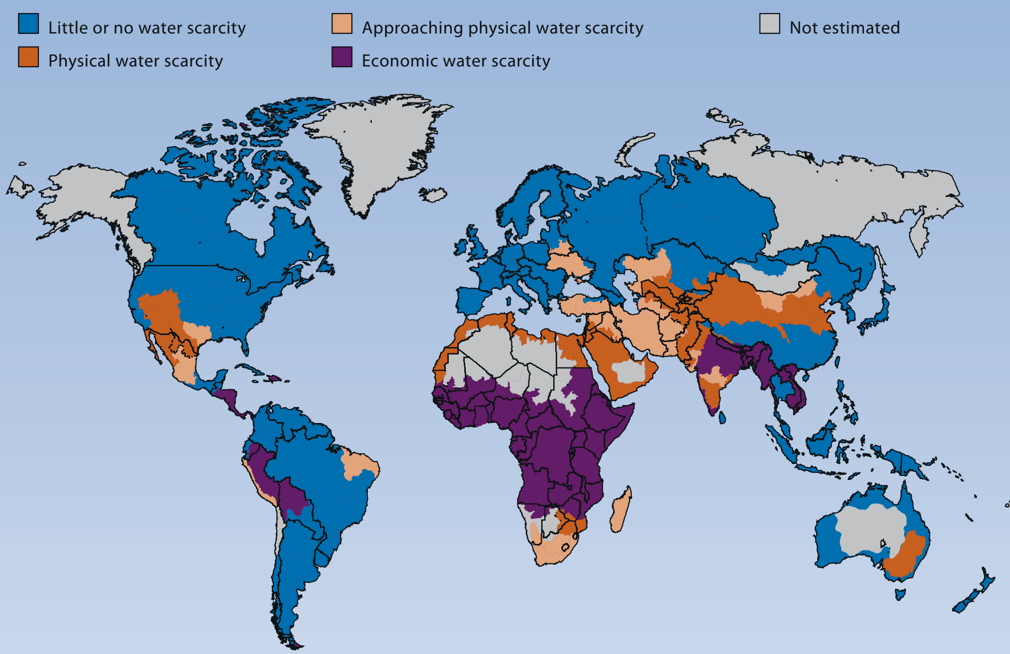


PLATE 1.2 Prevailing patterns of threat to human water security and biodiversity. Adjusted human water security threat is contrasted against incident biodiversity threat. A breakpoint of 0.5 delineates low from high threat



Definitions and indicators

- *Little or no water scarcity*. Abundant water resources relative to use, with less than 25% of water from rivers withdrawn for human purposes.
- *Physical water scarcity* (water resources development is approaching or has exceeded sustainable limits). More than 75% of river flows are withdrawn for agriculture, industry, and domestic purposes (accounting for recycling of return flows). This definition – relating water availability to water demand – implies that dry areas are not necessarily water scarce.
- *Approaching physical water scarcity*. More than 60% of river flows are withdrawn. These basins will experience physical water scarcity in the near future.
- *Economic water scarcity* (human, institutional, and financial capital limit access to water even though water in nature is available locally to meet human demands). Water resources are abundant relative to water use, with less than 25% of water from rivers withdrawn for human purposes, but malnutrition exists.

PLATE 1.3 Areas of physical and economic water scarcity

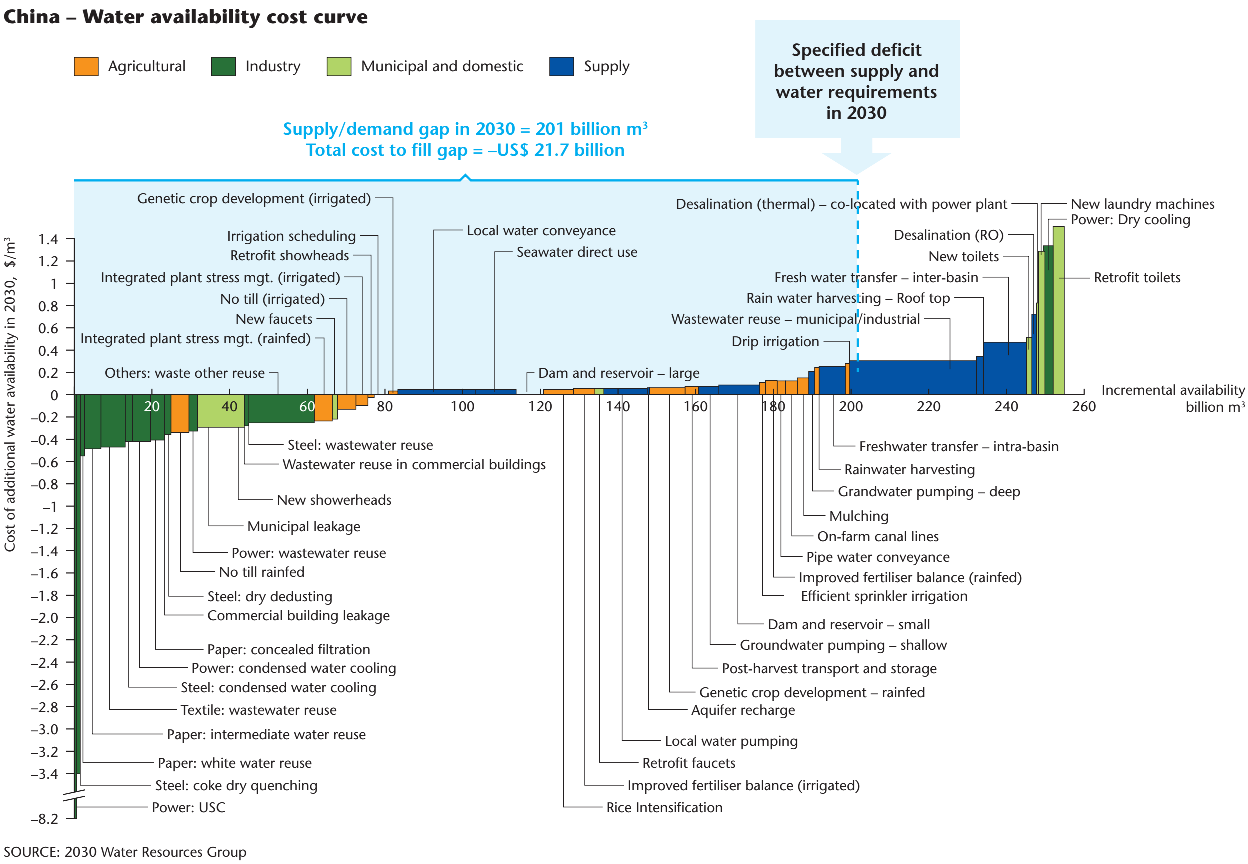


PLATE 1.4 Relative costs of different methods of supplying water in China

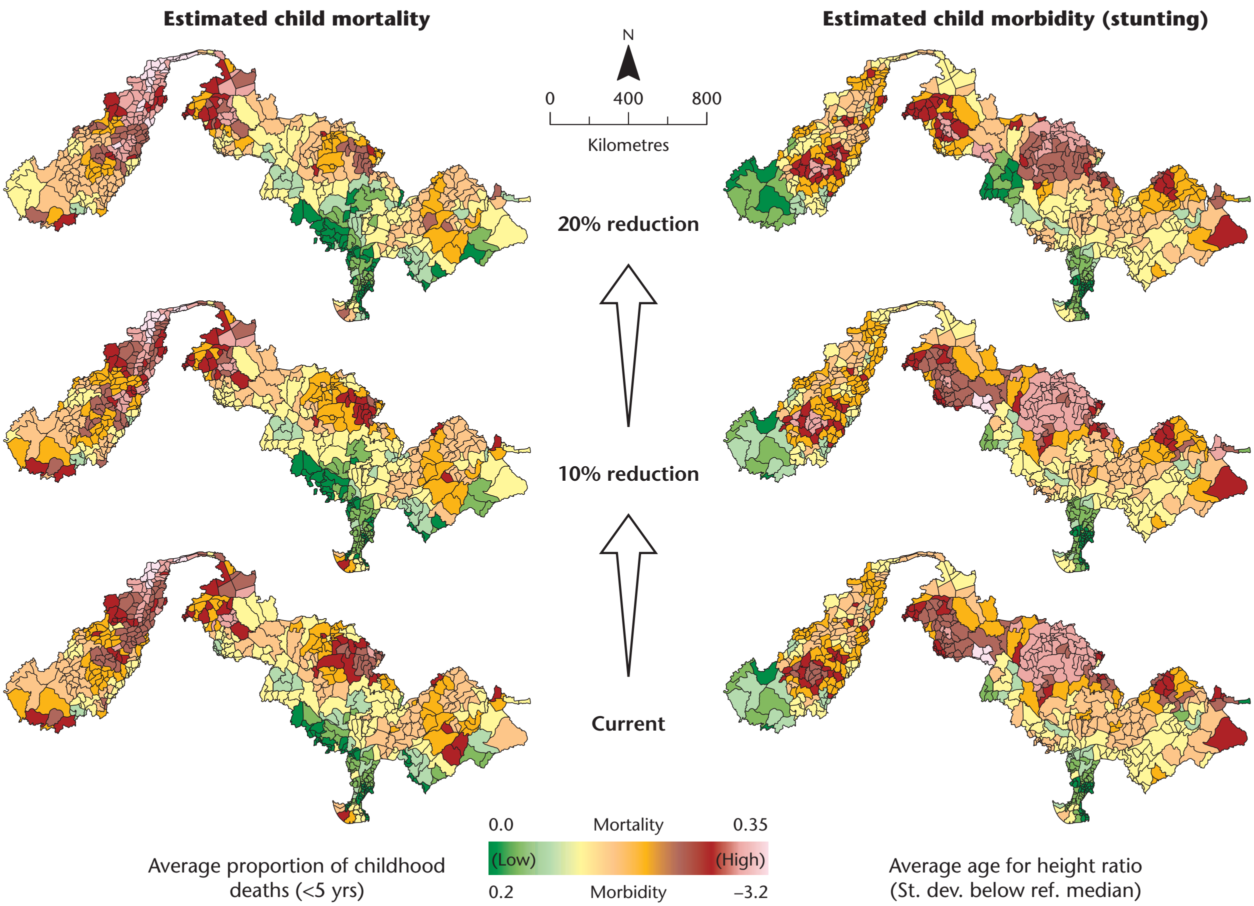


PLATE 1.5 Predicted effect of a 10 per cent and 20 per cent reduction in the proportion of people obtaining their primary water supply from surface water or unprotected well water on child mortality and child morbidity (stunting), Niger River Basin

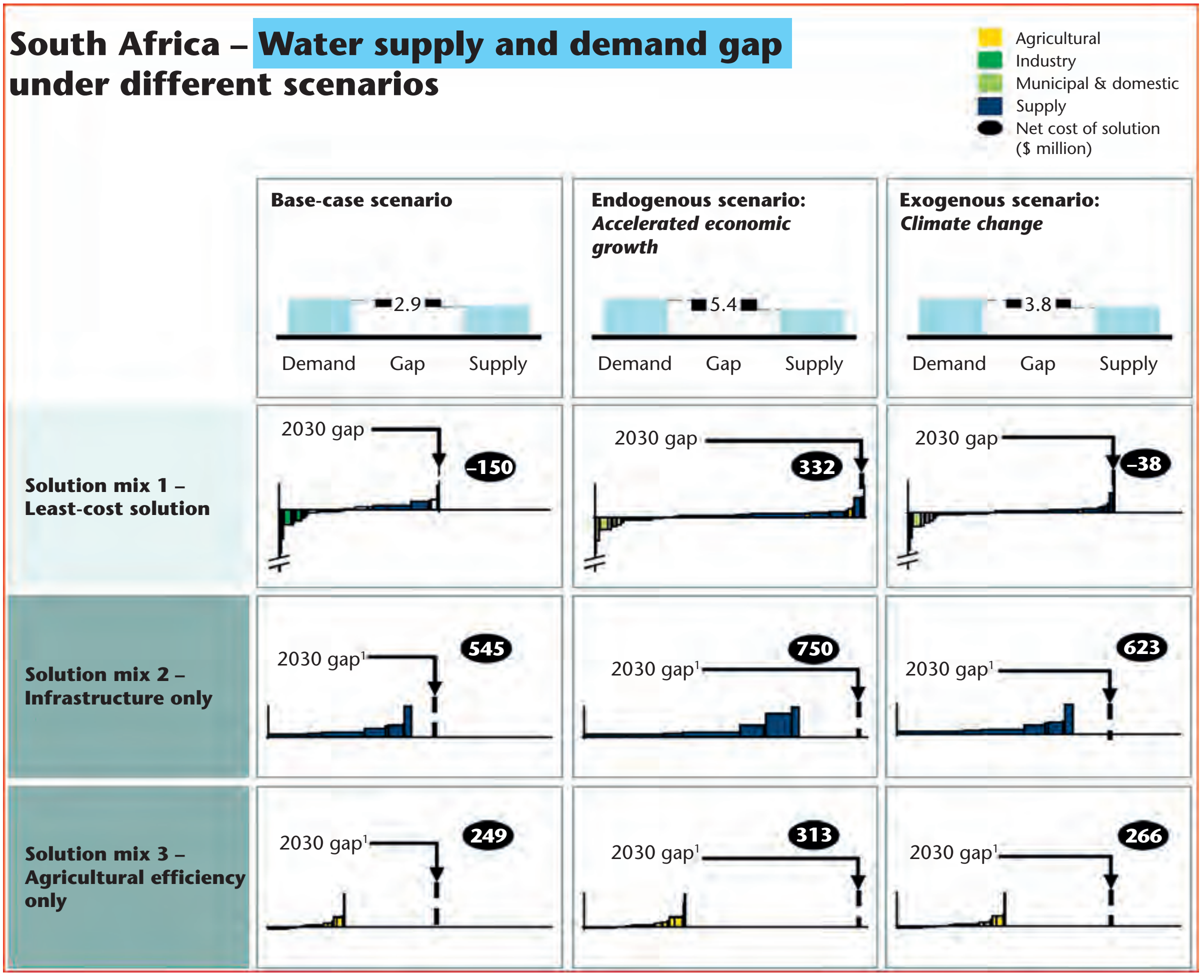


PLATE 2.1 South Africa – water supply and demand gap under different scenarios

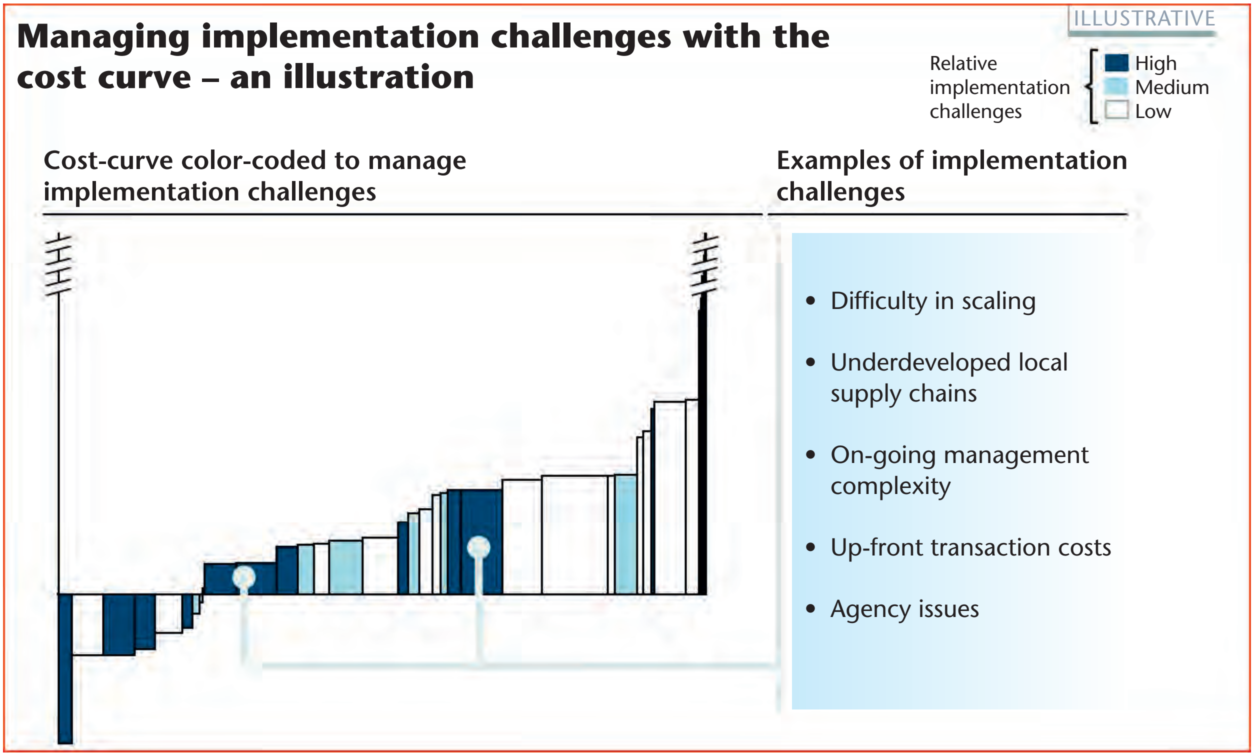


PLATE 2.2 Managing implementation challenges with the cost curve – an illustration

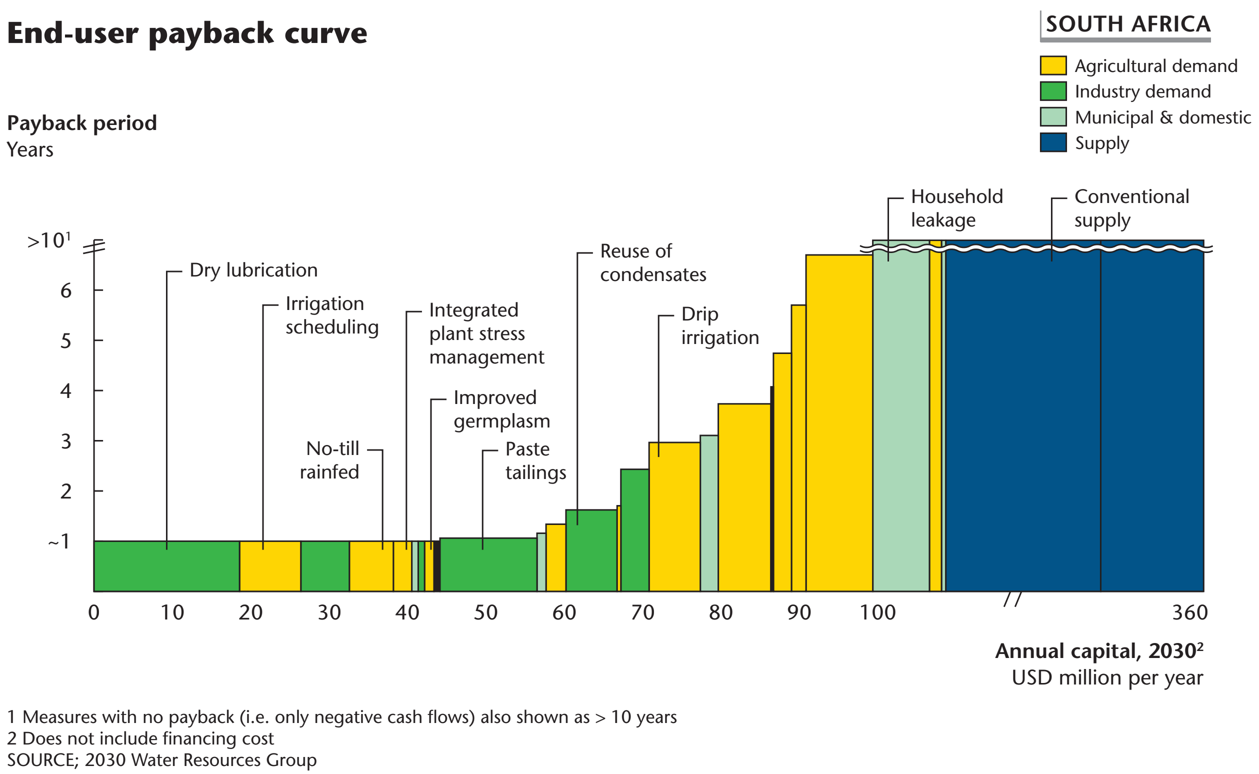


PLATE 2.3 End-user payback curve

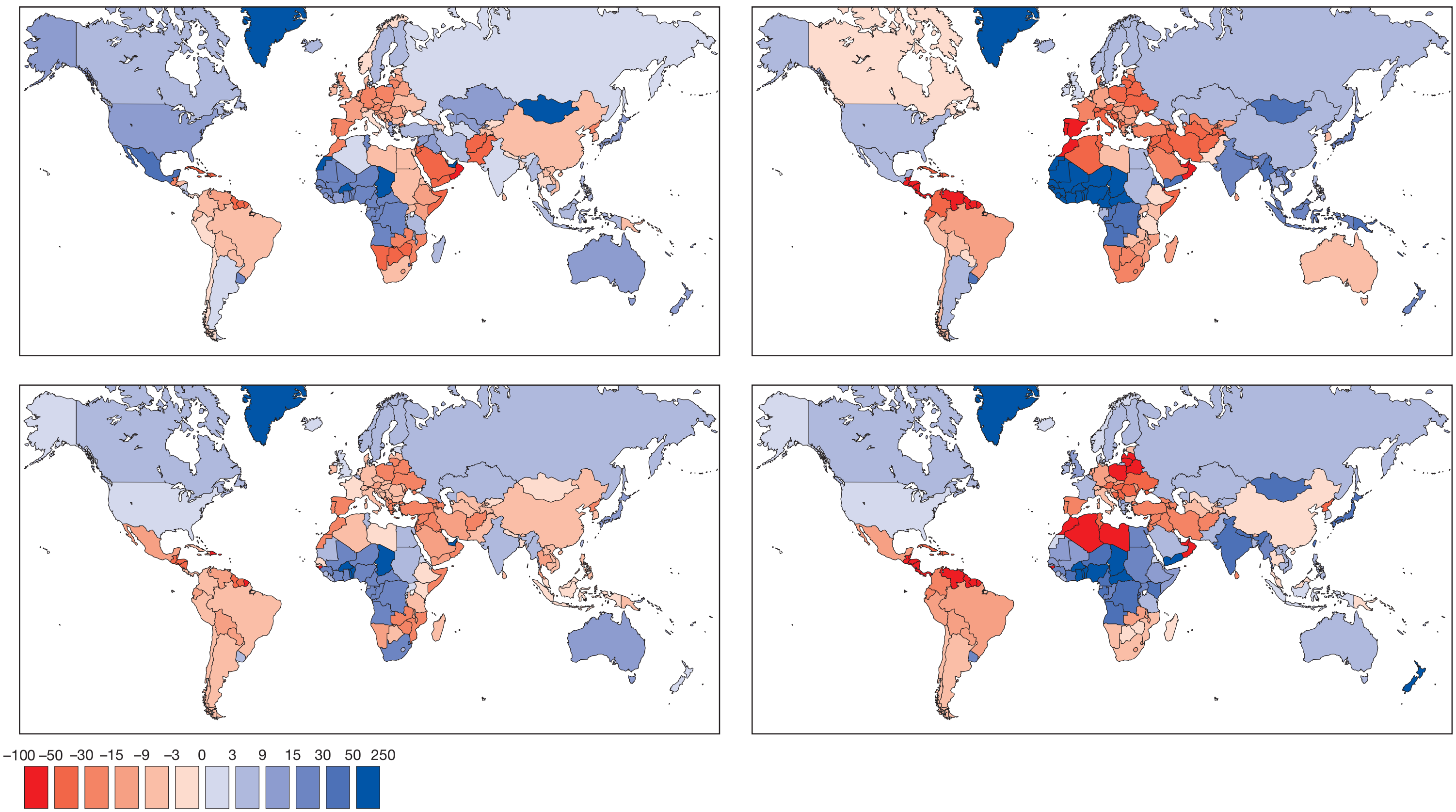


PLATE 4.1 Percentage change in annual average river flow under the two emission scenarios and for the two time periods, with respect to the 30-year average for the 1961–1990 period (historic-anthropogenic simulation)

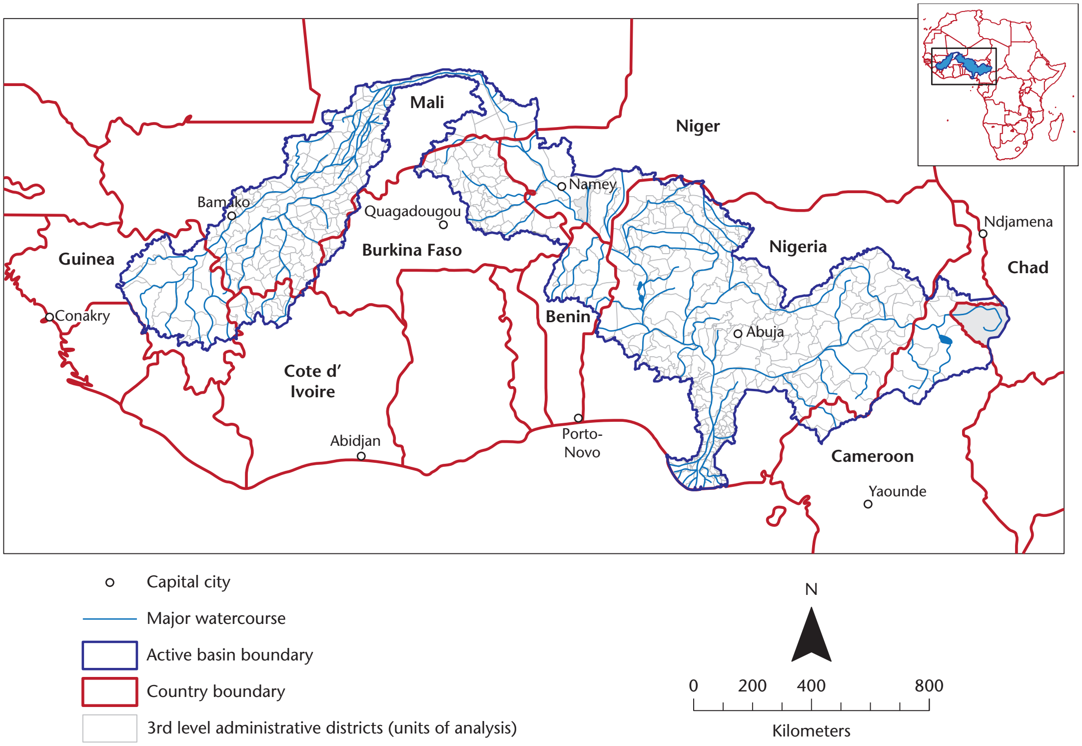


PLATE 9.1 Study region showing the active Niger Basin, major tributaries, basin countries and third-level administrative districts

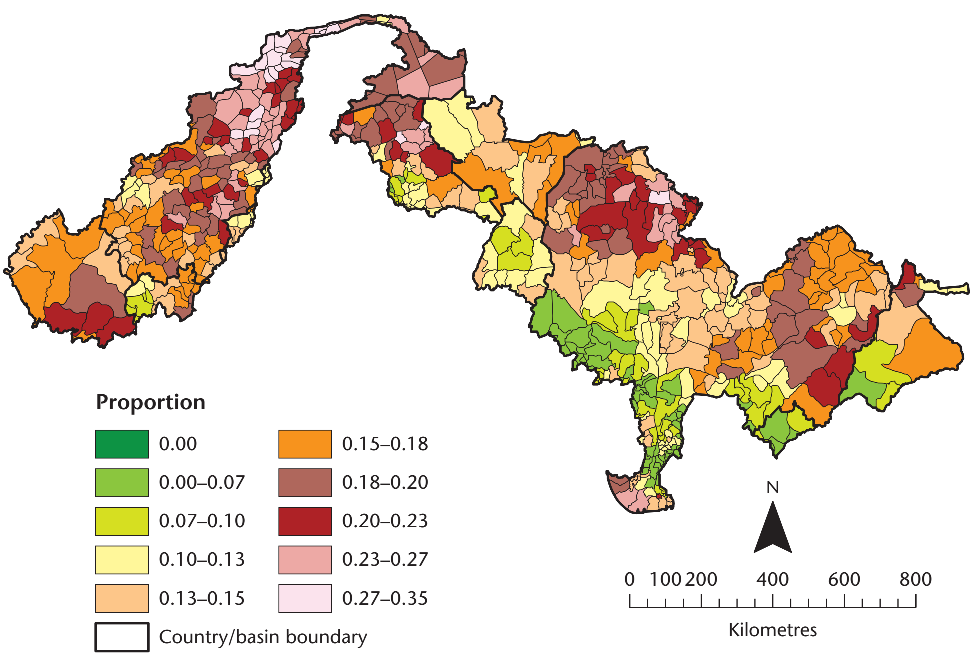


PLATE 9.2 Estimated child mortality (percentage of children who die before age 5) across the active Niger Basin (based on births recorded since 1980)

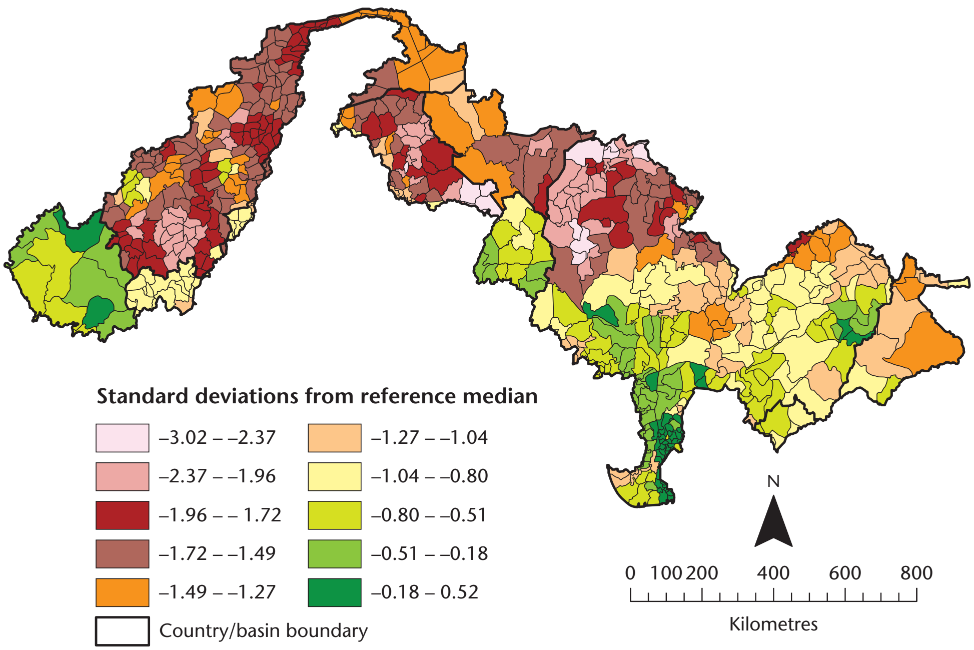


PLATE 9.3 Estimated child morbidity (height-age ratios) across the active Niger Basin

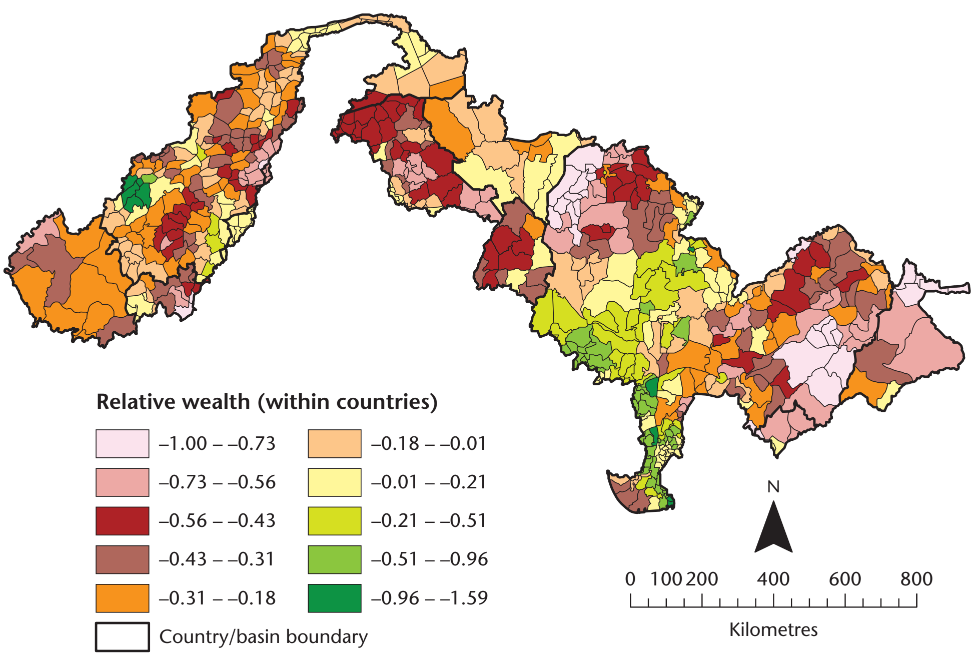


PLATE 9.4 Estimated relative wealth across the active Niger Basin, as indicated by possessions, land ownership, housing material and employees. Values are relative within countries, not between countries

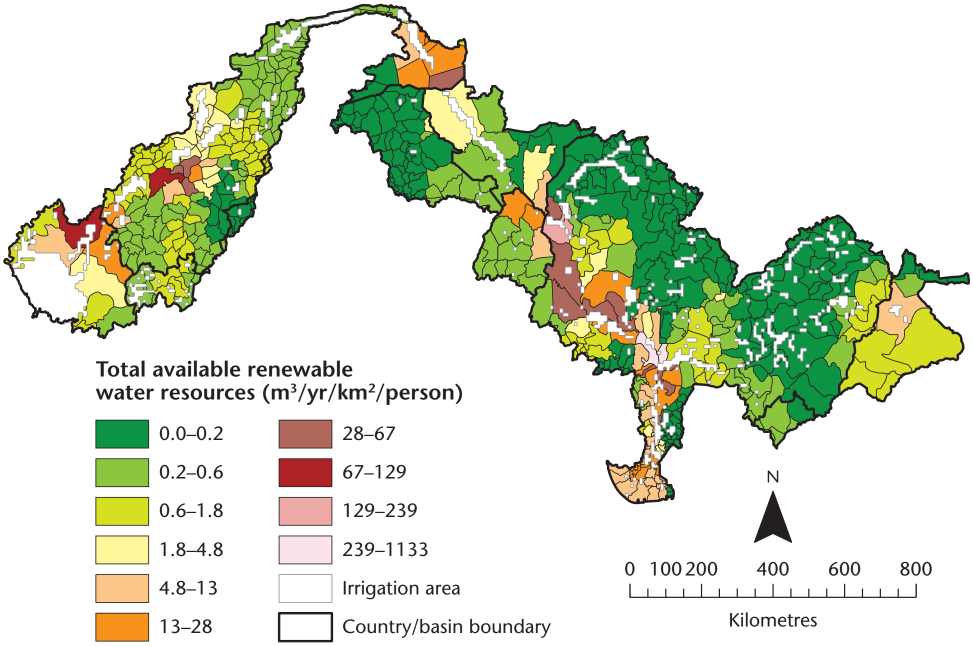


PLATE 9.5A Total available renewable water resources and irrigation areas within the active Niger Basin

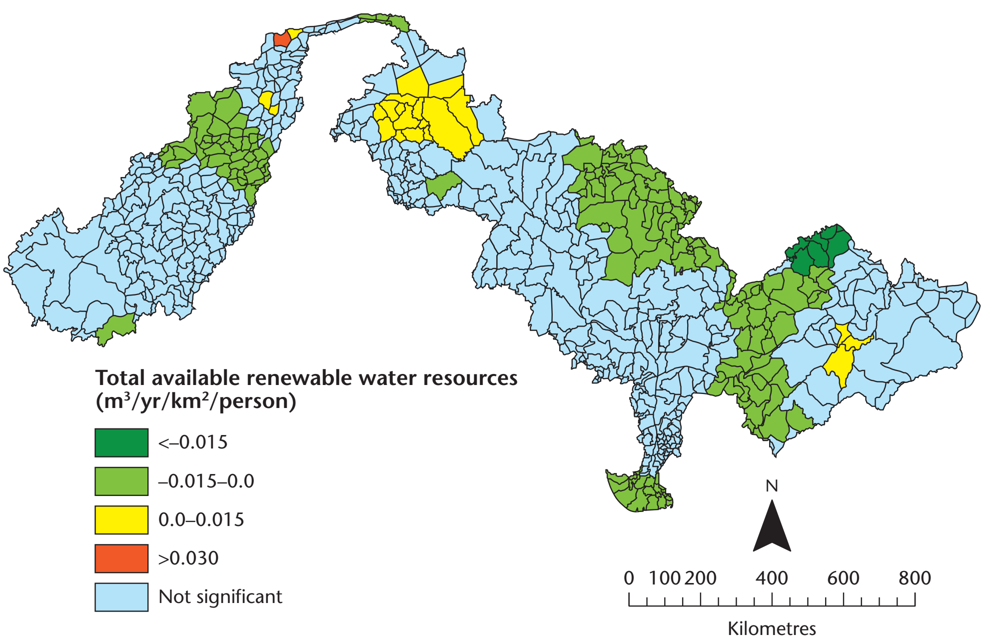


PLATE 9.5B Map of total available water resources and associated change in child mortality estimated with GWR

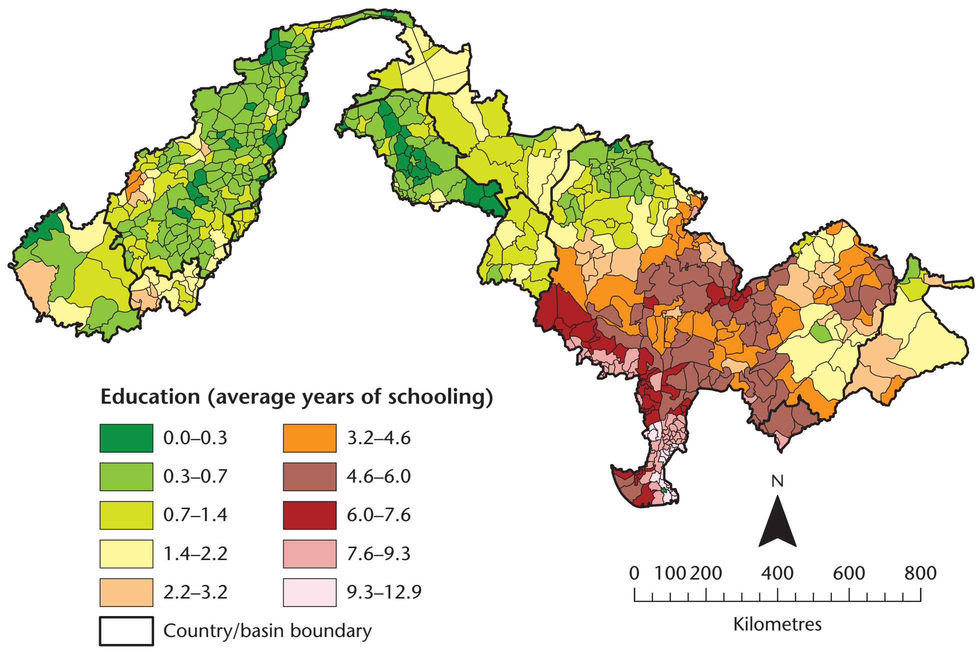


PLATE 9.6A Map of education levels (average years) across the Niger River Basin

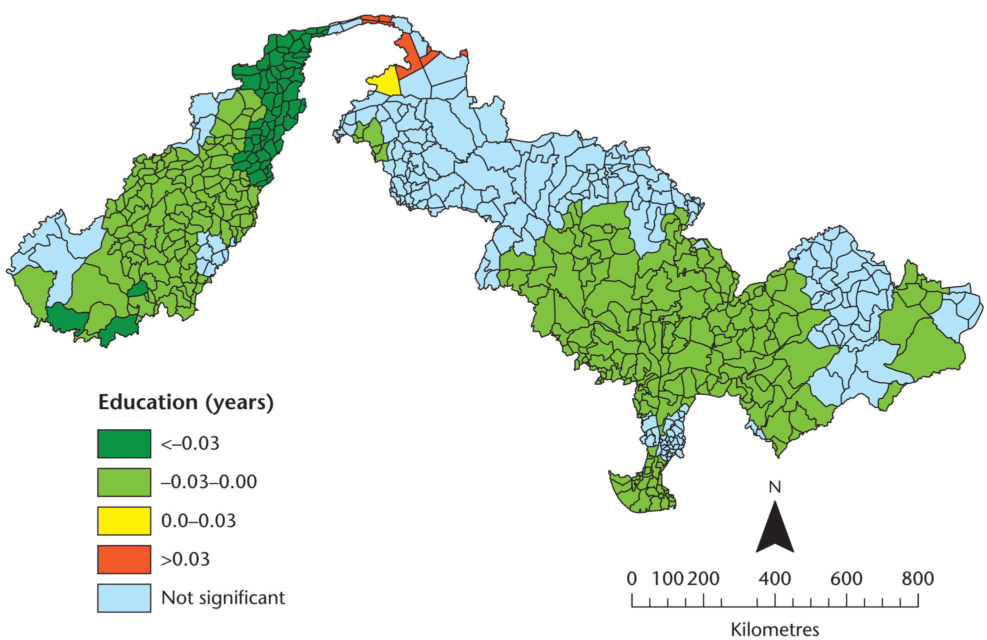


PLATE 9.6B Map of education levels and association with child mortality estimated using GWR

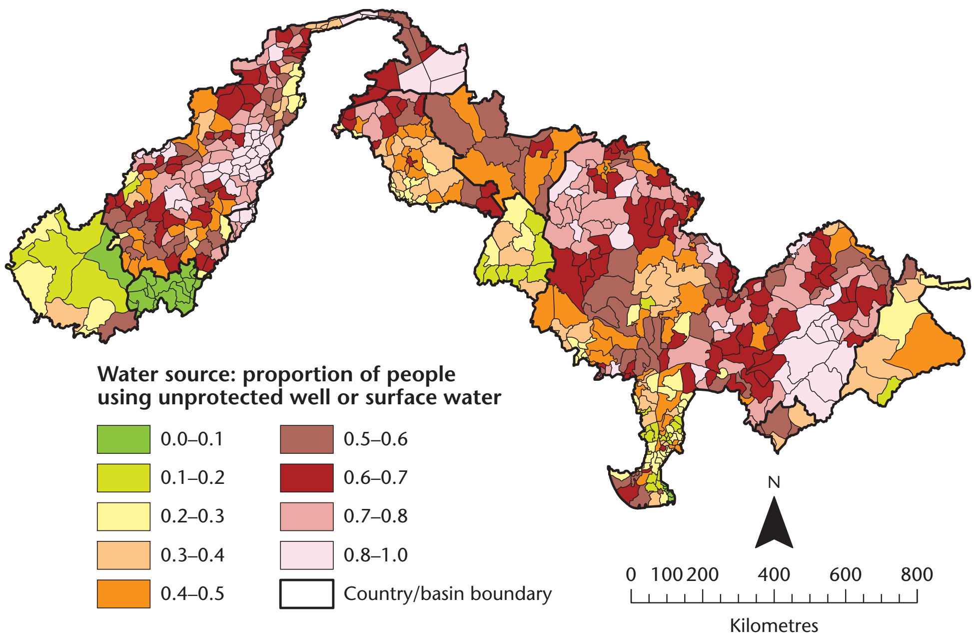


PLATE 9.7 Map of unprotected water and association with child mortality estimated using GWR

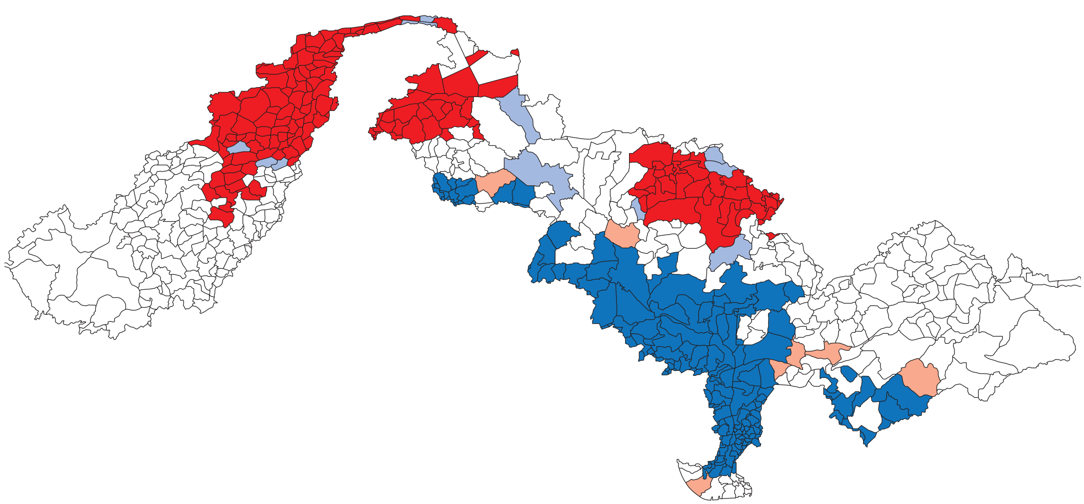


PLATE 9.8A LISA clusters of child mortality (proportion of children who die before age 5 years) across active Niger Basin. Moran's I value of 0.679 indicates moderate spatial autocorrelation in this variable

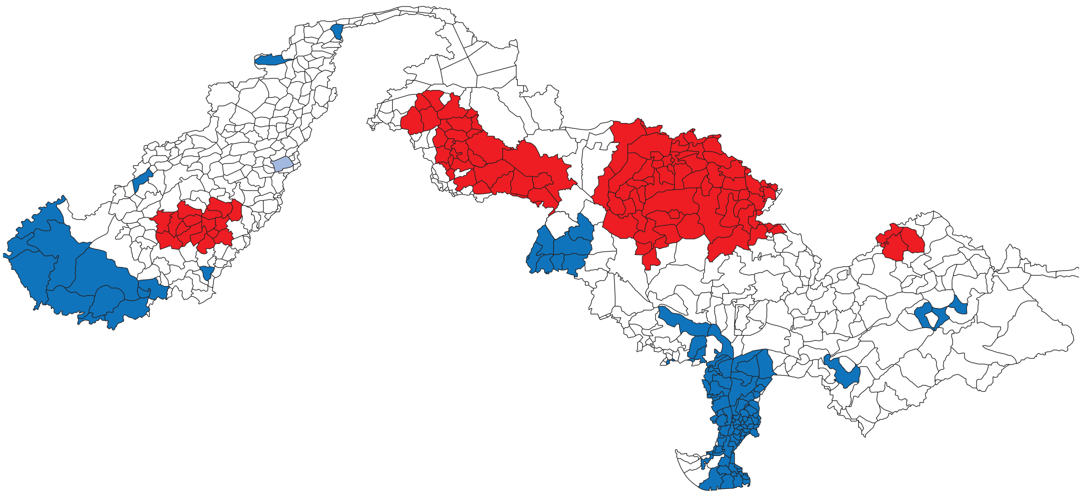


PLATE 9.8B LISA clusters of child morbidity stunting (height-age ratios) across active Niger Basin. Moran's I value of 0.833 indicates high spatial autocorrelation in this variable

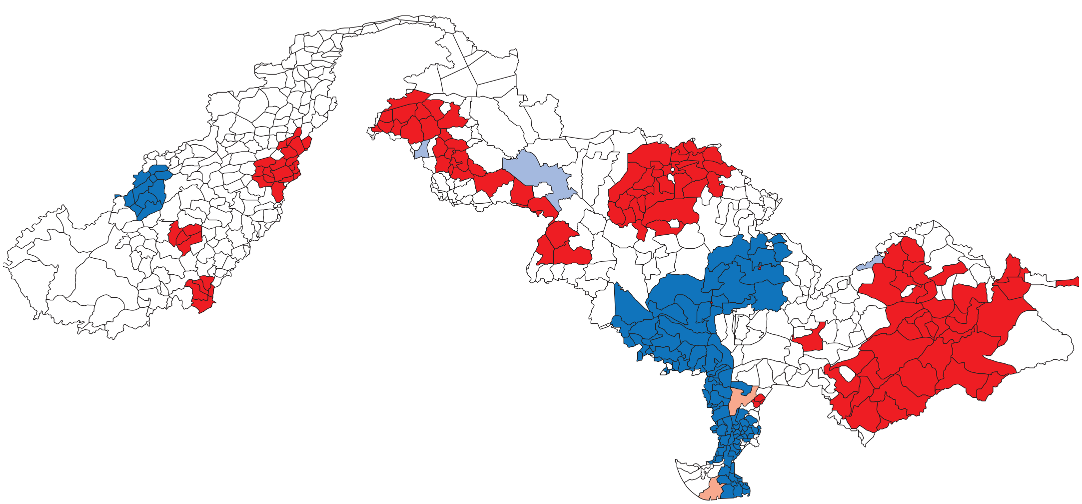


PLATE 9.8C LISA clusters of relative wealth across active Niger Basin. Moran's I value of 0.767 indicates moderate spatial autocorrelation in this variable

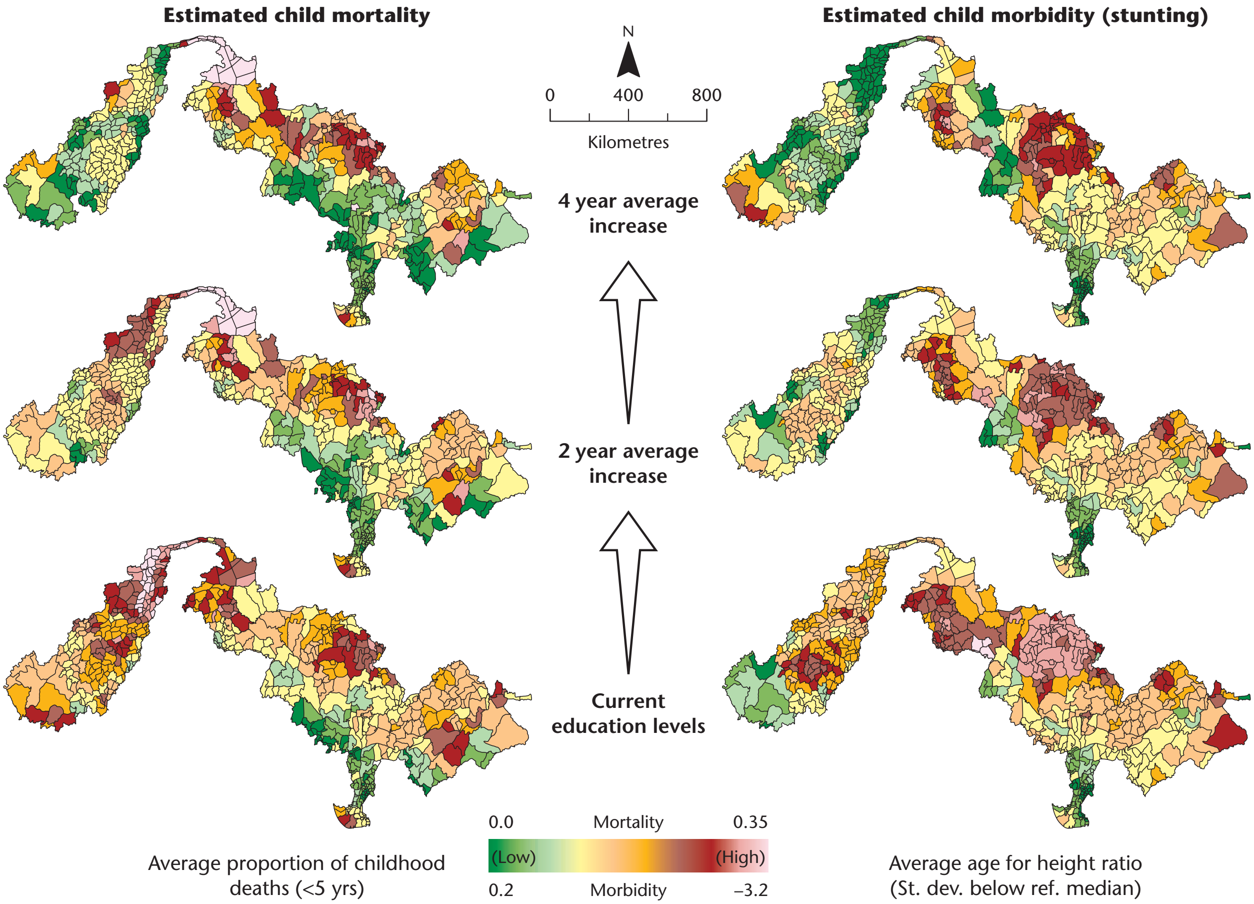


PLATE 9.9 Predicted effect on child mortality and child morbidity (stunting) levels due to an increase in the average number of years of education in the active Niger Basin

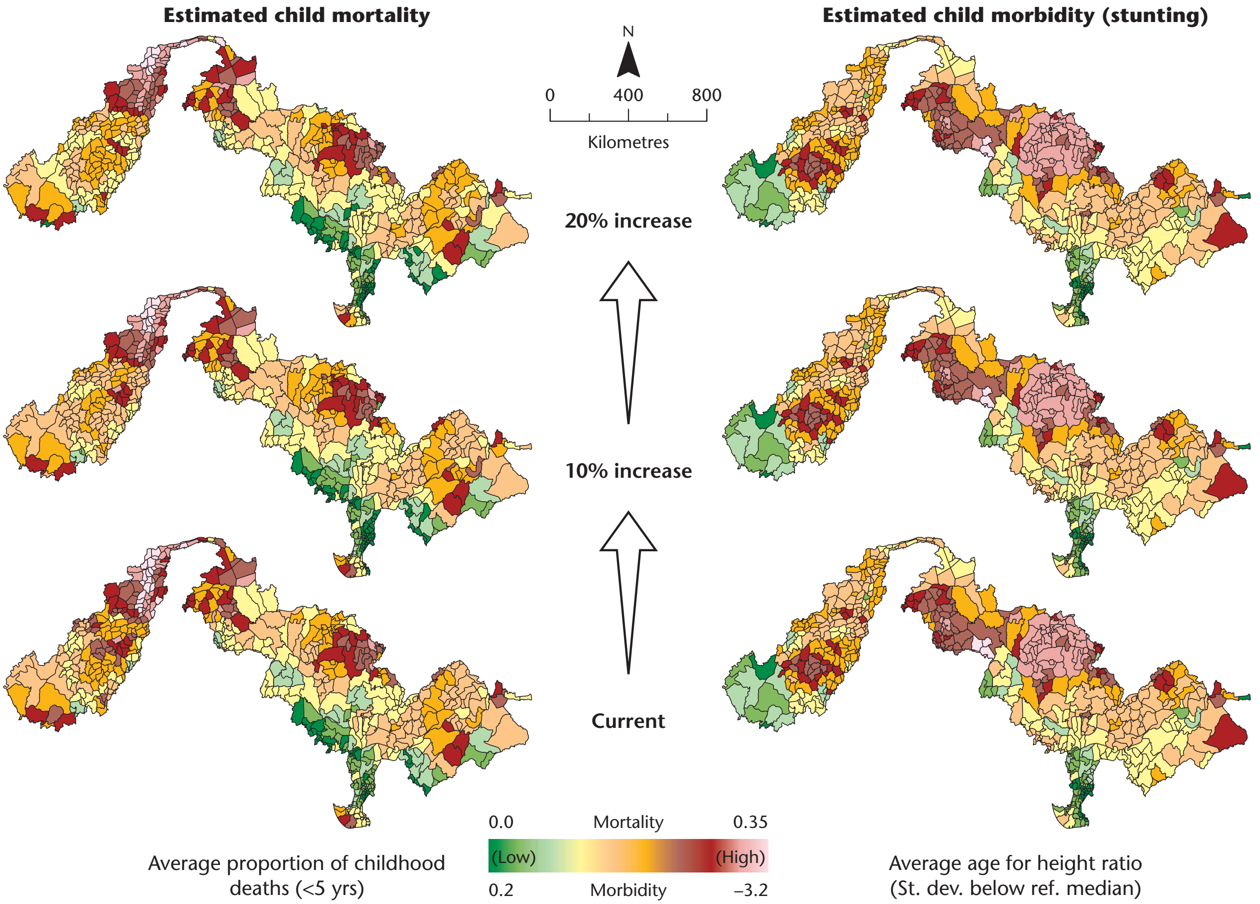


PLATE 9.10 Predicted effect on child mortality and child morbidity (stunting) levels due to an increase in irrigation intensity in the active Niger Basin

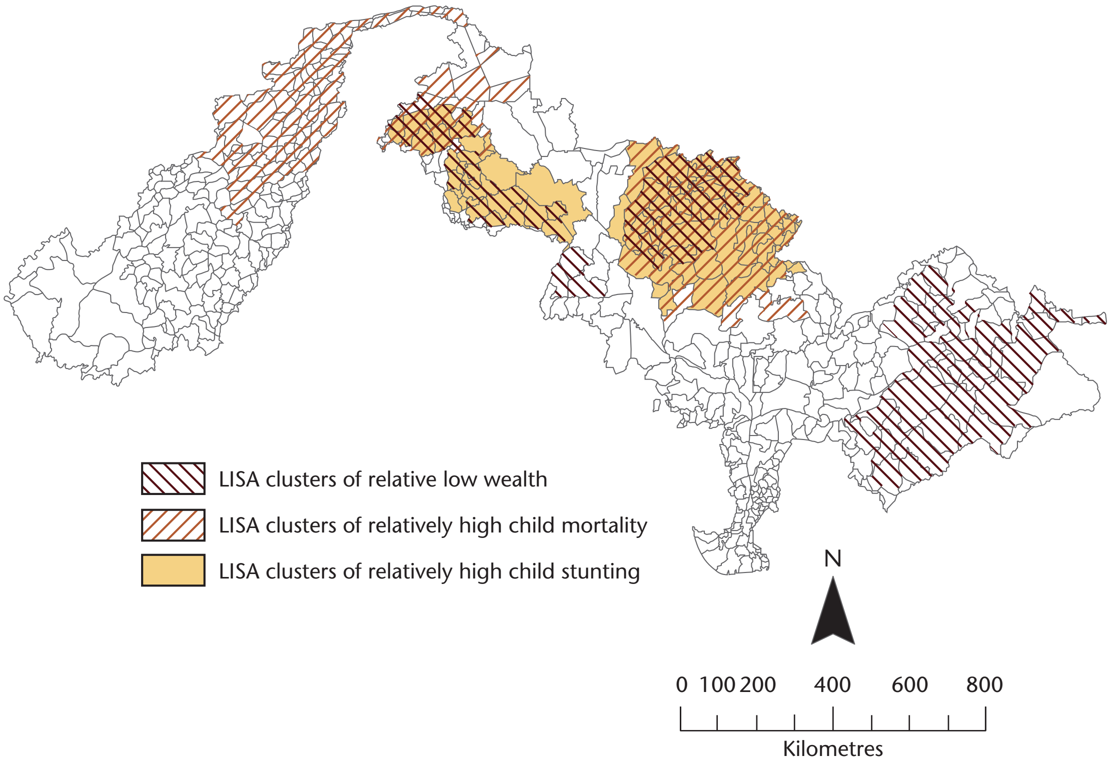


PLATE 9.11 Overlapping of major poverty hot spots

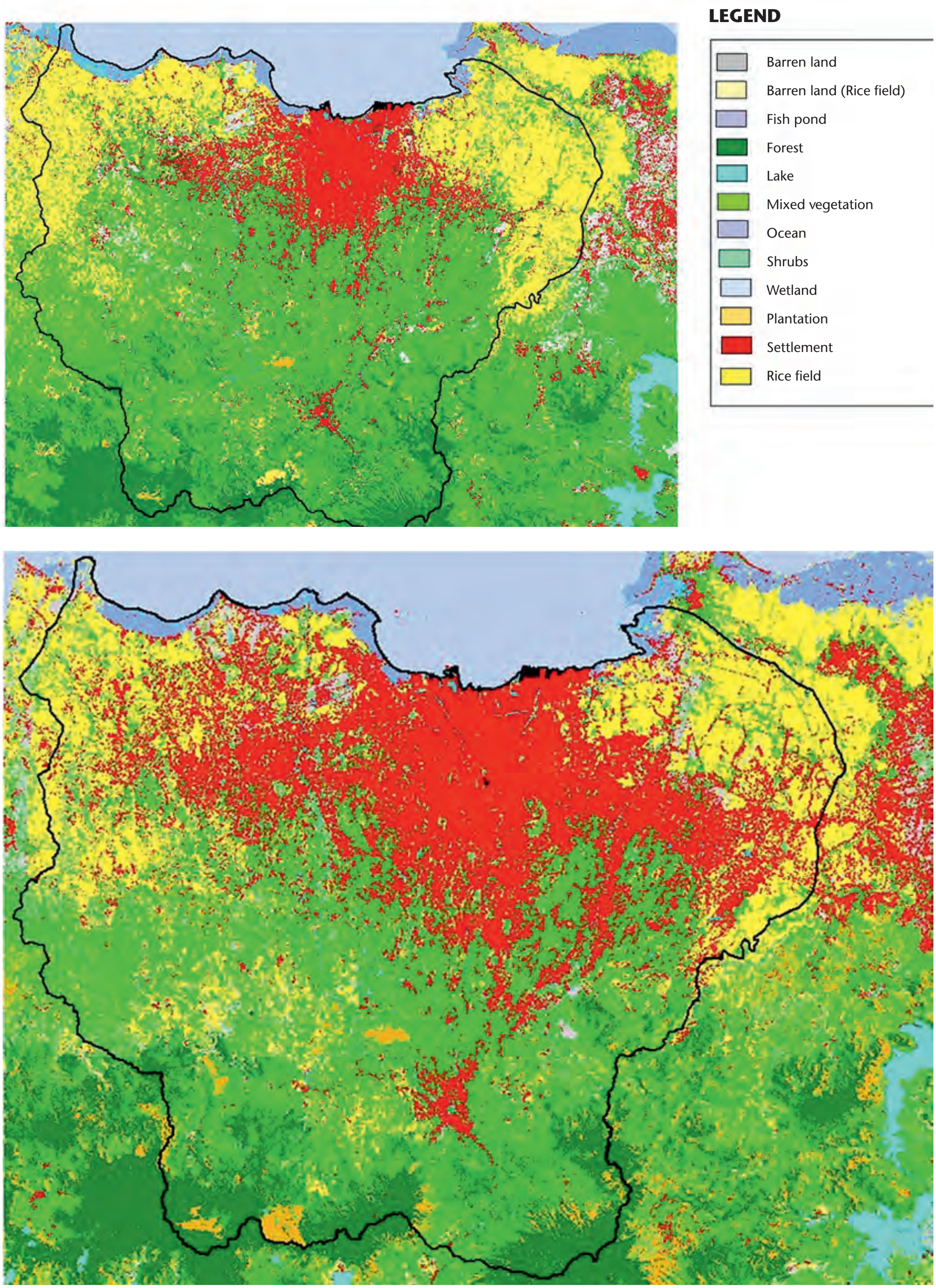


PLATE 10.1 Expansion of urban settlement in Jakarta between 1992–2002

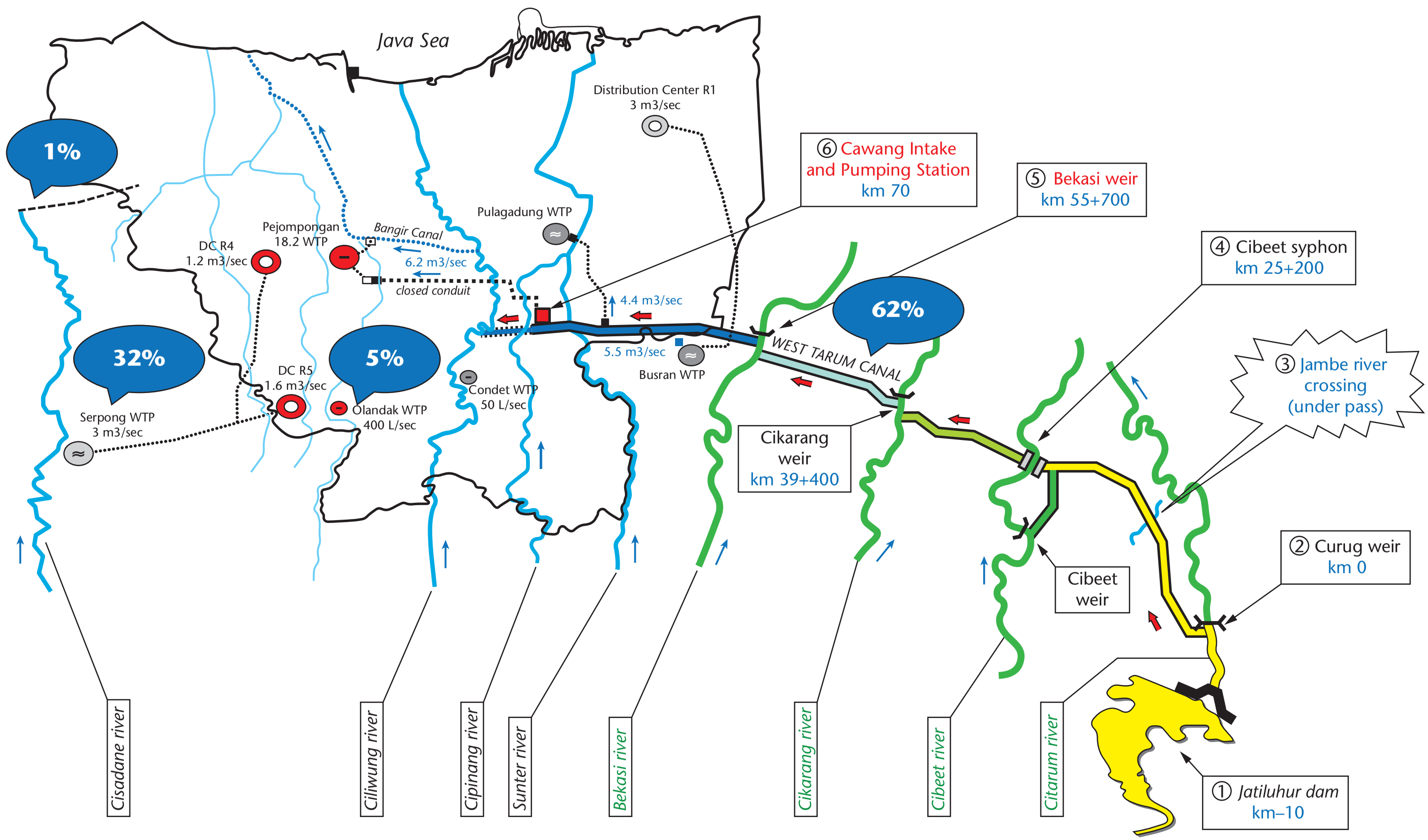


PLATE 10.2 Jakarta water supply network

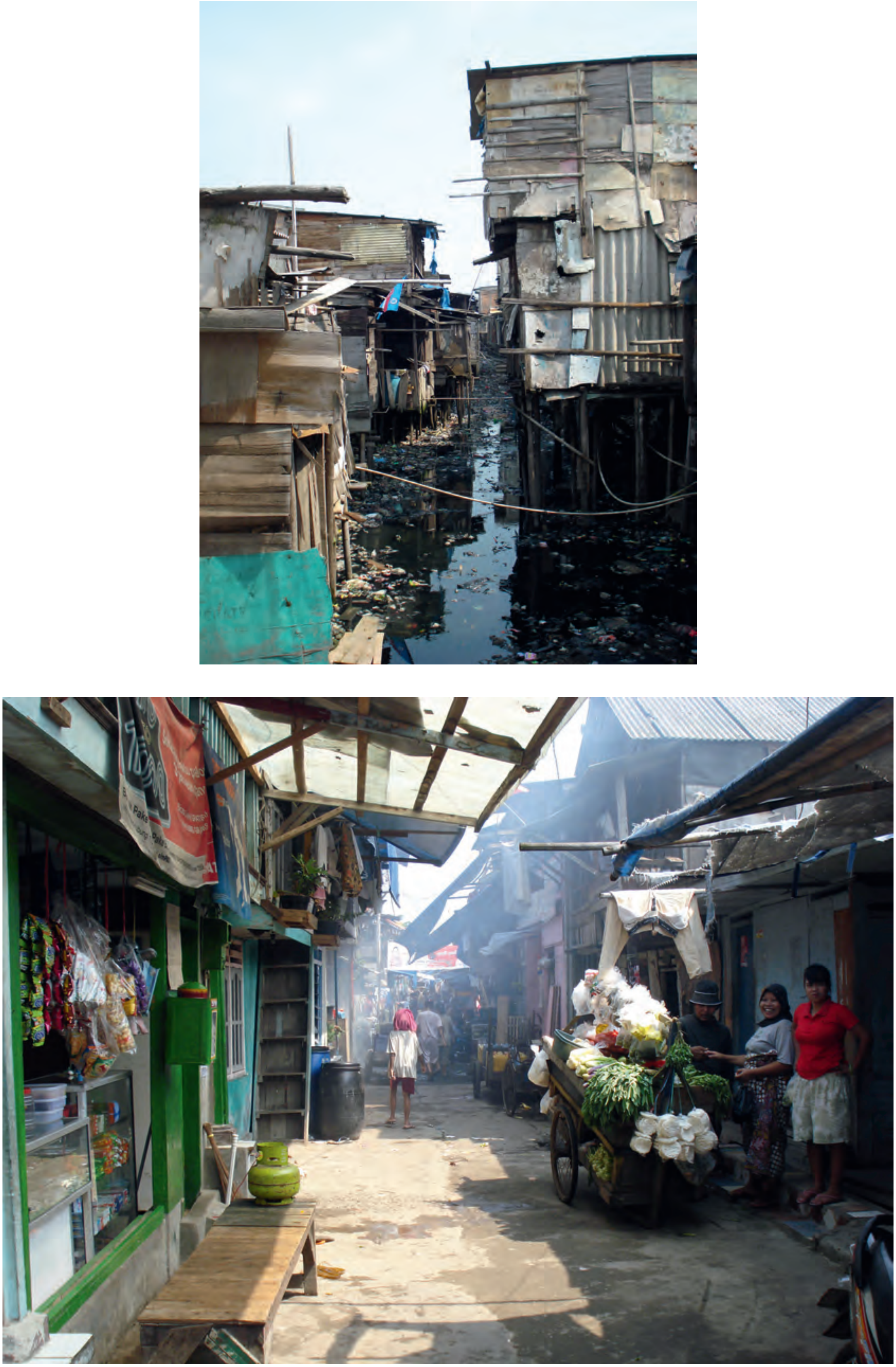


PLATE 10.3 Living conditions in Jakarta's illegal settlements

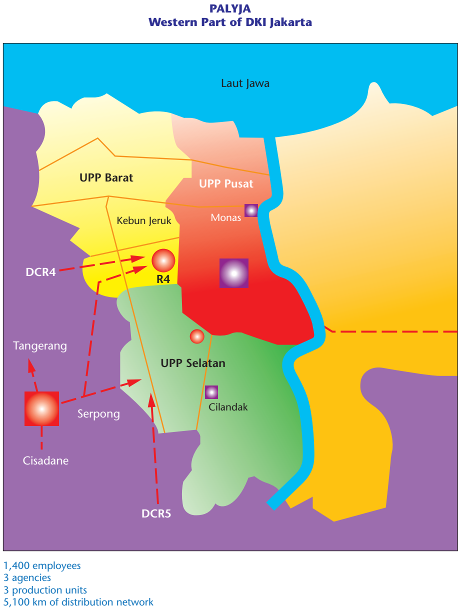


PLATE 10.4 The location of customer districts in Palyja's concession on the western side of Jakarta

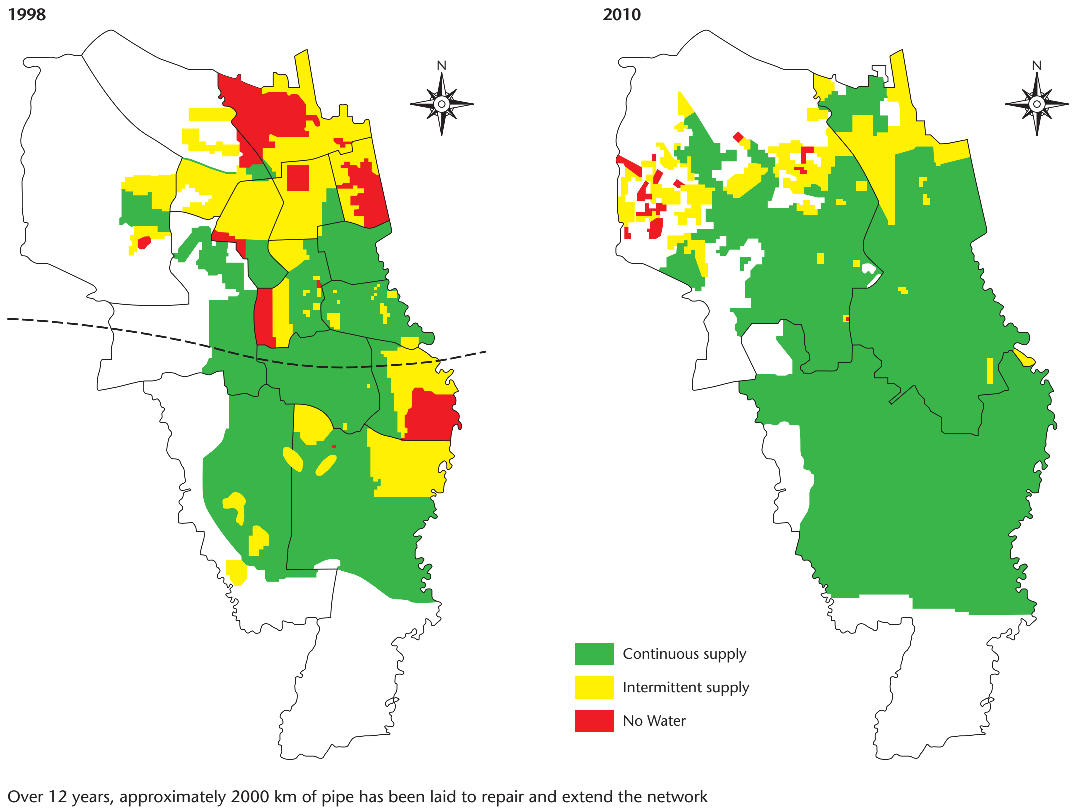


PLATE 10.5 Evolution of supply reliability from 1998 to 2009

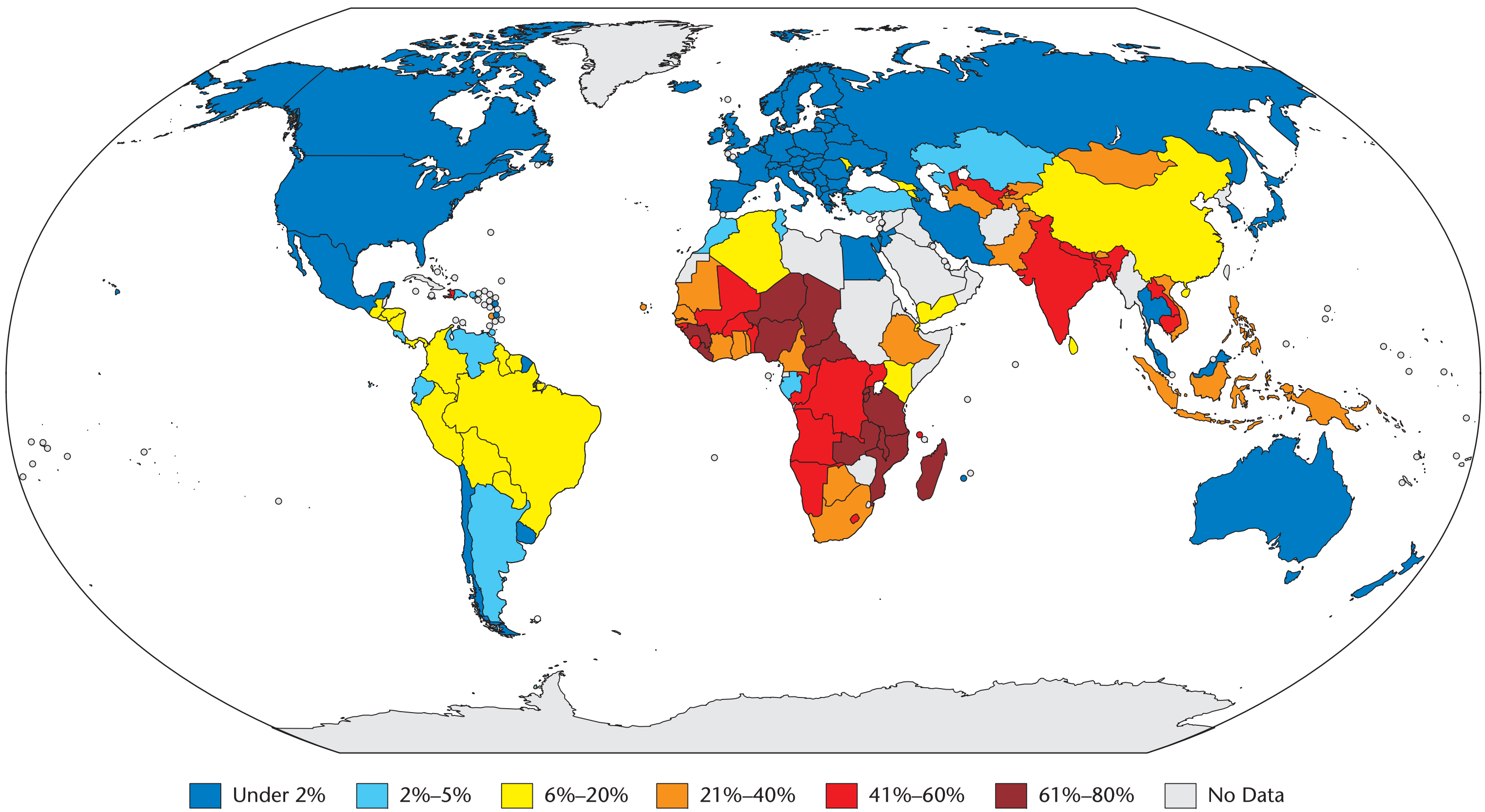


PLATE 11.1 World map showing the percentage of national populations living on less than $1.25 per day, UN Estimates 2000–2007

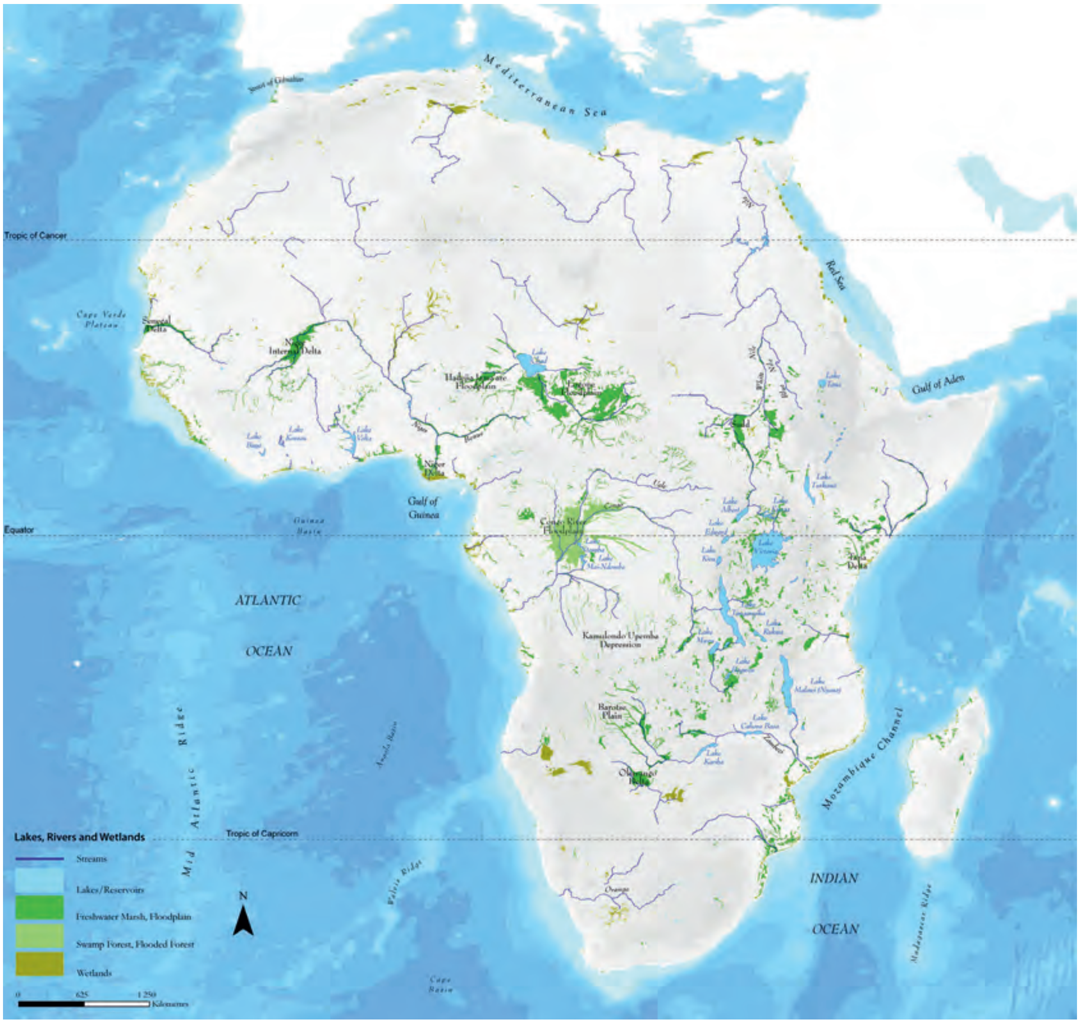


PLATE 11.2 Distribution of natural infrastructure in Sub-Saharan Africa

7

A PRIMER ON WATER FINANCING

Antonio Vives and Paulina Beato[1]

Introduction

The pricing and political problems outlined in the previous chapter are compounded by fact that the business climate in most developing countries is not conducive to investment in such a risky sector. Key elements such as macro-economic stability, rule of law, fiscal management, regulatory institutions and the functioning of the judicial system are in need of improvement in many developing countries. An enabling policy environment is critical for access to finance for the sector. This situation is exacerbated by the decrease in public and private investment in infrastructure in general and the water and sanitation sector in particular.

Private-sector participation in water investments dropped from an average of US$5.8 billion a year in the last five years of the twentieth century to less than US$2.2 a year in the first six years of the current one. Encouragingly, this lower level of participation includes more projects than before (albeit of a smaller size) and a significant increase in participation by local operators. The number of countries with private participation in such a complex sector has increased by 10 per cent in the last five years and 16 countries have introduced private participation for the first time since the low point in private participation was reached in 2000. Even the peak figures achieved in the mid-1990s were a drop in the bucket compared to existing water-finance requirements. Official development aid for the sector has also increased considerably in the last few years, as has that of multilateral donors, but the combined US$4 billion (in 2005) of these two sources are still insufficient to meet needs.

Most of the financial resources are expected to come from both national and sub-national governments, although the need is so great that the financial, technical and managerial contributions of the private sector cannot be neglected. Ways must be found to increase the availability of new public and private resources and, more particularly, to make better use of existing ones. While it must be recognized that private investment and structured finance go in and out of fashion, this does not mean that the sector can afford to ignore their potential contributions, particularly when seen in the broader context of their possible technical and managerial contributions.

The goal of this chapter is to present a schematic discussion of the issues involved in increasing the economic and financial efficiency and availability of resources for improving access to water. Given the short space available, the issues cannot be discussed in any length, and the reader is referred to the extensive bibliography at the end of the chapter.

Efficiency as a source of finance

Introduction

Water is a capital-intensive sector and significant investment is required to collect and distribute the resource. Ways must be found to increase public and private investment in the water and sanitation sector.

Reducing inefficiencies in water supply and establishing a positive environment for investment are vital steps towards sources financing. Before exploring the possibilities of obtaining public and private finance to carry out needed investments, governments must consider the elimination of technical and managerial inefficiencies in the provision of water services as well as the creation of the proper policy, regulatory and investment environment to attract investment.

The elimination of inefficiency in supply arrangements and treatment arrangements may reduce the need for further investment in infrastructure or may generate internal savings that diminish the need for external financing. In many countries, water-service provision is relatively inefficient and the potential for improvement is very high. This chapter discusses the major sources of inefficiencies only in the context of their potential for reducing capital needs and considers the need for improving the sector's enabling environment. Inefficiencies stem from technical, managerial and sectoral sources. Micro-economic inefficiencies are discussed in the previous chapter.

Technical inefficiencies

Among the major **technical inefficiencies** are non-revenue water and energy consumption; that is, losses from old pipes, illegal connections and non-metered water, which can reach upwards of 50 per cent (although an overall average could be closer to 20 per cent). Some of the losses are unavoidable, but many can be controlled. Investments to reduce non-revenue water and encourage conservation, water reuse and recycling can help avoid or postpone much more expensive capital investments. One of the major expenses in the provision of water is the cost of the electricity used mainly to pump water. In Mexico and Brazil, electricity consumption accounts for between 30 and 40 per cent of water-utility revenues. It is estimated that energy savings through efficiency improvements could reduce energy consumption by 10–40 per cent, thereby saving between 5 and 15 per cent of operating costs. Significantly, problems created by losses and energy efficiency compound one another. For instance, energy required to pump non-revenue water has a significant cost. In Brazil, 3.5 billion kWh per year is needed to pump water that is eventually lost. The cost of this electricity is over US$300 million a year. Added to that figure is the potential savings in investment costs between US$1 billion and US$1.5 billion if the water itself was not lost in the system. The potential savings would be sufficient to build and maintain a 500–1000-megawatt generator plant (which would also contribute to reducing emissions). These figures illustrate the potential energy savings of reducing non-revenue water are important, even for smaller countries.

Inefficiencies in irrigation tell a similar story and also include productivity losses resulting from the failure to manage catchments, losses due to evaporation, and losses from inappropriate irrigation and agricultural practices (such as irrigation of low-value crops or even the cultivation of high-value water-intensive crops where the marginal value of water is very high – the traditional "more crop per drop").

Managerial inefficiencies

Among the major **managerial inefficiencies** at the service-provider level are corruption, billing and collection issues, perverse consumption incentives, bloated payrolls (some public utilities are used for political patronage) and deficient management systems. The World Bank has estimated that the excess costs for civil works due to collusion between contractors are more than 15 per cent and that those resulting from kickbacks for contract awards are in the range of 6–11 per cent.

Moreover, the World Bank has found that 40 per cent of customers in South Asia reported having paid a bribe. In terms of inefficient billings and collections, it has been found regularly that not all the water used is billed, not all bills are collected and not all of the revenues collected are used efficiently. In many cases, the incentives for consumption are perverse. In many instances, there is a lack of metering, illegal unbilled connections, invoices are not issued or do not get collected and tariff structures do not provide the right incentives. In many cases, tariffs are insufficient to cover costs and are not related to the consumers' ability to pay. Correcting some of these inefficiencies can reduce costs and/or increase revenues, thereby reducing the need for additional investment.

Other managerial inefficiencies include institutional weaknesses as they relate to the capacity of the sector authorities to prepare projects that will attract public or private finance. Most of the investments, particularly in new services, are the result of projects that have identified the community needs and trade-offs, demonstrated that they are a good use of resources and included plans for effective and efficient implementation. Many countries need to improve their institutional capacity in the areas of project preparation, execution and management of the operation of the system. This is particularly relevant at the sub-national level, where most water service projects are developed. In developing countries, there are many opportunities for bilateral and multilateral aid geared to helping these countries help themselves. Indeed, several donors have developed special programmes to support project development and institutional strengthening.

Sector inefficiencies

A third major source of inefficiency surrounds **sector inefficiencies** and relates to issues of sector governance, policies and management. The water-services sector is very complicated. In addition to the competing uses of water for domestic consumption, industry, agriculture and energy, water is a politically and socially sensitive resource. There are myriad institutions and government levels involved. In most developing countries, the sector has traditionally faced scarcity of resources. In some cases, there are even cross-border management issues. There can also be a lack of national and sub-national coordination in management responsibilities as well as an inability to develop robust water-resource management policies and deal with institutional fragmentation and inefficient competition for the water resource. Limited capacity to develop management policies and regulatory institutions can be a problem too, especially when more than one level of government is involved. Clear allocation of ownership, responsibilities and resources coupled with the preparation and updating of Integrated Water Resource Management (IWRM) plans to improve allocation and management efficiency are critical ingredients of any improvement programme.

Regulation and business climate

It is important to emphasize the significance of the proper regulatory framework for the sector. With or without private participation, the water sector is so complex and sensitive that it requires strong institutions that have access to the required human and financial resources to do their job. In particular, experience has demonstrated the need for independent regulation and supervision (that is, independent from the service providers) to ensure the proper checks and balances.

As many water-service investments fall within the responsibilities of sub-national governments, their institutional and fiscal capacity will have a large impact on the water sector. Thankfully, due to decentralization, in most developing countries responsibilities fall closer to where the action is, enhancing the potential for responsiveness to local needs. Unfortunately, however, when institutional arrangements are decentralized, the rate of change of local government can get out of step with the rate of change at higher levels in a manner that creates rivalry among the political parties governing different jurisdictions. This tends to complicate these intergovernmental relationships and can make the investments unstable.

Nevertheless, the decentralization of responsibilities and fiscal transfers can make it more likely that general taxation can be used to transfer resources from areas of the country that are richer to those that are poorer. In water services, these national and regional cross-subsidies can make some investments feasible and can have a significant impact in investment, regardless of the breakdown between public and private responsibilities.

When evaluating options to stimulate investment in water services, policymakers often concentrate their efforts on specific investments. While micro-economic and sectoral conditions have an important role in determining which investments are made, usually investments develop in the broader macro-economic and institutional environment. The right investment climate is necessary to attract investment and finance. Necessary conditions include robust policies for the development of long-term financial and capital markets. Macro-economic stability is a prerequisite for almost all investment activity that involves third parties. Other directly relevant conditions that can facilitate access to financial resources at reasonable cost include the development of institutional investors with a long-term view, respect for property rights, an effective and efficient judiciary system and alternative mechanisms for the resolution of investment disputes.

As part of the reform process, it is important that institutions, policies and investment structures present all participants with the proper incentives. Public-sector ownership and operation of a water supply system can have perverse and unintended effects. For example, water managers can manipulate the budgetary process to attract more money to their sector because they historically receive large amounts and perpetuate the allocation even though it is not always spent in an efficient or purposeful way and might be better allocated to another sector. Performance contracts for senior employees may help to overcome these problems.

At a different level, as long marginal benefits exceed the cost of supply, the private sector will have an incentive to increase the number of people and communities they are willing to supply. However, without the proper administrative oversight, there is a risk that private suppliers may not provide sufficient coverage or that the quality of their services might be low. The cheapest way to provide access to water and sanitation services is through a monopoly, so it is vital that tariffs, quality, availability, coverage and the like are adequately regulated and managed.

Even where water services are operated efficiently, there will still be large needs for public and private investments in water infrastructure and services. Removing some of these inefficiencies can go a long way toward reducing costs, enhancing the availability of the resource and attracting investments.

A thorough review of the micro-economic, technical, managerial and sectoral inefficiencies is a good place to start to enhance investment in water services. In developing countries, such reviews are a very suitable use of international donor resources and can be expected to have a multiplier effect on the ability of a country to attract investments and other financial resources.

Sources and arrangements for financing water infrastructure

In order to enhance water services, it is necessary to identify ways of attracting more finance by exploring potential sources of public and private financing, and structuring investments in such a way that the availability of finance is improved (alternative financial structures and risk-mitigation tools).

Financial planning

The first step in the process of financing is to identify the needs and the financing gaps. Several models have been developed to assist governments in these tasks. The most widely used one is FEASIBLE, a software tool developed to assist in the preparation of environmental financing strategies for water, wastewater and municipal solid-waste services. FEASIBLE can be used to run an iterative process to determine financing deficits or surpluses and the structure of any gaps in financing. It can also be used to balance the required finance with that which is available (OECD 2007b). The results help policymakers understand where the main financial bottlenecks are. In addition, they can identify where, when and what additional policy interventions are needed to facilitate the effective financing of infrastructure development programmes. Figure 7.1 provides an overview of the iterative process, which is self-explanatory.

Commonly, governments will find that water supply and sanitation goals have to be scaled down to conform to available and potential resources. Alternatively, they will find that they have to resort to some of the measures discussed earlier in order to reduce demand and increase the willingness of donors or financiers to commit resources. Ultimately, the only sources of finance are users, taxpayers and donors, but time gaps in the availability of these resources need to be financed through government or directly from the private sector and subsequently recovered by way of taxes or fees.

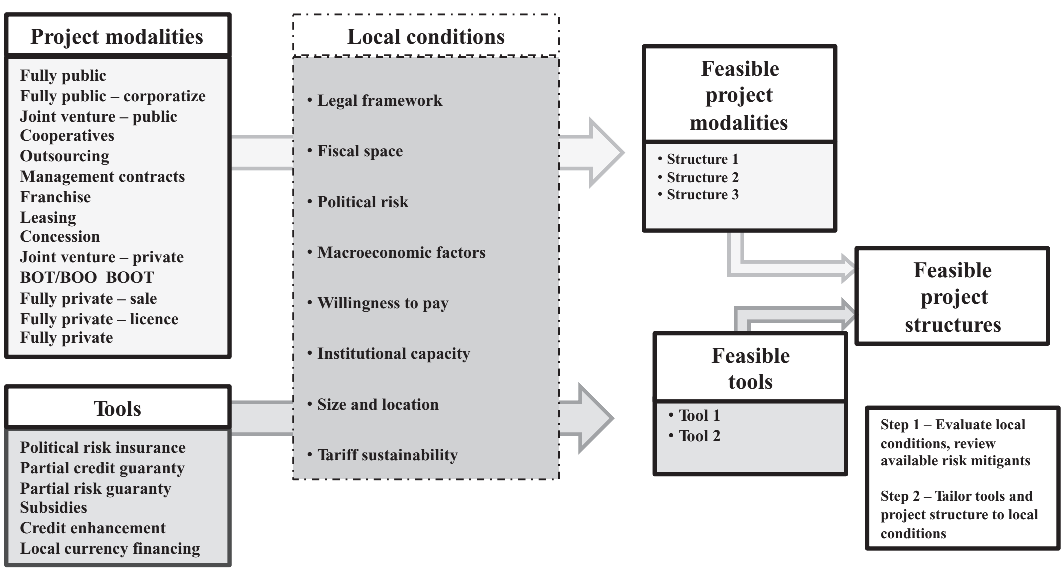


FIGURE 7.1 FEASIBLE model.

Source: OECD (2007b).

Financing sources: public and private

For a politically risky sector such as the provision of water services in a developing country, most of the financing will have to be provided by the public sector at the national and/or sub-national levels. The public sector can provide resources through capital contributions and outright loans to water utilities or through development intermediaries such as development banks or infrastructure funds, among others. These banks and funds may, in turn, seek financing either from government contributions or borrowing (loans and marketable debt instruments), as well as from equity contributions from the national and international financial markets, including multilateral development banks (most likely) and bilateral aid. These indirect instruments can leverage public resources and attract private resources through the pooling of risks (assets are invested in a pool of projects) and/or by providing explicit or implicit government guarantees (depending on the instrument structure). There are, however, quantitative limitations to the amounts of funds that can be attracted from these sources. Due diligence must be exercised to ensure that decisions follow commercial rules as funds are raised from the general public and financial markets.

Nevertheless, the large size of the unmet need to invest in the development of water supply and sanitation infrastructure, especially as populations grow, implies that the sector cannot ignore the potential of direct private investment. That is, all possible avenues must be explored. In the water sector, the low return on investment given the extent of social and political risk is an inherent problem that restricts private-sector investment. To attract private resources, it is important to enhance returns and decrease risks.

Some will argue that public-sector finance should be the preferred choice because it tends to be cheaper than private financing. However, there are limitations to the availability of public financing. Also, there are alternative uses for public resources that may not have access to private finance. That is, if scarce public resources are used to fund the development of water services, less money is available for other social services such as the provision of education and health services and the construction of roads.

In addition, the need to maintain a stable macro-economic environment means that the capacity to borrow (in local and international markets), the capacity to tax and the capacity to spend also has limits. Some of these limits arise out of International Monetary Fund guidelines on current spending (in spite of the fact that some of these may be properly classified as investments and not current spending). As a result, the choice of financing must be able to provide value for money and carefully avoid the use of private resources only as a means to bypass budgetary rules. Also, the choice of financing structures has to consider the relative efficiency gains of private-versus-public finance and operation (construction, management, operation and finance), the transactions and management costs, institutional arrangements necessary to manage and regulate the operation, opportunities for technology transfer and the need for the efficient allocation of risk. As well as these considerations, political and social feasibility has to be considered. In the next section, we consider ways to structure projects to capture the best of both the public-sector and the private-sector worlds.

When properly structured, some projects can tap domestic and international capital markets. Given that the sources of revenue for these projects are denominated in local currency, it is almost imperative that funds be raised in domestic markets. Unfortunately, in developing countries these markets tend to have limited resources and are under-developed. The most common instruments used are debt securities with or without guarantees. Some countries have been developing local institutional arrangements; in particular, arrangements are being put in place to enable pension and insurance funds to invest in water supply and sanitation projects. This involves the structuring of investment arrangements to suit their risk and/or return strategies that include doing such things as pooling projects to diversify risk, using guarantees to reduce risk and carefully selecting projects that are likely to generate a good return on investment. In recognition of emerging opportunities in this sector, there has lately been a revival in privately managed national- and international-funded infrastructure funds for the provision of finance to the water sector. This private finance has to be confined to projects and utilities that are credit-worthy in their own right.

One of these sources of financing is foreign bilateral or multilateral aid. As these resources come at either low cost or no cost at all, it is important to leverage them as much as possible (within the restrictions that they may have. Preferential use of grant resources should be used to attract other financial resources. For example, they can be used for improving sector and investment efficiency, instead of direct investment in infrastructure. Similarly, they can be used to cover revenue gaps resulting from insufficient tariffs until pricing reforms take hold and for setting up guarantee funds. Clearly, this type of aid should not be used to fund projects that are already credit-worthy. Rather, they should be used to improve the credit-worthiness of potential projects. Resources that come with a cost, such as loans from multilateral financial institutions or export credit agencies, should be used as seed finance to leverage other funds. Even better, their guarantees should be used to obtain access to other resources.

In all cases, whether the financing stems from public or private donors, it is critical that financial support be predicated on previous or concurrent sector reform and linked to performance. A prerequisite of access to finance is efficiency in all aspects of water-service provision and investment.

All options are open

The current environment of risk aversion and the experience of unsuccessful ventures, which included private participation, has the risk of creating a mindset "to throw the baby out with the bathwater." Governments need to be careful not to eschew private participation because of lack of attention to detail in the development of previous arrangements. At the very least, the private sector can bring its technical and managerial expertise to a project, even if it does not contribute any finances. In many cases, the private sector can be actively involved in the construction of a project and, in some cases, private operators can be involved in helping to operate the system. The latter can range from providing advice to managing certain functions such as maintenance, billing and fee collections and to the control of non-revenue water.

A more involved option that has recently been proposed in that of franchising, whereby an experienced private operator undertakes to transfer know-how and a business management model in exchange for an upfront fee and a percentage of revenue collected. Through this process, the local franchisee appointed to manage the utility acquires experience from an experienced private operator that can be transferred to other projects. Unlike retail franchises, most of the franchisor's involvement is in the provision of management systems and specialist assistance. Under a franchise arrangement, central management functions can continue to be provided by the franchisor, which can be most useful in regions where economies of scale are insufficient to develop all the management systems necessary for efficient operation. Nevertheless, this modality has yet to take off.

The public sector has other opportunities for engaging in non-traditional partnerships with the private sector, taking advantage of the willingness of large water users (for instance, the beverage and the mining industries) to engage in community development as part of their responsible community response for consuming a large share of the resource. This type of community involvement could take the form of providing access to their water supply systems or transferring know-how, for example. Some large water users, such as Antofagasta Minerals in Chile, have gone as far as becoming the owner of a water utility, thereby serving both its needs and those of the community. In early 2008, Pepsi announced a partnership with the Earth Institute and H_2O Africa to improve access to water, sanitation and irrigation in Brazil, China, India and Africa. As part of this partnership, they will donate US$8 million and management expertise. In mid-2007 and as part of its Global Water Compact, the United Nations launched a CEO Water Mandate that sought to engage large companies in improving and deepening their involvement in the responsible management of water resources. As of March 2010, 63 companies had adhered to the call for action and strategic principles, including Nestlé, Coca-Cola, Diageo, Unilever and Dow Chemical, among others.

Financial structuring of water projects

Given the very wide variations in the characteristics of water-services projects, the relatively high political and social risk involved and the scarcity of funds, all available sources of finance must be explored. The availability of these sources for a given investment is a function of the modality chosen for the delivery of the services. The economic, social and political conditions that prevail in the country, the governance of the sector and the availability of tools to mitigate the ever-present risk are other considerations. This section explores the most suitable investment structures given prevailing conditions. We can learn from recent projects that failed because they did not properly incorporate prevailing conditions and the sector's environment into the design of the project.

Figure 7.2 presents a schematic model for structuring of water projects. It proposes that the feasible modalities of service provision (fully public, fully private and all the possibilities in between) are a function of local conditions (legal and regulatory framework, the government's fiscal space and macro-economic

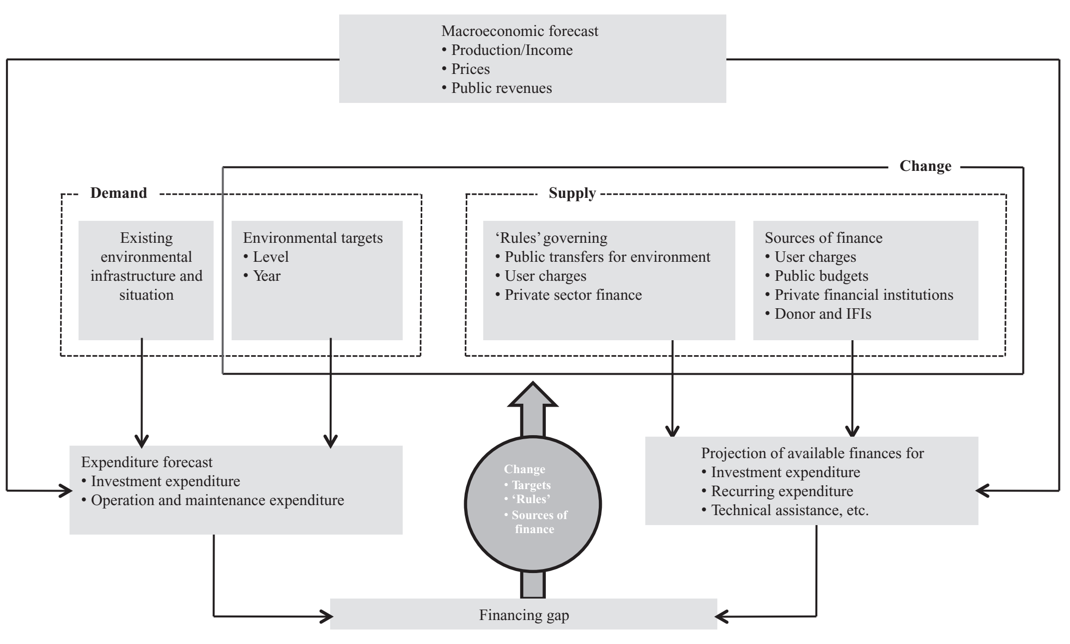


FIGURE 7.2 Financial structuring model.

Source: Vives *et al.* (2006).

factors, among others) prevailing in the country and sector, as well as the availability of risk-mitigation tools (political risk insurance, subsidies, partial credit/partial risk guarantees and the like).

Depending on the modalities of service provision, the different parties involved will face different rewards and risks and will have different incentives to perform. This will affect the efficiency of service provision and access to finance. Figure 7.2 lists 14 typical modalities. They include provision by a government office, a publicly owned public utility, cooperatives owned by the customers and various private-sector arrangements with varying responsibilities. For instance, in the case of a water-supply concession, the operator is responsible for investments, coverage, quality, collections, finance and so on, but does not own the assets. In a typical leasing case, the private sector pays a fee (or receives a fee or subsidy), does not own the assets and is not responsible for investments or finance, but is responsible for the provision of services.

In management contracts, the private sector is responsible for some aspect of service delivery (collections, maintenance or even full managerial responsibility for the service. The fact that tariffs do not cover costs does not mean that the private sector cannot have a role. It could receive subsidies from the government in the form of payments for water served (tariffs for certain users). The government has to pay for this water anyway but by involving the private sector it has an opportunity to take advantage of the sector's managerial and/or technical efficiencies. However, because there are many documented cases of publicly owned public utilities that have shown very high levels of managerial and technical inefficiency, the case is not clear cut. With the proper incentives and regulations, these wide variations in responsibilities can be used to obtain the best of both worlds; that is, the best that the public and the private sector have to offer under the prevailing conditions.

As an example, Figure 7.2 lists eight local conditions that can impact on the selection of modalities and hence financing. These conditions vary from the legal and regulatory framework to macro-economic stability and from the fiscal capacity of the government to willingness to pay and capacity to set tariffs. Not all modalities are feasible when the local conditions are less than ideal as is normally the case in developing countries. If the legal and regulatory framework is weak, the option of a water concession is unlikely to be successful, as it requires strong and effective regulation and may require recourse to the legal system to solve disputes. If there is macro-economic uncertainty, with the potential for inflation and depreciation of the currency, it will be unwise to use a modality that relies on foreign investment. If the government is politically unstable, a modality that relies on government guarantees may not succeed. If the fiscal situation of the state is weak, modalities that depend on subsidies are likely to fail. Local conditions are critical to determining how investments will be structured and financed. However, some weaknesses may be countered by the application of risk-mitigation tools.

As many of the local conditions affecting water projects in developing countries are weak, the most tempting answer is to rely on purely public-sector solutions. Complete reliance on the public sector, however, may miss significant possibilities to attract other funds and, in any case, may also fail because, at the very least, the provision of water services is dependent on a government's limited financial resources.

Some form of public provision is the most likely outcome when institutional conditions are weak, but even then arrangements can be put in place to access other funds.

There are some modalities that can work properly in the face of weak local conditions, with or without mitigation tools. If due diligence, for instance, finds that the legal framework is weak, the suitable modalities are those that do not require recourse to full public provision. When political risk is high, for example, outsourcing may be out of the question. In this scenario, if a mitigating tool such as prepayment for services provided is offered, outsourcing may yet become feasible. Similarly, if fiscal space is weak, then the only feasible private-sector modalities are those that do not need government payment. If in addition to weak fiscal space, the legal framework is weak, then all these modalities cease to be feasible. Then any form of private-sector involvement is bound to fail, sooner or later, because these modalities require strong and consistent legal and regulatory frameworks.

The model included in Figure 7.2 is just one tool for analyzing feasible modalities and identifying tools that mitigate the risk resulting from weak local conditions. Suffice to say that consideration of all possible modalities and enhancement tools may help avoid mistakes and open up some avenues to increase the flow of financial resources to the sector (Vives *et al.* 2006).

Enhancing the availability of finance through risk mitigation

The final step to increasing investment in water services (after having improved the investment environment, improved the operation of the existing assets, assessed the needs and gaps in new investments and decided on the most suitable financial structures for the investment) is to use available financial tools to mitigate as many of the investment risks as possible in order to enhance the risk and/or return profile. Some of the tools will mitigate risks inherent in the structure and some will mitigate the risks involved in the chosen finance sources. Some of these risks affect even pure public-sector projects, although those with private participation will face a broader sets of risks derived from the relationships between the public and private parties.

Space precludes consideration of all possible risks that investment in water services may entail, but for the purposes of this chapter the risks can be classified into three broad categories: construction, commercial and financial, and political risks. Construction risks are incurred during the project's construction phase and refer to things such as completion risks (likelihood that the project will be completed on time and at the budgeted cost) and associated risks including fire and accidents. Commercial and financial risks are those involved in the operation of the investment and include exposures to inflation, currency depreciation, revenue losses, interest and tenor of financing (that is, risks that arise when debt has been incurred at variable interest rates or for short periods of time, requiring refinancing. Political risks refer to changes in the contractual conditions of the investment and in the legal and regulatory environment (including devaluations and currency convertibility issue), outright expropriation and acts of war or terrorism. Some of these risks affect all projects regardless of ownership, while others are a function of the ownership and financial structure. Some are mitigated with insurance (accidents, war and terrorism, currency convertibility), others require guarantees or other contractual arrangements with third parties, and still others cannot be mitigated at any reasonable cost. We will discuss briefly some of the commercial and political risks that affect financing and are affected by financing, and their mitigation. Most of the commercial risks are simply an assumed part of doing business and are absorbed by the operation. Some risks, those of a more extraordinary nature, have to be mitigated.

The possibility of mitigating financial risks can have a significant impact on the feasibility of an investment and attracting finance for it. The most common financial risks derive from the relative underdevelopment of local financial markets and risk aversion in international ones. As a result, international willingness to supply funds is limited to those with a relatively short payback period, which is unsuited to the water services that typically seek a long-term loan. One way to mitigate this refinancing risk is to obtain a guarantee from a multilateral institution. Generally, this is in the form of a guarantee to service the debt if the borrower cannot do so. Normally, this is achieved by offering a rolling guarantee, guaranteeing, say, payment for the first year and then extending for a second year if the borrower complies with the obligations, and so on. This type of guarantee encourages the lender to agree to a longer term because it increases the likelihood that the debt will be serviced. This arrangement can also be offered to a public corporation; however, in this case, it is likely that the guarantee will be extended by the government (although then the risk of default becomes a political risk and lenders may want an external guarantee). For a fee, such guarantees help to reduce the overall cost of the loan, thereby enhancing the feasibility of an investment and of private sector participation.

Foreign-exchange exposure presents a critical risk. Sometimes projects demand equipment that has to be imported from overseas and financed from overseas. When this is the case, the debt has to be serviced in foreign currency. In such situations, exchange-rate fluctuations will have an effect on investment risk because all the revenue collected from the investment will be in local currency. This mismatch between the currency in which the debt is denominated and the currency in which the revenues are received gives rise to foreign exchange exposure and risk as exchange rates move or when currencies are devalued. Unfortunately, there are very few easy options for mitigating this risk. The most obvious one is to avoid it by obtaining credit in the local market. However, the financial markets of most developing countries are ill suited to supplying credit in the amounts and terms required for water-service projects.

Another way of mitigating this risk is to denominate the revenues in foreign exchange, as was the case in Aguas Argentinas, Buenos Aires. Unfortunately, this experience did not end well. Devaluation hit with a vengeance and the required increase in the tariff was politically and economically unsustainable. Notwithstanding the Aguas Argentinas experience, this option may work when expectations are that currency depreciation will be small and incremental, if at all. This would be very similar to indexing tariffs to inflation. If mitigated this way, the commercial risk becomes a political risk because the government or regulator will have to approve the increase in tariffs. Such arrangements, however, tend to break down as elections near. If expectations are that exchange rates are not headed in a single direction (namely down), another option for mitigating these risks is to obtain contingent lines of credit to cover the temporary shortfalls in the hope of recovering the losses when the trend reverses. Finally, foreign-exchange risk can also be mitigated by setting tariffs above the required level, thus generating extra revenues that can be saved for use when tariffs are not sufficient to provide the minimum revenues required. The latter option can seldom be put into place; however, all options should be explored.

Multilateral institutions such as the World Bank and regional development banks provide credit risk guarantees, which are normally called partial risk guarantees because they only cover the default arising out of certain predetermined events (not just any event). Alternatively, partial credit guarantees (as opposed to partial risk guarantees) cover a portion of the credit default under a broader range of circumstances. Full credit guarantees cover the entire amount of the loan. Normally used to enhance the credit rating of local or international debt issues, they are guaranteed by what are called monoline (specialized) insurers. For a fee, these guarantees can reduce the cost of debt and increase the availability of finance by allowing the project to tap other financial markets and other market players like institutional investors.

Another large group of risks are known as political and regulatory risks. These refer to the exposure of the investments to political and regulatory decisions. Investment in public services, which is normally provided by a monopoly, cannot be left to the market to allocate. Government regulation is needed regardless of the ownership of the assets and responsibility of the operation. The nature of water resources makes its regulation even more compelling. Tariffs, quality, coverage, termination payments (to a private operator at the expected or unforeseen termination of the project) and off-take payments (say, for the purchase of bulk water) are some of the areas subject to regulation. This gives rise to what is referred to as policy risk; that is, the risk resulting from changes in government policies.

Governments, for example, may not agree with the service provider about the need to increase tariffs, improve the reliability of the water supply system or expand the service or speed with which the service coverage is achieved. Alternatively, for example, a government may simply refuse to honour an agreement to increase a tariff to the extent provided for in an agreement. Unfortunately, the main options for managing these types of risks are limited. They include ensuring that regulators are competent and independent, that service providers have recourse to binding, independent arbitration and that the judicial system is efficient, effective and fair (as a measure of last resort). These policy risks are harder to mitigate and guarantee, and insurance agencies provide little coverage for them (although some are starting to include policy risks among their products). Some agencies will guarantee specific events such as the termination payment (for which they normally obtain counter-guarantees from a government). As the departure of many private operators from the water sector in Latin America clearly shows, however, policy failures have been the most common cause of investment failures in the sector. These failures can lead to what is called creeping expropriation; that is, the loss in the value of an investment resulting from violations of the original agreements. In the case of private-sector capital, this may lead to the failure of the investment, while in the case of a publicly owned utility it may lead to the deterioration of service and the need for additional public funds.

The problems created by currency convertibility are also in the hands of the government. If the project has external financing (equity and/or debt), it will need to convert the local currency earned into foreign exchange to service its debts in a timely fashion (this does not refer to the value of the exchange rate, which was addressed above, but to the availability of foreign exchange). Some countries will provide assurances and/or guarantees of availability but the risk remains. This type of convertibility insurance is provided by international agencies such as the Multilateral Investment Guarantee Agency (MIGA) and national export credit agencies (for investments by the country's nationals). They also provide insurance against what are called acts of war and outright expropriation (but not for creeping expropriation, as mentioned earlier). This is "traditional" political risk insurance. There have been some recent extensions of this political risk insurance to cover breach of contracts and arbitration award default (that is, when the government does not recognize the results of the binding arbitration).

More complicated guarantees or insurance to cover the event that a government may not honour its contractual obligations (policy risk) have been emerging as well. For the most part, they are provided by multilateral financial institutions. Policies cover failure to pay termination payments, off-take payments, subsidies, failure to increase tariffs, failure to supply inputs, and specified changes in laws, regulations, taxes and the cancellation of licenses, among other risks. As these are very specific risks and the consequences can be very large, the approach has been almost on a case-by-case basis. Unlike traditional political risk insurance that can be analyzed based on past experience, these policy risk policies tend to be unique.

After an initial project structure has been selected, including the risk mitigators, further analysis must be conducted to make sure that one risk is not substituted by another, such as converting a commercial risk (revenue) into a political risk by taking on a government guarantee. If this is the case, then the government's political and fiscal capacity to pay and its political will and freedom from political interference to honour those commitments will have to be considered.

And finally, it must be remembered that water services are a strategic and social service, considered by many to be a basic human right. As such, there will always be the risk that some governments will want to have control of these services, particularly at the sub-national level, where governments are more visible, and the level of institutional development is less. These risks are very hard to avoid. If the analysis shows that they are present in a given situation, then structures with some public-sector involvement should be considered, sometimes sacrificing potential sources of finance and technological and managerial know-how. The long-term sustainability of the services is also a key consideration.

The way forward

The two keys aspects that define the water sector now and in the future are increasing water scarcity and the rising cost of supplying water to users. If the high cost of expanding water supply and its scarcity were translated into higher water-supply charges, demand for water would be reduced. Moreover, high charges would generate enough cash flow to finance new investment. However, it is not that simple, and this does not happen because prices and allocation usually involve a social dimension and are generally determined without reference to basic economic and financial realities.

This chapter has summarized the economic principles, the institutional and investment policies, the efficiency measures and the financial sources and structures that need to be in place to enhance water investments and facilitate access to water. While the economic policies, institutions and financing tools are known, their implementation is fraught with great difficulty. Prime causes arise from political and social resistance to change and a lack of human and financial resources. While some of these difficulties will be hard to overcome, the rewards of the implementation of the proper policies are large and must be pursued, wherever possible.

Notes

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8

THE EFFECTIVENESS OF ALTERNATIVE WATER-GOVERNANCE ARRANGEMENTS

Claude Ménard and Rathinasamy Maria Saleth[1]

Introduction

There is a consensus both in the literature and policy circles that "water crisis is essentially a crisis of governance" (Global Water Partnership 2000). This fact applies equally to both the water sector as a whole as well as its main subsectors, i.e. urban water supply and irrigation. Given the economic, social, and environmental costs associated with ineffective water-governance arrangements, there is an urgent need to evaluate the effectiveness of existing water-governance arrangements and their alternatives. Such an evaluation requires a clear, operationally applicable and commonly understood definition of water governance and its alternative forms and their key features and indicators of effectiveness applicable at various scales. Such an operational and analytical understanding can form the basis for evaluating alternative water-governance arrangements in terms of their ability to meet the efficiency, equity, and sustainability goals. It can also form the basis for the evaluation of ongoing and proposed reforms that might improve the effectiveness of water governance in specific contexts.

Given the strong and positive association between effective governance and better development outcomes (Kaufmann *et al.* 1999), many countries have been trying to improve the effectiveness of water governance through various forms of institutional reforms and technical modifications over the past two decades. Although such reforms are neither uniform across countries or across water subsectors, there are certain common trends and patterns. While countries with institutionally advanced water sectors are going for high-level institutional changes, in other countries there is a gradual move away from state-centric and centralized forms to more user-centric, market-based, and inclusive forms of governance. There is an increasing tendency towards basin-based decentralization, better cost recovery, water-demand management, and user and private-sector participation (Saleth and Dinar 2000; Tropp 2007). The changes brought by reforms have changed the governance structure in the water sector in general and water subsectors in particular.

A comparative approach, based on numerous experiences of water governance reforms in many different countries (see Shirley 2002; Saleth and Dinar 2004, 2005, 2006) suggests that there is no optimal answer to the problems of urban water and irrigation governance problems. There is no particular arrangement that would be effective in all contexts. This is because the success of a specific arrangement, its implementation, and its monitoring depends on its relationship with the suite of institutional arrangements within which it sits. At a general level, this means that there is the need for a collection of polycentric governance systems to meet the goals of efficiency and equity in different contexts. As a result, and this is what we commonly observe most of the time, we have a mix of systems. This raises a difficult problem for decision-makers because selecting effective governance requires identifying its feasibility, which depends on different considerations including the efficiency, equity, and sustainability dimensions in specific circumstances.

This chapter aims to provide some answers using both theoretical considerations as well as practical illustrations at the subsectoral levels of urban water supply and irrigation, as well as at the water sector as a whole. It examines different possibilities to deal with governance issues appropriately using several criteria, particularly feasibility, performance efficiency, transparency of the process, and accountability of decision-makers. It also derives certain guidelines and principles that can be used to enhance the effectiveness of water governance in subsectoral and the general water sector context.

The chapter is organized as follows. The next section discusses the concept and analytics of water governance. This is followed with an examination of the alternative modes of organization that can be implemented in urban and/or rural water supply and in irrigation. Experience with past and ongoing reforms is then examined so that lessons with regard to the effectiveness of utilities generally and the water sector as a whole can be identified. The last sections identify principles and propose guidelines for accompanying reforms so that recommendations can be made to policymakers.

Water governance: concept and framework

Like the general concept of governance, the concept of water governance also has different definitions. While Franks (2004) discusses the historical evolution of the concept of water governance, Rogers and Hall (2003) and Tropp (2007) have provided a review of different definitions of governance in general and water governance in particular. The Global Water Partnership (2002) defines water governance as the range of political, social, economic, and administrative systems that are in place to develop and manage water resources, and the delivery of water services at different levels of society.

According to Rogers and Hall (2003), the concept of water governance:

> . . . encompasses laws, regulations, and institutions but it also relates to government policies and actions, to domestic activities, and to networks of influence, including international market forces, the private sector and civil society. These in turn are affected by the political systems within which they function. National sovereignty, social values or political ideology may have a strong impact on attempts to change governance arrangements related to the water sector, as is the case for example, with land and water rights or corruption.

This looks to be a very general definition of water governance but, from an institutional economics perspective, it sheds light on the two analytical dimensions of governance: "governance framework or environment" and "governance structure", including their main institutional components (North 1990; Saleth and Dinar 2004).

Figures 8.1 and 8.2 summarize relationships between the environment and water governance (Saleth and Dinar 2004, 2005). From the perspective of water, the governance environment covers the elements of the general governance system in the country, including the constitution, political arrangements, resources potential, development stage, and population, among other considerations. In the water sector, institutional performance is affected by the interaction of all these arrangements. The interaction process

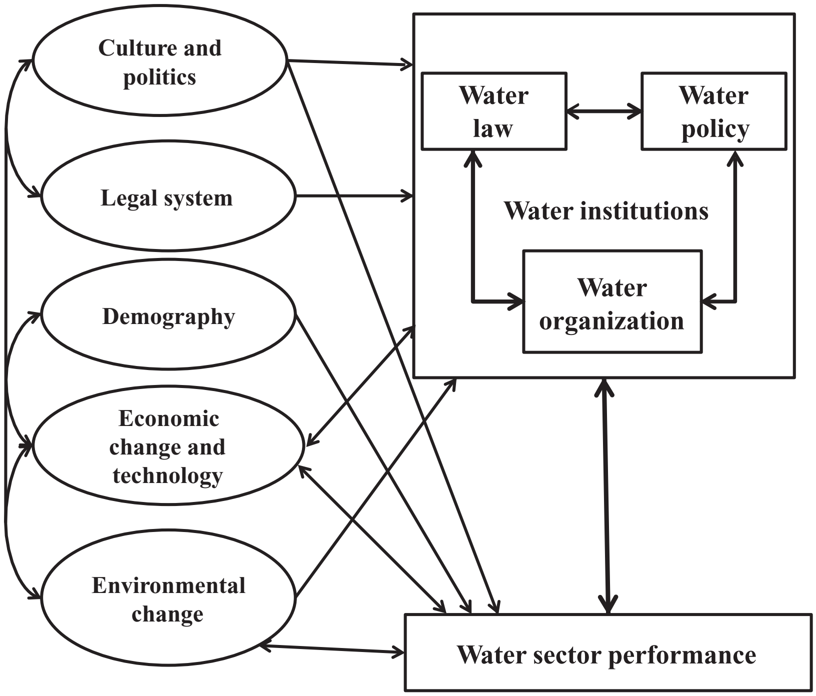

FIGURE 8.1 Arrangements influencing institutional performance in the water sector.

Source: Saleth and Dinar (2004).

is influenced by factors that are both exogenous and endogenous to the water sector and its institutional arrangements. A change in any of these factors can, therefore, affect not only the process of institutional change but also the performance of the water sector. The governance structure, on the other hand, captures the institutional basis of water governance and covers essentially the water-related legal, policy, and organizational elements (Ostrom 1990; Saleth and Dinar 2004).

To see these elements, one can follow the following unbundling exercise. Initially, water governance structure is unbundled to identify its three main components – water law, water policy, and water organization. Then each of these components is unbundled further to identify the key institutional aspects (see Figure 8.1). The main advantage of this exercise is that it is possible to trace the structural and functional linkages evident both within and across institutional components.

Figure 8.1 indicates the embedded nature of water governance within the overall socio-economic, political, and resource context. In other words, the water-governance system functions within the general governance system of the country, indicating also the sources from which reform pressures can originate. While Figures 8.1 and 8.2 deal with water governance at the overall sectoral level, water governance systems can also be identified in different sectoral and spatial contexts. They will have unique characteristics depending on whether the water is required for drinking, irrigation, or other purposes and whether or not the scale involves local urban, rural, national, basin, region, watershed, or city use. But these context-specific governance arrangements are hierarchically or vertically intersecting due to intersectoral and interregional water dependence. Thus, the nature of the alternative governance

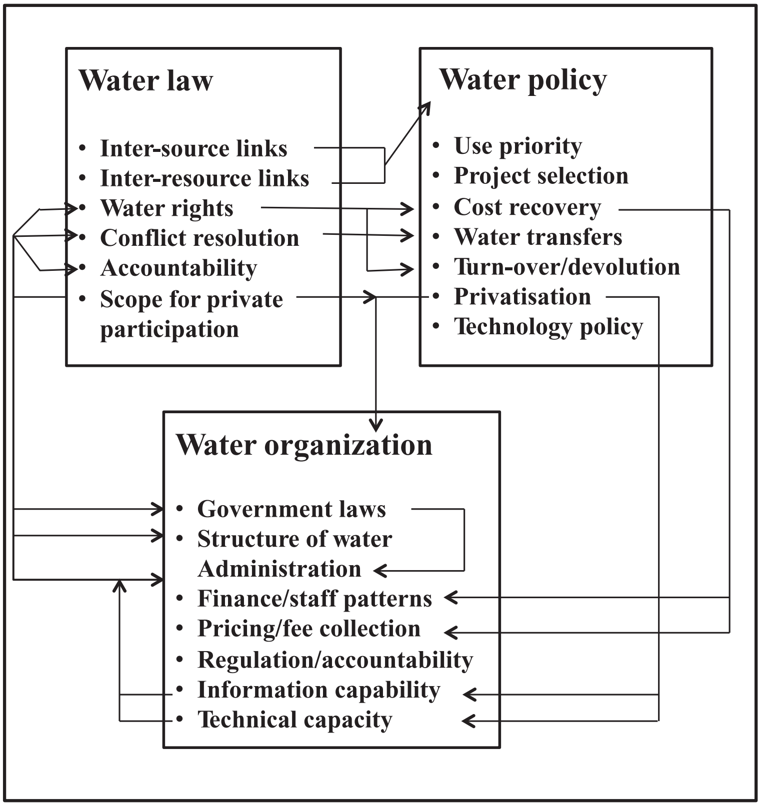

FIGURE 8.2 Water governance structure.

Source: Saleth and Dinar (2004).

arrangements and their effectiveness depend clearly on the context or the unit of analysis (Ostrom 1990). There is also an important issue of the governance scale and forms (Huitema and Bressers 2007; Tropp 2007). While evaluating the effectiveness of alternative governance arrangements, there is a need for a distinction between governance forms in terms of centralized versus decentralized, single state actor versus multiple actors and stakeholders, top-down versus bottom-up, and bureaucratic versus market-centric. Connected with this, especially in the context of decentralized governance, is the issue of "poly-centric" and "distributed" governance (Kooiman 1993; Keohane and Ostrom 1995; Ostrom *et al.* 1999), where there are parallel but related governance arrangements functioning side-by-side in different levels and contexts.

There are at least three different dimensions or levels of governance that need to be aligned. At the physical and/or technical level, the set of feasible solutions is already restricted by different constraints that need to be taken into account, including the geology of the region, its hydrogeology, the density of population and its distribution over the relevant territory, the existence (or not) of urban planning, the characteristics of the existing water network, and so forth. At the organizational level, the choice of a specific arrangement is also conditional on several factors, including the existence of expertise among local or regional authorities, the availability of adequate financial resources, the possibility of private-sector participation, which in turn depends on the status of financial markets and the risks at stake, and finally the existence and availability of competent management. At the institutional level, the combination of policymaking and the political process that provides its backbone, which in water systems always involves local and regional authorities, and of the existence of more or less efficient dispute resolution mechanisms (including courts), also condition the type of arrangement that will be feasible. Three major consequences result from this complexity. First, because of the diversity of situations at these three levels, we necessarily need a poly-centric approach that can meet this diversity, an issue of particular significance in water systems that differentiates it from other infrastructures (e.g. electricity or telecommunications). Second, a key issue for the implementation of successful governance as a whole is that the feasibility of a solution and its success will depend on its capacity to appropriately align the three levels of governance identified above. Third, reforming and monitoring water governance is necessarily a team exercise involving different experts, policymakers, and concerned populations. In that respect, the capacity to build consensus is a decisive aspect of effective governance.

How does one evaluate the effectiveness of governance arrangements? This issue can be addressed both from a qualitative and quantitative perspective. The indicators of effective governess suggested by Rogers and Hall (2003) capture essentially the desirable features of effective governance such as: (a) transparency, (b) accountability, (c) participatory, (d) communicative, (e) integrative, (f) efficiency, (g) incentive-compatibility, (h) sustainability and (i) equity. One can also add feasibility and replicability, given the technical, social, and information conditions present in many developing countries. Although some of these features can be assessed quantitatively in a specific context (e.g. efficiency and equity), others can be evaluated largely from a qualitative perspective. But, the effectiveness of particular elements of governance (legal, policy, and organizational aspects) can be evaluated more closely using specific economic and technical variables such as those based on pricing, cost recovery, use efficiency, conflict reduction, supply adequacy and coverage, and the reduction of unaccounted-for water. The variable-based indicators are particularly effective in evaluating water governance at the regional and subsectoral levels. While evaluating different water-governance arrangements in this paper, both the quantitative indicators as well as qualitative features that are listed above will be used.

Alternative water-governance systems

Different forms of governance are available for managing water in urban water supply and irrigation sectors. They are easier to identify and evaluate for their performance in specific sectors and contexts. Although they are treated as alternatives in specific context, from a general perspective they are complementary in the sense that they can operate side-by-side to meet the specific sectoral and regional water requirements. This is illustrated in this section in the specific contexts of water supply and irrigation sectors.

Water-governance arrangements in urban supply

There is a variety of possible arrangements for providing drinkable water in an urban environment. The main arrangements are now relatively well known and have been implemented in many different environments. They can be identified through the allocation of property rights (and the associated decision rights) and the allocation of risks (and the associated incentives) (see Figure 8.3).

At one extreme, the water entity providing water is government owned and operated, either as a bureau or agency that is part of a ministry, or as a publicly owned corporation operating with greater autonomy. At the other extreme, the water entity is sold and the provision of water services controlled by a private firm that is usually highly regulated. Between these polar cases, we find a whole range of

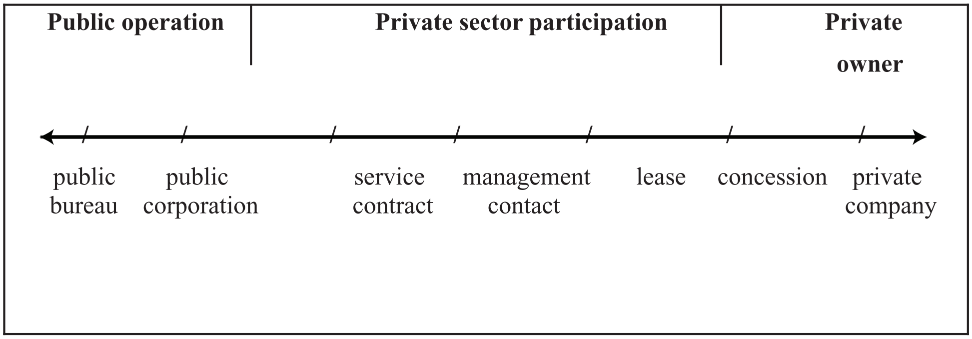

FIGURE 8.3 Allocation of rights that defines different institutional arrangements for the supply of water.
Source: Ménard (2009).

public-private arrangements, based on contracts in which property rights and/or decision rights are shared and risks more or less supported by one party (most of the time, public authorities as a last resort).

Service contracts are cases where a private firm is paid for delivering specific services in response to a purchase order (e.g. fixing leaks or collecting bills). The private operator carries almost no risk, beside default of payment from public authorities.

Management contracts transfer some decision rights to a private operator, who has ongoing responsibility for managing most or all daily operations, usually for a management fee. However, property rights and risks remain with the authority.

Lease contracts give the private operator full responsibility for management and maintenance. The government is in charge of major investments and the operator is usually paid in part or entirely from the profits of the company.

Concessions, often identified as the "French model", are contracts that transfer investment, maintenance decisions, and risks, as well as management to a private operator for a relatively long period of time, where the operator is in principle[2] paid entirely from profits.

Choosing the right duck for the right pond remains a controversial issue. Recent reforms in urban water systems have been motivated mainly by two different, although often complementary, goals:

- First, to reduce the gap between supply and demand, which remains a major issue for a substantial part of the world population and raises problems of effectiveness as well as of equity.
- Second, to reach that goal efficiently in a context of increasing environmental and financial constraints.

Three main solutions, each one with its own problems, seem to prevail in developed as well as developing countries. First, there has been a shift from bureaus to corporatization for those water utilities that remain under full public control. Corporatization gives autonomy to decision-makers, essentially the management and the capacity to control investment cycles without being entirely captured by political cycles. However, public corporations are often faced with incentive problems and remain at risk of political interference. Second, full privatization has been implemented in some countries, although this solution is uncommon due to the political sensitivity associated with the use of markets to manage water. Specification of water rights to the degree necessary to enable the use of market mechanisms

TABLE 8.1 Urban water governance: characteristics and problems of major arrangements

Particulars	*Public corporation*	*Management contract*	*Lease contract*	*Privatization*
Property rights	Public	Public	Infrastructure: public Equipment: private	Private
Autonomy of decision rights	Partial (political control in last resort)	Limited. Strategic decisions remain in public hands	Extended, but also dependent on decisions of public authorities	In theory: total. But: highly regulated
Risk sharing	None: public	None: public	Very limited for lessee	Total (but can be limited by contractual clauses)
Incentives	Weak	Weak (cost plus system)	Intermediate	Strong
Mode of regulation	Command-and-control	Combination of public bureau and contract	Through contracts or competition laws	Regulatory agency
Political interferences	Significant	Significant	Mostly on strategic decisions (through control over major investments)	In principle: none In practice: through regulator

to manage water is difficult. Nevertheless, it is being tried with varying degrees of success in Australia, the UK, the USA, and Chile.[3] Third, private-sector participation became highly fashionable in the reform of the water sector in the 1990s, mainly through management or lease contracts, with mixed results (Gassner *et al*. 2009). Some problems that have plagued these solutions relate to the risk of political opportunism and the reluctance of private operators to support financial risks associated with the long-term investments that prevail in the urban water sector. Others include the difficulties of adequate regulation. Public authorities frequently find themselves squeezed between operators and users when fixing and regulating water prices and they must also balance the need to control operators efficiently without undue interference.

A controversial alternative that has existed in rural areas for a long time and has surfaced in some large cities recently is the concept of a local self-sustained system. Self-sustained systems rely on collective actions; for example, when inhabitants of a neighbourhood organize themselves to pump and deliver water from an underground reservoir. However, these solutions have limited capacities to provide drinkable water in large cities and raise important environmental problems. Table 8.1 summarizes some characteristics and problems of these leading organizational arrangements.

Water-governance arrangements in the irrigation sector

The alternative water-governance arrangements in the urban sector are distinguished and evaluated in terms of the different forms of public and private roles in asset ownership, operational management, and contractual arrangements, regulations and mutual responsibilities. Similar principles apply to an even greater extent in the irrigation subsector where governance arrangements can be differentiated by property right regimes. Rogers and Hall (2003) suggest that open access, common property, private property and state property provide an appropriate classification. From an organizational perspective, since irrigation-governance systems vary in terms of their key features and coverage, they can also be differentiated in terms of their regional structure such as those based on basins, projects, and administrative regions, as well as their focus such as those based on quantity and quality, and also whether or not they are surface water and groundwater based. Since the irrigation sector is spatially vast and physically diverse, all these forms of governance can coexist and be designed to fit different regional, agronomic, and socio-economic requirements. From a governance perspective, they can also be classified as "hierarchical", "poly-centric", "distributed", and "market-centric" (Kooiman 1993; Keohane and Ostrom 1995; Ostrom *et al*. 1999; Rogers and Hall 2003). There are also some new forms of governance arrangements such as those that involve irrigation companies (as in Australia and the USA), as well as those based on the formation of irrigation water development corporations as is being trialled in India (see Box 8.1).

Box 8.1 EMERGENCE OF WATER CORPORATIONS IN INDIA

The creation of autonomous water corporations in several Indian states represents a new development in irrigation water governance.

These corporations aim to mobilize private funds through water bonds for development irrigation projects. For instance, Karnataka has formed the Krishna Bhagya Jal Nigam Limited (KBJNL) in 1994 under the Companies Act. With a high return (about 17.5 percent) and government guarantee, the water bonds issued by KBJNL fetched an unexpected sum of Rs. 23 billion (US$1 = 46.8 Rs) during 1995–1999. Similarly, the Maharashtra Krishna Valley Development Corporation (MKVDC) floated by Maharashtra in 1996 mobilized Rs. 4.28 billion as against the target of only Rs. 1.5 billion for 1996.

As these corporations are expected to run on commercial principle, they are likely to enhance the financial viability and productivity of the irrigation sector. As these are public corporations, they are also likely to improve accountability and transparency in irrigation management.

Source: Saleth (2004).

Despite the diversity in their features and functional roles, the main forms of water governance that are observed in the irrigation sector can be broadly identified as no governance (open access), centralized bureaucratic systems, market- or negotiation-driven systems, and community- and user-based arrangements (common pool resources). From a spatial perspective, these arrangements are also operating at different spatial scales such as basin, watershed and administrative regions. Although some forms of governance arrangements can be alternative (e.g. bureaucratic and market-based), in many contexts they can also be complementary in the sense that even within a centralized and bureaucratic system, user groups and market-based water allocation can operate. Obviously, a centralized system is better as it reduces the anarchy in resource use associated with the open-access condition in terms of criteria such as efficiency and equity. However, when compared to a decentralized user-based or market-oriented system, a centralized system cannot be considered effective because it fails to meet the desirable features of efficiency, accountability, transparency, and participation. Then again, a market-based system, although efficient and transparent, may not be able to meet the equity and sustainability criteria that often requires some form of social control through some type of regulation. Similarly, decentralized arrangements are effective in terms of transparency and participation, from the view of the planning and coordination requirement of the goal of integrated water-resource management but may not be that effective, unless they are functioning within an overall framework of centralized coordination. Community-based governance arrangements, although effective in addressing equity, participatory, and sustainability requirements, in view of a high degree of their context-specificity, can be difficult to upscale or replicate.

There is a rich body of knowledge on the nature and features of water-governance arrangements in the irrigation sector in a wide variety of countries around the world (Maass and Anderson 1978; Keohane and Ostrom 1995; Ostrom 1990; Ostrom *et al.* 1999; Saleth and Dinar 2000, 2004). Broadly speaking, water-rights-centred and market-oriented governance arrangements are common in irrigation water management countries such as the USA, Australia, Chile, and Mexico. Similarly, community-based governance arrangements exist in many developing countries such as India, Nepal, and Bangladesh, as well as some countries in Africa.

In India, for instance, while community-based governance arrangements were the dominant form in the pre-colonial era, with the development of large-scale irrigation projects during the British period, they have been sidelined or replaced by centralized bureaucratic governance. Today, they are confined to few pockets, especially in fragile resource regions. This is also true of most British colonies in Asia and Africa as well. As a result, the dominant form of irrigation governance in most developing countries is centralized governance, with state playing the major role in water development, allocation, and management. However, with the promotion of irrigation management transfer (IMT) to outlet and system level water user associations and with the advent of the pump technologies, there has been some dilution in the centralized system. This dilution has not been uniform across developing countries and the extent of it depends on the degree of success of the IMT program. It has been quite effective in Mexico (see Box 8.2) and relatively successful in countries including Columbia, Turkey, Philippines, Indonesia, and India (Vermillion 1997). As far as the governance of groundwater irrigation, most countries lack any systematic governance arrangements, leading to anarchy in groundwater withdrawal and use. Although there has not been any formal and lawful water-rights system, de facto rights within the open access system and groundwater markets have emerged, as observed widely in several countries such as India, Pakistan, China, and Bangladesh. A review of groundwater markets in India, for instance, suggests that they are quite effective in promoting efficiency in water use as well as equity in the access to water by small farmers (Saleth 2004).

Box 8.2 IRRIGATION MANAGEMENT TRANSFER IN MEXICO

The main plank irrigation reform in Mexico was the transfer of irrigation management to farmer associations. This programme covered almost all irrigation schemes in the country. The evaluation of the programme suggests that the outcomes were positive on all counts. As compared to the pre-reform period (1988), water fees paid by water users rose from 18 to 80 per cent of the operation and maintenance costs. The efficiency of water distribution rose from 8 to 65 per cent. Along with a general reduction in operation and maintenance costs, there has also been a 50 percent reduction in the size of irrigation bureaucracy. A farmers' survey suggests that 80 per cent of the respondents reported that the reform had improved water management. Although there are still financial difficulties and scarcity issues, the transfer from a centralized and state-operated system to water users has certainly improved irrigation and yield performance in Mexico.

The centralized bureaucratic arrangements observed in many developing countries are gradually evolving to accommodate user participation and market role as well as community decision-making within the irrigation sector. Considering the vast and diverse nature of the irrigation sector, with millions of small farmers observed in many developing countries, the sudden introduction of governance arrangements centred on water rights and market-based transaction may not be that easy. As the irrigation sector matures, such governance arrangements are expected to evolve, especially in areas with advanced and commercialized agriculture. Such an evolution is expected to be faster in countries such as China, Mexico, Chile, Spain, and South Africa but would be slower in countries such as India, Pakistan, and Sri Lanka (Saleth and Dinar 2000). While different forms of irrigation governance have their own advantages and defects in terms of the desirable criteria of effective governance, in many contexts these forms are complimentary and can meet the requirements of different regional contexts. Although one cannot be dogmatic about the appropriateness of different governance arrangements, especially in the irrigation sector, it is still necessary to ensure some universally acceptable attributes of effective governance (Rogers and Hall 2003).

Reforming water-governance arrangements

For establishing more effective water governance, there is a critical need to create an enabling environment that can promote public- and private-sector involvement and wider stakeholder participation (Rogers and Hall 2003). The creation of an enabling environment requires various forms of reforms in the water institutional structure that provide the operational form for water governance in different contexts. The choice between the different possible arrangements described above is determined not so much by the search for the best feasible solution as by forces pushing towards changes in governance. In most cases, it is a combination of macro-economic tensions, particularly in public finance, and subsector problems, which are distinct in irrigation and in drinkable urban water, that triggers the search for more effective governance. In that respect, environmental issues entered into the picture quite recently and permeate the debate about water governance very slowly.

Governance reforms in urban water: requirements and trends

In what follows, we discuss the nature and role of the main forces at work and their respective weight in engaging changes in the governance of water systems. Figure 8.4 depicts the factors that motivate reforms in urban water governance. The balance of these forces determine expectations with respect to: (a) accessibility, both in terms of connection and continuity of services; (b) affordability, which depends on pricing and its capacity to either provide enough resources to make adequate investments or to provide sufficient guarantee to borrow from financial markets; (c) safety, which relates to the continuity and quality of water delivered; and (d) sustainability, which concerns externalities in the short term (e.g. damages to the road system due to leakages or flood resulting from poor maintenance or insufficient investments) and the capacity to maintain the resource (and its quality) in the long term.

Because of their very nature, which is that water systems are local or regional, potential benefits of a reform in the governance of water are quite modest for national politicians. Hence, what might change political preferences? With the exception of rivers that raise geopolitical issues (e.g. the Jordan or the Nile), pressures are mostly on local and regional politicians and reach higher levels of government largely through their influence. Therefore, it is primarily at that level that pressures for change come, or should be put. Unsatisfied demand and service problems play a major role in that respect since reforms

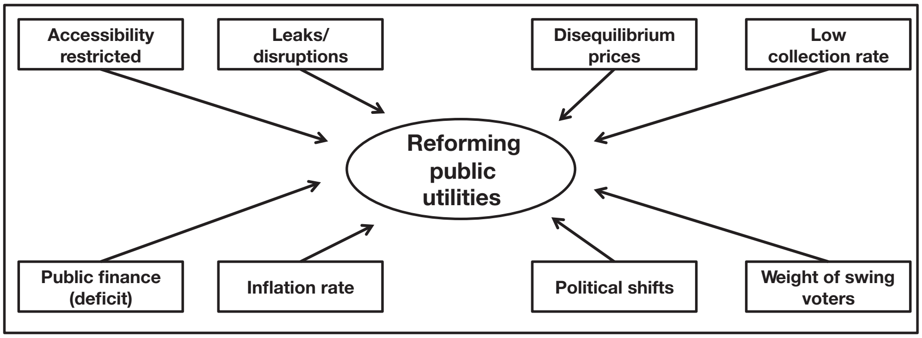

FIGURE 8.4 Forces pushing towards reforms in urban governance.

Source: Ménard (2009).

implemented to increase both efficiency and effectiveness create a significant pool of beneficiaries. Environmental issues are also increasingly part of unsatisfied demand. The main indicators signalling problems include:

- Low rates of connection for households in urban water and/or limited availability for households (e.g. only a few hours per day) or farmers.
- Unaccounted-for water so that only part of the water produced reaches users, which has a negative impact on availability, prices, and quality (leaks can be a source of pollution).
- Pricing, since the demand for water is quite inelastic. This makes users, and above all the poorest segment of the population, very sensitive to price issues. It should be noted that very often this difficulty is bypassed by plunging water bill into the general bill for local services, which generates lack of transparency and reduces accountability for the operators, whether public or private.
- Related to prices, cost coverage is also an issue since it determines investments as well as return on investments, therefore determining the sustainability (and quality) of effective water systems in the long run.

However, part of these sector problems can be hidden if local and/or central governments have soft budget constraints, so that they can, for example, subsidize the systems or maintain overstaffing. This explains why most changes in governance happen at times of hard budget constraints generated by:

- growing public deficits;
- accumulated public debt that makes recourses to debt or equity very costly or even hazardous; and
- inflation that can cause costs to rise quickly and outpace opportunities to increase water charges.

Finally, the combination of sector problems and macro-economic tensions need to be transformed into policymaking oriented towards more effective governance. This is the political economy of water. If we simplify an issue that is quite complex, we can argue that:

- Substantial changes in water governance happen when there is a regime change or coalition shift that brings to power a governing group perceiving net political benefits from reform. Potential winners must exceed losers.

TABLE 8.2 Combination of factors motivating urban government reform

Particulars	*Buenos Aires*	*Lima*	*Mexico-DF*	*Santiago*	*Abidjan*	*Conakry*
Sector crisis:						
– Not connected	30%	25%	3%	1%	40%	60%+
– Service	Poor	Very poor some areas	Poor in good	Relatively good	Relatively	Very poor
Macro conditions:						
Inflation	2,314%	3,393%	27%	19%	2%	37%
Deficit/GDP	0.4%	5.2%	2.5%	0.9%	2%	3.5%[f]
Public debt/GDP	25%	152%[c]	46%	56%[d]	Low[e]	High[g]
Political change	Regime change	Regime change	Coalition shift	Change earlier	Increased opposition	Regime change
Nature of change in governance	Shift to PSP (concession)	Failed attempt at PSP	DF split in distinct areas, with limited PSP in each	Corporatization (relatively minor changes at the time)	Renewal of concession (with relatively minor changes	From public entity to introduction of PSP (leasing in distribution)

Notes: (a) National annual averages for third year before reform. (b) End of year, 1990=100. (c) Two years before. (d) One year before. (e) No data, but sources describe it as low. (f) One year after reform; Guinea was in fiscal crisis in period before reform. (g) No data, but sources describe it as very high.

Source: adapted from Menard and Shirley (2002).

- Since water is rarely a top priority on the long-term agenda of politicians, the window opening for reforms is usually relatively short and comes immediately after political change happens, or alternatively right before an election in which constituencies concerned by water issues become an important target.

A comparative study of reforms in several major cities in Africa and Latin America illustrates the weight of these factors and how they push with varying intensity towards reform of water utilities. This is shown in Table 8.2.

Taking into account the powerful forces pushing for changes in water systems, a striking fact at the empirical level is the slow rate of reforms in water governance and the ambiguous results. In an extensive review of urban water and sanitation systems that prevail in developing countries,[4] Gassner *et al.* (2009) identified a sample of 977 utilities.

Most of them (85 per cent) maintained a state-owned enterprise (SOE), the main change being in corporatization of the utility, while the adoption of arrangements involving private-sector participation (PSP) remained limited in percentage (15 per cent) as well as geographically (67 per cent of the PSP were in Latin America and the Caribbean, and actually mostly concentrated on a very small number of cases), with significant fluctuations over time. The market share of PSP in developing and emerging countries increased from about 1 per cent in 1997 to 7 per cent in 2007 but still remains low since PSP supplies only about 160 million people in these countries (Marin 2009). According to the PPI database, there was a peak at the end of the 1990s, followed by an abrupt decline, a new trend upward between 2003 and 2005, and again a decline.[5] Even more disturbing are the ambiguous results of these changes along the criteria identified above, particularly when it comes to PSP.[6] According to Perard (2009), who systematically reviewed 27 econometric studies covering up to hundreds of water utilities, eight of them concluded that private operators were more efficient than public ones. Of the others, 16 found no substantial difference in efficiency and three concluded there were some advantages on the side of public entities. This is in line with studies on developed countries (see Ménard and Saussier 2002; Wallsten and Kosec 2008).

Governance reforms in the irigation sector: requirements and trends

Countries are increasingly recognizing the importance and urgency of reorientating their irrigation governance arrangements in line with the emerging realities and requirements of their irrigation sector. Despite the political challenges and practical difficulties, many countries have indeed undertaken significant reforms in an effort to create irrigation governance arrangements that will be more responsive to their current and future economic and environmental requirements. These reform initiatives are visible both at the macro-level (e.g. declaration of water laws and water policies, preparation of national and regional water plans, and administrative reorganizations) and at the micro-level (e.g. IMT, corporatization and private-sector participation, revision of irrigation water pricing, and the spontaneous emergence of water markets as well as rental markets for irrigation wells and pump sets). Specific reforms observed in many countries include the creation of basin organizations, promotion of user organizations, and management decentralization to promote stakeholder and/or user participation, privatization of urban and irrigation water supplies, establishment of water rights system, promotion of inter and intra-sectoral water markets, reorientation of water prices, and water quality regulations (Saleth and Dinar 2000, 2006).

Governance reforms are motivated both by factors that are endogenous from the water sector as well as those that are exogenous from the water sector (Saleth and Dinar 2004). The endogenous factors include water scarcity, water conflicts, financial crisis, drought, floods and water-quality problems. The exogenous factors, which relate mainly to aspects defining water governance environment (see Figure 8.1), include macro-economic crisis, political reforms, international agreement, and pressures from donors and/or aid agencies. It is also important to note that although there can be sector-specific factors, most factors triggering governance reforms in the irrigation sector are more or less the same as those that lead to reforms in the water sector as a whole. The configuration and relative importance of the major factors behind the reforms in six countries are shown in Table 8.3. While the factors are identified with a diagnostic use of the transaction-cost framework, their relative importance is established through subjective evaluation. Although water scarcity and conflicts remain the underlying force for reforms in all the sample countries, there is variation in the factors that trigger reform. For instance, in Australia, the first reform trigger came from recognition of a need to make the Australian economy as a whole more competitive. The second involved recognition of the need to resolve tensions between irrigators who wanted access to more water and environmentalists concerned about the declining health of several river systems. The need to impose water restriction on residents in all major southern and eastern cities acted as a third trigger and made dramatic water reform possible. The dominant trigger for water reform in Mexico was economic crisis. In Chile and South Africa, dramatic political change provided the necessary trigger for water-sector reforms. In Morocco, the main trigger behind reforms was physical scarcity of water due to a near-exhaustion of freshwater. In Sri Lanka, the major stimulus for reform came from the macro-economic crisis of 1983 that occurred during successive droughts between 1980 and 1985. Water institutional reforms in Namibia resulted from the economic and political reorganization that has occurred since the country's independence in 1990 (see Table 8.3).

TABLE 8.3 Configuration and role of factors behind water institutional reforms

Particulars	*Australia*	*Chile*	*Morocco*	*Namibia*	*South Africa*	*Sri Lanka*
Water scarcity/conflicts	⋆⋆	⋆	⋆⋆	⋆⋆	⋆⋆	⋆
Financial crisis	⋆	⋆⋆	⋆⋆	⋆⋆⋆	⋆	⋆⋆⋆
Draughts/salinity	⋆⋆⋆	–	⋆⋆⋆	⋆	⋆⋆	–
Macro economic reforms	⋆⋆⋆	⋆⋆	⋆⋆⋆	–	–	⋆⋆⋆
Political reforms	–	⋆⋆⋆	–	⋆⋆⋆	⋆⋆⋆	⋆
Social issues	⋆	–	⋆	⋆⋆	⋆⋆	–
Donor pressures	–	⋆	⋆⋆	⋆	–	⋆⋆⋆
Internal/external agreements	⋆⋆⋆	–	–	⋆	⋆	–
Institutional synergy/pressures	⋆⋆	⋆⋆⋆	⋆	⋆	⋆	⋆

Note: The number of ⋆s signifies the relative importance of the factors in the context of each country. "–" means the aspect in question is "not applicable" or "not evaluated."

Source: Saleth and Dinar (2000).

Despite country-specific differences in the extent and intensity of reforms in irrigation governance, there are certain commonalities as to the central focus and trends in these reform initiatives. The change in the thrust and focus of reforms are changing the old forms of water governance into new forms with certain distinguishable characteristics (see Box 8.3). Based on a cross-country review and comparison of the governance reform initiatives in 43 countries and regions around the world, Saleth and Dinar (2004) have identified five common aspects of the ongoing reform initiatives at the international level.

First, there has been a paradigmatic shift from water development to water allocation with the concurrent reorientation of water governance structure. Second, concurrent with an increasing focus on water allocation, there has been a definite shift from engineering approach and supply-side management to economic approach and demand-side management. Third, the trend towards decentralization is also strong, although it occurs through a variety of routes, including the creation of various forms of basin organizations (e.g. watershed committees in Brazil, water conservancy commissions in China, basin councils in Mexico, and hydrogeological federations in Spain), as well as the promotion of IMT and the development of irrigation privatization. Fourth, there has also been an increasing commitment to an integrated approach to irrigation management necessary to use water from both surface and subsurface resources, as well as the efficient use of water in rainfed regions. Fifth, there is unanimity among countries that a phased improvement in cost recovery is the first step to salvage the water sector from both financial crisis and physical degeneration. While better financial health can facilitate the physical health of water distribution and drainage infrastructures, the physical sustainability of the water sector cannot be ensured without controlling the pollution and water-quality problems. The common approach in this respect involves water-quality grading, quality standards and pollution-control regulations.

The general thrust of water reforms suggest that while they are certainly very positive from a long-term historical perspective, they are still far from adequate in meeting the efficiency, equity, and sustainability requirements of the irrigation sector in many developing countries. Many reforms amount to empty promises that take the form of declared policies that are not implemented or nominal increases in water charges that have very little real value or cosmetic changes, such as new names for existing organizations. Substantive reforms such as the enactment of new water laws, conversion to a volumetric allocation system, the establishment of a new water-rights system, or the reorganization of a

Box 8.3 WATER GOVERNANCE: OLD AND NEW FORMS

- Government and bureaucracy to civil society and markets.
- Centralized power to diversity of actors and diffused power.
- Hierarchical control to horizontally shared control.
- State-enforced rules and regulations to inter-organizational relations and coordination.
- Centralized/top-down to decentralized/bottom-up governance.
- Formal institutions to informal institutions (network or distributed governance).
- Bureaucratic allocation to voluntary exchange, self-governance, and market mechanisms.
- Unilateral and centralized decision to dialogue and partnership as well as participation and negotiation.

Source: Tropp (2007: Table 8.1).

water-administration system is much rarer. Too often, significant initiatives are undertaken tentatively more as a crisis response than as part of any comprehensive reform package (Saleth and Dinar 2006). As a result, there have been considerable variations in the effectiveness of governance arrangements both within the irrigation sector as well as in the water sector as whole.

Globally, and as scarcity problems emerge with increasing intensity, there is recognition of the benefits of moving to volumetric allocations systems. Some countries (e.g. Australia and Chile, as well as regions such as California and Colorado in the USA) already have the capability to implement the allocation paradigm. Others (e.g. Spain, Mexico, Chile, South Africa, Brazil, and China) are moving quickly to develop the institutional potential necessary for effective governance whereas the remaining countries (e.g. India, Pakistan, and Sri Lanka) have a long way to go before being in a position to create the necessary institutions for efficient water allocation and demand management.

Governance of the water sector as a whole: issues and effectiveness

Just as water-sector governance is embedded within the overall governance arrangements in a country, those at the subsectoral levels are also embedded within overall water governance. In this sense, the effectiveness of the governance arrangements at the subsectoral level depends critically on the effectiveness of governance systems at the water-sector level as a whole. The sector-level governance issues that are important to address relate to the overall planning and management of the resources, meeting environmental water needs, water quality and related environmental pollution, and intersectoral water allocation and conflict resolution. Obviously, these issues are closely related to the implementation of integrated water-resource management (IWRM) principles. In fact, the sector-level governance provides the institutional context within which IWRM principles are operationalized (Rogers and Hall 2003).

Sector-level governance arrangements include water law, water policy, and water organization involved in the overall planning and management of the resource. As in the case of subsectoral governance arrangements, the macro- or sector-level governance also has alternative forms. These macro-level arrangements in countries such as Australia, the USA, Mexico, or Chile are confined to overall water planning and management, leaving most of the allocation decisions to the basin-level bodies and market-based arrangements. Such a division of the sphere of influence between the state, private users, and water companies is possible due to the existence of well-developed volumetric water-rights systems. The water-rights system also enables market- or negotiation-based water allocation across sectors and regions with minimum conflict. Although it is commonly held that market-based governance arrangements are weak in addressing environmental problems, the experience of Australia shows that there are possibilities to explore in that direction (see Box 8.4). In other countries such as India, Pakistan, and China, the state-centred governance arrangements provide scope for the role of private groups and stakeholders, especially at the local level involved in water development, allocation, and management within a centralized organizational structure. Since volumetric water rights are weak in these countries, sectoral allocation (including the allocation for environment) has to be performed through bureaucratic means with very little stakeholder involvement. Lack of individual and sectoral water rights and entitlements also leads to sectoral and regional water conflicts. Such conflicts are resolved through centralized non-market mechanisms such as arbitration by central government or other state-based technical agencies, tribunals, courts, and water-resource courts as in South Africa and Spain for instance.

Box 8.4 MEETING ENVIRONMENTAL NEEDS: EXPERIENCE OF AUSTRALIA

Australia was able to start bringing over-allocation problems under control by placing a cap or limit on the amount of water that could be diverted from the Murray-Darling Basin in 1993–1994. This was followed by the development of a salinity-trading scheme designed to force states to offset the salinity impacts of any new development and address a legacy of existing salinity management problems. As pressures for water reform grew and public pressure for change mounted, Australian governments have started buying back water for the environment and have agreed to transfer planning responsibility from states to an independent Murray-Darling Basin Authority established under federal legislation. Among other things, this has involved the referral of constitutional powers held by state governments to the federal government.

The success of these reforms was possible only because of the existence of transferable water-right systems maintained by user-oriented public agencies with effective regulatory capabilities and a high level of commitment from the federal and all state governments.

Sources: Saleth and Dinar (2004); Young (personal communication 2010).

Although market-based approaches can be used, effective governance at this level requires some form of centralized system at the national level. Such a system can be still more effective if transparency and participation are added. Based on a review of reform experienced in several countries, Saleth and Dinar (2006) have developed a few stylized facts as to the nature and characteristics of the ongoing water governance reforms process at the global level. First, although factors endogenous to the water sector (e.g. scarcity, cost recovery, and salinity) remain an underlying force, the immediate trigger for reform comes mainly from exogenous factors (e.g. macro-economic crisis and political reforms). Second, while countries including Chile, Mexico, and South Africa have successfully exploited the strategic context set by exogenous factors, this happened more by coincidence than by design. Third, there are fundamental links between the induced changes caused by formal reforms at the macro-level and the autonomous changes occurring at the micro-level. Fourth, impromptu approaches to reform dictated by political and financial expediencies can be counterproductive, especially when the processes used are not thought through sufficiently well and can therefore be criticized by those opposed to the reforms.

Fifth, in politically and fiscally constraining conditions, the best strategy is to have selective but sequentially linked reforms focused on institutional components, regions, and sectors with better prospects and quicker benefits. Finally, besides the country-specific reforms, there are also notable instances of transnational governance not only in transboundary river contexts but also in the context of a whole economic region such as the European Union (see Box 8.5).

Box 8.5 WATER FRAMEWORK DIRECTIVE: A CASE OF INTERNATIONAL WATER GOVERNANCE

Introduced in 2000, the Water Framework Directive (WFD) of the European Union represents the primary water-policy legislation in the European Union. It aims to achieve effective water governance at the European Union level, including a coherent and effective legal and institutional framework, water-pricing policies, public participation and an integrated water-resource management system. The key components of the WFD are: (a) protecting all waters, surface and ground waters in a holistic way; (b) good quality ("good status") to be achieved by 2015; (c) integrated water management based on river basins, including the development basin plans; (d) combined approach of emission controls and water-quality standards, plus phasing out of particularly hazardous pesticides; (e) use of economic instruments such as economic analysis and getting the prices right; and (f) participation of citizens and stakeholders involved.

Source: Barreira (2006).

Effectiveness of water governance: principles and guidelines

The effectiveness of water-governance arrangements has two complementary dimensions. During the design stage, a specific mode of organization should be selected. Following completion of the project, conditions of implementation and enforcement of the selected arrangement must be assessed on a regular basis. Most of the theoretical literature and too many actual reforms of water governance have focused on the first dimension designing optimal contracts or focusing on the technical requirements. However, we argue that post-implementation conditions matter as much and that their benign neglect often derails well-intentioned reforms.

How to select a governance arrangement

The identification of the appropriate governance arrangements during the design stage requires a demarcation of different water-related activities such as planning, allocation, use, and management. While governance elements with centralized features are required at the planning level as well as in the protection of water quality and environment, market- or negotiation-based mechanisms are ideal at the allocation level.

At this point, it is important to remind decision-makers that the choice of an arrangement is largely determined by institutional constraints. Conditions of embeddedness should therefore be considered closely. To illustrate, it might be desirable to consider major private-sector participation for efficiency reasons or because of the financial constraints that a public authority faces; but an approach can encounter new problems such as a lack of institutional arrangements sufficient to protect investors. Private investors do not want to assume investment risks of this kind and, hence, when a tender is called there may only be one or even no bids.

At the most general level, there are four questions that must be satisfied before the domain of feasible governance arrangements can be identified.

1 Do we find an institutional environment, particularly when it comes to political guarantees, well-designed regulation, and a performing judiciary that can provide adequate support to alternative solutions? Note that this remains true even when a public entity is the preferred arrangement.
2 Water governance usually involves multiple principal agents (different ministries, different levels of government, different agencies, etc.). Is the institutional environment able to coordinate adequately these principal agents, able to simplify the decision process, and able to implement the choices that have been made?
3 Are there dispute-resolution mechanisms that can efficiently arbitrate among the conflicting interests of the different stakeholders and enforce decisions made?
4 Are the conditions judged by the parties involved as credible (e.g. between public authorities and private operators)? There are now institutional indicators provided by different organizations (World Bank, Transparency International, Institutional Profiles Database, etc.) that can help to establish a relevant checklist.

Box 8.6 CREDIBLE COMMITMENT AND THE PROBLEM OF MULTIPLE PRINCIPLE AGENTS

A major reform was initiated in Metropolitan Manila in 1996. The water system then run by a public operator was split in two zones (Manila Eastern zone and Manila Western zone) in order to facilitate benchmarking. Two concessions were awarded (Maynilad in the Western zone, Manila Water in the Eastern zone). The implementation of the contracts faced major difficulties from the very beginning. Analyses of these difficulties focused essentially on the impact of the Asian financial crisis. However, there is another dimension, of an institutional nature, that also played an important role (e.g. in adjusting tariffs, etc.). Based on two detailed empirical studies, we identified up to 32 principals (ministries, city hall, agencies, bureaus, etc.), often conflicting and simultaneously interfering with the regulator as well as with the two operators. This subverted commitments from public authorities and made adjustments for operators chaotic and unpredictable.

Sources: Castalia (2005); Wu and Malaluan (2008).

At a more specific level, the search for effective modes of governance must take into account constraints imposed by the characteristics of the water sector and of its subsectors. First, there are technical constraints that delineate the domain of possible solutions. Building a dam in order to provide water to the city or to farmers, for instance, imposes a centralized approach that differs from the possibilities an extended underground reservoir offers. Second, financial resources and their appropriateness to financial needs are also determining factors. The existence of a local or regional active financial market or the political credibility that makes foreign investments attractive might make effective a solution that involves private-sector participation, which would otherwise be impossible or very limited. Third, there is the very sensitive problem in the water sector of social acceptability. There are two main issues at stake here: one that concerns users' participation in the very early stages of the decision process, the other to do with the consequences of solutions considered, particularly with respect to pricing.

A final issue to be taken into account in the selection of a specific mode of governance is the conditions under which the selected solution is actually played out. For example, let us assume that a contractual solution (e.g. a lease or concession) has been chosen as the most adequate solution for reforming and extending an urban water system and that it is decided to proceed through open tenders to all interested operators. Let us also assume that there are several potential candidates (which is often not the case in the water sector). We know both from experience and from the theory that there are different ways of organizing selection among bidders (e.g. selecting the best offer, which creates a bias described as "the winner's cursor", according to which some candidates overestimate potential gains and overshoot their offer in order to win) versus selecting second- or even third-rank bidders. Alternatively, a first round of open tenders may be followed by a second round of negotiations with operators who exhibited the most promising potential at first, a solution that involves high risks (of collusion and/or corruption) but also allows defining a better-fitted solution when complex issues and/or missing information are at stake.

It should be emphasized here that all these solutions involve significant transaction costs. In the trade-offs among alternative modes of governance, which go far beyond the initial trade-off between public and private solutions, these costs are too often neglected by international donors and decision-makers. To put it bluntly, complex arrangements may not make sense because they are too costly to monitor and/or because the required expertise is not available and/or because it becomes too obscure to users.

Conditions of effectiveness in implementing new water governance

The difficulty is that many of these problems are revealed only after the new governance regime has been implemented. Therefore, the effectiveness of selected water governance should also incorporate the conditions of implementation and enforcement of the solution selected. The accumulated experience of the last two decades suggests that at the management level, especially at the local level, which is central in the water sector, user- and community-based systems are more effective than the bureaucratic ones that are currently operating. Similarly, basin-based and stakeholder-oriented systems of governance will be more effective than administrative unit-based systems. In that respect, two series of conditions to success should be emphasized. These are often neglected or underestimated in the approach to water governance.

First, decision-makers as well as theoreticians have become increasingly aware of the key role of institutions. However, they have mostly focused on the general institutional environment; for instance, the implementation of adequate laws and regulations at the national level and the creation of central regulatory agencies. When it comes to water governance, whether in an urban environment or in relation to irrigation, we would argue that micro-institutions implemented at the local and/or regional level matter at least as much as the global ones and play a decisive role in making new governance sustainable. Among these micro-institutions, the role of regulatory bodies embedded in local and or regional governments is worth noting, since they are directly in charge of designing the agreements (and/or the conditions of their implementation) and in monitoring the arrangement. Basin agencies are good examples of the significance of these micro-institutions in the water sector. Important functions of these bodies concern the information they can collect on alternative solutions implemented elsewhere and the way this information is used to establish benchmark indicators of performance. The other function concerns the mechanisms of control and sanctions they can activate. In that respect, an active role for users and adequate modalities of this participation in order to avoid capture by specific groups of interest are key issues.

Second, human capital makes the difference.[7] This is a much underestimated component of effectiveness. Building adequate human assets often makes the difference, as so many reforms in the governance of water illustrates, whether it is through a public entity, as illustrated by the urban water system in Phnom-Penh (Araral 2009; Marin 2009), or with private-sector participation, as with the *Société de Distribution d'Eau de la Côte d'Ivoire* (SODECI) in Abidjan (Ménard and Clarke 2002). Four conditions particularly matter here:

1 adequate training for all personnel, particularly the management;
2 well-aligned incentives, so that the entire personnel benefits from improved performance and motivation to pursue results;
3 delegating responsibilities at the local level so that there is more room for management to interact with community representatives and develop local solutions; and
4 promoting leadership, since successful reforms all substantiate the key role of a leader or a leading team capable of convincing the decision-makers and stakeholders of the necessity to radically reform or improve water governance and capable of implementing changes needed.

Box 8.7 THE ROLE OF HUMAN CAPITAL: THE CASE OF PHNOM PENH

The reform of the public utility in charge of water and sanitation in Phnom Penh is considered a success story. Its causes were summarized as follows: "To achieve this, the concerned governments have had to make choices. These include putting in place sound tariff policies, refraining from interference in operations, and putting in place professional management that is held accountable for results." (Marin 2009: 146). However, this last factor is left undeveloped in this review and is ignored in too many reports and case studies. In the case of Phnom Penh, building adequate human assets was a key to success. It involved two dimensions: an intensive training programme for all the staff, and the existence of a strong leadership that could provide internal cohesion and dynamism and simultaneously convince political leaders of the value of choices made and maintain their stamina in that respect. Triche *et al.* (2006) rightly emphasize the key role of training, consultation and promotional activities, including communities' involvement, at the time of reform in Cambodia. But they also identify the lack of training and support in the long run, when difficulties in implementing contracts emerged. This is where a motivated staff and a strong leadership become really central, as illustrated by the case of Phnom Penh.

Source: Araral (2009).

The many elements outlined above that are required for an effective governance of the water sector exhibit the difficulty of selecting a particular governance arrangement that can fit all contexts. A mix of governance systems – both state, market, and user- and/or community-based ones – are needed to achieve the efficiency, equity, and sustainability goals within the irrigation sector. Choosing the right mode of organization for the right project requires taking into account these different dimensions and weighting them accordingly. Our analysis provides a framework that must be followed according to the context, in order to guarantee that solutions adopted are properly aligned with technical and/or physical requirements, organizational capacities, and the institutional environment. Appropriate alignment is the key to success.

Concluding remarks and policy implications

As far as the effectiveness of alternative water-governance arrangements both at the subsectoral and at the sectoral level is concerned, there is no silver bullet that fits all conditions and requirements. A more realistic approach is to promote different governance forms to suit different contexts; a mix of such systems may be the best solution. For effective water governance, neither state-centric nor market-centric governance are going to be of much help. Cooperative relationships between various institutions, representing complementary logics and functions, will provide a more durable solution (Blatter and Ingram 2000). This clearly suggests the need for a comparative approach in building local and/or regional institutions that can fit well the requirements of the urban water utilities and irrigation sector. There is no foolproof water-governance arrangement but some arrangements are relatively more effective than other alternatives in specific contexts. Suitability of governance arrangements depends on specific contexts. Some are good for efficiency while others are good for equity. Similarly, for some functions such as planning and water quality, centralized forms may be better for scale-economy and technical considerations, but for others such as allocation and management, more decentralized and market- or negotiation-based arrangements are better in terms of flexibility.

From the perspective of both urban water supply and the irrigation sector, the identification of the appropriate governance arrangements requires a demarcation of different water-related activities such as planning, allocation, use, and management. This is also applicable to the governance question at the water sector as a whole. While governance elements with centralized features are required at the planning level as well as in the protection of water quality and environment, market- or negotiation-based mechanisms are ideal at the allocation level. At the management level, especially at the local-level user, community-based systems are more effective than the bureaucratic ones that are operating at present. Similarly, basin-based and stakeholder-oriented systems of governance will be more effective than administrative, unit-based systems. As a result, it is difficult to select a particular governance arrangement that can fit all contexts. A mix of governance systems – both state, market, and user- and/or community-based ones – are needed to achieve the efficiency, equity, and sustainability goals within the irrigation sector. However, we have identified three key issues:

1 Feasibility on the supply side depends on the appropriate alignment between technical conditions, organizational possibilities, and institutional frame.
2 Acceptability on the demand side depends on users' perceptions and needs as well as the capacity for operators and public authorities to implement and maintain open channels of communication.
3 The need for capacity building and technical upgrading of the organizations involved in water management.

Notes

1 Claude Ménard is Professor of Economics at the University of Paris-Pantheon Sorbonne, Paris, France and Maria Saleth is Director, Madras Institute of Development Studies, Chennai, India.
2 There might be subsidies; for example, to allow low-income population to benefit from connection to the system.
3 Competition in the market remains extremely limited so far. See recent and difficult efforts in the UK to develop common-carriage, cross-border supply, and competition on vertical supply. In developing countries, privately delivering water by trucks introduces some competition in the market . . . at very high costs.
4 The sample covers 71 countries, spanning the years 1973–2005. Most of the data are actually concentrated in 1992–2004.
5 See ppi.worldbank.org/ (note 23 from June 2009) and Marin (2009: 24).

6 Gassner *et al*. (2009: 4–5) conclude that PSP resulted in gains in labour productivity (due to relatively small reduction in staff), with no clear investment gains, no significant changes in prices, and mixed efficiency gains.
7 For instructive discussions and data on this issue, see the series of reports for ILO on "Social Dialogue" in the reform of water and sanitation (e.g. Fajana 2008, on Nigeria; Masanjala 2009, on Malawi).

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PART 4

Regional experience

9

CHALLENGING HYDROLOGICAL PANACEAS

Evidence from the Niger River Basin

John Ward, David Kaczan, Andrew Ogilvie and Anna Lukasiewicz[1]

Introduction

In 2009, 700 million people in 43 countries were estimated to live below the water-stress threshold of 1,700 cubic metres per person. By 2025 that number is estimated to reach 3 billion (UNDP 2006). Global water diversions for agriculture represent approximately 70 per cent of total water consumption and are expected to grow by up to 17 per cent by 2025 (de Fraiture *et al*. 2001). Climate change and rapidly expanding populations in the developing world threaten to exacerbate water-related poverty and undermine alleviating efforts. There is an enduring consensus that the extent of West Africa's poverty remains both acute and chronic, and efforts to address water-related poverty and agricultural water use are identified as key elements in poverty reduction.

From the perspective of policy initiatives to alleviate poverty, what remains unclear is the relationship between water-related poverty with the widely deployed metrics of poverty, and methods to identify and estimate co-determinants. The primary focus of this chapter is the evaluation of spatial and statistical methods to quantify the extent, magnitude and location of the potential non-water- and water-related determinants of poverty in the Niger Basin, West Africa (Ward *et al*. 2009).

Water poverty occurs as the combined effect of factors including increasing and competing water demand, changes in hydrological regimes due in part to climate change, increasing population, environmental degradation, reduced water quality, impediments to water access, conflict, corruption and changing levels of water productivity. These relationships are dynamic and likely to vary spatially and temporally. Past policy responses have relied on poverty assessments that are generally not spatially explicit coupled with hydrological models based on historical flows that may be redundant under regimes of climate change. Policy initiatives that rely solely on hydrologic probabilities or fail to account for the different causal relationships of spatially differentiated poverty may be either ineffective or accelerate poverty levels and disparities of well-being.

Water poverty occurs when people are unable to access dependable water resources or lack the capacity to use them. Water may be insufficient for basic needs, for food production or for wider economic and environmental services. Water scarcity is commonly thought to arise due to physical or economic constraints, although Molle and Mollinga (2003) distinguish three further causes of scarcity: managerial, institutional and political scarcity. This distinction reflects the complex nature of water poverty and points to the need to look beyond technical and financial means alone to reduce it.

Institutional arrangements for poverty alleviation and the unit of analysis where decisions are made and implemented can occur at the whole of basin, national, administrative district and community scale. Regional perspectives of poverty that guide policy decisions cannot be presumed to be aligned or concordant with basin differentiation of poverty, livelihood vulnerability or institutional diversity (Hyman *et al.* 2005). An important focus of the research described in this chapter was to guide methodological development and application that imputes variables at scales that simultaneously align water productivity, access and poverty data.

Alignment indicates opportunities for water-policy formulation that is administratively and politically feasible across the Niger Basin countries. The analysis was intended to guide water-management policy formulation in the direction of the causes of poverty, threats to livelihoods and increased vulnerability at scales that reflect hot spots of priority where social units are most threatened or exposed. With such analysis, measures of water productivity and access, when significant, can be incorporated into aspects of policies that support sustainable livelihoods and become an integral part of mainstream development support.

We hypothesize that water-policy design and ultimately performance, are sensitive to spatial scale effects and, as a consequence, initiatives to reduce poverty will need to account for the spatial variation of poverty and include an expanded array of poverty determinants.

The first research objective we describe in this chapter identifies methodologies capable of integrating impact analysis and policy formulation that reliably differentiates poverty at multiple scales. The second research objective describes poverty mapping as a unit of analysis that aligns water productivity and water access with poverty data, revealing opportunities for politically feasible water-policy formulation. The final objective describes an evidence-based and spatially explicit analysis that guides effective policy development in the direction of the causes of poverty at scales that reflect the most exposed communities.

To achieve these objectives, we considered four core questions:

1 How can water-related poverty be defined, measured and spatially referenced, particularly in economies where a majority of provisioning or livelihood activities remain non-monetized?
2 Do the explanatory relationships of water poverty differ at variable spatial scales of decision-making? If so, what is an appropriate scale or unit of analysis to capture the heterogeneity of poverty, to identify areas of critical need and to quantify the diversity of explanatory variables?
3 What is the most appropriate scale to reliably inform policy innovation, formulation and intervention that is feasible and most likely to be effective in poverty alleviation?
4 When constructing vulnerability or water poverty indices, is there a reliable alternative to subjectively determined weightings of composite variables? Is there a rapid and feasible alternative when expert opinion or participatory processes are unreliable or not available?

Water poverty and water scarcity

In terms of agricultural water use, Cook and Gichuki (2007) define water wealth/poverty as "a function of water availability and water productivity of the agricultural water management system that enables people to derive a livelihood from it." This definition takes into account three variables:

1 The water system – determines availability and reliability of water.
2 The agricultural system – converts water into livelihood support through food, income or other attributes. This is defined by water productivity.

3 The livelihood system – modifies water access according to social relations, institutions or organizations.

Black and Hall (2003) suggest that the water-poor include those whose livelihoods are persistently threatened by drought or flood, those who are constrained from improving agricultural productivity due to uncertain water availability, those who are water-constrained from growing higher-value products and those who live with a high level of water-associated disease and cannot avoid such risks.

It follows that improvements in water access will lead to improved food security, health and economic prosperity, addressing simultaneously multiple dimensions of poverty (Molden 2007). Although other non-water constraints can prevent these benefits from materializing (Hanjra and Gichucki 2008), improving the water situation can have a disproportionately large positive impact due to the number and variety of linkages in the water-poverty nexus.

The Niger River Basin Authority (2005), Namara *et al.* (2009) and Hussain and Hanjra (2004) argue that increased irrigation and proximity to dams in West Africa provides a pathway out of poverty, indicating community opportunities and capacity to access and transform water into food. However, despite agricultural productivity growth being expected to reduce poverty in the rural agriculture-dominant economies of West Africa (Thirtle *et al.* 2003) poverty prevails in areas of good soil quality, high productivity and sufficient water availability.

A person who lacks safe and affordable water for the purposes of drinking, washing and deriving income is water insecure. When a large number of people are water insecure in a particular geographic area, that area is considered water scarce (Rijsberman 2006).

Finally, water scarcity may result not only from environmental factors but also due to a community's economic situation. Economic water scarcity is defined by the lack of financial means to develop otherwise abundant water resources, contributing to an underperformance in agricultural productivity (Hussain and Hanjra 2004; Cook and Gichucki 2007). Regions of economic water scarcity offer attractive opportunities for investment towards poverty alleviation (Fan *et al.* 2000) and much of sub-Saharan Africa (SSA) may be categorized as an area of high potential for water-productivity enhancement along these lines (Molden *et al.* 2001).

Turton and Warner (2002) discuss water scarcity as a product of a "first-order" resource scarcity and a "second-order" social scarcity. The former is due to physical limitations while the latter refers to the institutional ability to utilize the resource in question and thus manage scarcity. Countries that suffer from both order scarcities are considered "water-poor" and may consequently find themselves trapped in a spiral of under-development.

Accordingly the conceptual links between water and poverty are well developed (Castillo *et al.* 2007). A large number of causal relationships have been hypothesized; however, there remains a need for research that convincingly demonstrates how an improvement in a community's water situation changes the incidence of poverty (Rijsberman 2003; Asian Development Bank 2004). Furthermore, it is likely that these causal relationships are spatially, temporally and institutionally scale-dependent.

Brown and Lall (2006) demonstrate this by using variables of mean annual temperature, mean annual precipitation, intra- and inter-annual variability and spatial variability of rainfall to predict macro-economic performance. As well as demonstrating the significance of temporal variability of rainfall on gross domestic product (GDP), they argue that different water policies are required for different categories of water-concerned countries. Those with insufficient mean rainfall require "soft" policies (efficiency, water trading, food importation), while those with inadequate temporal distribution require "hard" policies (construction of water impoundments).

The remainder of this chapter describes spatially explicit analyses that attempt to differentiate and quantify the relative importance of water- and non-water-related determinants of poverty and as a corollary, the potential role of "soft" and "hard" policies to reduce poverty in the Niger Basin.

Poverty profile of the Niger Basin

The Niger River has a total length of approximately 4200 km, making it the third longest river in Africa (after the Nile and the Congo/Zaire Rivers). Theoretically the basin covers 2,170,500 km^2, although the active (hydrologically connected) basin is smaller, at approximately 1,500,000 km^2 (see Plate 9.1). The basin's extent lies over 10 riparian countries, namely Nigeria, Mali, Niger, Algeria, Guinea (where the sources are located), Cameroon, Burkina Faso, Benin, Côte d'Ivoire and Chad.

The river traverses agro-ecological zones of considerable diversity. The source waters originate in the wet monsoonal uplands of Guinea and provide the bulk of river flows. The Niger flows through the generally flat Sudanian and Sahelian regions of Mali. This region includes the Niger Inner Delta, a large area of wetlands and floodplains recognized for both its ecological and agricultural importance. The Niger then passes through the southern region of the Sahara desert, before turning to the south-east and flowing towards Nigeria. A major tributary, the Benue River, joins the Niger in Central Nigeria.

The population of the Niger Basin countries is approximately 277 million, of which approximately 94 million live within the extent of the river basin (UN Population Division 2006). Population growth of the basin countries is high, with a long-term average (1975–2005) of between 2.5 and 3.5 per cent per year (UNDP 2007). The demographic profile is female-biased and young, with 44 per cent of the basin's population under 15 years of age. The proportion of the basin's inhabitants living in urban areas is around 30 per cent, although this proportion is smaller in the Sahelian regions (Niger Basin Authority 2005). Despite recent economic growth, as measured by GDP in Nigeria for example,[2] economic development in West African nations remains low. When ranked by GDP (purchasing power parity, per capita), all nine countries of the Niger Basin fall in the bottom quarter of national incomes. The United Nations Human Development Index, a composite ranking based on national income, life expectancy and adult literacy rate, ranks all the Niger Basin countries in the lowest quintile of countries (UNDP 2007).

The proportion of people living below the poverty line (US$1.25 per day) is high throughout the Niger Basin countries and especially acute in Burkina Faso (70.3 per cent), Guinea (70.1 per cent) and Niger (65.9 per cent) (World Bank 2009). This amounts to an estimated 138 million poor in the basin countries, of which a disproportionate number live in rural areas. The labour force is concentrated in industries associated with agriculture, although agriculture as a share of GDP is often disproportionately low. This is partially due to low productivity, a problem common across SSA where the average annual cereal yield is 1,230 kg/ha, compared with over 3,000 kg/ha in South America and Asia (Castillo *et al.* 2007; Hanjra and Gichucki 2008). Furthermore, a large proportion of food production occurs within subsistence-based economic systems, and is therefore not recorded under conventional national accounting measures such as GDP.

Life expectancies are in the bottom 15 per cent of all countries worldwide in the Niger Basin. Childhood mortality rates (death prior to the age of five) of up to 250 per 1000 live births are approximately two to three times higher than neighbouring countries in northern and southern Africa (Balk *et al.* 2003). The region is characterized by a high prevalence of endemic and epidemic communicable diseases. Respiratory diseases, malaria and diarrhoeal diseases are the largest causes of child mortality (ECOWAS-SWAC/OECD 2008). Human immunodeficiency virus (HIV) infection rates are considered high (between 1.1 per cent and 7.1 per cent), although less severe than those in southern

Africa. Across the study region countries, 53 per cent of people used an improved source of drinking water in 2004, and only 37 per cent had access to adequate sanitation facilities, statistics that are low by world standards (UNICEF 2008).

Adult rates of literacy are some of the lowest in the world, and female literacy levels are significantly less than those for males (UNDP 2007). Recent UNESCO (2008) figures indicate substantial improvements over the previous decade. Primary education participation rates have increased in all the basin countries, with Niger, Mali, Chad and Benin increasing net enrolment ratios by more than 10 per cent.

Economic output in the Niger Basin countries, and especially in the Sahelian countries, is highly dependent on the Niger River. However, the Niger Basin Authority (2005) argues that the basin has further untapped potential and that additional water resources would become available with further infrastructure development. Contingent on focused investment, the Niger Basin Authority (2005) contends that expansions are possible in dryland agriculture, irrigation and electricity development.

Climatic variability is estimated to reduce the exploitable environmental value of the basin's agricultural regions, and a 30 per cent long-term reduction in rainfall in the Sahelian regions since the 1970s may be indicative of a new, drier climatic regime (Niger Basin Authority 2005). However, it is important to recognize that protracted dry spells have occurred before and the current climate's stability or degree of permanency is a subject of ongoing debate. Reductions in rainfall have also led to a reduction in surface flows of between 20 and 50 per cent. An increase in climate variability has made the Sahel region and its people more vulnerable to desertification and land degradation, a process that is a function of climate change, increased human activity and land management. The impact of climate change on the population of the Niger Basin is potentially severe; however, the lack of consensus in modelling predictions leaves governments to consider and resolve multiple outcomes arising from a number of possible land use scenarios and water development trajectories (Mitchell *et al.* 2004).

Table 9.1 summarizes the development status for Niger Basin countries according to an array of commonly applied poverty metrics. Such indicators have become increasingly widespread and favoured by decision-makers. Although indices capture the multifaceted nature of a complex issue, they amalgamate and often arbitrarily weight disparate pieces of information. Indices provide a viewpoint for a particular purpose, and implicitly represent the personal values of their architects (Molle and Mollinga 2003). Yet composite indicators retain their prominence: they simplify and rationalize complex problems, they allow for easy comparisons, they suggest scientific legitimacy and they are easily communicated.

Widely deployed poverty measures such as individual or household income often fail to reflect the many dimensions of poverty, notably when considering the mostly cashless, subsistence-farming society of West Africa (among others, see Cook and Gichucki 2007; World Bank 2009). Index measures attempt to capture the multi-dimensional nature of either poverty or vulnerability by aggregating a range of selected social-economic indicators; however, they rely on subjective or even arbitrary construction of composite indices and attribution of variable weights (Vincent 2004). Indicators that objectively measure a single dimension (e.g. childhood mortality rate) may offer the closest depiction of poverty in these communities (Molle and Mollinga 2003).

Water poverty in the Niger Basin

Water poverty occurs when people do not have access to dependable water resources or lack the capacity to use them. Water may be insufficient for basic needs, for food production or for wider economic and environmental services.

TABLE 9.1 Poverty and water situation indicators for countries of the Niger Basin

	GDP (PPP, per capita)	*Population below poverty line (US$1.25/day)*	*Life expectancy at birth*	*Under 5 mortality rate*	*Total available renewable water resources*	*Water Poverty Index*	*Basic Human Needs Index*	*Social Vulnerability Index*	*HDI*	*Gini co-efficient*
	2007	*2007*	*2007*	*2007*	*2005*	*2002*	*2000*	*2004*	*2007–8*	*2007*
	US$/capita	*%*	*Years*	*%*	*m^3/yr/capita*	*100 – lowest poverty 0 – highest poverty*	*50L – minimum basic needs*	*Index value (higher – more vulnerable)*	*Index value (higher – more developed) (rank in brackets)*	*100 – complete inequality, 0 – complete equality*
Benin	1,500	47.3	55.4	19.1	3,820	39.3	15	0.584	0.437 (163)	36.5
Burkina Faso	1,200	70.3	51.4	15.0	930	41.5	17	0.658	0.370 (176)	39.5
Cameroon	2,300	32.8	49.8	14.9	17,520	53.6	33	0.640	0.532 (144)	44.6
Chad	1,600	61.9	50	20.8	4,860	38.5	11	0.618	0.388 (170)	–
Cote d'Ivoire	1,800	23.3	47.4	19.5	4,790	45.7	28	0.584	0.432 (166)	44.6
Guinea	1,000	70.1	54.8	15.0	26,220	51.7	26	0.562	0.456 (160)	38.1
Mali	1,200	51.4	53.1	21.8	7,460	40.6	6	0.585	0.380 (173)	40.1
Niger	700	65.9	55.8	25.6	2,710	35.2	20	0.725	0.374 (174)	50.5
Nigeria	2,200	64.4	46.4	19.4	2,250	43.9	24	0.621	0.470 (158)	43.7
OECD* mean	37,496	n/a	78.3	0.52	39,085	39.7	n/a	n/a	0.939	10.39
Non-OECD* mean	10,898	n/a	66.1	6.76	26,802	23.6	n/a	n/a	0.686	18.65

Notes: compiled from Gleick (1999); Lawrence *et al.* (2002); Vincent (2004); UNESCO (2006); UNDP (2007); CIA (2008); World Bank (2009); *OECD mean based on the 27 high-income countries as defined by the World Bank (2009).

There exist a number of indicators designed to measure or characterise water poverty (see Table 9.1). Like poverty indicators, these require moving from raw data towards a composite aggregated indicator and as a result often gain in simplicity what they lose in precision. The widely used Falkenmark "water stress index" (Falkenmark *et al.* 1989) defines a threshold of 1,700m^3 of total available renewable water resources (TARWR) per capita per year, under which a country is deemed to suffer from water scarcity. All countries except Burkina Faso exceed this threshold; however, the indicator fails to capture spatio-temporal variations, crucial in a country such as Mali that spans from a sub-humid to a hyper-arid climate. A more comprehensive measurement of water poverty is the Water Poverty Index (WPI), which notably takes into account communities' abilities to access and use water but suffers from the use of arbitrary weights and must ideally be generated at a local rather than national or regional scale (Sullivan and Meigh 2003).

Relationships between water and poverty

Though indices provide an overview of the poverty and water situations faced in the basin, they are not designed to reflect the linkages between water and poverty. Composite indices intrinsically mask the importance of individual factors, confounding interpretation of the potential causes of water poverty and the formulation of subsequent interventions. Furthermore, identifying a state of water poverty (i.e. low level of water resource, access or use) may not necessarily explain the associated level of poverty, manifest as reduced levels of livelihood, well-being or economic poverty.

To address the question of a hypothetical relationship between water and poverty at the national scale, we estimated statistical relationships using poverty maps and correlation coefficients. Significant correlations do not imply causality but point towards water-resource factors that may influence poverty. At the national scale, weak correlations between widely used water and poverty metrics of between 0.02 and 0.47 are characteristic for all African nations (excluding small island states). Table 9.2 summarizes the correlation matrix between the Falkenmark Index of water availability and widely used poverty indices. Note that data for Libya, Liberia and Somalia were unavailable and the table does not include small island states. To this extent, at a national level there is little evidence for a strong association between a country's water situation and its development performance on the African continent. Note that the total available renewable water resource (TARWR) correlation with the WPI is to be expected given that the latter incorporates a form of the total water resources statistic. Similarly, the WPI also incorporates measures of the Human Development Index.

In this analysis, we hypothesized that variables associated with water access and productivity would significantly affect observed levels of poverty. We therefore modelled poverty indices as individual variables and examined an expanded array of water and non-water poverty determinants at high-resolution spatial scales to detect statistical relationships.

For this study, we relied on three common poverty variables and assessed the role of water related variables in explaining the observed distribution in each for the countries of the Niger River Basin. The basin is socially and economically heterogeneous, has a high proportion of subsistence livelihoods and a relatively large non-market, hybrid economy. A singular monetary measure of poverty (for instance, household income) is unlikely to capture either the full magnitude or distribution of poverty. We therefore used two health variables: child mortality and child stunting (height-for-age ratios) and a composite relative wealth index. The singular dimension of the first two variables avoids the problem of subjective weighting of composite indices and provides evidence-based poverty measures that intersect cultural, economic and policy boundaries (Setboonsarng 2005). Note that the wealth index is country specific and cannot be compared internationally (Rutstein and Johnson 2004). Data were taken from

TABLE 9.2 Correlation matrix of poverty indices and the Falkenmark index of water availability (TARWR), based on 48 African countries (2001–2002 data)

	TARWR	*WPI*	*Headcount ratio*	*HDI*	*GSI*
TARWR[1]	–	–	–	–	–
Water Poverty Index[1]	0.30*	–	–	–	–
Headcount ratio[2]	0.26	–0.34*	–	–	–
Human Development Index[3]	–0.21	0.67*	–0.58*	–	–
Genuine Savings Indicator[4]	–0.18	–0.08	–0.17	0.16	–
Social Vulnerability Index[5]	0.07	–0.47*	0.48*	–0.48*	–0.02

Notes: * statistically significant correlation ($p < 0.05$); 1 Lawrence *et al.* (2002); 2 World Bank (2009); 3 UNDP (2007); 4 Hamilton and Celemens (1999); 5 Vincent (2004).

the Demographic and Health Surveys (Measure DHS 2008) and interpolated to estimate values in non-sampled regions.

Plates 9.2, 9.3 and 9.4 illustrate the spatial distribution of child mortality, child morbidity and relative wealth respectively in 630 administrative districts across the basin. The administrative district represents the highest spatial resolution where policy can be feasibly implemented while capturing variable heterogeneity.

Whole-of-basin assessment

The poverty estimates were assessed for statistical correlation with possible poverty determinants, both water and non-water related, and were undertaken in the first instance at a basin scale using geographically weighted regression (GWR). The explanatory variables employed in the analysis are detailed in Appendix 1. GWR formally accounts for significant spatial correlations or spatial patterning, which can otherwise bias regression results and lead to misinterpretation (Ward *et al.* 2009). This demonstrated that the influence of different poverty determinants (such as geographical isolation, education levels and availability of water) is variable over the Niger Basin – unsurprising given the socio-economic and biophysical diversity of this large study area.

Furthermore, considerable disparity between results analyzed for child mortality and child stunting was found despite the widely accepted relationship between these variables. This highlights the need for poverty analysis that incorporates a number of alternative poverty metrics for cross-validation. At the whole-of-basin scale, we considered robust only those results that were supported by both the mortality and morbidity analyses.

The total available renewable water resources (TARWR) (cf. Plates 9.5a and 9.5b) was significant ($p<0.05$ for all statistical tests, unless noted otherwise) in north-west Nigeria, east Nigeria and central Mali.

TARWR was only occasionally associated with poverty, suggesting that social or institutional factors of water use are more important than water availability. The quality of water used by households appears to be as important, or more so, than the total quantity of water available in the environment.

The use of unprotected well or surface water is generally positively correlated with increased child mortality and increased stunting. In north-west Nigeria and east Nigeria, a 1 per cent decrease in the number of people using unprotected water is correlated with an up to 2.4 per cent decrease in child mortality.

Increased irrigation development is correlated with reductions in child stunting in central Mali, north-west Nigeria, central and eastern Nigeria and north Burkina Faso.

Increased time spent in education is significantly correlated with a decrease in both child mortality and child stunting. In much of the Mali Inner Delta, a one-year increase in the average level of education is associated with an approximately 3 per cent decrease in child mortality.

Education and access to improved water quality (see Plates 9.6b and 9.7 respectively) are variables that are significant and relatively stationary across the study area. They can therefore be addressed with whole-of-catchment scale policies with less attention to regional differences. Certainly, a variable as important as education will require its own nuances due to cultural factors; however, its gross importance is relatively spatially consistent.

The variables demonstrated to be statistically non-stationary (i.e. their influence varies across the landscape) may be more appropriately addressed using a geographically targeted policy approach. The differences in coefficient estimates are likely to be symptomatic of the ways in which a variable influences communities subject to local conditions.

Note that in Plates 9.5b, 9.6b and 9.7b, blue represents districts where the variable in question was not found to have a significant impact, green represents correlation with decreased childhood mortality, and yellow and orange represent correlation with increased childhood mortality. Data limitations mean that the identified areas should be considered approximate only, and some contrasting results would require additional detailed analysis.

National and sub-national poverty analysis (LISA clusters)

Policy decisions are often made at the state or national level, and regional perspectives of poverty cannot be presumed to be aligned or concordant with the differentiation of poverty, livelihood vulnerability or institutional diversity across the entire Niger Basin (Hyman *et al.* 2005). A finer resolution of poverty analysis was used as an alternative to a whole-of-basin analysis, enabling the identification of poverty hot spots at a sub-national scale. Anselin (2005) has developed localized indicators of spatial autocorrelation (LISA) to account for spatial clustering at defined local scales. These clusters represent areas that have significantly elevated poverty levels ($P<0.05$), referred to as "hot spots" (Ward *et al.* 2009).

There is broad convergence in the hot spots found using different poverty measures. A hot spot indicates those regions where the poverty measure is spatially correlated and significantly worse than the basin median. Plate 9.8a shows child mortality hot spots (coloured red) in central Mali and the Inner Niger Delta, north Burkina Faso and north-west Nigeria. Plate 9.8b shows hot spots of child stunting (coloured red) clustered in southern Mali, north-east Burkina Faso, north-west Nigeria and south-west Nigeria (stunting is measured by a height-for-age ratio, hence low values indicate worse conditions). Plate 9.8c shows hot spots of low relative wealth or asset value (coloured red). Because the wealth index cannot be compared internationally (Rutstein and Johnson 2004), this map provides less robust evidence; however, it shows very similar results to the other metrics. Poverty hot spots occur in south Mali, east Burkina Faso and north-west Nigeria.

Potential causative factors of each poverty hot spot were explored using spatially explicit regression analysis. As indicated by the "whole-of-basin" approach, this sub-basin scale assessment also found considerable differences in the way poverty manifests in different regions. Table 9.4 details the coefficients and statistics typical of the spatial lag regressions for child mortality, morbidity and wealth, estimated for north-west Nigeria. Nearest-neighbour relationships were used to determine the spatial weights matrix and estimate the spatial lag regression model according to Anselin (2005).

In north-west Nigeria, water quality is the primary water-related factor that correlated with poverty. A 1 per cent decrease in the number of people who access their primary drinking water from unprotected well or surface water is associated with a 1.1 per cent decrease in child mortality. Weaker evidence was found linking water access to child mortality: an average reduction of 10 minutes travelling time taken to access the primary water source is correlated with a 1.7 per cent decrease in child mortality rates. Similarly, a 1 per cent increase in a district's irrigated area corresponds with a 0.04 standard deviation improvement in height-for-age ratios. Education is the strongest non-water correlate: a 1-year increase in average years of schooling is associated with a 0.6 per cent decrease in child mortality rates where all other factors are held constant.

The central Mali region is an important area of the Niger Basin containing the Ramsar listed Inner Delta – a highly productive flood plain covering an area of more than 80,000 km^2. This region is characterized by average child mortality rates of 240 per 1,000 live births. The relationship between water and poverty is ambiguous in this region. Non-water variables were more clearly correlated with poverty. For instance, a 1-year increase in the average years of schooling is associated with a 3.1 per cent decrease in child mortality rates.

In east Burkina Faso, the use of unprotected water is correlated to poverty suggesting that quality is more important than quantity or access in this region. Environmental degradation, as measured by the World Wildlife Fund's "Human Footprint" score, significantly explained wealth and child mortality. An increase in environmental damage was associated with an increase in child mortality and a decrease in wealth.

TABLE 9.3 Summary of spatial lag regressions at the scale of identified poverty hot spots

Poverty hot spot	*Measure of poverty*	*Water poverty variables*	*Non-water poverty variables*	*Utility of the TARWR variable*
North-west Nigeria	Identified using all three metrics. Wealth index model strongest (R^2 = 0.956)	Water access Unprotected water Irrigation TARWR	Education Telephones	Moderate – child mortality only
Central Mali and the Inner Delta	Identified only in child mortality. Wealth index model strongest (R^2 = 0.816)	Unprotected water	Education Telephones Malaria	Limited – contradictory signs
East Burkina Faso	Identified using all three metrics. Child morbidity model strongest (R^2 = 0.791). Consistency of results weak.	Unprotected water	Education Environ. damage	Limited – child morbidity only, contrary signs
East Nigeria and North Cameroon	Identified only in wealth index. Child mortality model strongest (R^2 = 0.647)	Unprotected water	Education Population density Malaria	Limited – not significant
South and Central Nigeria *('wealth hot spot')*	Identified using all three metrics. Wealth index model strongest (R^2 = 0.632)	Unprotected water	Access to towns Education Electricity Telephones	Limited – contrary sign, small effect

In east Nigeria and north Cameroon, the use of unprotected water sources is significantly correlated both with reduced wealth and increased child mortality. A 1 per cent decrease in the use of unprotected well and surface waters is associated with a 0.16 per cent decrease in child mortality. Evidence was also found for a positive correlation of dams and irrigation on poverty levels. Education is associated with reduced poverty in the wealth and mortality models, and a 1-year increase in average education levels is associated with a 0.7 per cent decrease in child mortality. Table 9.3 summarizes the water and non-water determinants of poverty, estimated using spatial lag regression at the scale of administrative district.

At a national level, TARWR is only weakly correlated with widely used development and poverty indicators. Even at district scales, the total quantity of water available per capita is only occasionally significant in predicting child mortality, morbidity or the asset index. Water quality, however, was

TABLE 9.4 Variables explaining wealth, morbidity and mortality at the administrative scale in the north-western Nigeria region

	Wealth Index		*Child height-for-age ratio (s.d)*		*Child mortality rate (proportion)*	
(Constant)	–0.32330	**	–2.90450	***	–0.07228	*
Population density (people/km^2)	0.00017	***	–0.00018	**	0.00001	
Population (people)	–		–		–	
Telephones (proportion)	–		1.32720	**	0.05563	
Electricity (proportion)	–		–		0.01361	
Net primary product (produced) (tonnes/0.25° cell)	–		–		–	
Access ('00 km)	–		0.52565		0.03358	
Education (years)	0.07467	**	0.08867	***	–0.00655	***
Forest cover (proportion)	–0.16014		0.22228		0.01170	
Cattle density (units/ km^2)	–0.00217		–0.01003	**	–0.00076	**
Chicken density (units/ km^2)	0.00130	***	–		0.00024	
Sheep density (units/ km^2)	0.00003		–0.00381	**	0.00021	
Goat density (units/ km^2)	–		0.00257		0.00006	
Pig density (units/ km^2)	–		–0.01177		–0.02104	***
Unprotected water (proportion)	–0.73068	***	–0.34122		0.10797	***
Water access (minutes)	–0.00046		–0.00408		0.00171	***
Dams (00 km)	–0.23005	***	0.03517		0.00041	
Irrigation (percent)	0.00645		0.04289	*	0.00126	
Precipitation (mm/yr)	0.00083	***	0.00064		0.00008	*
TARWR (m3/yr/ km^2/person)	–0.00014		–0.00034		–0.00015	**
Drought economic risk (decile)	0.00346		–0.01672		–0.00159	
Human footprint (1–100 index)	–		–		0.00109	
Malaria prevalence (parasite ratio)	–0.43230	*	0.44091	*	0.03178	
Moran's I for residuals	–0.014		–0.059		0.017	
Akaike information criterion	–92.14		6.77		–327.14	
Aprox. pseudo adj. R^2	0.95		0.92		0.89	
Spatial weights matrix	3 nearest neighbours		2 nearest neighbours		1 nearest neighbour	
Sample size	34		65		71	

Notes: * statistically significant at 90 per cent confidence level; ** 95 per cent; *** 99 per cent. Note that a positive child morbidity coefficient means increasing height for age ratios and thus an improvement in health.

more clearly associated with these measures of poverty. At most poverty hot spots, there were significant correlations between the proportion of people drinking from unprotected water sources and the incidence of poverty. The area of irrigated land was associated with decreases in poverty in only two cases, north-west Nigeria (by one poverty metric) and in eastern Nigeria and northern Cameroon (by two metrics). Other variables were tested for correlations with poverty such as the spatial distribution of livestock (sheep, cattle, goats, pigs and chickens), the percentage of human appropriation of net primary productivity and forest cover. While there is evidence that some of these variables play a role in explaining poverty levels in some locations, they were not systematically reliable or significant determinants.

Links between poverty and water, poverty and agricultural productivity

A statistical relationship between water quality and child health poverty measures seems consistent with the vital role given to water and sanitation in alleviating poverty (UNDP/SEI 2006). Insufficient access to clean water is known to impact on human health, through the development of water-borne diseases (e.g. diarrhoea, cholera) and water-washed diseases (e.g. scabies, trachoma) (Bradley 1974). Diarrhoea is the third cause of child mortality in West Africa after malaria and respiratory infections (ECOWAS-SWAC/OECD 2008) and new water-borne diseases such as Whipple's disease are still emerging (Fenollar *et al.* 2009).

Literature suggests that agricultural water management provides a pathway out of rural poverty (Namara *et al.* 2009; Hanjra and Gichucki 2008; Hanjra *et al.* 2009). In this study, weak correlations were found between agricultural water determinants and poverty variables. TARWR does not account for difficulties in accessing water and therefore only provides a theoretical value of water potentially available for agriculture. The metric also does not translate into annual inflow and recharge variations, crucial in countries that regularly experience drought and flooding in the same year (Rijsberman 2006). Although TARWR is a commonly used indicator, in the Niger Basin it neither reflects accurately the water availability situation of a community nor its poverty status.

Hussain and Hanjra (2004) argue that increased irrigation and proximity to dams provides a pathway out of poverty, indicating community opportunities and capacity to access and transform water into food. This analysis found such a relationship in only some instances. The spatial regression analyses suggest either that irrigation's contribution to rural welfare is low in the Niger Basin, or that the spatial extent of irrigation is too limited at present to cause any detectable reduction in poverty at this scale of analysis. The literature suggests that irrigation will be crucial for the future economic development of the basin, along with improvements in the productivity of rain-fed agriculture. However, it may be that the benefits of irrigation do not yet accrue to the people engaged in its practice, or that they do so at levels too small to register in these analyses.

The relative wealth advantage of the Office du Niger, illustrated in Plate 9.8c and the analysis of Zwarts *et al.* (2006) suggest that so far the benefits of irrigation are confined to local irrigators and external investors and do not sufficiently accrue to the local poor.

The Office du Niger region is one of the oldest and largest irrigation schemes in SSA and expansion of irrigated agriculture is cited as a factor in regional poverty reduction. In general terms, expansion can be accomplished by either improved water efficiencies reliant on existing impoundments or the construction of new dams (e.g. the proposed Fomi dam in Guinea) associated with maintaining existing water efficiencies.

A successful rehabilitation of the area undertaken between 1983 and 1994 saw average rice paddy yields triple to 5 tonnes/ha. Previously abandoned lands were cultivated and the settler population grew by 222 per cent (Aw and Dejou 1996). By 2004, the average paddy yields had increased to 6.5 tonnes/ha;

water use dropped from 1,500m^3/t to 250m^3/t and cultivation intensity climbed from 60 per cent to 115 per cent (Diemer 2004).

As an alternative to engineered solutions, successful rehabilitation was achieved by micro-management and institutional reforms, implemented by the Malian government in return for capital investment by donor countries (Zwarts *et al.* 2005, 2006; Molden 2007). Institutional reforms included the privatization of non-irrigation activities enabling farmers to sell produce and purchase agricultural inputs at will. Decision-making has gradually shifted from government officials to famers' representatives, formalized by 3-year performance contracts between the government and farmers. The arrangements have improved the effectiveness of incentives, evidenced by increased agricultural outputs and subsequent net productivity.

In this study, agriculture-related indicators, including primary productivity, soil quality or livestock numbers, provide limited explanatory power of poverty levels. A similar study in Malawi by Benson *et al.* (2005) found that a rise in maize yields actually resulted in increased poverty, presumably due to equity issues, with higher yields not benefiting local populations. Despite agricultural productivity growth being expected to reduce poverty in the rural agriculture-dominant economies of West Africa (Thirtle *et al.* 2003), poverty prevails in areas of good soil quality, high productivity and sufficient water availability.

These results point to the complexity involved in transforming available water into adequate food production and a pathway out of poverty. Beyond reliable water access, food production relies on several additional conditions being met such as access to land, labour, seeds, fertilizer, pesticides, tools and machinery, fuel, storage, transformation processes, roads, markets and political security. Hanjra *et al.* (2009) point to significant correlations between these variables and agricultural productivity; however, variable interactions are critical in determining resultant poverty. Some of these factors may be spatially stationary at the regional scale (such as roads and access to markets); others such as access to land may vary widely from one family or ethnic tribe compared to another within the same village and therefore require detailed analysis. The latter structural indicators of poverty are notably caused by the positioning of individuals in the socio-economic structure (Mulwafu and Msosa 2005).

Overall, it is difficult to isolate one contributing factor to poverty. Instead, the evidence from this analysis promotes a multi-variate consideration of the capabilities (e.g. level of training, diverse income sources, capital and support networks) of a household or community (Chambers and Conway 1992), as these determine whether they will fall or subsist in a state of poverty. The absence, presence or quality of water do not in themselves act as determinants of poverty. More accurately, it is what people choose to do with available water, within the parameters of their capabilities, that influences poverty (Bidou and Droy 2009). For instance, access to clean water may be seen as an implicit guarantee of improved health, but if wells are not maintained or communities prefer the taste of the water from the nearby pond (Becerra *et al.* 2009), then reduced poverty levels may not be evident.

Research application in policy deliberations

The final whole-of-basin analysis was comprised of 13 variables, producing spatially explicit predictive models with R^2 values between 0.6 and 0.99 for both child mortality and child morbidity. A number of other variables were excluded due to multi-collinearity. The results demonstrated that the magnitude of variable effect is spatially dependent and, as a corollary, we can conclude that landscape heterogeneity matters. Hence, use of the results provides high-resolution, spatially referenced information, allowing more targeted policy development and implementation. Even with only this constrained vector of variables included, the model's predictions of poverty closely match our original estimation (see Ward *et al.* 2009).

The purpose of variable aggregation into a cadastral representation of poverty was to provide an evidence-based, comprehensive and interpretable representation of the water poverty situation to assist policy deliberations and interventions. As poverty is a multi-dimensional, synthetic construct, collating the identified components with statistically estimated weighting coefficients is necessary for integrated and improved understanding. However, for assessing the potential impacts of different policy effects, a more tangible output is required. In Plates 9.9, 9.10 and 1.5, we remodel the original dependent variables, child mortality and child morbidity (stunting) and adjust specified independent variables to predict the likely effects of such a change. The models were constructed from the geographically weighted regression (GWR) results, meaning that the impact of a uniform independent variable change (for instance, from a particular policy approach) will manifest differently in different parts of the Niger Basin.

We consider six policy outcome hypotheticals:

- A uniform increase in average education (by two years and by four years; see Plate 9.9)
- A uniform decrease in the use of surface and unprotected well water (by 10 per cent and by 20 per cent; see Plate 1.5).
- A uniform increase in irrigation intensity (by 10 per cent and by 20 per cent; see Plate 9.10).

The colour scheme used to represent changes in the poverty variables are standard across all three figures, allowing for visual comparison of the different strategies. While uniform adjustments to these determinants is unrealistic, as a modelling exercise it demonstrates the differential effect of such change on different regions of the basin, and where such changes could be expected to deliver the greatest impact.

Education appears to be the most universally effective means of reducing poverty, with improvements in health predicted for much of Mali, north-west Nigeria, east Burkina Faso and central Nigeria. In particular, the poverty hot spot around the Inner Niger Delta appears substantially alleviated by an additional four years in average education.

A uniform reduction in the proportion of people using surface water or unprotected well water represents a likely improvement in the quality of water used. Our model suggests that this approach could substantially alleviate child mortality in north-west and central Nigeria, although other areas are affected only very slightly.

Plate 9.10 illustrates the predicted impacts from a uniform increase in irrigation intensity across the Niger Basin. According to the spatially weighted analysis of available data, a policy initiative based on increasing irrigation intensity did not lead to a prediction of substantial reductions in child mortality and child morbidity. This suggests that either irrigation's contribution to rural welfare is low in the Niger Basin, or that the current spatial extent of irrigation is too limited to cause any detectable reduction in poverty at this scale of analysis. As previously stated, Hanjra and Gichuki (2008) and the NBA (2005) propose that irrigation will be crucial for the future economic development of the basin, along with improvements in the productivity of rain-fed agriculture (Castillo *et al.* 2007). However, it may be that the benefits of irrigation do not yet accrue to the people engaged in its practice, or that they do so at levels too small to register in these analyses.

Conclusion

Policy decisions are often made at state or national level, and regional perspectives or understanding of poverty cannot be presumed to be aligned or concordant with the differentiation of poverty, livelihood vulnerability or institutional diversity across the entire Niger Basin (Hyman *et al.* 2005). More effective policy that influences water access or productivity is likely to be reliant on mixes of sequenced instruments tailored to address temporally and spatially diverse poverty patterns. An important focus of this research was the development and application of methods capable of aligning water management and poverty data at scales that are administratively and politically feasible across the Niger Basin countries.

The first research objective was to identify methodologies capable of integrating impact analysis and policy formulation that reliably differentiates poverty at these multiple scales. A second research objective was to map poverty as a unit of analysis that aligns water productivity and water access with poverty data, revealing opportunities for water-policy formulation. A final objective was to provide evidence-based analysis that guides effective policy development in the direction of the causes of poverty at scales that reflect the most exposed communities.

The lack of a comprehensive metric that reliably captures the multi-factorial characteristics of water poverty has led to a raft of measurement techniques, each with advantages and disadvantages. Attempting to develop another poverty index or measurement criteria was not the aim of this research. Our primary aim was to assess and develop methods to detect and analyze a hypothetical relationship between water and poverty through statistical methods and poverty mapping.

To account for a high proportion of subsistence livelihoods and a large non-market, hybrid economy, we used child mortality, child stunting and a composite wealth index as poverty metrics. The analysis of spatially referenced child mortality, child morbidity and the wealth index identified three major poverty hot spots in the Niger Basin. These are situated in southern Mali and the Inner Delta; north-east Burkina Faso; and north-west Nigeria (as summarized in Plate 9.11).

There is broad convergence in the spatial correlation between poverty measures illustrated in Plate 9.11. Communities situated in regions of intersecting hot spots for the three poverty metrics are those expected to face the greatest poverty and vulnerability challenges.

We found that education and access to improved water quality are the only variables that are consistently significant and relatively stationary across the entire basin. At all scales, education is the most consistent non-water predictor of poverty while access to protected water sources is the best water-related predictor of poverty. They can therefore be addressed with whole-of-catchment scale policies with less attention to regional differences.

The variables demonstrated to be statistically non-stationary (i.e. their influence varies across the landscape) may be more appropriately addressed using a geographically targeted policy approach. The differences in coefficient estimates are likely to be symptomatic of the ways in which a variable influences communities subject to local conditions.

Similar studies evaluating the significance of explanatory variables in poverty mapping have found limited correlations between poverty and agro-ecological or socio-economic determinants (Hyman *et al.* 2005). While established relations between water variables and poverty exist, notably water quality impacts on health and therefore poverty, these vary substantially through space and time. Access to water for agriculture and productive purposes plays a crucial role in poverty alleviation but is not a sufficient condition and much will depend on the capabilities and endowments of a given household or community. The research completed as part of this study indicates that landscape and scale matter in water poverty. Interactions between environmental, social and institutional factors are complex, and an evaluation of poverty and its causes requires analysis at multiple spatial resolutions.

The poverty maps, estimated at a high-resolution scale, can be viewed as evidence-based, easy to interpret participatory tools, rather than a final product. The cadastral representation of poverty vectors enables the community, policymakers and administrators to visually evaluate the relative effectiveness of alternative policy incentives and actions, the relative distribution of resources and investment priorities.

TABLE 9.5 Independent variables considered in the analysis of poverty prevalence

Variable	*Description and source*	*Assumed relationship with child mortality*	*Mean*	*Std. dev.*
Dependent variables				
Child mortality	Proportion of children who die before their 5th birthday	n/a	0.15	0.06
Child morbidity	Average height for age ratio (standard deviations below healthy reference median)	n/a	–1.40	0.62
Water variables				
Precipitation	Precipitation (millimetres/year) Source: FAO (2007)	Negative	1,006	563
TARWR	TARWR (total available renewable water resources) of Niger sub basins. Includes actual inflows into sub basin, plus internal water resources (rainfall). All relevant parameters (water volume) measured at the sub basin level (bigger than administrative districts), and are assumed constant across sub basin. (Specified with area and per capita component (m^3/year/km^2/person) Source: FAO (2000)	Negative	6.2	54.9
Unprotected water	Proportion of a district whose main water source is surface water or unprotected well water. The average is taken at the household level; estimation based on an inverse distance weighting interpolation across landscape. Source: Measure DHS (2008)	Positive	0.51	0.23
Water sccess	Average time taken to collect water from the primary water source. The average is taken at a household level; estimation based on an inverse distance weighting interpolation across landscape. Source: Measure DHS (2008)	Positive	23.1	14.3
Dams	Average direct distance from district to a large dam ('00 km). Source: FAO (2006)	Positive	1.11	0.93
Irrigation	Is the percentage of a district that is under irrigation. Source: FAO (2007a)	Negative	0.5	1.9
Other variables				
Drought economic risk	Economic loss (GDP) due to drought. Calculated both as a proportion of GDP. Global decile scale based on historical experience. Areas with less than 5 persons/km^2 and without significant agriculture are given a zero value. Source: Centre for Hazards and Risk Research (2005)	Positive	7.2	2.3
Population density (2005)	Population density of administrative district in 2005 (people/km^2). Source: CIESIN (2005)	Unknown	167	426
Population (2005)	Population of administrative district in 2005 (number of people). Source: CIESIN (2005)	Negative	117,794	124,736

TABLE 9.5 *continued*

Variable	*Description and source*	*Assumed relationship with child mortality*	*Mean*	*Std. dev.*
Telephones	Proportion of a district with a telephone in the home. The average is taken at the household level; estimation based on an inverse distance weighting interpolation across landscape. Source: Measure DHS (2008)	Negative	0.05	0.06
Electricity	Proportion of a district with electricity in the home. The average is taken at the household level; estimation based on an inverse distance weighting interpolation across landscape. Source: Measure DHS (2008)	Negative	0.31	0.27
Access	Average direct distance from district to an administrative centre or large populated place ('00 km). Source: FAO (2007b)	Positive	0.27	0.15
Education	Average years of education. The average is taken at the individual level; estimation based on an inverse distance weighting interpolation across landscape. Source: Measure DHS (2008)	Negative	2.7	3.0
NPP (produced)	Net primary productivity (NPP). Net amount of solar energy converted to plant organic matter through photosynthesis (tonnes of carbon per 0.25° cell) Source: Imhoff, *et al.* (2004)	Negative	2.9*10	1.6*10
Malaria	Estimated prevalence of malaria parasite in children 2–9 years. Data is from surveys and modelling based on climate, altitude, vegetation cover and agro-ecological zones (proportion). Source: MARA (1998)	Positive	0.43	0.18
Human footprint	Normalized scores from the Human Influence Index, a measure of environmental damage. Relative values range from 0 (least influence) to 100 (most influence) for the biome found in that district. Source: SEDAC (2005a)	Positive	29.9	7.8
Forest cover proportion	Proportion of district occupied by closed, open or fragmented forest. Source: Global Forest Resources Assessment (2000)	Negative	0.33	0.32
Cattle density	Average density of stock across the district (units/km^2). Source: FAO (2007b)	Negative	17.2	14.6
Chicken density	Average density of stock across the district (units/km^2). Source: FAO (2007b)	Negative	90.4	169.6
Sheep density	Average density of stock across the district (units/km^2). Source: FAO (2007b)	Negative	20.5	23.1
Goat density	Average density of stock across the district (units/km^2). Source: FAO (2007b)	Negative	31.6	45.9
Pig density	Average density of stock across the district (units/km^2). Source: FAO (2007b)	Negative	3.7	13.8

Combining research from the Challenge Programme on Water and Food (www.waterandfood.org) with the poverty coefficients developed here for the Niger Basin is intended to provide a reliable basis for agencies to explore the social and economic dimensions that enable adaptive water system management. Agencies are then able to concentrate on regions and cases that describe incremental but large change and investigate social sources of renewal and reorganization.

Estimating the covariance of significant, spatially referenced factors that comprise water-related poverty in the Niger Basin, combined with geographic information system mapping, would enhance the usefulness of deliberative tools. This would be especially salient to evaluating portfolio approaches to poverty reduction, targeted sequencing of instruments and prioritization of investments across several factors. This is the subject of ongoing research.

Appendix 1

Regression variables

The independent variables included in the regression models are described in Table 9.5. Of primary interest are the water-related variables. Other variables were selected to represent different forms of capital: physical (electricity, telephones, roads), human (population density, education) financial (livestock density) and natural (productivity, forest cover, environmental degradation, malaria). These were selected based on the findings of Kristjanson *et al.* (2005). Variables were compiled in a geographic information system (GIS) and then sampled to provide average values of each variable in each study unit. All variables were initially included in the models, with variables removed on the basis of high multi-collinearity (variance inflation factors >10; see Belsley *et al.* 1980). The electricity and telephone variables were excluded from wealth index models (as they are themselves components of the index).

Notes

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2 www.africaneconomicoutlook.org/en/outlook/macroeconomic-performances-in-africa/economic-growth/west-africa/.

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10

PALYJA "WATER FOR ALL" PROGRAMMES IN WESTERN JAKARTA

Vincent Fournier, Philippe Folliasson, Luc Martin, Arfiansyah and Irma Damayanti [1]

Introduction

In 1998, the Indonesian government decided to outsource provision of water services in Jakarta and awarded 25-year contracts to two private water utilities to produce and distribute clean drinking water. One of these contracts was allocated to Palyja, partly owned by Suez Environnement, a business subsidiary of GDF Suez.[2]

Since taking on its contract, Palyja has doubled the distribution of clean water through its concession district and refurbished two water treatment plants in Jakarta. As a result, more than 4.5 million customers, including thousands of low-income customers, now have access to clean water. Through a series of cross-tariffs and incentives, Palyja's ambition is to provide all people in western Jakarta with a water infrastructure that provides access to healthy water.

The remainder of this chapter describes Palyja's experience as a private company in producing and distributing water with a particular focus on the supply of water to low-income areas under an output-based agreement and the provision of water to illegal settlements through the provision of master meters and water kiosks.

The city of Jakarta used to be supplied with water by a state-owned company, Pam Jaya. In 1998, the water concession was split into two districts, western and eastern Jakarta, delimited by the Ciliwung River, and the contracts were appointed to private water utilities. Palyja won the contract for western Jakarta and Aetra has the contract for eastern Jakarta.

Palyja has been producing and distributing clean water in western Jakarta for about 11 years. Since that time, Palyja's network has more than doubled so that it now reaches about 2.9 million customers (about 63.5 per cent) of the population in western Jakarta. With more than 414,000 active connections, Palyja sells approximately 420,000 m^3 of clean water per day.

Palyja's objective is to connect all households

Palyja's objective is to connect all households within its concession district. Currently about 36.5 per cent (1.6 million people) are still without access to a mains water supply. With a strong commitment towards its population, Palyja has designed three methods to improve water access in poor neighbourhoods.

Extension of the network in low-income areas

In conjunction with jointly funded aid programme projects including the Global Partnership on Output Based Aid (GPOBA) and using World Bank finance, Palyja has established a project that aims to pipe clean water to more than 6,500 low-income households and provide access at an affordable rate.

Implementation of master meter systems

Implemented in cooperation with non-governmental organizations (NGOs) and with a strong focus on community participation, master meters are being installed both in legal settlements and illegal settlements.

Construction of water kiosks

This program aims to provide access to clean and affordable water beyond the network by carting water in trucks to a tank with hydrants attached to it. Community-based hydrant managers are in charge of distribution and the collection of the money required to pay for this water. The result is the introduction of a transparent water-pricing system that reflects the actual cost of providing water to customers not connected to mains water at a fair price that is substantially cheaper than the inflated price charged by some independently operated profiteering water vendors.

Jakarta's water supply

Box 10.1 provides a brief history of the development of water supplies in Jakarta. Jakarta's population includes a significant number that live in wretched, unsanitary conditions with no access to clean water services. In these conditions, people are forced to choose either to draw water from heavily polluted rivers, contaminated and often saline aquifers or, when no mains water is available, purchase it from private pushcart vendors at the price of US$0.15 per 20-litre jerrycan or US$7.50 per m^3 ,which is more than 70 times the price of mains water if it were available.

There is only one sewage-treatment plant in Jakarta and it is only able to service about 2 per cent of the total population. It is estimated that more than 7 million Jakarta residents (about 88 per cent of Jakarta's population) lack sanitary toilets and properly constructed septic tanks (WSP-EAP 2008). Open defecation is common. Most of the septic tanks are not properly sealed, often contaminating underground water by natural infiltration. Moreover, septic tanks are not emptied on a regular basis and, as a result, tend to overflow into nearby rivers or drain into the groundwater system, increasing the level of excrement in the river system.

A related problem is the over-consumption of ground water, which has caused infiltration of seawater into the underground water table. As a result, the groundwater in Northern Jakarta is now too saline to be used for cooking or drinking. In other parts of Jakarta, groundwater is still the main source of drinking water.

Indonesia's urban growth rate is one of the fastest in the world. While the countrywide growth rate is 1.1 per cent per year, the urban population growth rate is 3 per cent per year (UN 2005). Currently, 114 million people (more than half of the country's population), live in urban areas of Indonesia. This rapid urbanization presents a challenge for service provision in a country where existing urban water supply and sanitation infrastructure fails to provide for the majority of urban residents, and development is not on track to achieve Millennium Development Goal (MDG) targets for water supply and

Box 10.1 HISTORY OF JAKARTA WATER SUPPLY

Until the 1870s, people living in Jakarta used to rely on river and shallow groundwater. Under Dutch rule in the 1870s this changed, and a centralized water-supply system using artesian wells was established to supply European people living in the Batavia district and then gradually extended into the European quarter (Monas area, old town, Menteng).

Between 1910 and 1920, four hydrants were installed for the indigenous urban population to supply 116,740 residents in the south of Jakarta. As the north of Jakarta was subject to flooding and had poor groundwater quality, no hydrants were installed in this part of the city. Sanitary conditions were poor, and in 1 year some 60,000 native residents died from cholera and typhus.

In the 1920s and under Dutch administration, the city began using spring water from Bogor and supplying water for free. Reflecting the values operating at the time, supply arrangements took race into account.

- European people were entitled to 140 litres/capita/day – 90 per cent coverage.
- Chinese and other Asians were entitled to 100 litres/capita/day – 60 per cent coverage.
- Native people were entitled to 30 litres/capita/day – 30 per cent coverage.

Initially, the Dutch Council decided to provide water to local communities by establishing free hydrants in each area, but when the council began losing money it started to charge local water vendors, and customers ended up paying. As a result, many people returned to former ways of getting free water.

These arrangements continued until the water supply system was destroyed during the independence war (1945–1949). By 1959, only 15 per cent of the population had access to piped water. The first water-treatment plants were built under Sukarno's regime in the early 1950s.

sanitation (UN-ESCAP 2007). Significant urban population growth in the past decade has been accompanied by a proportional increased demand for water and the construction of deeper wells to reach the shrinking underground water table. Plate 10.1 shows the rate of population growth in Jakarta.

In Jakarta, where the population is more than 8 million, the number of deep wells has become a tangible problem as people continue the practice of drawing free water from dwindling underground supplies. While it is difficult to estimate the number of wells being used, over-consumption is clearly occurring. So much so, that some parts of the city are sinking at a rate up to 5 cm per year. In an effort to redress this problem, it was recently decided to tax people who draw on underground water from private wells in the hope that this would act as an incentive to encourage them to buy piped water instead.

Most of Jakarta's untreated water supply (64 per cent) comes from the Jatiluhur reservoir (see Plate 10.2). The Jatiluhur reservoir is used to produce electricity and 94 per cent of water from this source is used for irrigation, leaving just 6 per cent to supply Jakarta's water needs. The water flows through agricultural fields to reach Jakarta via a 33 km long, open canal. Along the way, some water is drawn illegally by farmers for irrigation purposes. The water is also contaminated as people both defecate directly into the canal and allow rudimentary toilets to drain directly and untreated into the canal. By the time the water reaches the city of Jakarta, it is of poor quality.

Water supply options

Before Palyja entered into a contract with the government to supply water to western Jakarta and in particular before implementation of its outcome-based programmes, conditions for access to water in many areas was unacceptable in terms of quality and price. Essentially, there were only four water supply options.

Underground water

Most of the houses in low-income settlements had an electric pump connected to a well. As most of GPOBA areas are located in northern Jakarta, the underground water is brackish and contaminated by the surrounding lack of sanitation. It is considered unfit for consumption. However, people from the area, after boiling it, use it for drinking and cooking despite its bad taste and health risks. This water was also used without boiling for washing, cleaning, laundering and general household use.

Mobile water vendors

Some water vendors with access to Palyja water hydrants resell water to low-income customers who are not supplied with mains water. They charge up to US$7.50 per m^3, which is more than 20 times higher than Palyja tariff for low-income households that are supplied with mains water.

Bottled water

People living in low-income areas can buy bottled water that is suitable for consumption but is too expensive for the majority of people living in these areas.

River water

Rivers are highly contaminated due to the dumping of industrial waste by factories and as a result of open defecation, open sewers and poor septic tank systems. Despite the unsanitary nature of the water, many Indonesians hand wash their clothes by crouching on a riverbank with their hands and feet in direct contact with the water and often just metres away from drop toilets.

As a result of poor sanitation and water supply (see Plate 10.3), there are an estimated 121,100 incidents of diarrhoea annually, resulting in more than 50,000 deaths each year. The World Bank Water and Sanitation Group estimates that as a result of poor sanitation and water supply, Indonesia loses more than US$5.8 million per year on health and environmental costs – the equivalent of 2.3 per cent of the country's gross domestic product (GDP).

The role of Palyja

Palyja's concession is divided into three main customer districts (UPP) as shown in Plate 10.4.

Under its concession, Palyja receives a fixed payment for the delivery of water to customers. Tariffs are controlled by the government. Under the current policy, high-income customers and non-domestic water users subsidize water provision to low-income families (Table 10.1). Palyja receives a fixed tariff for water sales, independently from the tariff class associated. This system works as an incentive for Palyja to consider all demand equally in terms of generating income resulting in the ongoing development of a distribution network in low-income areas.

TABLE 10.1 Jakarta Water tariff structure in IDRs per m³ (US$1 = 10,000 IDR)

	Customer type	*Volume of water used*		
		0–10 m³	*11–20 m³*	*>20 m³*
K1	Social customers	1,050	1,050	1,050
K2	Low-income domestic	1,050	1,050	1,575
K3A	Middle-income domestic	3,550	4,700	5,500
K313	High-income domestic and small business	4,900	6,000	7,450
K4A	Large buildings, hotels, etc.	6,825	8,150	9,800
K413	Non-domestic	12,550	12,550	12,550

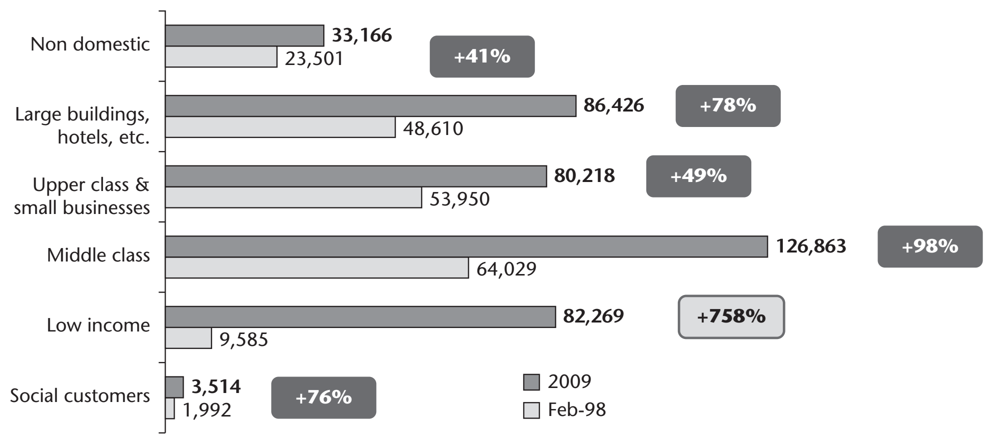


FIGURE 10.1 The evolution of Palyja's customer base and type from 1998 to 2009.

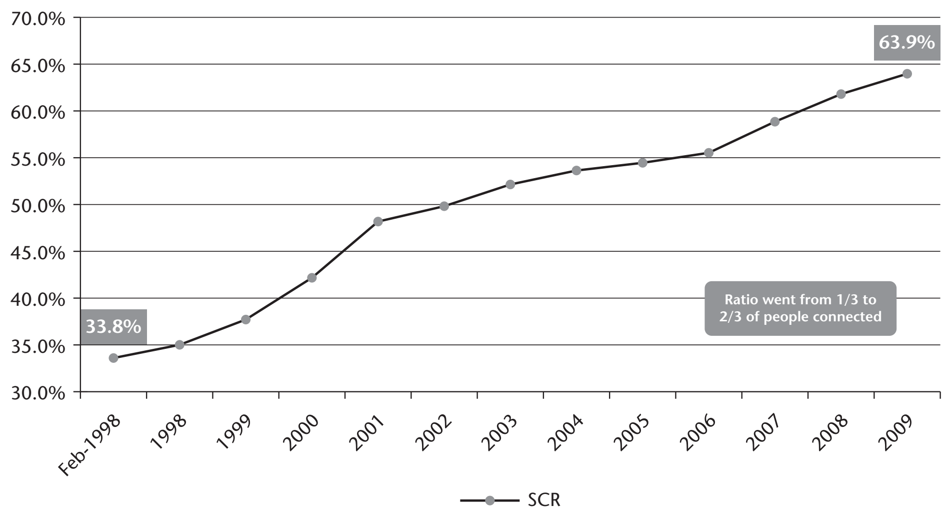


FIGURE 10.2 Service coverage ratio in the Palyja concession.

Plate 10.5 shows the nature of the evolution of supply reliability that has been achieved since taking over the concession in 1998 when large areas received either only had access to an intermittent supply and no mains supply at all. As can be seen from Plate 10.5 and as a result of extending and repairing 1,700 km of network, both reliability and coverage has been extended significantly. As a result of Palyja's policies and the tariff payment system it works under, most of the improvement in the supply system has been to low- and middle-class customers (see Plate 10.5).

Figure 10.1 shows progress towards meeting the MDG that requires 80 per cent of concession-area households to have access to a reliable water supply by 2015. Already, 63 per cent have been connected. In order to achieve the MDG goal, Palyja will need to connect an additional 17 per cent of households over the next 5 years. Most of the remaining households are located in low-income areas.

Financing improved water access in poor neighbourhoods in Palyja's concession district

Extension of the network in conjunction with jointly funded aid programmes including GPOBA and World Bank finance

Until 2007, extension of the network being installed and managed by Palyja was funded by a government entity known as Perusahan Air Minum (PAM). Water management system in Jakarta discouraged Palyja from connecting water into low-income areas because the government's policy of providing water to low-income families involved subsidies that made it less financially rewarding than providing water to more affluent customers and non-domestic users who were charged higher prices for their water. The government's cross-subsidy system meant that PAM generated less profit from water supply to subsidized households but the infrastructure costs paid to Palyja were the same. Palyja discovered that it could access alternative funding options. Palyja joined into a partnership with the World Bank's Global Partnership on Output Based Aid programme (GPOBA) to extend the supply of water to low-income communities.

Under Palyja's GPOBA US$2.5m agreement with the World Bank and PAM, Palyja is responsible for financing supply of water to low-income communities until a supply standard is reached and agreed supply targets are reached. By the end of 2010, it is expected some 11,600 households in western Jakarta will be connected to the piped water distribution network as a result of this project. The agreement requires Palyja to:

- connect an agreed number of new households to its network, obtain a signed connection form from the head of each household stating that the connection has been made and have more than 10 per cent of these forms verified for authenticity by an independent auditor; and
- provide each newly connected household with access to a reliable water supply of at least 10.8 cubic metres per month for three consecutive months.[3]

Under its GPOBA agreement, Palyja is to be paid only after both of these conditions are met. Figure 10.3 provides an overview of the administrative arrangements that underpin this agreement.

An important feature of the GPOBA programme is that it is targeted at small "pockets" of households and communities that are located within larger areas that are already served. Jakarta is affected by water shortages, which limit Palyja's ability to extend the network into some currently unserved areas, particularly in the northern part of the city. Thus, the GPOBA programme is not focused on "greenfield" areas, but rather on areas that are in close proximity to an existing water main.

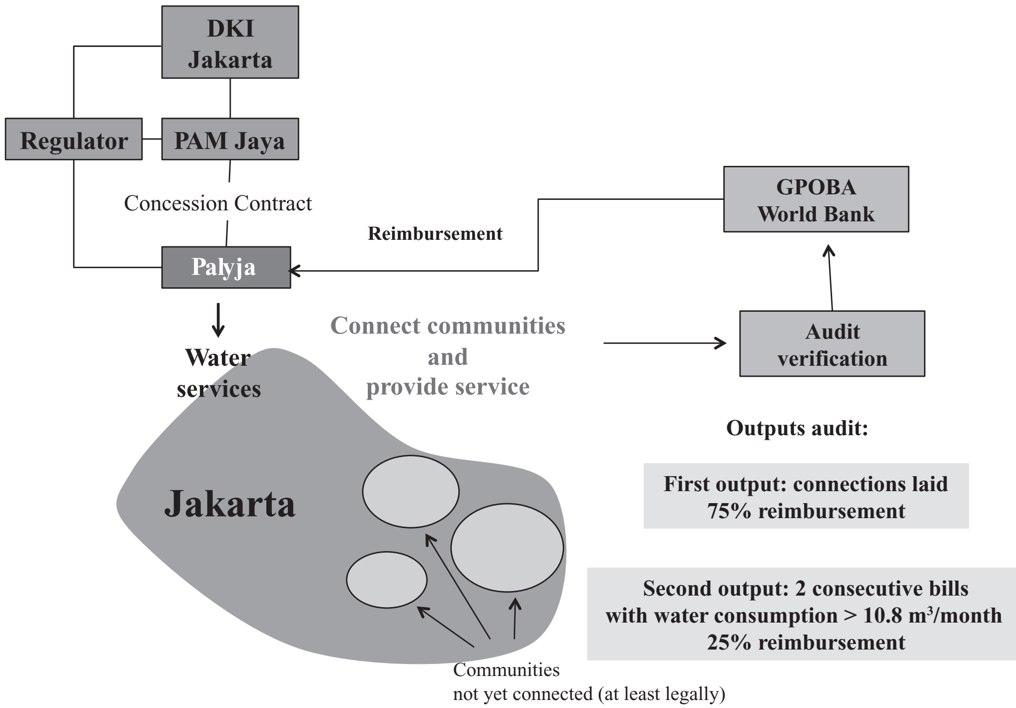


FIGURE 10.3 Overview of the administrative arrangements underpinning the GPOBA agreement.

One of the key features of these communities is that they typically have a clearly identified community leader.

The selection of communities for the GPOBA involved a multi-stage process. Thirteen communities were selected in 2006 during the GPOBA preparation phase. The implementation phase was delayed until 2008 due to complicated administration processes with the World Bank for the grant preparation. Due to the dynamism of urban growth in Jakarta, the field conditions had changed for some of the selected communities by the time the operational manual (grant effectiveness) was signed. The implementation in some of the selected communities had to be reconsidered for various reasons including instances where communities had been evicted, had already been connected to Palyja water services or became more difficult to supply due to increased priority for water demand elsewhere. As a result, only 9 of the original 13 agreed areas have been targeted for the GPOBA.

It was decided to implement the project in two stages:

- Phase 1: the installation of about 9,430 house connections.
- Phase 2: the installation of about 1,700 additional connections.

Phase 1 of the project included the installation of house connections to Muara Baru, an illegal settlement. Depending on the outcome of the installation in Muara Baru, phase 2 will include water connections to other illegal settlements in western Jakarta.

Initially, it was proposed to connect legal households with individual water connections and connect illegal households using master meter systems. However, the community of Muara Baru would not

TABLE 10.2 Water charges and proportion of connection tariff to be paid by households in phases one and two of the agreement

Connection type	Customer contribution (US$)	*Customer class*			
		Low-income domestic (K2)		*Middle class (K3A)*	
		Standard connection fee (US$)	*GPOBA contribution (%)*	*Standard connection fee (US$)*	*GPOBA contribution (%)*
Legal settlements	12	63	81	96	88
Illegal settlements	1.2		98		99

accept this and insisted that they be supplied with individual water connections. Learning from this experience and, in particular the importance of community consultation, Palyja is now committed to selling water to all communities involved in the GPOBA programme on a household-by-household basis, irrespective of whether they are legal or illegal households. As a result, the only difference is a different payment arrangement for illegal and legal households (see Table 10.2). As would be expected, the proportion of the tariff payment to be met by the World Bank is higher for households in illegal communities.

One of the major and unanticipated benefits to Palyja of the GPOBA scheme has been a dramatic reduction in the volume of water that is not paid for (non-revenue water). As shown in Figure 10.4, since the introduction of the programme, the amount of non-revenue water in the system has declined by more than 15 per cent and the volume of sales increased by a corresponding amount. By March 2010, GPOBA's first phase had been implemented in six areas.

FIGURE 10.4 Increase in water sales and reduction in non-revenue water (UFW - 6MMA).

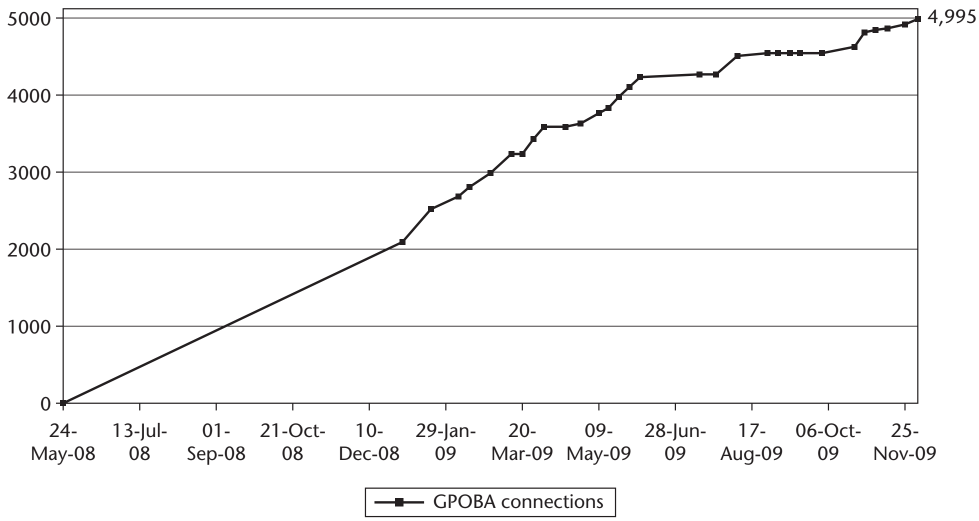


FIGURE 10.5 GPOBA connections to November 2009.

Under its contract, Palyja has to achieve a specified number of installations per type of water connection. This minimum target had to be achieved to get the full reimbursement for network expenses. For legal connections, this target has been achieved and Palyja is confident that it will soon achieve the GPOBA's target for connection to illegal households (see Figure 10.5).

To achieve the second condition/criteria required under Palyja's GPOBA agreement, average water consumption per household per month needs to be higher than 10.8 m^3 for three consecutive months. As can be seen in Figure 10.6, this is proving to be a particularly challenging requirement and has required Palyja to seek innovative solutions and fund this from its own resources. By way of example,

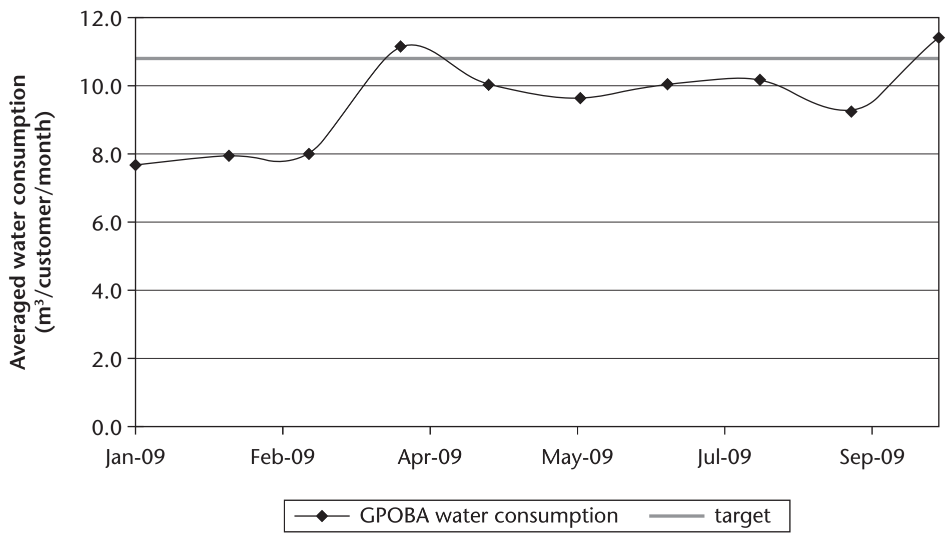


FIGURE 10.6 Household water consumption for connections made under the GPOBA agreement.

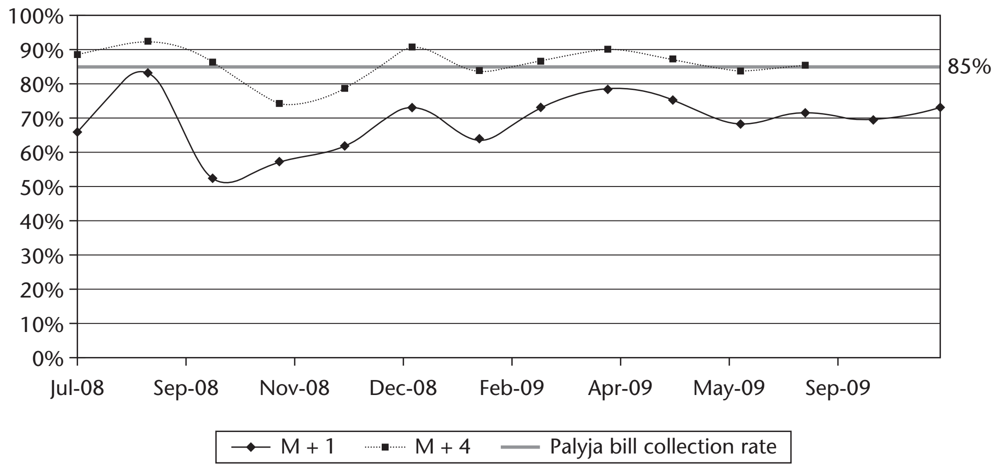


FIGURE 10.7 Comparison of GPOBA bill-collection ratio after 1 and 3 months.

as implementation proceeded it became clear that water supplies to the Menceng area could only be made available at night, which would mean that the three-monthly average water use requirement could not be achieved. In order to solve this problem, Palyja independently funded the extension of the network from further south so that average water consumption in the Menceng area could increase. Palyja was then able to achieve the output standard required in order to be paid by the World Bank.

In Indonesia, it is often perceived that low-income households do not pay their bills, including water and electricity accounts. Palyja's experience does not confirm this. Under current arrangements, Palyja is paid on time (within 1 month) by 85 per cent of its customers (M+1). As illustrated in Figure 10.7, the bill-collection ratio (M+1) in the GPOBA areas is lower than Palyja's average after 4 months (M+4), but after four months a correction is achieved and it becomes evident that, as a general rule, GPOBA customers are late payers rather than non-payers.

During the design of the GPOBA, it was considered that including the illegal settlement of Muara Baru in the first phase would be a pilot for including several illegal settlements in the second phase. Muara Baru, like many other illegal settlements has been threatened with eviction for more than 30 years. While a number of water-supply arrangements were problematic, one unanticipated consequence was the powerful group of water vendors who had previously sourced water from water hydrants and then resold it under controlled pricing conditions managed by a water "mafia." Typically, the price charged by these vendors was in the vicinity of US\$7.50 per m^3. That is, the price paid could be as much as 70 times the tariff set by PAM for low-income households (see Table 10.3). The impact of the GPOBA on these lucrative business practices was not considered during the implementation phase. Water vendors and their bosses targeted Palyja's workers and used threats and violence to impede Palyja's progress in order to maintain their livelihoods. As a result, implementation of the project was temporarily stopped until the problem with hydrant owners and the local water mafia could be solved.

In response, Palyja initiated a series of negotiations with local authorities from the area:

- Initially, Palyja contacted a government representative responsible for the Muara Baru sub-district. Palyja explained the objective of the project and the challenges to implementing it in Muara Baru, as well as the benefits to the community of having access to clean water. Initially, the government representative agreed to support Palyja's initiative through GPOBA to supply water to the

TABLE 10.3 Ratio of price paid for access to water supplied by water vendors at US$7.50 per m^3 and that charged by PAM to households people connected to the water supply system in western Jakarta

	Customer type	*Volume of water used*		
		0–10 m^3	*11–20 m^3*	*>20 m^3*
K1	Social customers	71	71	71
K2	Low-income domestic	71	71	48
K3A	Middle-income domestic	21	16	14
K313	High-income domestic and small business	15	13	10
K4A	High-income domestic and small business	11	9	8
K413	Non-domestic	6	6	6

settlement and proposed to get in touch with the settlement's local leader to try to convince him of the benefits of sourcing water from Palyja. A few weeks later, however, the government representative withdrew his support, explaining that the local settlement leader said he needed the income generated by water sellers to survive and feed his family. Palyja then contacted the local chief of police in the area, who suggested Palyja undertook a massive action that involved targeting illegal connections in the illegal settlement. The chief of police subsequently withdrew his support after meeting the local settlement leader.

- During 2009, after more than a year of negotiations, a solution was finally found. Palyja employed the local settlement leader as its representative in the area and the installation of individual connections has resumed in a safe working environment. To date, 413 new connections have been successfully completed.

The regulations regarding illegal settlements impedes Palyja garnering strong support from the Indonesian government for the implementation of the GPOBA in such areas so the connection of pipe distribution networks to illegal settlements remains a problem.

Before GPOBA implementation, people used to buy a few litres of clean water from mobile vendors, sometimes at prices 20 times higher than Palyja's tariff set for low-income households and six times the tariff set for high-income households. Currently, GPOBA customers pay US$0.105 or US$0.355 per m^3 depending on the tariff class, significantly less than water delivered by mobile vendors (US$7.50m). In terms of water consumption, consumers that previously used a few litres per day (40 litres to 80 litres per day, depending on the family size) are using about 300 litres a day for less money when connected as a GPOBA consumer.

A study is currently being undertaken to assess the health impact of the project on customers. Among other criteria, Palyja is comparing local health records before and after GPOBA implementation, focussing on the incidence of water-borne diseases and the number of cases of diarrhoea in the area.

One of the limits of the project is in terms of water-usage behaviour. Before GPOBA implementation, contaminated river water was one the few water sources available and many used it for laundering clothes, typically sitting on the riverbank with their hands and feet in contact with the water. Palyja and GPOBA hoped that by providing residents with affordable clean water, this behaviour would change. Unfortunately, as many residents are not deterred by the smell of river water and want to take advantage of free water, they continue washing their clothes on riverbanks, risking disease and sickness. Palyja, however, expects that this behaviour will change over time as customers get used to cheap, clean water in their homes.

Master meter provision to illegal settlements

In Jakarta, a significant proportion of the population live in illegal settlements and the government is concerned that by providing squatters with individual water connections to their house they might be seen to be legitimizing the unlawful occupation of the land. However, the government also accepts that in order to avoid health impacts and facilitate development it has a responsibility to provide access to healthy water and sanitary conditions to people living in illegal settlements. Palyja, under its contract, is expected to supply water to the people who live in these settlements.

One of the solutions to this dilemma that Palyja is trialling is the installation of master meters. As illustrated in Figure 1.8, under a master meter system, water is supplied to a group of houses and the community takes collective responsibility for the ongoing management of water use within the community and the payment of charges to Palyja. This system has been implemented in western Jakarta with the cooperation of two NGOs: MercyCorps and USAid's Environmental Service Program (ESP). Cooperation with NGOs is required in this type of programme, as master meter systems are fully managed by the community itself. During the implementation phase, the NGO establishes the community-based organization (CBO) that will manage the system.

Table 10.4 summarizes the key steps in setting up a master meter system. Working with an NGO, a CBO is formed and a supply agreement reached with it. Palyja then supplies the master meter and the CBO, working with the NGO, installs its supply system. Under this arrangement, both sides benefit. Specifically, the community gets reliable access to an affordable water supply and can manage payments to Palyja with a degree of flexibility. Palyja benefits because it has the opportunity to supply a large number of houses at much lower overheads and administrative costs. Details of the contract typically signed with a CBO under a master meter system are summarized in Box 10.2.

To date, two master meter systems have been installed, one in partnership with ESP and one in partnership with MercyCorps. The ESP system was implemented via ESP's small grant programme at a total cost of US$25,000. Palyja donated the piping, valued at US$10,000, to run water from the main water network to the master meter. The community provided pipes leading to their individual households from the Palyja meter. A total of 38 households were connected under this programme.

A master meter system installed in partnership with MercyCorps at Penjaringan was installed for an approximate total cost of US$14,000 and, like the master meter with ESP, Palyja donated the pipe extension to reach the area for an estimated cost of US$3,000. A total of 58 households were connected. As summarized in Figure 10.8, the community's water costs have dropped by 75 per cent. However, the community has not reached a level of consumption required under the GPOBA.

Water kiosks

Another approach to the supply of water to illegal communities developed by Palyja involves the construction of water kiosks. Under this system, water is trucked to a kiosk and then sold to users. A typical water kiosk comprises a building supplied by 5 m^3 water reservoir tanks and taps that can be used to fill containers. People take their containers to the kiosk and pay US$0.355 per m^3 (or 73 per cent less than the pushcart price). One water kiosk can serve up to 150 families or about 900 people.

Local communities or private partners, who buy water from Palyja at the price of US$0.355 per m^3, manage these water kiosks. Average sales at a water kiosk are 10,000 litres per day. In terms of cost for Palyja, a water kiosk costs US$ 5,000 and the distribution cost is estimated at US$1.05 per m^3 as the water is delivered by truck.

In 2008, Palyja built 11 water kiosks. A further 59 water kiosks are planned to be installed by 2012. Local managers are employed to run each kiosk and, to date, no significant problems have been experienced.

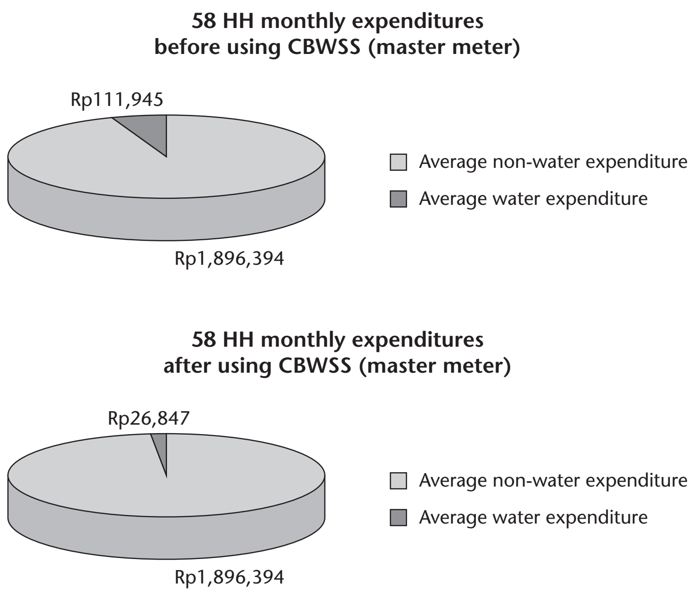
Palyja trains kiosk managers and provides them with directions and guidelines on how to manage a water kiosk. Periodical site inspections are undertaken to ensure that the water kiosk manager consistently applies the standard selling price and keeps the water kiosk clean and hygienic. As community leaders and sub-district leaders have supported the installation of water kiosks, there has been no interference from local water vendors.

Box 10.2 SUMMARY OF CONTRACTUAL ARRANGEMENTS INCLUDED IN A MASTER METER SYSTEM AGREEMENT WITH A COMMUNITY-BASED ORGANIZATION

- Stipulation that the system implemented cannot be used to make any legal claims (on households status or land, etc.).
- Define area (RT/ gang) and/or households type allowed to be connected.
- Maximum number of low-income households to be connected per MM system.
- Include (if water shortage) limit to total monthly consumption.
- Agreed tariff for Palyja: The tariff of water involves calculating the consumption, taking into account the rate paid by low-level households (customers pay US\$ 0.355/m^3 from 0 to 10 m^3/month/household consumption and US\$ 0.47/m^3 from 11 to 20 m^3/month/household). As there is only one meter for the master meter system, there is a need to establish a special customer procedure to calculate the bill taking into account the number of families having access to it.
- Agree on maximum additional charge that CBO can charge (either US\$/m^3 or as a percentage) for operation and maintenance cost (repair, fee, shared leakage).
- Agreement by Palyja on service (quantity, quality, continuity).
- Agreed sanctions for missuse, in form of penalties and/or disconnection.
- A Memorandum of Understanding (MoU) is signed between Palyja and the CBO. The main inclusions in a typical MoU are:
  - Definition of master meter in terms of tariff (tariff code: KIIIA/5B).
  - Requirement for the installation of the connection (location and size of land).
  - Exception clause: existing customer cannot be changed to master meter customer.
  - No objection from existing customer to have master meter distribution network in their neighbourhood.
  - Obligation and rights of Palyja to provide all materials, meter, clean water and assume responsibility for repairs, or change any network damage before meter, management of complaints.
  - Obligation and rights of CBO for lost or damaged meter, ensure proper maintenance of the meter and to have the right to distribute clean water through pipe network to eligible customers.
  - Prohibition for CBO: no water sold by truck, no bypass of the meter, no modification of the meter, not allowed to relocate the meter.

TABLE 10.4 Key steps in developing the master meter system

1	*2*	*3*	*4*
Community preparation	*Agreement between utility and community-based organization*	*Construction of master meter system*	*Strengthening of community-based organization*
Community and non-governmental organization selection. Community discussions. Community planning and design options. Outreach and awareness training. Establish community-based organization.	Detailed design and cost estimation. Contract between PAM and community-based organization. Procurement of materials.	Arrange community involvement in construction. Construction supervision.	Technical, financial, operations and management training. Assist community-based organization in start-up, operations and management, arranging billing and/or outsourcing if required.



Note: *The average data of HH monthly water expenditure after using CBWSS was taken up until August 2009*

FIGURE 10.8 Reduction in the costs to the community of water use achieved by installation of a master meter supply system in Penjaringan in partnership with MercyCorps.

Conclusion

Palyja is committed to the supply of water to 100 per cent of the population living within western Jakarta. The company employs more than 1,300 people and is one of the largest water utilities in Indonesia. Since 1998, the number of connections in its concession area has more than doubled. Currently, the company maintains approximately 414,000 active connections and serves around 3 million people. Service coverage has increased from 33 per cent to 63.5 per cent and water sales have increased from 89 to 153 million m^3 of clean water per year. The total size of the network is now 5,300 km in length.

In terms of investment in low-income areas, the highest increase of number of connections occurred in low-income communities, with an increase of more than 758 per cent compared to the situation in 1998. There are still approximately 1.6 million people living in Jakarta that do not yet having access to a clean water service, mostly living in low-income neighbourhoods.

In order to improve the access to clean water distribution in poor neighbourhoods, Palyja has developed three programmes: the GPOBA, the master meter system and the water kiosks.

Through the GPOBA programme, Palyja achieved connections of 5,041 households to distribution networks in six districts, mainly located in the north and western part of Jakarta, areas known for their poor alternative water supplies. As a result, people connected to clean water through Palyja pay only US$0.105 or US$0.355 per m^3 (depending on tariff), significantly less than clean water sold by pushcart vendors (US$7.5 per m^3). This project made the connection of poor neighbourhoods feasible by offering a financial contribution to the connection fee of between 1 per cent and 20 per cent of the usual connection fee depending on the tariff and location. Operating under an outcome-focused contract and with current expenses of more than US$1.49 million, Palyja bears a high financial risk until a full reimbursement by the World Bank.

Although 5,041 connections newly installed represents a significant step forward to achieving Millennium Development Goals in western Jakarta, Palyja needs to secure additional funding to reach a service coverage of 80 per cent by 2015.

Two master meter pilot projects have been successfully implemented in 2009. These projects resulted in the connection of 96 households to a piped water distribution system. Palyja invested more than US$13,000 to make this implementation feasible. The next few years will be important for assessing the long-term sustainability of such programmes.

In 2008, Palyja installed 11 water kiosks with an investment of US$5,000 per kiosk. The cost to supply water to these kiosks is estimated to be US$1.05 per m^3 of clean water delivered by truck; however, Palyja sells clean water to these water kiosks at US$0.355 per m^3.

Notes

1 All of these authors are employed by Palyja, the private company that won the contract to supply water to Western Jakarta.

2 One of these contracts was allocated to Pam Lyonnaise Jaya (Palyja). Palyja is partly owned by Suez Environnement and partly owned by PT Astratel Nusantara runs infrastructure in Indonesia. Suez Environment is a business subsidiary of GDF SUEZ in France. Suez-Environnement owns 51 per cent of Palyja's shares, Astratel, Nusantara, an infrastructure business line of ASTRA Group Indonesia owns 30 per cent and the remaining 19 per cent of Palyja is owned by City Group, an Astra Group partner.

3 This condition was set by PAM (Perusahan Air Minum). The estimate of 10.8 m^3 comes from an Indonesian regulation stating that a family should have access to a minimum of 360 litres/day (10.8 m^3/month) of clean water.

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11

OPPORTUNITIES AND CONSTRAINTS TO DEVELOPMENT OF WATER-RESOURCE INFRASTRUCTURE INVESTMENT IN SUB-SAHARAN AFRICA

Barbara Schreiner, Guy Pegram, Constantin von der Heyden and Fulton Eaglin[1]

Introduction

This chapter explores the opportunities and constraints surrounding the development of water-resource infrastructure in sub-Saharan Africa (SSA). Water-resource infrastructure plays a critical role in security, development, and economic growth. SSA, most of which is characterized by difficult hydrology, lacks significant investment in this infrastructure, resulting in threatened security, uneven development, and impeded growth.

Water-resource infrastructure is broadly defined as any system for the collection, storage, delivery, and utilization of water for social and economic activity, and for the environment. Such infrastructure includes large, medium and small dams, irrigation schemes, inter-basin transfer schemes, and urban schemes, as well as natural infrastructure including wetlands, dambos, flood plains, and groundwater. This infrastructure provides the basis for many primary and secondarily livelihoods across the world and underpins the possibility of sustainable economic growth, particularly in contexts of "difficult hydrology."

This chapter examines the relationship between water and socio-economic development, the nature of water-resource infrastructure and the institutional implications, the constraints and challenges surrounding infrastructure, financing issues pertaining to water-resource infrastructure, and finally, some of the development opportunities around infrastructure in Africa. In particular, the overview provided of water-resource infrastructure challenges and opportunities at all scales, and the inclusion of natural infrastructure in the examination, provides an integrated picture that allows for the determination of appropriate responses to different contexts and challenges, and for the determination of nuanced responses that integrate different scales of infrastructural development and use. It is this nuanced and integrated approach that is necessary to address the water-resource infrastructure and poverty-related issues in sub-Saharan Africa.

Water and development

Water-resource infrastructure is of particular importance in most parts of SSA because the region is characterized by difficult hydrology, seen in highly variable inter-seasonal and inter-annual precipitation

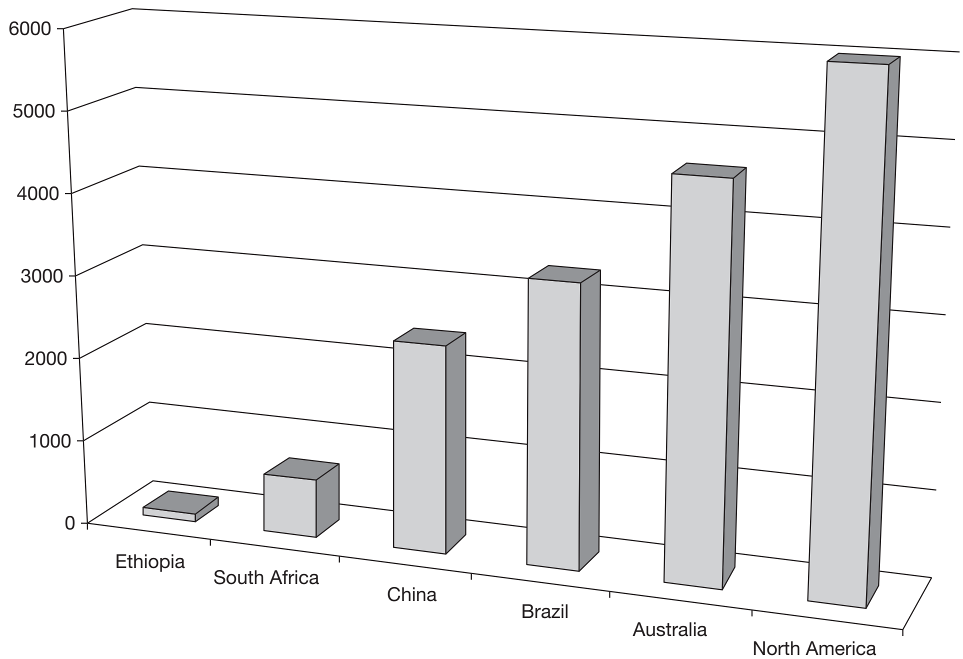


FIGURE 11.1 Water storage (m^3 per capita per annum).

Source: UNEP (2008).

and intermittent high impact rainfall events, which often lead to severe flooding and extended droughts. The low level of water-resource infrastructure in the region (see Figure 11.1) results in social well-being and economic growth being "held hostage to hydrology" (Grey and Sadoff 2005). To exacerbate this picture, climate-change predictions indicate that precipitation variability and high-impact events will increase as temperatures rise. Rain-fed agriculture is one of the key primary economic activities in SSA, and this variability leads to frequent loss of crops or reduced harvests, with enormous impacts on social and economic development, and both household and national food security.

Several authors (see Gray and Sadoff 2005; Barrios *et al.* 2003) have shown how dramatically economic growth is affected in the absence of a sufficient infrastructural and institutional platform, with GDP rising and falling with rainfall. Barrios *et al.* (2003) show how economic development has decreased in sub-Saharan Africa over the past 30 years along with the decrease in rainfall (see Figure 11.2) and note that improved water-resource management and a larger resource base are necessary to achieve economic growth and stability.

Building on this assessment, the section below outlines briefly some of the key linkages and interactions between socio-economic development and water-resource infrastructure.

National development

Appropriate water resources-infrastructure brings a range of benefits for national development, primarily through energy supply from hydropower and the multi-year storage of water for irrigation, urban water supply, and industrial development. The "difficult hydrology" of large parts of Africa referred to above

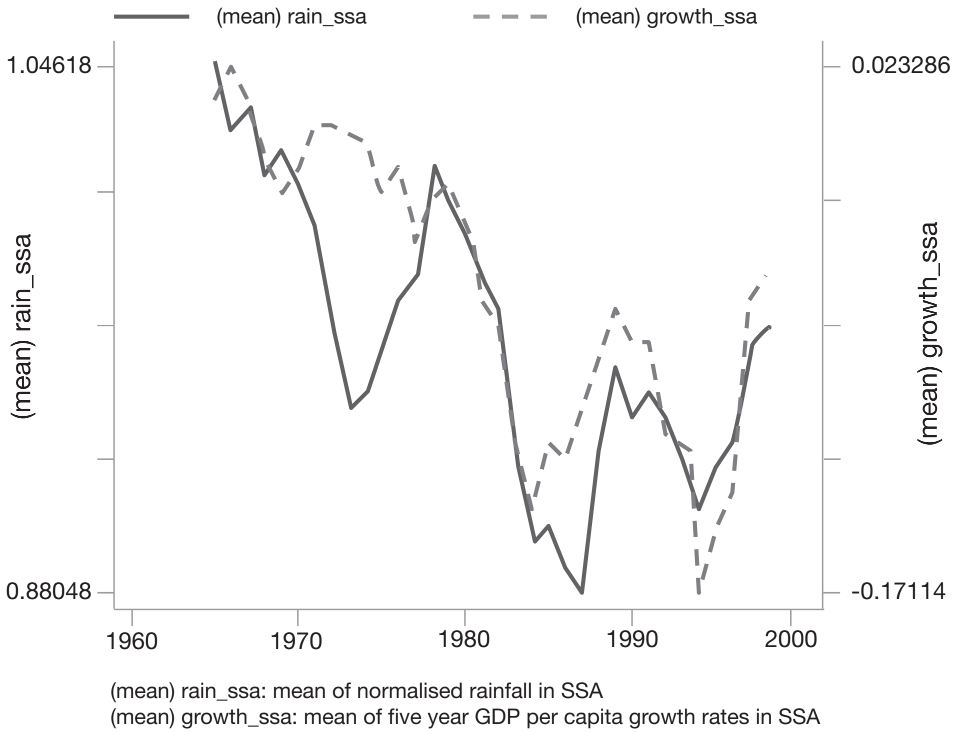


FIGURE 11.2 Links between GDP per capita growth rates and rainfall in sub-Saharan Africa.

Source: Barrios *et al*. (2003).

means that the creation, operation and maintenance of appropriate infrastructure and the development and capacitation of institutions able to manage this infrastructure is a critical factor in breaking the devastating relationship between GDP and rainfall referred to by Barrios *et al*. (2003). Unfortunately, current climate change scenarios in many basins suggest a possible intensification of rainfall and drought events, posing increasing threats to stable economic growth scenarios in the absence of infrastructure.

A reliable supply of water through dry years is critical for the growth of a stable economy, particularly where the economy is primarily based on agriculture, as is still the case in most SSA countries. This can only be provided by the development and effective management of water-resource infrastructure, whether this be in the form of large dams, or smaller options to serve households and communities. At the same time, the appropriate construction and management of water-resource infrastructure can play a vital role in flood attenuation. Throughout the SSA region, due to the dependence on rain-fed agriculture and the nature of the hydrology, 220 million Africans are exposed to drought annually and 1.5 million affected by floods. Mozambique's gross domestic product (GDP) growth is reduced by more than 1 per cent annually because of water shocks (World Bank 2007). In Zambia, a study of how hydrologic variability affects the economy found that rainfall variability will cost the country $4.3 billion in lost GDP over 10 years, and lower the country's agricultural growth by 1 per cent each year (World Bank 2008). In Kenya, losses from floods caused by El Niño in 1997–1998 and drought caused by La Niña in 1998–2000 ranged from 10 to 16 per cent of GDP during those years (World Bank 2004).

Hunger and poverty

Large parts of SSA suffer from high levels of hunger and poverty, particularly, but not only, in rural areas where there is a high level of dependence on rain-fed and subsistence agriculture. Extreme poverty is considered the most severe state of poverty where households cannot meet their basic needs for shelter, food, water, sanitation, and healthcare. The World Bank defines this state as those people living under US$1.25 per day. SSA is the area with the highest levels of extreme poverty, as shown in Plate 11.1. With large areas experiencing limited and irregular rainfall, rural communities in particular are extremely vulnerable to drought, resulting in increasing poverty, famine, and the associated social and physical impacts on human well-being (Plate 11.1). Climate change is likely, in many areas, to exacerbate this vulnerability. The extreme poor described by Sachs (2005) are worst hit by floods and droughts, lacking the assets to weather the crisis. Often, indeed, such poor households either lose their assets to extreme weather events or are forced to sell assets such as livestock to survive, thus deepening their poverty.

On the other hand, research conducted by the South African NGO, AWARD, in 13 villages in the Bushbuckridge municipal area, show that increased access to water doubled the economic activities of many poor households in the village (Pérez de Mendiguren and Mabelane 2001) through activities such as brick making, stock watering, hair salons, beer brewing and ice making, and backyard or community gardens.

For those who are part of, or closely linked into, the formal economy, where industrial or economic growth is negatively impacted by floods, interrupted hydropower production and water shortages, increased unemployment, or a failure to reduce unemployment through economic growth, may increase the number of people in urban and peri-urban areas living in poverty and facing food insecurity.

Within this bigger picture, poverty and hunger have a strong gender dimension, with the worst impacts being borne by women- and child-headed households (Sachs 2005). In addition, the effect of HIV/AIDS has had a profound effect on families in SSA. The issue of infrastructure in SSA is therefore strongly related to the issues of empowerment and meeting the needs of women.

Physical security

The physical security of many in sub-Saharan Africa is threatened by floods in smaller unregulated river tributaries and at the basin scale. As the population grows, increasing numbers are forced into flood-prone areas. Floods cause loss of life, destruction of infrastructure and property, loss of housing, displacement of people, and significant setbacks to economic prosperity.

While appropriate construction, operation, and maintenance of infrastructure can reduce flood risks, it needs to be appreciated that floods play an important role in the maintenance and provision of ecosystem services that often play an important part in community well-being. Over-regulation of floods can, in its own right, be damaging to community and household prosperity.

The physical security of people is also compromised, in some cases, by the changed vectors of disease arising from the development of water-resource infrastructure. The relationship of water-resource infrastructure to disease is a complex one. Reliable access to water is vital to ensure food security and poverty eradication, including the reduction of diseases associated with poverty caused by lack of access to safe drinking water. At the same time, however, the construction of large dams has often led to increases in some diseases and pests, such as black fly, Bilharzia and malaria. The impact of infrastructure on vectors of disease needs careful scrutiny, particularly since the high prevalence of HIV/AIDS in SSA makes people in this region particularly vulnerable. This is particularly iniquitous where, as is often

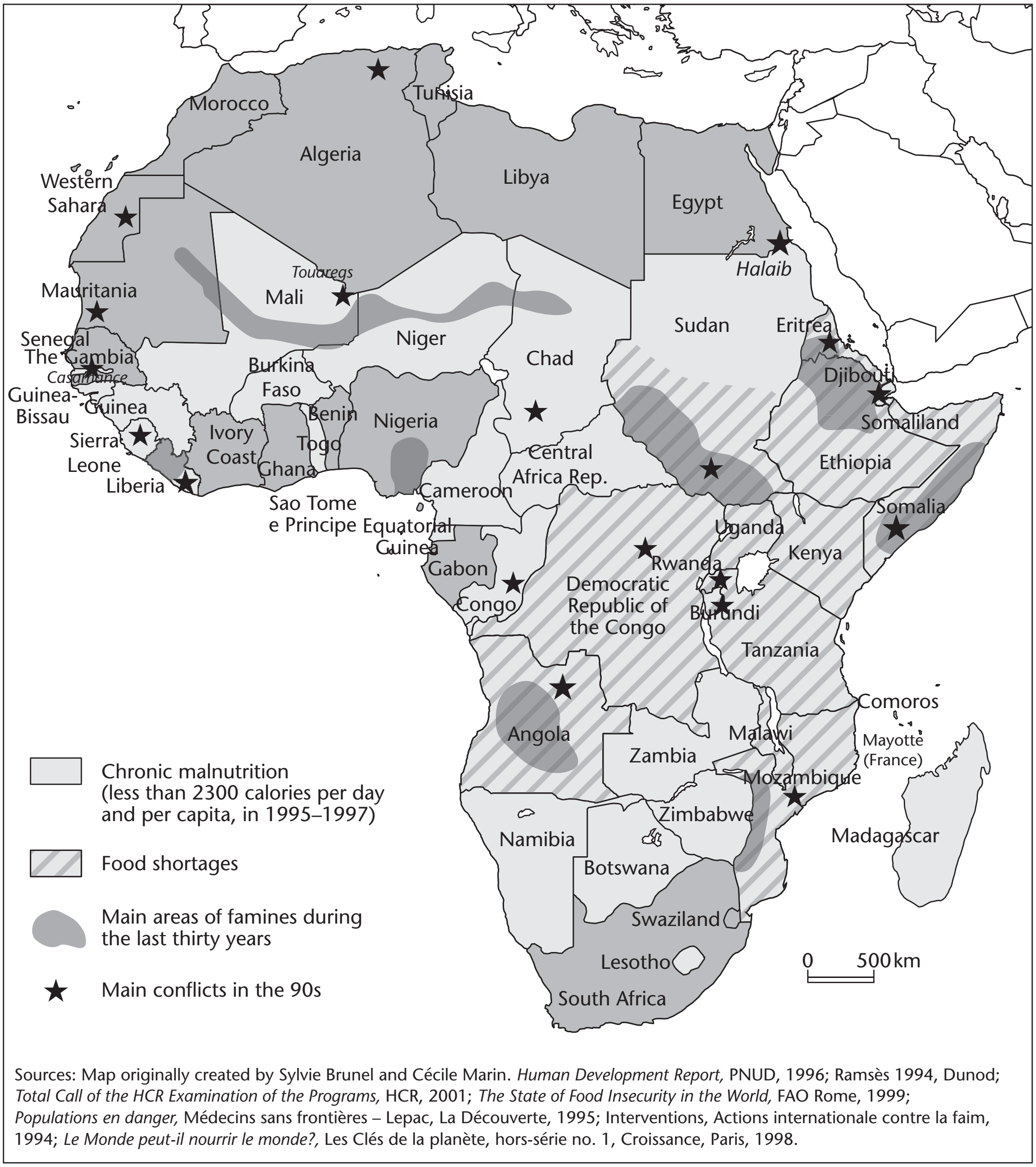


FIGURE 11.3 Map of hunger and famine in Africa, 1995–1997.

Sources: UN Development Program (1998); www.grida.no/publications/vg/africa.

the case, the infrastructure development serves more highly developed sectors of the society, through the provision of hydropower, drinking water, or water for industry and irrigation, while the rural communities close to the dam sites face the added burden of new and increased disease risks.

Agriculture and hydropower

According to a recently released study by the Africa Infrastructure Country Diagnostic (AICD), although agriculture represents the primary livelihood in SSA, only 5 per cent of cultivated land is under irrigation compared to 42.2 per cent in South Asia and 33.6 per cent in North Africa and the Middle East. Only 4 million new hectares of irrigation have been developed over the last 40 years in SSA compared to 25 million and 32 million hectares in India and China respectively. Moreover, just 10 per cent of the hydropower potential in Africa has been tapped, only 58 per cent of people have access to safe drinking water, and a meagre 2.9 per cent of renewable water resources are used (Dankova *et al.* 2009). Unfortunately, water resources are unevenly spread, and there are many catchments and countries facing severe water stress, in many cases resulting from the lack of appropriate infrastructure development. Thus, while there is considerable untapped economic potential in the hydropower and agricultural sectors in Africa, both are reliant on appropriate, and currently under-developed, infrastructure.

Water scarcity

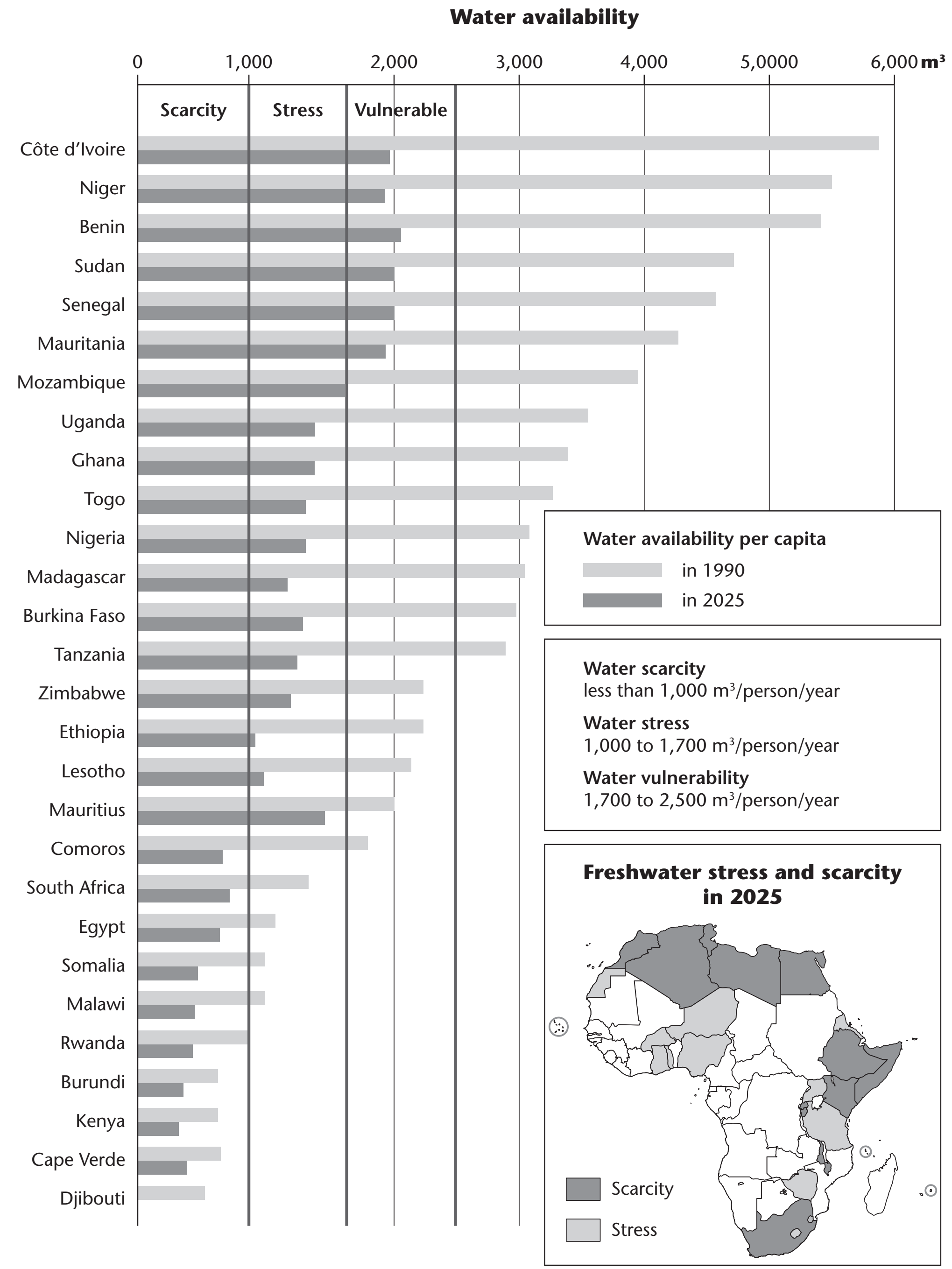
Even those countries that are well endowed with water from a physical perspective still face major challenges in terms of making that water available for use. Turton and Ohlsson (1999) distinguish between primary scarcity and water abundance and secondary water scarcity and abundance. Primary scarcity or abundance refers to the amount of water available in the country, per capita, as per the Falkenmark (1989) assessment of water stress and water scarcity.

Secondary scarcity or abundance is a more interesting concept, indicating the level of water development in a particular country, and the ability to provide reliable sources of water, of an appropriate quality, where it is needed for domestic or economic purposes. Thus, in a country with highly developed infrastructure and management capabilities, it is possible to have secondary abundance on the back of primary scarcity. Equally, in an under-developed country with high water availability per capita, lack of infrastructure and management capacity can result in secondary scarcity, or lack of reliable water supply where it is needed for domestic and economic purposes (Turton and Ohlson 1999).

Therefore, in Ethiopia, for example, where the current per capita freshwater total availability is relatively high, lack of water storage and high variations in rainfall result in insufficient water for farmers to produce more than one crop per annum, with frequent crop failures due to dry spells and droughts (Makombe 2005). Climate change and economic and population growth will exacerbate the situation as the amount of water per capita decreases over time (Figure 11.4).

Transboundary basins

The majority of the river basins in SSA, as a result of its colonial past, are transboundary in nature, adding to a water-resource management scenario already made difficult by high levels of poverty and low GDP, lack of technical and managerial skills, under-development, political instability, inefficient bureaucracies, and difficult hydrology. Over 60 per cent of the surface area in the region is covered by transboundary river basins, with most countries sharing at least one river with another country. Effective water-resource management and infrastructure development in these basins requires a high



Source: United Nations Economic Commission for Africa (UNECA), Addis Abeba; Global Environment Outlook 2000 (GEO), UNEP, Earthscan, London, 1999.

FIGURE 11.4 Water availability in Africa.

Source: UNEP (1999); www.grida.no/graphicslib/detail/wateravailability-in-africa.3368.

level of cooperation and sophisticated institutional structures between countries and regions. The cost of non-cooperation is high, including the economic cost of negative environmental impacts, suboptimal water-resource development, political tensions over shared resources, and the forgone benefits of joint water-resource development (Sadoff *et al.* 2003).

The transboundary nature of the basins adds another level of complexity to an already complex process to reach a minimum level of development of both infrastructure and institutions, since decisions are often in the hands of two or more riparian states, some of which may have seen political conflict in relatively recent times. Infrastructure development therefore requires a political maturity that can allow for joint decision-making, joint development, and joint operation and management of water-resource infrastructure.

On the positive side, SSA already has many international river basin organizations (RBOs) in place, such those in the Senegal, Niger, Okavango, Orange-Senqu and Volta basins. Some of these organizations, such as the *Organization de Mise en Valeur du fleuve Sénégal* (OMVS) in the Senegal basin, and the Lesotho Highlands Development Authority (LHDA) in the Orange-Senqu basin, have a specific mandate in terms of infrastructure development, operation and maintenance. Others are more focused on building relationships between the countries and facilitating the exchange of information. In the SADC context, the Revised SADC Protocol on Shared Watercourses sets out the parameters for the development and management of shared water resources – an approach only paralleled in terms of regional agreements by the Water Framework Directive of the EU.

Water-resource infrastructure

The debate on water-resource infrastructure in Africa is often focused on large-scale infrastructure, whether for storage, inter-basin transfers, or hydropower. However, an equal focus on infrastructure at the meso- and micro-level is required to understand the ways in which water-resource infrastructure operates most effectively in SSA. When analyzed on these levels, discrete institutional and financing arrangements accompany the development of water-resource infrastructure, which illuminate the concomittant opportunities and constraints.

A variety of water-resource infrastructure options exist including, most commonly, dams, irrigation schemes, inter-basin transfer schemes, groundwater schemes, rainwater-harvesting infrastructure and natural infrastructure. Additional infrastructure such as wastewater treatment plants and desalination plants can also be considered to be part of a suite of water-resource infrastructure options. This infrastructure can vary from the very large to the very small, serving different purposes and with different benefits, costs, and beneficiaries.

Dams

Dams play a critical role in water-resource infrastructure, creating opportunities for irrigation, water storage, and electricity generation. Given the multiplicity of functions they perform within an economy, many consider dams to be prerequisite for economic growth. Dams allow for large irrigation schemes, a critical driver in increasing agricultural production and enabling opportunities for the generation of electricity necessary for industrial development. Dams are necessary for the achievement of economic development. However, they can, as a result of managing river flows, produce negative environmental impacts such as habitat degradation, decreasing water quality, reduction of fishing stocks, and changes in disease vectors, to name a few.

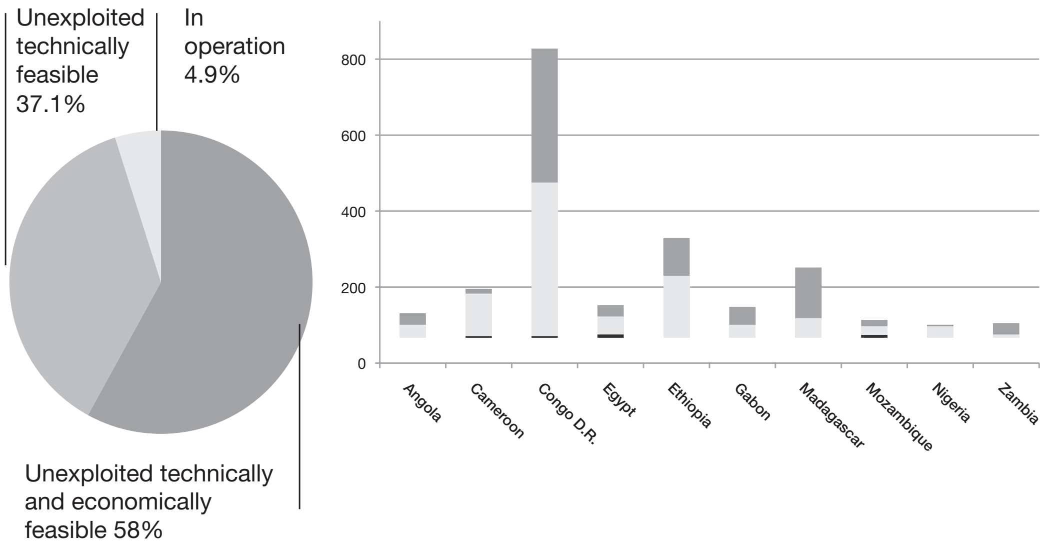


FIGURE 11.5 African hydropower potential.

Source: UN Water (2008).

There are many large-, medium-, and small-scale dam schemes planned for river basins throughout SSA. However, to date, dam development has been intermittent. As Figure 11.5 demonstrates, SSA still has many untapped hydropower resources, with only about 10 per cent of the potential capacity having been developed.

According to Aquastat (FAO 2003), Africa has approximately 1,300 medium-sized dams (structures with walls of 15 m or higher) of which 40 per cent are located in South Africa and were mostly constructed in the last 30 years. The use of these dams is as follows:

- 52 per cent is used for irrigation.
- 20 per cent supply municipalities.
- 6 per cent generate hydropower.
- 1 per cent is used for flood control.
- 21 per cent is used for other purposes.

Africa has an additional 54 large dams with a reservoir capacity of greater than 1 billion m^3. The total storage capacity of large dams comprises 794 billion m^3. Of these large-capacity dams, 20 are multi-purpose (hydropower and irrigation), 22 are for hydropower only, and 12 are mainly for irrigation. The two largest dams by capacity are Kariba (188 billion m^3) on the Zambezi River and Akosombo (148 billion m^3) on the Volta River. Most large dams, as Kariba and Akosombo demonstrate, are situated in transboundary basins.

This capacity translates into an average 200 m^3 of storage capacity per capita in Africa – in stark contrast to other areas in the developing world. In Mexico, for instance, storage capacity stands at an average 1,104 m^3 per person, China at 2,486 m^3 per person, and Brazil at 3,386 m^3 per person.

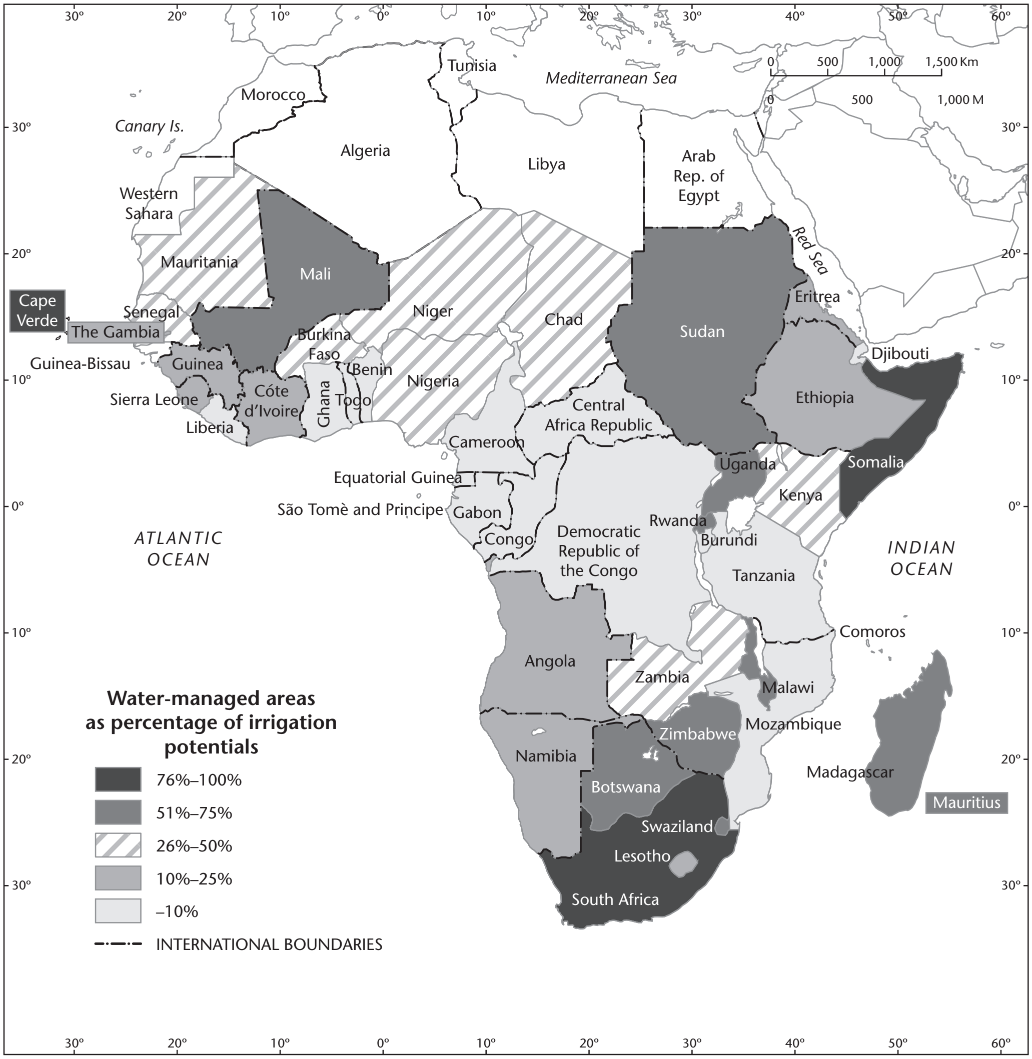


FIGURE 11.6 Water-managed areas as percentage of irrigation potentials

Source: Dankova *et al.* (2009).

Irrigation schemes

Irrigation occurs on multiple levels: large agricultural schemes, often funded by national governments or large corporations; regional schemes, which often consist of private-sector investment or public-private partnerships; and small-scale schemes using available groundwater and diversion from local rivers.

Given the agricultural potential of large parts of SSA, well planned and well executed irrigation schemes form an engine for economic growth. Irrigation schemes are required for local, regional, national, and international development. Despite the primacy of irrigation in agricultural development, SSA is one of the lowest users of irrigation. A large proportion of SSA's population is dependent on agriculture for a livelihood, but the country has one of the lowest efficiency rates in the world. Of Africa's poor, 85 per cent live in rural areas and depend largely on agriculture for livelihoods. Increasing evidence points to the economic benefits of small-scale irrigation projects, rather than large-scale, resource-intensive schemes.

As Figure 11.6 illustrates, a great deal of irrigation potential exists within SSA but cultivation remains low. At present, only 7 million hectares of irrigated agriculture exist within SSA, 4 million of which was developed over the past 40 years. This development is in contrast to 25 million hectares and 32 million hectares of irrigated agriculture developed in India and China respectively over the same period. Of the irrigated agriculture, 60 per cent is located within Madagascar, South Africa, and the Sudan. Irrigated agricultural accounts for 25 per cent of agricultural output, yet only constitutes 5 per cent of cultivated land.

The opportunities for the development of irrigation range from the very large to the very small. The treadle pump is currently one of the fastest growing micro-scale irrigation technologies in SSA. In the last decade, more than 120,000 treadle pumps have been distributed in Malawi, creating an irrigation potential of 48,000 hectares. This technology is being promoted in other countries including Zambia, Zimbabwe, and Mozambique, and plays an increasingly important role in food production and income generation in these countries (Rosegrant *et al.* 2009).

There is some evidence from Ethiopia of increased cereal yields of up to 15 per cent in high-potential cereal zones and up to 7.5 per cent in low-potential cereal zones as a result of rainwater harvesting and conservation techniques such as soil and or stone embankments, bench terraces, retention ditches, runoff diversion, and small dams (Makombe 2005).

Inter-basin transfer schemes

Due to the huge spatial differences in rainfall in SSA, inter-basin transfers are necessary in some areas to provide water into basins where it is needed for development purposes. South Africa is probably the best example of major inter-basin transfers, with many of the catchments linked through inter-basin transfers, as well as intra-basin transfer schemes between Lesotho to South Africa.

Water-transfer schemes also accrue environmental and economic benefits within countries. Many inter-basin and intra-basin transfers, more common than international transfers, are useful in supporting economic development and growth. These schemes are also easier to manage, given the lack of international sovereignty and economic development difficulties that attend international transfer schemes.

Groundwater schemes

Groundwater is a critical component of the water picture in Africa. These schemes form the cornerstone of economic and domestic water provision in certain areas. Groundwater and aquifers provide options for irrigation and urban, rural, and peri-urban industrial and domestic extraction. However, as the links between users of groundwater and the resource are not apparent, and many of the benefits associated with groundwater are public goods such as environmental maintenance, health, and poverty alleviation, the overall economic value of groundwater goes largely unrecognized in SSA (Braune *et al.* 2007). As a result, there is a dearth of information on groundwater resources and their development and management.

However, it is known that groundwater is a major source for small-scale irrigation and livestock farming in many SSA countries. Groundwater for these purposes is largely developed privately and, as

TABLE 11.1 Groundwater usage in Southern Africa

Country	*Part of groundwater in total water supply (%)* (1)	*Part of groundwater in total water supply (%)* (2)	*Other main users* (3)
Angola	1	22	
Botswana	64	41	Agricultural (stock-water); some small-scale irrigation
DRC	–	25[a]	
Lesotho	41	58	
Malawai	3	29	
Mauritius	21	50	Irrigation, industrial
Mozambique	6	34	
Namibia	50	37	
Seychelles	2	–	
South Africa	16.5	35[b]	Agricultural (stock-water) 60 to 70%
Swaziland	2	70	
Tanzania	4	25	Small-scale irrigation
Zambia	9	40	Irrigation
Zimbabwe	10	10	Livestock, local irrigation

Source: Braune *et al*. (2008).

Notes: (a) Only for urban water. (b) Based on population served.

a result, reliable statistics are not readily available. It is estimated that in semi-arid regions such as Namibia and Botswana, groundwater may account for up to 56 per cent of water usage (FAO 2003).

Groundwater use in the Southern African Development Community (SADC) is outlined in Table 11.1.

Groundwater use needs to be balanced with the rate of recharge to avoid over-exploitation. Recharge may occur through natural means or managed processes.

Shallow groundwater can be made readily available through affordable micro-level infrastructure such as treadle pumps, and can contribute enormously to health and food-security and local economies in this way. The use of groundwater also has less impact in terms of changing vectors of disease than the retention of surface water, unless excess groundwater or wastewater is allowed to pool and form a breeding ground for new pests and diseases.

Multiple-use systems

Water infrastructure has, historically, been segmented into categories by authority institutions, with a particular division between the provision of domestic water services and water for productive purposes in the rural areas. Often, the former is provided by the water-services authority and the latter by the irrigation, rural development or water-infrastructure department or agency. Such institutional division has often resulted in either one or the other being provided, without an integrated approach being taken to meeting the overall water needs of a community. The reality on the ground is that, where irrigation water is provided but not domestic water, the irrigation water is used for domestic purposes, and vice versa.

The multiple-use systems approach attempts to bridge this divide, looking at meeting the total water needs of a community, including through the appropriate design and operation of water infrastructure.

Natural infrastructure

In addition to built infrastructure, increasing emphasis is being placed on the maintenance, use and rehabilitation of natural infrastructure. Wetlands, aquifers, flood plains and natural collection points are a key element of the water infrastructure and provide significant services to water users. Wetlands, for example, provide natural infrastructure for small-scale agriculture, a groundwater recharge point, or a source of biodiversity resources. The construction of artificial infrastructure requires a consideration of the trade-offs against protection of natural infrastructure. When considering infrastructure investment, a measured appraisal of natural infrastructure may limit the extent of additional investment. In certain circumstances, a change to the design or management of existing or planned artificial infrastructure, such as lowering a dam wall or improving flood-management techniques, can draw on the benefits of natural infrastructure and avoid more expensive artificial infrastructure investment.

Unfortunately, large areas of SSA suffer from land degradation as a result of poor land management, with concomitant erosion and siltation of infrastructure. Good land-use management and rehabilitation is critical to ensure the long-term sustainability of infrastructure, through, in particular, reduction of siltation. In parallel, good land-use management results in improved crop yields, resulting in a double benefit.

The protection of natural infrastructure can contribute to rural development through downstream water users paying rural communities to protect the natural infrastructure in order to provide downstream environmental services, such as reduced sediment loads and increased baseflows. This process is generally known as payment for environmental services.

SSA has a rich natural infrastructure. Plate 11.2 for example, shows the extent of wetlands in SSA. Although the map excludes dambos (which cover up to 20 per cent of the land in areas of rainfall higher than 700 mm per annum), it demonstrates the ubiquity of wetland areas, which provide important developmental opportunities, particularly for rural communities outside the reach of large infrastructure development.

Alternative infrastructural approaches

Conventional water-supply infrastructure, such as dams and well fields, are increasingly being supported by rainwater harvesting, desalination, recycling, and water conservation. At the community or household level, rainwater harvesting is playing an increasingly important role in SSA in supporting food production, either through conservation practices that enhance soil infiltration and water-holding capacity, or through the construction of small storage dams to provide supplemental irrigation. Rainwater harvesting provides an effective local response to erratic rainfall and dry spells, requiring, unlike large infrastructure, limited investment, the ability to use local labour resources in lieu of financial investment, and limited management skills.

Scale and intent

Water-resource infrastructure can be looked at through the lens of scale in order to understand different opportunities, functions, and institutional implications at the different scales (see Figure 11.7). At the macro-level, infrastructure is characterized by large hydropower and storage schemes, inter-basin tranfers,

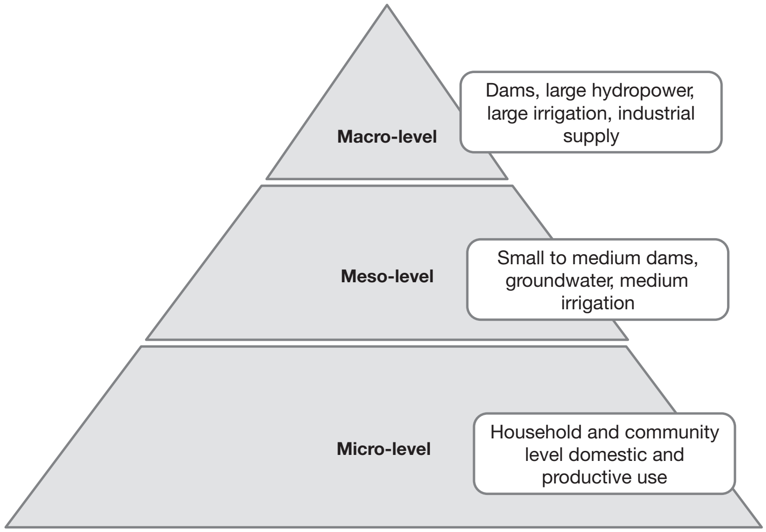


FIGURE 11.7 Multiple scales of water infrastructure.

large agricultural irrigation schemes, and significant urban or industrial abstraction. These structures are generally managed at the national or transboundary basin level. One level down, meso-scale infrastructure includes small to medium dams, medium-scale irrigation schemes, groundwater extraction, and focused urban extraction schemes, managed mostly at the catchment or sub-catchment level. The lowest level, although by no means the least important, sees micro-infrastructure, characterized by individual schemes for families, communities, or small enterprises in the rural, urban, and peri-urban spaces. At the base of the water-resource infrastructure pyramid are rural communities that are primarily agrarian and are the most vulnerable to water scarcity, climate change, and water-related disasters.

The scale distinction is critically important, delineating the institutional map of water-resource infrastructure and providing further understanding of the constraints and opportunities that attend their development in SSA. When considering the institutional landscape of water-resource infrastructure, it is important to pose questions such as: (1) Who develops it? (2) Who builds it? (3) Who operates it? (4) Who finances it? (5) Who owns it? These questions are addressed in the analysis of the micro-, meso-, and macro-spaces below.

Micro-level infrastructure

As earlier stated, water-resource infrastructure at the micro-level consist primarily of small schemes for domestic, urban, and peri-urban use at the local level. Micro-water-resource infrastructure includes small dams (less than 6 metres wall height), small irrigation schemes, and local water allocation initiatives. This infrastructure often relies heavily on groundwater resources and the collection of seasonal rainfall. The focus of these initiatives in SSA is largely directed towards addressing poverty and household food security, and the provision of such infrastructure can have a profound effect on the livelihoods of poor communities.

The primary infrastructure providers at this level include local government, NGOs, and communities themselves. The development cycle for water-resource infrastructure projects of this nature is typically between one and two years and costs range typically between US$50,000 and US$250,000. The main portion of the development cycle is focused on local stakeholder engagement to ensure that the infrastructure development has the buy-in and support of the local community, given that they will be the owners and users of this infrastructure. In the best practice, development practitioners focus on leveraging indigenous knowledge to ensure that the infrastructure is appropriate for the environmental, social, political, and economic conditions in the area. The construction process, usually completed in partnership by the funder and the local community, is on average three to six months, as the technologies are not complicated.

Business cases for this type of infrastructure are focused on socio-economic rather than financial returns, and there is often no intention of capital repayment. Donors and local and regional governments generally fund micro-level infrastructure through grants. Ideally, capacity building and targeted extension services should attend these developments to ensure sustainable use into the future, but poor institutional arrangements and lack of resources often leave communities largely on their own in this regard.

Where individuals and communities are directly involved in the development of the infrastructure, and reap the direct benefits, there is a vested interest in maintaining and operating it effectively. Thus, for micro-infrastructure to be successful, there must sufficient community engagement and ownership, aligned with appropriate funding, and the appropriate institutional arrangements to provide technical support where needed.

Micro-level infrastructure is particularly important in addressing the gender aspects of rural development since women are often the primary cultivators and holders of agricultural indigenous knowledge in SSA At the same time, the development of micro-infrastructure must enable the participation and empowerment of women. Unfortunately, experience has shown that when external financial support is provided, the decision-making roles of women are usurped by men, leading to the disempowerment rather than empowerment of women (van Koppen 2009), and providers of finance and technical assistance must take great care not to unwittingly support such disempowerment.

Meso-level infrastructure

Meso-level water-resource infrastructure includes small-scale irrigation, groundwater abstraction for irrigation or industrial use, and small- to medium-sized dams (dam wall less than 15 metres). The focus of these initiatives is usually regional (sub-national) economic growth and development, including medium-sized agricultural and industrial enterprises and small- to medium-sized towns. Currently, there are about 1,300 medium-sized dams in SSA.

The primary institutional actors at this level include the private sector, development agencies, and municipal or provincial government. A range of agricultural, agri-business and industrial users depend on meso-level infrastructure, often, but not always, privately funded. Development agencies often support small- to medium-size loans in this regard where there are clear returns and significant development impact from such infrastructure. In parallel, the lower tiers of government play a critical role in the development and financing of such projects, and may be the default owner of the infrastructure. However, public institutions in SSA have not been as effective as in other regions at implementing these initiatives because of weak institutional capacity and the fact that such schemes do not always yield the required political return.

Meso-level infrastructure projects, unlike micro-level infrastructure, are often challenging to develop, build, finance, and operate. They may have significant environmental and social impacts, can be costly, and necessitate joint operation with other schemes in the catchment area. The development cycle is typically three to five years and costs range between US$500,000 and US$5,000,000. Much of the development cycle is focused on infrastructure design, water resource usage, understanding environmental and social impacts, and securing appropriate financing. The typical repayment period is between 20 and 40 years, and financial returns play a large role in the business case for these projects even though they also yield significant socio-economic returns.

Given the size and potential impacts of meso-level infrastructure, robust institutional arrangements are required to ensure their appropriate development, construction, operation, and maintenance, and water user associations (WUA) form an important element of this institutional picture. The legal arrangements for the water user association may vary, depending on whether they are managing private or public infrastructure. The private sector, public-private partnerships and regional government also own, operate, and maintain this type of infrastructure.

Access to financial institutions plays a critical role in the ability to development of meso-level infrastructure. Small to medium private-sector actors require significant funds to finance the development and construction of infrastructure, while larger corporations can inject equity from their balance sheets to ensure completion of these assets. Development agencies, multilateral institutions, public–private partnerships, and regional financial institutions are critical players in this regard. Given the complexity of available funding instruments, reliable contracts are required to complete the construction process.

Many development agencies and funders have focused their attention on this level of infrastructure, recognizing that it can be a major catalyst for sustainable local or regional economic growth. The Development Bank of Southern Africa (DBSA), for example, is primarily focused on medium-sized water-resource infrastructure development as a path to sustainable growth. Similarly, in Mozambique, the Swedish International Development Agency (SIDA) is funding a feasibility study of the role of this level of infrastructure in the development process.

Macro-level infrastructure

Big water-resource infrastructure projects function at the basin scale, and include large dams and hydropower schemes, large urban abstraction schemes, large agriculture and industrial supply, and major inter-basin transfers. These initiatives are directly aimed at supporting national economic growth. However, this is still an under-developed area of infrastructure, with only 52 dams in SSA that fall into this category (with a dam wall height of over 30 metres).

The construction of such infrastructure is extremely costly (at least US$15 million), with the result that the participation of a number of institutional players is a prerequisite for success. This infrastructure also has a long lead time, with a development cycle of at least 10 years from the initiation of the first credible feasibility study. Critical to the usefulness of large infrastructure of this nature is the availability of reliable attendant infrastructure to transport the water provided to areas of high demand.

Due to the cost and nature of such large infrastructure projects, government is clearly a key player, but in SSA many governments lack the financial or institutional capacity to complete macro-water-resource infrastructure projects on their own, and require external support. As a result, many African governments have substantially diminished influence in the decision-making process around large infrastructure with the potential for developed country priorities to take precedence over national priorities. Nonetheless, national governments are usually the ultimate owner of the infrastructure and play an active role throughout the development and operation cycles, although in a reduced capacity.

As a result of the geopolitical arrangements of SSA, large dams are often constructed in transboundary basins, requiring joint planning, decision-making and financing arrangements. Unequal economic relations in the basins enable basin hegemons such as South Africa and Egypt to influence the extent of the benefit derived from the infrastructure.

The countries of SSA are not only dependent on external funding in the construction of large infrastructure projects, but also, to a large degree, on external technical expertise.

As a result of the need for external finance and expertise, development agencies play a critical role in developing infrastructure, often participating in capacity building and financing. However, financing of large infrastructure sees a larger number of role players at work, including national and international financial institutions such as commercial, development, and multilateral banks, which in turn set standards and criteria for the asset life cycle.

The involvement of NGOs at this level is largely around the protection of environmental and social interests, and the representation of the perceived needs and desires of local communities affected by the planned infrastructure. Unfortunately, the development of such projects has historically often been to the disadvantage of local communities who have borne the brunt of negative social impacts, often without reaping much in the way of benefits. The approach outlined by the World Commission on Dams is intended to prevent this happening with new projects, and international financing institutions have a critical role to play in ensuring that the interests of poor, local communities are protected.

All these actors interact dynamically in the lengthy process of planning, design, and implementation of large water-resource infrastructure projects.

Constraints and challenges

Having disaggregated water-resource infrastructure at various scales, a clear picture of the panoply of institutions and their relative dynamism emerges. From this analysis, we can provisionally conclude the following:

- there are a variety of institutional actors at each level;
- many institutions operate on multiple levels, creating competing interests and conflicting goals;
- significant opportunity for regional and economic growth exists around meso-level infrastructure; and
- the influence of local communities and governments decreases as the size of the infrastructure increases.

The disaggregation process provides an important backdrop for the assessment of the constraints and opportunities for development. A great deal of literature has dealt with the difficulties attached to the development of water-resource infrastructure in SSA and more broadly. Many initiatives, such as Financing Water for Growth in Africa (FWGA 2008) and the Africa Infrastructure Country Diagnostic (Dankova *et al.* 2009), have focused on assessing these constraints. The primary constraints are as follows:

- *Physical* – There may be a shortage of natural water availability to support infrastructure development, either resulting from primary scarcity due to aridity and low rainfall, or the distance of the centre requiring water from the available water, which demands large and expensive transfer schemes.
- *Political* – Political will may be lacking as a result of insufficient incentive for domestic, regional, or international cooperation, insufficient immediate returns on investments, and redirection of resources to political bases away from areas of strategic water importance.
- *Financial* – Financing at all levels of water-resource infrastructure is difficult due to lack of returns at the micro-level and financing complexity at the meso-level. Financing water-resource infrastructure at the macro-level remains a particular challenge because of the size of investment

required, the potential resistance to the infrastructure from local and international NGOs in particular, and the complicated institutional arrangements, particularly in transboundary basins. That being said, there is currently a strong focus from international partners and funding institutions on supporting transboundary arrangements in Africa, with concomitant support for transboundary infrastructure development, and some significant developments are going ahead at this scale.

- *Information* – There is a widespread lack of appropriate data surrounding the hydrological environment (groundwater and surface water) to form the basis of infrastructure decisions both in terms of determining yield and storage capacity and in terms of determining potential impacts of the infrastructure. The weakness in data and information is compounded by the impacts of climate change, which render historical data less useful in determining water availability and rainfall trends.
- *Institutional* – In many cases, relevant institutions have failed to work cooperatively together to plan and develop sufficient water-resource infrastructure at all levels. Many institutions are under-resourced and lack sufficient technical expertise for the development, operation, and maintenance of infrastructure. Government institutions are also often slow to adapt to new approaches, such as the multiple-use approach to infrastructure, particularly at the local level.

Often, the public sector is directly implicated in institutional failure. However, from the analysis of the different levels of infrastructure development and the different actors at each scale, a more complex and dynamic picture emerges. The actors have varying interests and objectives, which can promote or retard water-resource infrastructure development. The private sector and non-profit sector are of particular interest.

In water-resource infrastructure development, the following different players emerge in the private sector:

- *Utilities and agencies* – While many utilities in SSA are government agencies, some are partially owned by the private sector, as is the case in Cameroon. A large number of these SSA utilities have been established to develop and manage hydropower infrastructure. These institutions drive the expansion of their service area, often to the detriment of development of other initiatives in the water-resources area. One adverse outcome is that many utilities focus on building large infrastructure instead of smaller schemes. For instance, the hydropower project lists on the national development plans of Zambia and Mozambique focus on projects of 30 MW and higher, most of which are beyond the capacity of the national utilities to develop construct, build, and operate independently. However, they play a vital role in the management of large-scale assets and project development.
- *Financiers* – These institutions are concerned with making investments that will yield stable returns over the repayment period. Some financiers impose requirements that are onerous and unenforceable within many SSA countries, as a result of what is called "political risk", increasing the cost of investment. The definitions of political risk are often created outside SSA by rating agencies and banks that do not have strong local operations in the region, which often results in an imbalanced and undifferentiated view of risk. The financial requirements for mitigating this risk will often make the project prohibitively expensive and forestall its development, such as the Inga dams in the DRC and the Zambezi valley dams in Zambia and Mozambique. Moreover, many financial institutions are unable to factor in social and development benefits into their risk and return profile.
- *Construction industry* – These institutions, often foreign, bring in much-needed skills and are focused on ensuring the project is developed in a technically sound manner, sometimes importing

mal-adaptive practices based on previous experience in dissimilar environments. As these firms often lack local understanding, the cost for developing and constructing water-resource infrastructure increases greatly.

- *Agricultural and/or industrial sector* – This sector is primarily concerned with maximum extraction of water for agricultural production and processing, sometimes implementing schemes that create significant environmental degradation or may be disadvantageous to poor rural, peri-urban, or urban populations, such as the Volta River dam in Ghana, which provides continuous electricity to large mining companies but has significantly degraded the surrounding environment and prompted migration away from the area.

Clearly, private-sector players have divergent interests and may influence or promote mal-adaptive practices, which may retard water-resource infrastructure development and result in institutional failures. In addition, private-sector actors are not interested in addressing poverty eradication unless there is a direct financial benefit, which influences their involvement in the nature of water-resource infrastructure to be developed. Therefore, rather than referring to public-policy failures, institutional failures represent the inability of the multiplicity of actors within a given sphere to coordinate their activities, leverage their strengths, and mitigate their weakness, to ensure the achievement of a desired outcome for SSA.

Financing of infrastructure

The underperformance of the agricultural and energy sectors in Africa can be directly linked to under-investment (Sirte 2008), both in terms of capital investment and investment in ongoing operations and maintenance. Despite the critical role of agriculture in most African economies, in the last 30 years agriculture received less than 10 per cent of the budget (Sirte 2008). At the same time, from the early 1990s, international aid to large dams, irrigation, drainage, and hydropower also dropped significantly.

However, there has been a turnaround in recent years, with increasing aid commitments and increasing commitment by African governments. In Maputo, in 2003, all African governments committed themselves to the implementation of the Comprehensive Africa Agricultural Development Programme (CAADP) and agreed to allocate at least 10 per cent of national budgets to agricultural development by 2008 (Sirte 2008). Unfortunately, by 2008, only a handful of countries had achieved this target, while about 12 countries had reached or exceeded half of the target. African countries therefore still have a long way to go to show their commitment to agricultural development in budgetary terms.

While financing is available for a range of water-resource infrastructure projects from international development partners, and banks such as the African Development Bank, constraints in the "bankability" of projects has resulted in an understanding of the need to provide increased support for project preparation. The African Water Facility has created a fund to support the development of project proposals for African governments. Financing for micro-level infrastructure and infrastructure in poor communities remains a major challenge, addressed to some extent by donor grants and NGO support, but insufficiently addressed by both national governments and financing institutions.

The issue of financing of operation and maintenance requires improved focus on the issue of water pricing and proper costing procedures. In many African countries, pricing of raw water is poorly implemented, if at all, and full cost recovery may not be possible from poor consumers. Appropriate pricing is necessary to support the sustainable operation and maintenance of infrastructure. However, pricing structures must take into account the burden of the poor, given the extremely high poverty levels throughout SSA.

The infrastructure cycle

Beyond the categories of constraints outlined above, three primary areas of focus emerge that are critical to the effective development, operation, and maintenance of water-resource infrastructure. These focus areas of strategic planning, development, and operation and maintenance are linked into a synergistic cycle.

Strategic planning

Prior to focusing on any individual project, basin- and catchment-level strategic planning must occur to ensure that water requirements are anticipated, appropriate infrastructure planned, requisite institutions developed, and operation and maintenance requirements are clearly understood, planned for, and budgeted for. The AICD, in describing the types of investments that should occur in water-resource infrastructure, is focused at this strategic level. They include investments that achieve the following:

- focus on continual growth;
- reduce rural poverty;
- build climate resilience and adaptation; and
- foster cooperation in international river basins.

(Dankova *et al.* 2009)

These decisions occur at a strategic planning level into which individual projects fit as components of a bigger whole. The four principles for development of infrastructure pertain at all levels. They require robust institutional arrangements, rich data about the existing and future environment, and political support.

At the micro-level, strategic planning is important for assessing technologies, providing financial support for implementation, and creating an appropriate policy and regulatory environment.

At the macro-level, strategic planning is critical for and understanding of the role of infrastructure in broader river basin management, whether transboundary or not. Effective river basin development requires political leadership, government commitment, confidence building between countries where appropriate, substantial investments for assessments, project preparation and feasibility studies, and, ultimately, the realization of tangible benefits.

However, many SSA countries lack the institutional capacity to effectively carry out strategic planning, exacerbated by poor data. These institutions need to actively engage actors in the development cycle and in the operation and maintenance so that continual feedback can be given to improve the strategic planning process.

Development phase

The effective planning and implementation of a robust development phase is a critical element of water-resource infrastructure. Each water-resource asset must adhere to the principles that the investment must be technologically sound and be appropriately structured so that loans or grants can be used efficiently and repaid if required. The design and operation of infrastructure assets at all levels must ensure that local communities derive equitable benefits and that possible negative environmental and social impacts are mitigated.

A great deal of emphasis has been placed on the need to ensure "bankable" projects. The high costs and sometimes low financial returns of water-resource infrastructure do not, however, necessarily make for easily bankable projects, particularly in the context of under-developed, primarily agricultural economies. An approach that recognizes water as both a social and an economic good, and the specific nature of water-resource infrastructure, is needed to ensure the financial viability of infrastructure development, particularly in support of poverty eradication and social development. There are some key criteria that can be identified that support the successful planning and financing of infrastructure:

- experienced project sponsors;
- secure contract structure;
- robust technical design appropriate to the needs of the users (including for micro- and small-scale infrastructure) and appropriate to available O&M capacity;
- credible business plan; and
- comprehensive risk-mitigation strategy.

Having these components in place will allow the infrastructure projects to attract financial institutions and stakeholder support. However, many water-resource infrastructure projects in SSA are lacking in one or many of the criteria above, which can significantly retard the development process. Much of the literature on infrastructure investment focuses on these constraints. A well-constructed development phase, which incorporates the elements above, can yield multipurpose water projects, which generally result in optimal water development, maximize economic returns on investments, and need to be implemented in the basin-wide context.

Much has been written about the need to involve stakeholders in the plannng of infrastructure. At the micro-level in particular, the involvement of the infrastructure users not only in planning, but also in the development phase is critical to ensuring that the infrastructure meets the needs of the users, and is appropriate for local O&M capacity. Of particular importance at this level is ensuring the involvement of women, who are often the primary water users, but not so often presented in consultative and decision-making structures and processes.

Operation and maintenance

While a great deal of discussion on infrastructure in SSA is focused on the need for more of it on all levels, there is an equal challenge pertaining to the operation and maintenance of existing infrastructure. Two scenarios commonly occur: one concerning inadequate use and another concerning inadequate maintenance.

The first scenario occurs when infrastructure is developed but not used. The construction of the Pongola Dam in South Africa, which was only fully utilized 40 years after its construction, is a good example of this. Similar examples can be found in other parts of SSA such as the Cahora Bassa dam in Mozambique and the Inga dams in the Democratic Republic of Congo. A second scenario occurs when infrastructure is used, but not maintained effectively, resulting ultimately in its deterioration or collapse. Major irrigation schemes and municipal infrastructure suffer this fate in many SSA countries, and some dams have become high risk as a result of poor maintenance of floodgates and dam walls.

Often in SSA countries, maintenance is neglected, which results in dams losing their ability to provide the desired services, as well as becoming structurally damaged during high-impact events. Critical to operations and maintenance for dam safety is the collection of environmental data and its appropriate use in information systems so that reliable maintenance regimes may be enacted.

The operation of dams also has implications for the potential negative health impacts of those same dams. Levels and rate of flow downstream of a dam may have significant impacts on vectors of disease.

Unfortunately, the optimal operation for managing health impacts and for managing water-user needs may not coincide, requiring once more that trade-offs must be made. In the Orange River basin, for example, black fly downstream of the Gariep Dam could be managed by a changed flow regime, but the necessary flow regime to manage the black fly would be sub-optimal in terms of management of water for irrigation.

It goes without saying that operation and maintenance are imperative at each level of water-resource infrastructure. At the macro-level, appropriate operations provide important services such as electricity and irrigation, which are time sensitive and interlinked to other assets in a given basin. Unfortunately, different uses such as hydropower and irrigation may demand conflicting operating regimes, and trade-offs need to be sought to meet both sets of needs. Coordinated operating regimes can prevent the damage from high-impact events such as flooding or droughts. At the micro-level, where funding support is usually only for capital expenditure, a robust operation and maintenance regime usually requires sweat equity on the part of the water users.

The question of effective operation and maintenance requires consideration of both institutional capacity and financing regimes, including the issue of water pricing.

Conclusion

Grey and Sadoff (2005) have postulated that the full realization of Africa's water potential and the optimal allocation of water among various sectors require the right institutional arrangements, including (a) capable water-management organizations; (b) provisions for public participation in water-management decisions; (c) water-rights regimes; and (d) tailored incentive systems. The Financing Water for Growth in Africa forum (FWGA 2008) identified (1) adaptive capacity; (2) the development of "bankable" infrastructure projects; and (3) knowledge transfer between African countries as key areas of focus.

This paper has examined the links between water-resource infrastructure and economic growth and poverty reduction. Through this lens, several important opportunities around water-resource infrastructure can be identified.

Optimization of existing systems

SSA already has a wealth of natural infrastructure and existing artificial water-resource infrastructure that should be leveraged. An optimization of this infrastructure through appropriate planning and operation and maintenance regimes can make an immediate contribution, ensuring greater access to reliable supplies of water for economic growth and poverty reduction. Improved management and optimization of use applies at all levels of infrastructure.

Focus on all levels of investments

A combination of all levels of infrastructure development is likely to bring the best development benefits to SSA, and appropriate financing and institutional arrangements at all three levels are necessary to provide these results. Micro-level infrastructure has shown remarkable benefits in poverty reduction at the local level, with a very short lead time before development impacts can be seen and felt. It has the ability to reduce poverty and improve climate-change resilience among the most vulnerable populations in the continent, particularly where it serves the multiple-use needs of the communities.

Climate-proofed infrastructure to support development

Planned infrastructure must be aligned with clear development objectives at all levels. Appropriate water-resource infrastructure plays a critical role in social and economic development and eradication of poverty. Improved social and economic development and the eradication of poverty, in turn, result in improved resilience to climate change. Thus, appropriate infrastructure development can lead to both socio-economic development and improved climate-change resilience for the society as a whole, and the poor in particular. At the same time, the construction of new infrastructure needs to take into account the potential climate-change impacts so as to remain viable under a climate-change scenario. Developing water-infrastructure assets that mitigate climate risks can also assist in poverty reduction and economic growth strategies. However, these opportunities can only be achieved through robust institutions that cooperate constructively.

Strategic planning and investment

The transboundary nature of African river basins, coupled with increasing pressure from population growth, economic growth, and climate change, requires for a more strategic and regional view of water-resource infrastructure planning and development, and greater regional integration both in water-resource management and in financial arrangements. This integration is necessary to achieve the most efficient and sustainable use of limited water resources. The opportunity for governments to look at optimizing energy, food, and water security at a strategic regional rather than purely national level exists.

In conclusion, the need for infrastructure development at all three levels in Africa has been articulated in this chapter, although it has been widely recognized and acknowledged before. What is necessary now is for African governments to show the political will and make the necessary budgetary and political commitments to make this infrastructure development a reality, in partnership with financing institutions, development partners, and affected communities. While major water-resource infrastructure projects are increasingly a focus of attention in Africa, often due to hydropower potential, poor, rural communities are particularly in need of appropriate infrastructure that will assist in increasing food security, reducing poverty, and building their resilience to the current and future impacts of climate change. The selection of an appropriate scale and mix of infrastructure is needed to meet the range of socio-economic needs across the society.

Note

1 All the authors are from Pegasys Strategy and Development.

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12

FREE BASIC WATER

A sustainable instrument for a sustainable future in South Africa

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This paper was first published in *Environment & Urbanization* in 2008. Since then, further progress has been made in the provision of free basic water to the people of South Africa. The process, however, has not been without controversy. In 2009, a legal challenge by a coalition of community groups to the policy as well as to the application of pre-paid meters reached South Africa's Constitutional Court. The Court ruled that policy as implemented as well as the application of pre-paid meters "falls within the bounds of reasonableness" and did not violate the Constitutional right to water as had been claimed. In its judgement, the Court nonetheless highlighted the value of the legal challenge:

> Government must disclose what it has done to formulate the policy: its investigation and research, the alternatives considered, and the reasons why the option underlying the policy was selected. The Constitution does not require government to be held to an impossible standard of perfection. Nor does it require courts to take over the tasks that in a democracy should properly be reserved for the democratic arms of government. Simply put, through the institution of the courts, government can be called upon to account to citizens for its decisions. This understanding of social and economic rights litigation accords with the founding values of our Constitution and, in particular, the principles that government should be responsive, accountable and open.

This chapter highlights many of the underlying issues and the process by which the "free basic water" policy was derived and implemented.

Introduction

Following the establishment of a democratic government in 1994, the new South African government introduced sweeping changes in the water sector. A major programme to provide basic water and sanitation services to the large number of unserved communities was launched immediately.

In 1996, a "right to sufficient water" was included in the country's new Constitution (Government of South Africa 1996), which also mandated extensive decentralization of powers and functions to local governments, with significant implications for water provision.

Separate, although related, policies were established for water resources and water services (Department of Water Affairs and Forestry 1994). New legislation repealed previous laws and gave effect to the new policies (Government of South Africa 1997). However, it gradually became obvious that there were problems of access, as many people were too poor to take advantage of the new services. Thus, a new policy determined that all South Africans should receive a basic water supply free of charge.

This policy was controversial. Introduced on the eve of local government elections, it was seen by some as a populist political ploy. It ran contrary to the conventional wisdom at the time, which was that water, as an economic good, should be paid for. It also represented a substantial deviation from the original policies of the ruling African National Congress (ANC) party, which reflected this international consensus. Six years after its implementation, the impact of the free basic water policy can now be evaluated. The critical question is whether it has achieved its objectives.

This paper argues that its objectives were not limited to social distribution and welfare goals but were part of a broader effort to achieve equitable access to, and efficient use of, water in an environmentally sustainable manner. When measured against these broader criteria, the programme would appear to have been largely successful.

The success of the programme highlights the importance of the compromise on water issues at the Rio de Janeiro Earth Summit in 1992 between the (largely) northern environmental movements and their governments, which focused on sustainability, and the (largely) southern voices, which called for priority to be given to social and economic development. The Dublin principles on water management, which gave priority to sustainability and economics (Dublin Statement on Water and Sustainable Development 1992), were not adopted at the Rio de Janeiro Summit; the language that ". . . water has an economic value in all its competing uses and should be recognized as an economic good" was changed to reflect water as ". . . a natural resource and a social and economic good . . ." (UN Conference on Environment and Development 1992). The outcomes of South Africa's free basic water policy suggest that this compromise has produced positive results.

The context of South Africa's free basic water policy

Aside from the overarching opportunities created by democratizing and de-racializing the country, which immediately gave greater priority to meeting the basic needs of the poor majority of the population, there were other drivers that led to the introduction of South Africa's free basic water policy in 2001.

Social development challenges

In 1994, South Africa confronted the structural consequences of 50 years of active discrimination against and political control over the movement of the majority African population. This had left the country with many dysfunctional settlements with little economic base, and skewed communities with few economically active workers and made up largely old people, women and children. The ending of "influx control" saw accelerated urbanization, which put substantial pressures on the city administrations that are responsible for housing and service provision (Policy Coordination and Advisory Services 2006).

Another inheritance was that a large proportion of the economically active population had low educational and skills levels and hence low employability. This aggravated already high unemployment levels (40 per cent according to broad definitions) and dependence on formal (social grant) or informal (social and family networks) sources of support. These factors, defining as they do the situation of a large proportion of household water users, inevitably affect the water services sector.

Scarcity and variability

The other critical contextual factor is South Africa's relative water scarcity – with 1,154 cubic metres per person in 2000, South Africa was, in terms of available water per capita, among the "driest" countries in the world, at 150th out of 180 countries, on par with Somalia, Lebanon, Burkina Faso and Morocco (UNESCO-WWAP 2003). The scarcity is aggravated by the fact that more than 60 per cent of the country's gross domestic product (GDP) comes from inland areas, where a substantial proportion of the population live high up in the main river basins. Water is expensive as it has to be sourced from further afield and pumped up to the users, and the population's waste has an impact on downstream users.

The scarcity challenge is compounded by high levels of climatic variability. Extensive storage is required to provide assured supplies during dry cycles. This situation makes efficient water use and demand management a high priority, and substantial investment in storage and transmission is required. Intensive water use also places great pressure on water ecosystems through the withdrawal of water as well as the discharge of wastes (River Health Programme 2003).

The water-intensive suburban lifestyle of South Africa's minority population at the upper end of the household income scale was thus also a challenge. Water demand was predicted to rise rapidly with urbanization and improved living standards for the poor unless there were specific interventions to contain demand. The fact that new supplies (where they are available) usually cost substantially more than existing systems added to the pressure to promote water-demand management measures to contain the growth in water use in the expanding affluent community (DWAF 1997).

A new national custodian for water supply and sanitation services

Another important challenge in 1994 was the absence of a national institution for overseeing water supply and sanitation services. Responsibility for water services had been left largely at local level, with little national oversight. This was identified as a policy problem, and the need for an "apex institution" to take responsibility for the country's water supply and sanitation was highlighted as a priority (Muller 1993).

In order to achieve the goals set out for the new government in the Reconstruction and Development Programme (RDP), the Department of Water Affairs and Forestry (DWAF) was tasked with this responsibility. However, DWAF had little capacity or knowledge of domestic water supply matters despite a long history of water-resource management. Before a new policy for water supply and sanitation could be formalized and implemented, DWAF's technical, operational and administrative capacity had to be built.

Expansion of service infrastructure

Immediately post-1994, a priority of the new South African government was to address the situation of the large proportion of the population, estimated at 12 million out of a total of 36 million, who were without access to safe water (SCOWSAS 1991). In 10 years, the national investment programme provided infrastructure for basic water supply to more than 10 million people, supported by the larger metropolitan municipalities and housing programmes. By 2005, only an estimated 3.7 million out of 48.1 million people were without some access to safe water (DWAF 2005).

Decentralization to local government

South Africa's 1996 Constitution mandated a high degree of decentralization as part of the country's political settlement (Government of South Africa 1996). While the majority ANC party supported the devolution of powers to local institutions, reflecting its commitment to participative democracy, minority parties supported it in the hope that they would retain some autonomy in their communities (Muller 2007).

So, while the water supply programme was driven and implemented by the national DWAF for the first five years, the second five years were a period of decentralization, during which new local government institutions were established following the local government elections of 2000. Indeed, the DWAF programme had been characterized from the start in terms of "building local government" and "making the constitution work" rather than simply expanding water supplies.

As then-Minister of Water Affairs and Forestry, Kader Asmal explained in his 1996 budget speech:

> It is not up to central government to provide services, but to create a framework within which they can be provided. This requires clear regulations and legislation to protect both consumer and provider, which I intend to promote.
>
> (Asmal 1996)

In 2001, a decentralized fiscal system was established that integrated the financing of the national water supply and sanitation programme and required that attention be paid to supporting new municipalities so that they could exercise their responsibilities.

While the water-services functions were being decentralized, the water-resource management functions were kept at central level. This helped to maintain the integrity of rivers as management units by establishing an institutional counterbalance between local government as water users and central government and its regional agencies as custodians of the resource.

Establishing effective local government

An important aspect of the post-2001 water-supply programme was to build the capacity of local government not only to sustain the water-services investment programme but also to ensure effective, ongoing operations and maintenance of the new water infrastructure. This required the establishment of financial systems to support the physical and operational planning of the water services, one element of which was the development of tariff and subsidy policies that would support the long-term financial sustainability of the local governments.

Initial policy in 1994 was that central government would fund the infrastructure for basic water-service provision in poor communities while the communities themselves would fund their operational costs. However, it became clear that in the poorer parts of the country, municipalities would require support to maintain even a minimum level of services.

The Constitution therefore provided for an inter-governmental transfer, the "equitable share of revenue" from national to local level, ". . . to enable it to provide basic services" (Government of South

Africa 1996). It was still intended that funding for water above "basic supply" levels would come from tariffs.

Initial tariff and subsidy policies

The initial policy on water supply financing was outlined in the ruling ANC's election manifesto, the RDP. This committed the new government to a programme of investment in infrastructure to provide basic services, but also to conventional positions on payment for services.

Some authors, critical of what they describe as the neo-liberal policies of the South African government post-1994 (Bond 2000), attribute South Africa's water-tariff policy to World Bank intervention in 1995 (Bond and Ngwane 2001). However, the tariff policy was spelt out in some detail in the RDP and reflected the then-dominant (if rather uncritical) civil society view strongly promoted by local NGOs such as the Rural Advice Centre and the Mvula Trust (Mvula Trust 2001).

> *2.6.10 Tariffs.* To ensure that every person has an adequate water supply, the national tariff structure must include the following:
>
> *2.6.10.1* a lifeline tariff to ensure that all South Africans are able to afford water services sufficient for health and hygiene requirements;
>
> *2.6.10.2* in urban areas, a progressive block tariff to ensure that the long-term costs of supplying large-volume users are met and that there is a cross-subsidy to promote affordability for the poor, and
>
> *2.6.10.3* in rural areas, a tariff that covers operating and maintenance costs of services, and recovery of capital costs from users on the basis of a cross-subsidy from urban areas in cases of limited rural affordability.
>
> (ANC 1994)

Standards for basic water supplies

One important issue for the investment programme was the amount of water to be provided as a basic service for each household, which is linked to the question of what price should be charged for that supply. The initial programme took its definition from the RDP, which stated that:

> *2.6.6* The RDP's short-term aim is to provide every person with adequate facilities for health. The RDP will achieve this by establishing a national water and sanitation programme which aims to provide all households with a clean, safe water supply of 20–30 litres per capita per day (lcd) within 200 metres, an adequate/safe sanitation facility per site, and a refuse removal system to all urban households.
>
> *2.6.7* In the medium term, the RDP aims to provide an on-site supply of 50–60 lcd of clean water, improved on-site sanitation, and an appropriate household refuse collection system . . .
>
> (ANC 2004)

Subsequently, the Water Services Act established the concept of a "basic water supply", prescribed in regulations that could be adjusted over time. The initial "basic water supply" was defined as access to 25 litres of safe water per person per day, within 200 metres of the household (DWAF 2001). This definition was to become important in the context of the free water debate.

Challenges of access

As infrastructure provision proceeded and operational experience was accumulated, concerns were raised about access. It was found that the cost of water was deterring poor people from using it, limiting the benefits of the programme.

This was first demonstrated in rural programmes when attempts were made to implement the "payment for operations" policy. One of the best-documented projects was the Shemula water project in an impoverished region of KwaZulu-Natal province. In this instance, a water project run by the local public utility established "water kiosks" where people could buy water at prices that, while highly subsidized, were, at R5/kilolitre, (US$0.75), expensive in relation to local incomes.

> Where people are paying on a volumetric basis, consumption from public standpipes would appear to be significantly less. Systems with pre-payment systems such as the Shemula water project in KwaZulu-Natal record an average use of about six litres per person per day. In that system, it is reported that only 323 of the 7,500 households in the area use the system. The majority of families continue to use traditional water sources.
>
> (WEDC 2000)

Similar situations arose in peri-urban areas, where alternative supplies were less easily available and many households experienced difficulty in making payments. Suppliers who sought to manage payments in poor areas found themselves forced to disconnect users or develop expensive administrative systems to pursue their debts.

The challenge was captured by South Africa's second Minister of Water Affairs, Ronnie Kasrils, in a personal anecdote:

> Last year, I visited a newly installed water supply scheme in a typical South African rural village called Lutsheko. The project was well run by a village water committee and had improved the lives of 3,000 people. But when I went down to see the borehole, on the banks of a dried out riverbed, I found a young woman, with a three-week old baby on her back, scooping water out of a hole she had dug in the riverbed. She told me she could not afford to use the taps.
>
> (Kasrils 2001)

Experiences like this, repeated across the country, established the context for a review of water-pricing policy. It was in urban rather than rural areas where water challenges were most acute because better urban infrastructure made higher levels of household consumption possible.

Conceptualization and design of the free basic water policy

By 2000, five years experience of operation had shown that the initial policy assumptions were flawed, and that elements of the policy needed to be reviewed if the objective of meeting the water needs of all South Africans was to be achieved. There was also a need to consider the implications of the newly established local government structures.

The core of the review was to address the overall financial sustainability of municipal water services. However, this had to ensure that the key objective of ensuring access to safe water for all South Africans was achieved. It was in this context that the approach to prices and tariffs was reconsidered.

Innovation and response

The review was informed by experiences at the local level. There was particular interest in the metropolitan areas, which covered South Africa's six major conurbations, where institutional reform had proceeded faster than in the rest of local government. Durban (now called Ethekwini), the only metropolitan area with a sizeable population from the former black "homelands", was seeking a tariff policy that would address the challenges of service delivery in poor peri-urban communities, and had come up with some innovative approaches.

Of its population of more than 2.5 million, half a million people were without household connections and used public standpipes. In addition, an estimated 20,000 households had been connected illegally to the piped water network. After initially trying to enforce payment in all communities, Durban weighed the costs and benefits (social, political and financial) and decided that it was not appropriate to pursue payment at all costs. A two-fold approach was adopted:

1 Limit demand by using small bore pipes together with yard tanks for storage (which, incidentally, helped to reduce the costs of the reticulation system).
2 Provide some free water to all users of the restricted access system.

This was funded by cross-subsidies from the higher-volume consumers in the formal urban area and showed that it was financially feasible to provide a basic supply of water, free of charge, in a city such as Durban (Brocklehurst 2001).

Political intervention

The policy review process was accelerated when the first elections for new local government structures were scheduled for December 2000.

Water supply remained a political priority and technical discussions about the feasibility of a free basic water policy at national level were overtaken by the political timetable.

The possibility of providing some free water had first been raised officially in June 2000 (DWAF 2000). In September 2000, free basic water was formally included as part of the election programme by President Thabo Mbeki, at the launch of the ANC's manifesto for local government elections (ANC 2000).

It was proposed that a basic minimum quantity of water (6,000 litres per household per month) be provided free of charge to poor South Africans. This could be implemented and funded in a variety of ways:

- by providing free water to all, using cross-subsidies as in Durban;
- by supplying free water only to "indigent" households, as identified by the local municipality; or
- by providing free water only at certain service levels, recognizing that households that obtained their water through public standpipes invariably used less than the basic amount.

These options were later detailed and expanded in formal guidelines (DWAF 2002a).

Implementation was given impetus when a cholera epidemic that had broken out in rural KwaZulu-Natal in August 2000 began to reach serious proportions in December (KwaZulu-Natal Department of Health 2002). The free basic water policy was finally given legal status through the promulgation of tariff regulations in June 2001 (DWAF 2001).

The rationale underlying the free basic water policy

The underlying rationale for the free basic water policy was elucidated recently in relation to a legal challenge calling for the "free" water amount to be raised to 50 lcd, and for "pre-payment" meters to be outlawed. In court papers, addressing a challenge to the policy, a DWAF official highlighted the complexities of addressing the pricing of water in a social and environmental as well as in an economic context.

> *110.* The approach to the pricing of water supply services and indeed the very question of whether the supply of water should be subject to payment is a technically complex and politically vexed question.
>
> This is because water use has a number of distinct properties, those of a resource essential for life, those of a productive or of a luxury consumption nature and those of a limited environmental resource.
>
> In addition, regardless of the status of water, the activity of supplying it to people for consumption is a complex undertaking, which incurs substantial costs for which a funding mechanism is required if supplies are to be sustained.
>
> *111.* A particular challenge is to distinguish between the different types of use within the consumption patterns of a single household.
>
> Thus, while all households require a certain amount of water for basic survival, some may choose to use more because they have more bathrooms and water-using appliances. Others may use water for gardening for recreational or productive purposes. An ideal system would have one approach to paying for the essential water use and another for luxury or productive use, which is what the block tariff system seeks to do.
>
> *112.* However, the government is acutely aware of the significant number of poverty-stricken people who are unable to afford even the minimal cost attached to essential water use. Hence, the introduction of the Free Basic Water policy as part of the government's strategy to alleviate poverty.
>
> (Schreiner 2007)

Administrative confirmation

This approach to free basic water was reflected in the tariff regulations, which, since domestic water supply is constitutionally a local government function, could only establish norms and standards for tariff structures rather than prescribe actual tariff levels. The regulations address a range of objectives in addition to the provision of free basic water, although that intention is emphasized:

> *S.3 (1)* A water services institution must consider the right of access to basic water supply and the right of access to basic sanitation when determining which water services tariffs are to be subsidized.
>
> (DWAF 2001)

> *S.6 (1)* A tariff set by a water services institution for the supply of water through a water services work or consumer installation designed to provide an uncontrolled volume of water to a household must include a volume-based charge that:

- Supports the viability and sustainability of water supply services to the poor.
- Discourages wasteful or inefficient water use.
- Takes into account the incremental cost that would be incurred to increase the capacity of the water supply infrastructure to meet an incremental growth in demand.

(2) The requirements of sub-regulation (1) are deemed to have been met where the tariff is set as a volume-based charge that provides for a rising block tariff structure which includes:

- Three or more tariff blocks with the tariff increasing for higher consumption blocks.
- A consumption level for each block defined as a volume consumed by a household during any 30-day period.
- A first tariff block or lowest tariff block with a maximum consumption volume of six kilolitres and which is set at the lowest amount, including a zero amount, required to ensure the viability and sustainability of water supply services.
- A tariff for the last block or highest consumption block set at an amount that would discourage high water use and that reflects the incremental cost that would be incurred to increase the capacity of the water supply infrastructure to meet an incremental growth in demand.

(DWAF 2001)

The regulations did not prescribe a free amount, recognizing that no service can be provided without funding and that if no source of funding could be identified for a zero tariff, it would be inappropriate to impose one – and would indeed intrude on local government's constitutional powers. However, the regulations emphasized the economic and sustainability objectives of reflecting the cost of making additional water available and discouraging its wasteful and inefficient use.

Development of a systematic welfare approach

This process coincided with the development of an approach to social welfare that emphasized the value of the "social wage", the package of goods and services made available by government in addition to formal welfare grants (SARPN 2003). Under this approach, when evaluating support to the poor and indigent, the value of the full menu of government services was considered to allow the analysis of redistribution trends in a normalizing society.

Although it was only formally mentioned by the president in his 2003 State of the Nation Address to Parliament (Mbeki 2003), the social wage had been discussed politically within the ANC since at least 1998, and free basic services, including water, were very much part of the concept. As DWAF court papers explain:

> It should be stressed that the free basic water policy is but one element of a broader approach to the development of a comprehensive social security framework for South Africa. In terms of this, there are a number of pillars in the system established to ensure that all South Africans enjoy protection against social contingencies. The first pillar, of basic universal protection for all citizens, comprises conventional social grants as well as the 'social wage', the package of essential social services provided by government. Free basic water should be seen as an element of this social wage.
>
> (Schreiner 2007)

Civil society contestation

There is a small but prolific civil society community in South Africa, including organizations such as the Anti-Privatization Forum, the Soweto Electricity Crisis Committee and the Freedom of Expression Institute, which has consistently criticized government's water policy as "neoliberal", and its approach to tariffs as "commodification" and "preparation for privatization" (Bond 2006).

They have recently supported court action challenging the policy of the city of Johannesburg in setting the level of free basic water at 6 kilolitres per household per month. This action also challenges the Regulations Relating to Compulsory National Standards and Measures to Conserve Water, which define a basic water supply (Mazibuko 2006).

Although the idea of a free basic water supply was supported, the details of its implementation soon came under attack:

> After the ruling African National Congress promised free basic water supplies in December 2000 during a municipal election campaign, the same bureaucrats responsible for water disconnections began redesigning the water tariffs. In July 2001, revised price schedules provided a very small free lifeline: 6,000 litres per household per month, followed by a very steep, convex curve. But the next consumption block was unaffordable, leading to even higher rates of water disconnections in poor areas. The 6,000 litres represent just two toilet flushes a day per person for a household of eight, for those lucky enough to have flush toilets. It left no additional water to drink, wash with, clean clothes or for any other household purposes. In contrast, from the progressive point of view, an optimal strategy would provide a larger free lifeline tariff, ideally on a per person, not per household basis, and then rise in a concave manner to penalize luxury consumption.
>
> (Bond 2005)

The alternative approach proposed by critics such as Bond, above, would provide more water than is required for basic health needs and would benefit predominantly urban consumers rather than the poorer rural communities, which have limited infrastructure capacity. Perhaps 80 per cent of domestic consumers (i.e. a far greater proportion of the non-poor) would receive free supplies. An allocation based on the number of people in a household would be administratively complex and open to abuse. The proposals would also undermine the financial base of the system by reducing cross-subsidization and requiring greater central subsidies for free supplies, to the rich as well as the poor.

Sustainability, quality and reliability

As highlighted in the court papers cited (Schreiner 2001) and in the tariff regulations themselves, the challenges of environmental sustainability were important considerations in defining the approach to water pricing.

A variety of instruments can be used to promote water conservation and manage water demand. Many are technical, such as requiring the installation of low-volume flush toilets. Others are operational, including the effective management and reduction of leaks and breaks in the distribution system. But the menu of options will usually include setting appropriate prices, as this reduces consumption while also communicating the cost of services directly to their users.

Given South Africa's limited water resources, the promotion of conservation and demand management, have long been on the agenda. The water services development planning process, mandated by the Water Services Act, requires municipalities to consider how they will restrain water use. In this context, tariff regulations, including the free basic water provision, are one instrument that can be used to achieve more sustainable water use.

However, the focus on access and environmental sustainability was not matched with action to ensure that services achieved biological and chemical quality standards and appropriate levels of reliability. In South Africa, it has been taken for granted that tap water is safe to drink and that in urban areas at least, is always available. Experience from other middle-income developing countries has indicated that this cannot be taken for granted and, more recently, service standards, particularly for water quality and reliability, have begun to be taken more seriously (Parliament of South Africa 2007).

The achievement of service delivery standards depends on adequate funding, either from tariffs or from subsidies. Other countries, where tariffs have fallen below the level needed, offer cautionary tales. In India, according to an official review:

> On the urban water supply front, transmission and distribution networks are largely of very poor quality, in addition to being outdated and badly maintained, resulting in higher operating costs. Physical losses are typically high, ranging from 25 to over 50 per cent. Low pressures and intermittent supplies lead to back siphoning, resulting in contamination in the distribution network. Water is generally available for only two to eight hours a day in most Indian cities. Unsatisfactory service standards has led to low tariff structures, which in turn has resulted in poor resource positions of Urban Local Bodies (ULBs), poor maintenance and service – a vicious circle. The problem is compounded by the rapid growth of urban centres and corresponding growth in the demand for services.
>
> (Government of India Planning Commission 2002)

In Malaysia, the Economic Planning Unit Director-General reported:

> State water supply authorities have problems covering the cost of services and many have deferred maintenance due to capital shortages. This has led to deterioration in the quality of services, such as poor water quality and low pressure. In fact, there are water supply authorities that have not reviewed the water tariff in the last 20 years. Non-revenue water (NRW) in the water supply sector is high, with a national average of 40.6 per cent and a range of 18.0 to 73.9 per cent (2002).
>
> (Abidin, Raja Dato' Zaharaton Raja Zainal 2005)

These are outcomes that South Africa clearly wishes to avoid.

Implementation of free basic water

The implementation of free basic water was both helped and hindered by the process of establishing new municipalities where the local government elections were an important milestone. While the process had created a degree of urgency and energy in local administrations, many were restructuring to merge different organizations and put new management in place. Local governments' annual budget cycles begin in July, so there was little time to plan new tariff systems. In the event, free basic water was first implemented in those municipalities, notably the large metropolitan areas that had suffered less dislocation.

A task team developed and supported an implementation strategy. Workshops were held to inform and gather inputs from all stakeholders, and draft guidelines were produced for local authorities. The guidelines were tested in nine pilot municipalities and finalized with other support materials by July 2001. For the next two years, dedicated regional support structures provided specific problem solving, technical support and advice to municipalities, as well as monitoring and reporting on progress.

The guidelines

The guidelines (DWAF 2002a) offered municipalities a range of options for implementing free basic water, depending on their specific conditions.

The introduction of "stepped tariffs" was promoted in metropolitan areas where it was possible for high-volume users to cross-subsidize low-volume users, and also to encourage conservation. Service levels such as communal taps would serve as "rationing" mechanisms in rural areas where the vast majority of people are poor. Finally, "indigency policy" mechanisms to identify free basic water beneficiaries were suggested for poorer towns where cross-subsidization was not feasible but where households already had individual connections. The advantage of the first two approaches is that they are, administratively, relatively simple to implement; the last approach addresses the financial challenge by allowing closer targeting, to make the most of available subsidies.

Complementary support programmes

The free basic water programme was implemented and supported within the framework of the Department of Provincial and Local Government's (DPLG's) broad programme to support local government transformation. The national Cabinet had agreed that local government should be encouraged to use an appropriate combination of the "equitable share" and cross-subsidies within tariffs to fund the provision of free basic water. The subsidy requirements for free basic water for the poor were therefore considered during the determination of the "equitable share" formula, a complex (DPLG 2007) and contested (FFC 2006) process. In parallel, the drafting of tariff regulations proceeded in consultation with the ministers of the National Treasury and the DPLG.

The National Treasury, the DPLG and DWAF were required to report to the Cabinet on the implementation of the "equitable share" and related financial arrangements.

Challenges of implementation were rarely related solely to free basic water and, in 2004, the Consolidate! project, described as a "hands-on local government engagement programme", was launched to tackle local government failures, including problems in the provision of free basic services. According to the base document:

> *10.3.1* Some of the key challenges that must be addressed include the following matters:
>
> - Poor delivery mechanisms for FBS [free basic services].
> - FBS policy not being implemented at the desired level and not reaching intended beneficiaries.
> - Cut-offs, even for pensioners.
> - Poor billing systems.
> - Limited funds available to municipalities to fund services for the poor.
>
> (DPLG Project "Consolidate!" 2004)

Initial outcomes of the implementation of the free basic water policy

Despite these problems, in March 2007 DWAF reported that more than 75 per cent of South Africa's population were served by free basic water through one or more of these mechanisms (DWAF 2007). This included nearly 69 per cent of those classified as poor. Of the near 7 million poor people who did not enjoy access to free basic water, 2.2 million lived in areas without infrastructure, while the balance of 4.7 million had basic level services, or better, but lived in municipalities where free basic water was not yet provided. Of the 169 municipalities with water provision responsibilities, only five did not provide any free water, but 154 did not provide it formally to all households in the area.

Has the free basic water policy been successful? An analysis

Any analysis of the outcomes of the free basic water policy must be undertaken in the context of the overall tariff policy and indeed the overall water policy, recognizing that it was also part of a process to establish democratic local government. While the specific objectives were to improve the access of the poor to safe water, this was done within the framework of an approach with broader social, environmental and economic objectives.

The policy and its implementation has been criticized by civil society commentators for failing to reach all the poor, including too many non-poor users, providing insufficient water and charging too much for water supplied beyond the free amount.

National politicians were concerned about the apparent inequity of the "non-poor" receiving a "free" allowance, despite the fact that tariffs for higher usage had been increased to compensate. Meanwhile, local government was concerned about the adequacy of the "equitable share" funding as well as the formula and population estimates on which it was based. Finally, there was a technical concern, shared by most of the critics and indeed by government, that water requirements for sanitation – indeed the provision of a basic sanitation service – had not been dealt with adequately.

Inclusion and exclusion; equity and sustainability

The main concern from a traditional welfare perspective was the policy's efficiency and effectiveness. If the free basic water allowance is simply a subsidy, is it appropriately targeted? Analysts such as Mosdell and Leatt believed that:

> There are substantial errors of inclusion in the free basic water programme. Of the 32 million people who received free basic water in May 2005, only 17 million were considered poor by the definition of the Department of Provincial and Local Government . . . On the other hand, significant numbers of poor people are excluded from receipt of free basic water.
>
> (Mosdell and Leatt 2005)

The number of people receiving free basic water was of course not the same as those benefiting from a government subsidy through the "equitable share", which is calculated using estimates of the number of poor people in each jurisdiction. Where free basic water was supplied through a targeted indigent policy, as in some smaller towns or through public standpipes in rural areas, where users are overwhelmingly poor and their consumption is self-limited by the distance over which water is carried, unwarranted inclusion is not an issue, although exclusion by administrative decision may be a problem.

However, where free basic water is implemented through the stepped tariff system – in urban areas benefiting a large number of non-poor households – the question of targeting needs to be seen somewhat differently. While Mosdell and Leatt (2005) concluded correctly that: ". . . on average, the free basic water service is more likely to reach the non-poor than the poor . . ." they themselves state that this is ". . . the result of the poor being less likely to receive water services at all."

They conclude erroneously that: ". . . the targeting mechanism of this poverty alleviation programme is causing substantial errors of both inclusion and exclusion, and is therefore in need of review." The error they make is to conflate the subsidy provided from the budget of national government with that provided through user cross-subsidies. This error is the result of a failure to consider the broader objectives of the tariff policy, which include the promotion of conservation and sustainable resource use. The free basic water policy is simply one part of the tariff policy.

In terms of the system design, poor people receive free basic water funded from the "equitable share." The many non-poor households that enjoy free basic water as part of a stepped tariff system are funded by cross-subsidies from households that use higher volumes of water.

Since the explicit intention of the tariff policy (as opposed to free basic water policy) is to improve water use efficiency and reduce wastage, the policy approach would appear to be appropriate since it rewards careful non-poor water users at the expense of profligate non-poor users.

How much is enough free basic water?

Another criticism is that the policy fails to address the needs of large households (the plaintiff in the Mazibuko court case (Schreiner 2007) referred to above lives with 19 other people). There is also concern that the amount of free water provided is inadequate where there are special needs, for instance where a household member is in the terminal stages of HIV/AIDS.

With respect to large households, government's response has been to highlight the broad applicability of the policy:

> *114.* Following the proposal to introduce a "free basic water policy", consideration was given by DWAF to the volume of water to be provided free of charge . . . This discussion was guided by the policy process that had led to the adoption in the RDP and the 1994 White Paper of 20–30 lcd as the standard for a basic water supply. The precedent set by Durban Metropolitan Municipality of providing 6,000 litres per household per month (l/hh/pm) free of charge was also influential.
>
> *116.* 6,000 litres per month is equivalent to 200 litres per day per household. . . . for the purposes of the calculation of free basic water provision, [a household] was estimated at four people in urban areas and five in rural areas (The 2001 census subsequently found that the average household size in South Africa had fallen from 4.48 in 1996 to 3.8 in 2001). With four people per household, 200 l/d provides 50 lcd, with five people, 40 lcd.
>
> *117.* Since not all households are of an average size, consideration was given to the number of large households, comprising more than eight people, where the application of a household limit would reduce the water available below the 25 litres per person per day limit.
>
> *118.* The 1996 census found that 93 per cent of South African households had eight or less people. This figure had increased to 93.96 per cent in 2001.

Government also stated that no single instrument was likely to cater for all the needs of specific households.

> *119.* In the design of any welfare policy of general application, there is a need to balance the proportion of potential beneficiaries who receive less benefit s than intended with the proportion who receive more. This case, where without any adjustment, the policy of providing 200 lcd would target effectively 94 per cent of SA households, compares well with the targeting efficiency of many other welfare interventions.
>
> *120.* Government recognized that the free basic water allowance might not meet the needs of all users and that additional welfare and administrative mechanisms (as well as technical solutions) might be required in specific circumstances, for example households with disabled people or sites where a number of households share a single connection. In these cases, it was important to have another instrument to ensure that household water needs could be adequately addressed, although this was more likely to occur in the context of a generic social welfare policy. The introduction by DPLG of a municipal indigent policy (which was also considered to be a possible mechanism to fund the provision of basic water supplies to poor families) met this requirement.
>
> (Schreiner 2007)

The definition of a basic water supply as 25 lcd was supported by recent recommendations of the World Health Organization (WHO), which had for decades sought to avoid pronouncing on the matter. WHO's position reflected that taken 10 years previously by the drafters of South Africa's RDP. It identified a basic level of access (unlikely to exceed 20 lcd) and an intermediate level of access (50 lcd). While noting that there was still a health concern about the basic level of access, it explicitly recommended that:

> . . .the first priority for interventions to improve access to water supplies is to ensure that at least basic access is achieved. . .. Where the basic access service level has not been achieved, hygiene cannot be assured and consumption requirements may be at risk. Therefore providing a basic level of access is the highest priority.
>
> (Howard and Bartram 2003)

Coverage and local government administrative capacity

The gaps in coverage reported by government highlight some of the problems. While it is understandable that the 2 million people with no access to any infrastructure for safe water supply could not benefit from free basic water, it is less obvious why more than 4.5 million poor people who have infrastructure are excluded. There appear to be a number of different situations:

- Some municipalities could not afford to implement the free basic water policy (This was especially the case in some arid and sparsely populated areas where the cost of providing safe water is substantially more than grant-based formula provides for them to do this).
- Municipalities are simply not charging people for services and hence do not need to implement the free basic water policy as all water is free (this probably covers many of the 2 million people recorded as receiving an RDP level of service but not benefiting from free basic water).
- Municipalities that lack the administrative and technical capability to implement the policy (130 of South Africa's 284 municipalities need support simply to meet their minimum obligations (DPG Project "Consolidate!" 2004), and free basic water is victim to broader administrative failure).

- Municipalities where available funds are diverted for other purposes (although the "equitable share" is calculated to allow adequate funding for the provision of the prescribed free basic services, it is an unconditional grant and municipal officials with other priorities can thus divert the money).

In addition to these issues, the status of households that share connections (and consequently receive a reduced free basic water allowance) has also not been addressed. The size of this group is not known.

Sanitation – the permanent step-child

Despite widespread recognition that adequate sanitation is a vital component of any programme to improve environmental health in poor communities, it invariably takes second place to water supply. Typically, the link between sanitation and water supply was not effectively made in the design of the free basic water policy, and this is also contentious.

DWAF acknowledges this, although they suggest that the situation is not as acute as the critics claim:

> *126.* The supply of water becomes linked to the provision of sanitation where water-borne sanitation is used. The approach of DWAF to the provision of basic sanitation paralleled closely that of water supply. It was agreed that as a first step in providing universal access to adequate sanitation, provision of a properly designed, constructed and utilized improved pit toilet (a so-called VIP) would generally be acceptable. The provision of water-borne sanitation was not considered appropriate in view of the extremely high cost, aggravated by the additional requirement for a water supply service higher than the basic supply to be provided.
>
> *127.* It was however recognized that specific challenges would have to be addressed in communities where water-borne sanitation had previously been provided. In this context it is relevant that the amount of water required to flush a typical water-borne toilet is around 10 litres per single flush. It was noted that a proportion of the basic water supply that is used for cooking washing and laundry can be recovered and used to flush toilets. This implied that a household would be able to flush a toilet as many times per day as there were household members, adequate to maintain its functionality and that the basic water supply would be adequate to maintain functioning water-borne sanitation. It was also noted that the provision of additional water to households who already had domestic connections and water-borne sanitation would aggravate inequities with those who had neither safe water nor adequate sanitation.
>
> (Schreiner 2007)

Tariff policy and broader sustainability

The free basic water issue cannot be addressed in isolation from the systemic implementation of the national tariff policy for water services. Free basic water was conceived as part of a tariff system that also addressed the challenges of constraining the consumption of higher-volume users. The prescribed tariff structure explicitly provided for a:

> . . . highest consumption block set at an amount that would discourage high water use and that reflects the incremental cost that would be incurred to increase the capacity of the water supply infrastructure to meet an incremental growth in demand.
>
> (DWAF 2001)

By 2007, all metropolitan municipalities and most of the larger urban municipalities had introduced stepped tariffs, which provided for free basic water and set relatively high tariffs for the top tier of domestic use.

One indication that this has constrained consumption is that the volume of potable water supplied by bulk water utilities has grown by 20 per cent since the introduction of free basic water, while the number of people served has increased by nearly 50 per cent. Since, unlike electricity, most potable water is used for domestic purposes, per capita use of water has fallen steadily over the period.

Some of this decrease can be attributed to the fact that the growth in service has been at lower service levels in poor communities, while in better-off communities, deliberate densification of settlements is associated with a reduction in per capita water consumption. However, the trend is in the right direction and tariff increases have played a part.

International implications: rights to water, to human development

South Africa's free basic water has had international impact, challenging previously accepted wisdom that all water use should be paid for. The South African case demonstrates that practical politics will often challenge theory. A key point is that although South Africa enjoyed substantial external assistance, it is not donor-dependent and subject to aid conditionality.

Donors did raise concerns about the new policy, suggesting it might not conform to general principles for the equitable, efficient and sustainable management of water resources to which they were committed. South Africa responded that:

> . . . this point was clarified during the recent Bonn Conference on Freshwater, and the final recommendations made at that conference with which the EU delegation concurred reflect the importance of ensuring that "affordability" does not become a barrier to access to basic services. In addition, the free basic water provides a mechanism for meeting the constitutional test for "water as a human right", a position which again is strongly advocated by EU members. This mechanism is an important contribution to turning that social right into practical reality.
>
> (DWAF 2002b)

There were obvious reasons for these concerns. If the conventional wisdom that the poor could pay for their water was wrong, it raised awkward questions about how countries with inadequate public resources or affluent communities from whom to take cross-subsidies, could achieve the goal of safe water for the poor. The implication was that substantial additional resources from national budgets or external sources would be required to meet this Millennium Development Goal.

The South African government has stated that its approach is designed for its particular circumstances and is not a model for broad application. For low-income countries, it has suggested that the challenge is one of international public finance, requiring external rather than domestic financial support to ensure viable supplies in poor countries (Muller 2002). However, in the ongoing debate about financial resources for development, South Africa's free basic water policy raises uncomfortable questions about whether the poor can really afford to meet their water needs.

This links to the broader ethical challenge of the "right to water." There is an active campaign to declare access to safe water a basic human right in support of the goal of universal access, and water's affordability is an important element of this. The South African experience is often cited in this regard although it has been emphasized that the water supply programme was driven essentially by political priorities, and that the right to water was only introduced when the programme was well underway.

For their part, South Africa's civil society critics have been dismissive of the importance of the formal "right to water."

Thus, according to Patrick Bond of the University of KwaZulu-Natal Centre for Civil Society:

> Utterly useless as water-rights talk appears . . . South Africa's constitutional framing allows us to address two central issues: whether "commodification" of water is trumping both the heralded jurisprudence of socioeconomic rights, and whether the main implementing mechanism, the "free basic water" . . . has been sabotaged by neo-liberally oriented municipal officials.
>
> (Bond 2006)

Proponents of the "right to water" are not clear about how it will improve access in poor countries. Since domestic financial constraints will remain a barrier to expanded access in most low-income developing countries, the challenge will arguably be for the rich nations of the world either to provide the resources or to create the economic climate within which countries could fund such programmes themselves.

This dimension of the programme has been raised by the South African minister Ronnie Kasrils, who used his Eastern Cape experience to challenge an international audience on ethical grounds:

> In looking across the gulf that divides the rich and poor in this world, we must look beyond the cost, price and value of water to the values that govern our society. . . . We do not help the poor because we are charitable. We help them because they are part of us and we are nothing without each other . . . These are the values that guide our policies and I appeal for a recognition that the policies which may seem so eminently sensible to us in the pleasant surroundings of Stockholm and The Hague look very different to rural women in the cold morning light of the village water queue, to those who forgo the water queue to burrow in the ground for water.
>
> (Kasrils 2001)

The social movement activists predictably see it somewhat differently:

> . . . it simply goes to show that the "devil is in the details", and that the struggle over the shape and slope of the tariff curve is indeed a proxy for class struggle.
>
> (Bond 2006)

Conclusions

South Africa's free basic water policy has been criticized as an inefficient instrument in that it does not achieve social goals of redistribution in South Africa efficiently, due to errors of inclusion and exclusion. It has been further suggested that the way in which tariffs are now calculated reinforces inequality.

However, the policy should be seen in the larger context of the need to promote water conservation as well as ensure the financial sustainability of water supply institutions, which also serve the poor. Similarly, water pricing is part of a larger water policy that includes investment to extend services to poor communities that currently do not have access.

The free basic water policy, as part of the broader water programme, also had to respond to the establishment of local government and the decentralization of water supply responsibilities. It was explicitly considered as an element of the social wage, a key pillar of a social security framework that is essential in a country where so many people are marginalized from the economic mainstream.

Given the political dynamics, it would have been difficult to achieve many of the broader goals of water reform without specific attention to the poor majority who are the foundation of the government's political support. Objectives such as efficient and appropriately priced services to commercial users as well as the promotion of water conservation and ecosystem protection have thus benefited from the application of the free basic water policy.

A key conclusion of this paper is that a water policy that addresses social equity is also likely to support the achievement of economic and environmental goals.

A second conclusion from the South African experience is that its main drivers were political rather than technical; it was a the product of political forces mobilized by the advent and evolution of a democratic government in 1994 rather than a technical response to the introduction of a constitutional "right to water" in 1996.

This should reduce neither its impact on the international policy debate nor the ethical force of the arguments for ensuring that the needs of the poor of the world are met, in a manner that is both affordable to them and sustainable.

Note

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