PRACTICAL SOLUTIONS TO WATER CHALLENGES
Learning from the Spanish Experience

June 14 – September 14, 2008

THE WORLD BANK
Acknowledgments
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The water challenges and issues faced by Spain are unique in Europe but are highly relevant to the rest of the world. Precipitation is highly variable in space and time, with regions where it rains more than 2,000 mm per year, while others, such as Almeria, host one of the few deserts in Europe. This climatic variability has been overcome by building innovative water infrastructure and by establishing highly advanced and specialized Hydrographic Confederations (Confederaciones Hidrográficas), which are the oldest river basin management authorities in the world. An example of such infrastructure works includes the 2,000-year-old Cornalvo reservoir, which is still in operation. As for the institutions, special mention should be made of the Irrigation Associations, some of which have existed for more than a thousand years, and the Hydrographic Confederations, which are the oldest river basin management authorities in the world.

The city of Zaragoza, located by the Ebro River, was an ideal setting for Expo Zaragoza 2008, the international exhibition organized by the Government of Spain from June 14 through September 14, 2008. Like no other, this 700 million Euro event was fully dedicated to water and sustainable development and was set to attract about 6 million visitors, 20 percent of whom were expected to be from other countries. In one of its key components, the Water Tribune, relevant world national and international water professionals from governments, academia, civil society, and the private sector met to discuss sustainable initiatives and solutions to the many challenges facing water management around the globe.

At the request of the Government of Spain, the World Bank provided technical expert assistance for the policy and technical content of the Water Tribune and identified key representative participants from client countries for two Technical Visits and 14 Global Development Learning Network (GDLN) sessions guided by the World Bank Institute that took place throughout the three months of the World Water Expo. The inclusion of the two technical visits was considered very timely to learn from Spain’s rich water resources management experience. In both technical visits, participants toured the Ebro Hydrographic Confederation (CHE), where one of the highlights was to learn about the operation of the Automatic Hydrological Information System that the CHE has put in place. The Canal de Isabel II in Madrid, one of the oldest utilities in the world, was also visited in one of the tours, providing the participants with an array of technological and organizational insights; unlike many utilities, the Canal manages the full water cycle. The second visit allowed the group to see examples of conjunctive use of desalinated water with groundwater in Almeria in southern Spain. Highlights of the visit were the water metering and remote management systems in irrigated areas under greenhouses, the organization of water user associations, and the operation of a desalination plant.

The “Spanish Model” offers many worthwhile experiences that are highly relevant and applicable to the realities faced by many developing countries. We are thus pleased to present this report, which summarizes relevant aspects of the water knowledge shared by Spanish water experts and those from the Bank’s client countries during the Water Tribune and the technical visits.

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Expo Zaragoza
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A.1 Water Management in Spain (L. Ortega and F. Pizarro)
A.2 Influence of Climate Change on Droughts and Water Scarcity in Dry Regions (L. Mata)
A.3 Water, Economy, and Finance (A. Vives and P. Beato)
A.4 Technical Supporting Data (L. Ortega)
A.5 Economic and Financial Supporting Data (G. Donoso)

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<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>AEAS</td>
<td>Spanish Water Supply and Sanitation Association (Asociación Española de Abastecimiento de Agua y Saneamiento)</td>
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<tr>
<td>AFR</td>
<td>Africa Region, World Bank</td>
</tr>
<tr>
<td>ANA</td>
<td>National Water Agency (Agencia Nacional del Agua), Brazil</td>
</tr>
<tr>
<td>Bank</td>
<td>The World Bank</td>
</tr>
<tr>
<td>BTOR</td>
<td>Back to Office Report</td>
</tr>
<tr>
<td>CHE</td>
<td>Ebro Hydrographic Confederation (Confederación Hidrográfica del Ebro)</td>
</tr>
<tr>
<td>CH</td>
<td>Hydrographic Confederations (Confederaciones Hidrográficas)</td>
</tr>
<tr>
<td>CR</td>
<td>Irrigation Association (Comunidades de Regantes)</td>
</tr>
<tr>
<td>CUCN</td>
<td>Nijar Users Community (Comunidad de Usuarios de Agua de la Comarca de Nijar)</td>
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<tr>
<td>EAP</td>
<td>East Asia and the Pacific Region, World Bank</td>
</tr>
<tr>
<td>ECA</td>
<td>Europe and Central Asia Region, World Bank</td>
</tr>
<tr>
<td>ETW</td>
<td>Energy, Transport and Water Department, World Bank</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>ICA</td>
<td>Integrated Water Quality Network (Red Integrada de Calidad del Agua)</td>
</tr>
<tr>
<td>IDAM</td>
<td>Sea Water Desalination Center (Instalación Desaladora de Agua de Mar)</td>
</tr>
<tr>
<td>GDLN</td>
<td>Global Development Learning Network</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>LAC</td>
<td>Latin America and the Caribbean Region, World Bank</td>
</tr>
<tr>
<td>MDG</td>
<td>Millennium Development Goals</td>
</tr>
<tr>
<td>MENA</td>
<td>Middle East and North Africa Region, World Bank</td>
</tr>
<tr>
<td>OECD</td>
<td>Organization for Economic Co-operation and Development</td>
</tr>
<tr>
<td>PPP</td>
<td>Public Private Partnerships</td>
</tr>
<tr>
<td>SAR</td>
<td>South Asia Region, World Bank</td>
</tr>
<tr>
<td>SAT</td>
<td>Agrarian Processing Company (Sociedad Agraria de Transformación)</td>
</tr>
<tr>
<td>SEPRONA</td>
<td>Navy Guard of the Rural Civil Guard (Guardia Naval de la Guardia Civil Rural)</td>
</tr>
<tr>
<td>TTL</td>
<td>Task Team Leader, World Bank</td>
</tr>
<tr>
<td>UN</td>
<td>United Nations</td>
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<tr>
<td>WB</td>
<td>World Bank</td>
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<tr>
<td>WBI</td>
<td>World Bank Institute</td>
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<td>WRM</td>
<td>Water Resources Management</td>
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<td>WUA</td>
<td>Water Users Association</td>
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Spain has a long and rich history of water management and the “Spanish Model” offers many worthwhile experiences. For centuries, for example, it has coped with climatic variability by building hydraulic infrastructures and participatory institutions like the hydrographic confederations (Confederaciones Hidrográficas), which are the oldest river basin management authorities in the world. That is why, when the Government of Spain requested and provided financing for the Bank to facilitate technical expert assistance to, and collaborate with, the Water Tribune in Expo Zaragoza 2008, its was considered mutually beneficial, and the Bank gladly accepted.

To have an idea of the importance of the Water Tribune to the water community, one just has to look at its impressive numbers: the Water Tribune attracted around 65 specialists per day from all fields of knowledge; more than 350 lectures featured more than 400 speakers. The Bank and its member client countries played an active role throughout the Water Tribune’s ten thematic weeks. More than 35 Bank staff and representatives of client countries participated as speakers and panelists in approximately 40 percent of the Water Tribune sessions. Among them were seven high-level Bank officials who participated at the opening ceremony of the Water Tribune and at the opening ceremonies of thematic weeks one, three, four, five, six, seven, and nine. Among the panelists from the Bank’s client countries were Ministers from Brazil, Colombia, Ethiopia, and Mexico, and water authorities’ high-level officials from Burkina Faso, Niger, and Senegal. A total of 84 videos of these sessions were produced and are available for consultation.1 Thirty-seven (37) countries in all World Bank regions and 25 GDLN centers around the world were connected, bringing the total number of participants to more than 1,700.

A Common Challenge

The Government of Spain, local organizers and the Bank share a commitment to effective water resources management as an important means to foster sustainable socioeconomic advances and poverty reduction in the developing world. This persistent challenge, whose key issues may vary in priority in different parts of the world, was evident throughout the Water Tribune.

Water Resources and Development

Although there was no specific session about integrated approaches for water resources management and development, the issue was part of presentations throughout the Water Tribune, which examined value of water, not only from the traditional cultural point of view but also from social, economic, and environmental perspectives. It was also made evident that investments in water-related projects, in a participatory manner and with due consideration of social and environmental variables, provide multiple benefits and are drivers of growth and poverty alleviation. They produce health and education benefits, and environmental and gender empowerment gains; they can help build government track record of credibility and inclusiveness, and in general promote growth. Yet public investments in water infrastructure are decreasing. The main challenge for institutions like the World Bank and other donors is to bend the negative trend in public expenditure and assure that water supply service delivery, as well as other water-related productive services, remain high on the development agenda.

Shared Waters

There are 263 rivers around the world that cross the boundaries of two or more nations, and an untold number of international groundwater

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1. Details of these sessions as well as the video clips can be found at http://www.e-waterexpo.net.
Aquifers. So, in many parts of the world, the potential for conflict over water still exists, and parties involved have not yet embarked on the path of assessing incentives for regional cooperation or have not started systematic dialogue for exploration of shared use of water as a unique resource. Participants agreed that the development of negotiations skills to prevent conflict is urgently needed, as it is essential to learn to communicate and negotiate with each other to create win-win situations for the parties involved, and called for institution building in the field of “water diplomacy.” A key recommendation was that countries that share rivers should aim to share both costs and benefits. Emphasizing the perception of mutual benefits motivates dialogue between stakeholders, but negotiated agreements need to be robust, to allow for changes within the existing political and economic contexts.

Energy
Hydropower accounts for about 20 percent of the world’s electricity supply and 88 percent of the supply from non-biomass renewable resources. Scaling up hydropower is not limited by physical or engineering potential. However, hydropower development is and will remain risky, and a decade of learning about environmental and social risks has shifted the definition of sustainable hydropower infrastructure. Hydropower development faces many challenges to ensure that projects consider both water management and energy issues, that the benefits are shared across a wide range of stakeholders, and that uncertainty is dealt with by adaptive management and contingency planning. There is no “right” answer for these challenges—yet.

Water Supply and Sanitation
Even in developing nations with high percentages of water supply coverage, the need to improve quality and reliability of the services is still present. However, as many noted, a low level of service “now” is much better than a higher level of service “tomorrow.” Financing remains a major worldwide challenge. During the 1990s, there were high hopes that needed increases in financing were going to come from the private sector both domestic and international. Recent trends, however, show that this has not been the case. Public investment in infrastructure also shows a decreasing trend, and donor financing has been stable at best. During the second half of the last decade, however, a new trend of Public Private Partnerships (PPP) became evident, not only in developed but also in developing countries, where these cannot be considered as a failed proposition. Also, some stakeholders were concerned by the lack of economic incentives to regulate consumption and waste, while others concluded that water has not been valued by society and there is a need to reach and manage the harmony between water as a public and as an economic good.

Lessons learned from the African experience indicate that successful PPPs have been part of well designed comprehensive subsector reforms, driven by basic concepts of transparency, accountability, autonomy, and incentives. Success occurs when they take a customized approach to the prevailing national context and the particular situation of the subsector. Mixing public and private financing was viewed by the participants as the most pragmatic approach to turn around water utilities.

Urbanization was mentioned as one of the major causes of water pollution, but it was recognized that cities also play an important role in development and urbanization is increasingly seen as an opportunity rather than a burden. Several successful examples of waste water treatment programs were presented, but it was highlighted that, although the water pollution problem is global, we do not live in an “average” world and there is a need to act and think locally, in a specific context.

Food Security
Eighty-five percent of the poor in sub-Saharan Africa live in rural areas and depend largely on
agriculture for their livelihoods. Agricultural growth is the key driver to poverty reduction and economic improvement and agriculture is the major water user around the world. However, a lack of strategic vision impedes the link that ties agriculture and water development to poverty reduction and growth.

Irrigated areas have been increasing since 1961 in both developing and developed countries, but this increased capacity varies across regions and there is considerable room for expansion as well as for improvement and for intensification. However, agricultural water management goes beyond irrigation. It also includes water management of rain-fed agriculture (which includes practices such as water harvesting, flood and spate irrigation, water recession agriculture, soil moisture conservation, and others). In certain developing countries experiencing high population growth, high population pressure in highlands, high level of land degradation, and high inflation of food prices, and where development is linked to rain-fed agriculture, despite good economic performance in recent years, important development challenges persist.

It has been said that management of water for agriculture is “pro poor,” since 75 percent of the world’s poor are rural and most are involved in farming. However, not all investments in agriculture produce the same effect in all countries. It depends largely on the type of investment and the degree of development the country has achieved. In less developed countries, for example, water infrastructure investments result in greater rates of return than investments in management, but the converse also applies in more developed countries.

**Technology Innovations**

In the context of increasing scarcity pressures and evolving technology costs, desalination and water reuse appear to be reaching the threshold as economically and environmentally sustainable options for a growing range of situations worldwide. Desalination can increase the options for irrigation and potable water supply in certain parts of the world, as Spain’s experience demonstrates. Water reuse, on the other hand, can augment water resources for non-potable or indirect potable uses, while also affording environmental protection and deferring freshwater development costs.

**Highlights of the Spanish Experience**

To learn about the Spanish experience in water resources management in a more direct and participatory manner, the Bank organized two technical visits; Bank officials as well as key water resources client stakeholders participated. The experiences of the technical visits highlighted are the adaptation to changing climatic conditions in the Ebro basin, the efficient use of water use in Almería utilizing both groundwater and desalinated water, and the integrated urban water management system in the Madrid region.

**Adaptation to Changing Climatic Conditions in the Ebro Basin**

The Ebro basin is the largest in Spain. In this area, the agrarian sector (with strong irrigation support) remains important—the Valley of the Ebro generates around one fifth of total Spanish agrarian production—but its relative importance has been reduced compared to the urban sector and industrial development. The Ebro Hydrographic Confederation (CHE) manages the region’s water resources.

The environmental characteristics of the Ebro river basin have had an important influence in the evolution of the system of water resource use that historically has followed a trajectory of adaptation to the prevailing conditions. From a historical perspective, the establishment of irrigation in the central axis of the river valley represents an answer to the drought conditions and the necessity to supply food to the population. Irrigation has been a dynamic sector that defined water policy during the last century, in terms of the construction of infrastructure by the public sector and an unlimited
supply of water at a low price for farmers. Irrigation modernization plans currently under way respond to the need for more technical farming methods to achieve further cost savings.

Water users, both direct and end users, have been acquiring a greater degree of consciousness with respect to the importance of water and its dependence on climatic variability and change. Participation of direct users has been key in the operation of the CHE, as is evident both in their representation in the community groups associated with the CHE and their involvement in the public participation process for developing the Ebro River’s future hydrologic plan. Although the potential effects of climate change on available water resources in the CHE are yet to be determined, steps are being taken to extend supply guarantees, both by increasing the regulation capacity and by improving water management and allocation systems.

A commonly recognized effect of climate change is the increase in the frequency of floods and droughts, and the CHE has innovative responses to both. The Automatic Hydrological Information System provides information in real time on precipitation and flows that is recorded at a series of points in the basin, and makes it possible to anticipate how a flood might be controlled so as to diminish potential damages. As for droughts, the 2007 Special Drought Plan sets the strategies to be followed in dry periods. The Plan establishes, among other things, the minimum reserves in the reservoirs to ensure household supply as a priority use; and sets the objectives for water savings or reduced consumption by the population.

Almería

The region of Almería—the driest area in Europe—is home to agricultural production on more than 30,000 hectares intensely farmed, dedicated to fruits and vegetables for export, based on the following technological innovations: i) growing under plastic sheets, mainly using the Almería greenhouse model; ii) drip irrigation and joint management of water from different sources (surface, groundwater, rainwater, treatment, and desalination); and iii) soil management using the technique of sanding (enarenado almeriense). In 2005, Almeria’s GDP was approximately 13,200 Euros per hectare, while GDP in the Ebro region is 7,900 Euros per hectare.

Inadequate management of the aquifers lowered the piezometric levels, with subsequent salt water intrusion and deterioration of water quality. In order to recover the aquifer and the water supply for irrigation, a series of complementary measures have been implemented, including use of desalinated water. Using desalinated water from the Carboneras plant, which started operations in 2005 and uses reverse osmosis technology, is one of the major agricultural features of the region. Although local market conditions will determine the most suitable desalination technology for each zone, it is clear that the reduction in desalination costs per unit of production reached by reverse osmosis plants will generate worldwide implementation of this membrane system to produce desalinated water, mostly for water supply in scarce areas or in high-value tourism developments. In zones with structural water deficit, as is the case in southeast Spain and the Mediterranean river basin in general, water desalination systems (particularly those based on reverse osmosis) appear to be a technically and economically viable alternative. This situation is especially valid in zones that produce high-value crops such as Almería.

The Spanish government has taken a bold step in its commitment to desalination as a means to balance water budgets in the Spanish Mediterranean, but other nations may need to proceed with caution before adopting the Spanish policy. Investment costs are high and may only be sustainable if the added economic prosperity this water affords a region in the long term is sufficient to offset the project funding. A parallel commitment to water demand management through water tariffs is prudent to encourage recovery of degraded natural water reserves.
Canal de Isabel II

Canal de Isabel II is one of the oldest utilities in the world; unlike many others, it provides comprehensive water cycle management: water collection, purification and quality surveillance, transport, distribution, wastewater purification, sanitation, and managed reuse of some of the purified water for secondary supply uses. Responsible for water throughout the Madrid region, the Canal’s experiences provide many insights for the integrated urban water management approach in urban areas. An expressed objective of the Canal is to recycle as much waste as possible.

Unlike other urban regions, the Comunidad de Madrid has the advantage of having all of its water sources, both surface and groundwater, within the limits of its own jurisdiction, a feature that has been well used by the Canal since its beginning in 1851, when it was established to serve Madrid’s population of 220,000 inhabitants. It became a public utility in 1977, and today the company serves almost 6 million inhabitants, distributing a total of 620 hm³ of water per year using two sources: surface waters from seven rivers in the Guadarrama mountains (stored in 14 reservoirs with a total capacity of 946 hm³) and groundwater extracted from the main two aquifers in the Madrid region (using 81 facilities distributed in six well fields).

Practically 100 percent of the wastewater in the Comunidad has secondary treatment, using 146 wastewater treatment plants, some of which are being outfitted for tertiary treatment to produce some 40 hm³ per year of wastewater of adequate quality for re-use in the irrigation of 6,000 hectares of parks and gardens that are fully automated and managed from a central control, sports facilities, and street cleaning.

Another feature is that the distribution network managed by the Canal de Isabel II is linked in a ring, connecting the large canals running from two rivers, providing needed redundancy to the system. To address recurrent drought situations, the Canal has the so-called “Drought Office,” which administers resources as efficiently as possible, based on existing reserves. Also, due to an awareness-raising campaign, “Súmate al reto del Agua” (Join the water challenge), water consumption has decreased despite an increase in population. The pricing system ensures the sustainability and value of the service by progressively adapting the purification price to costs.
1.1 Water Resources Management in Spain

Water resources in Spain have special climatic characteristics that have no comparison to those of any other country in Europe or in the developed world; rather, they have similarities to conditions found in many developing countries. In effect, precipitation in Spain, where the annual average is 515 mm, is highly variable in space and time, much more so than in its European neighbors. Accordingly, in some regions of the country it rains more than 2,000 mm per year, while Almería hosts one of the few deserts in Europe, with annual precipitation of less than 250 mm. The country has a marked rainy season from October to April, but during the hot summer months, that is, the time of greatest water demand; it is common to go several months in a row with no precipitation. The irregularity is also evident in the periodic appearance of catastrophic droughts and floods.

For centuries, Spain has dealt with its climatic variability by building water infrastructure such as the 2,000-year-old Cornalvo reservoir, which is still in operation, and establishing institutions such irrigation associations (Comunidades de Regantes or CRs) and hydrographic confederations (Confederaciones Hidrográficas or CHs). Some Comunidades de Regantes have existed for more than a thousand years, and the Confederaciones Hidrográficas, established in 1926, are the oldest river basin management authorities in the world.

1.2 Expo Zaragoza 2008

Expo Zaragoza 2008 was an international exhibition organized by the Government of Spain in summer 2008 dedicated to water and sustainable development. This 700 million Euro event—70 percent of which came from the Government of Spain, 15 percent from the government of Aragon, and 15 percent from the city of Zaragoza—was expected to attract 6 million visitors (about 20 percent of whom were expected to be from other countries). One of its key components was the Water Tribune, whose goal was to stimulate reflection, debate, and a search for solutions related to water and sustainability. The most relevant national and international water professionals from governments, academia, civil society, and the private sector met during the 93 days of the Water Tribune to discuss sustainable initiatives and solutions to the many challenges facing water management in Spain and around the world.

The Water Tribune was organized around ten thematic weeks covering a broad range of issues. Week 1 was about Land Use Planning and Agriculture and was held from June 16 to June 20. The thematic axes of focus for the week were: Land Management, Forestry, and Irrigated Agriculture. Discussions centered on the organization of the territory and its consideration for water management in different complex contexts derived from water’s three main purposes: transpiration of natural vegetation,
provision of nutrients and other food sources that contribute to support the productivity of coastal ecosystems, and human consumption through products yielded by irrigated land.

The theme for week 2 was Water and Cities: Local Governments, Governance, and Urban Development; it was held from June 25 through 28. The thematic axes of focus for the week were: Local Governments and Governance, and Development of Urban Surroundings. Several crucial topics were addressed, including water efficiency in cities; city models; new technologies; urban landscape; the role of civil society; uncertainty and climate change; and the role of city networks. Discussions focused on assessing how to modify present urban trends to accommodate for water management improvement, how to deeply modify urban landscapes, and how to introduce sustainable improvements to the quality of life of urbanites worldwide by modifying prevailing terms of involvement among urban dwellers and their surrounding environment.

Week 3 dealt with Water for Life: Health, Quality of Life, and Environment and was held from June 30 through July 3. The thematic axes of focus for the week were: Health, Water Quality, and Rivers and Sustainability. Discussions on the relationship between public health, water availability, and water services were also held. One day centered around presentations on the degree of development and quality of life and how this relates to the quality and sustainability of riparian environments and specifically to the prevailing conditions on rivers and other water bodies.

Water, a Unique Resource: Shared Water, Governance, Watersheds, Geopolitics and Water was discussed during week 4, held from July 7 through 9. The thematic axes of focus were: Shared Waters: Governance and Governability; Water Geopolitics; and Basin and Aquifers: Planning and Management. Water as a unique resource is a feature mostly derived from its capacity to be relevant or even vital to an important of uses, sectors, social groups, behaviors, interests, and differing viewpoints, while simultaneously involving a complex and strong relationship with policy making, politics and overall relations among communities, subregions and countries. Thus, topics such as governance and geopolitics were part of the debate. This thematic week included discussions and debate on critical issues such as river basin water management vis-à-vis political boundaries, land management, subnational water management and land use planning, among others topics.

Water Services for Supply and Sanitation was discussed during week 5, from July 15 through 18. The thematic axes of focus for the week were: Regulatory and Institutional Framework; Society and Service Quality; and Efficiency, Management, and Development. Discussions and presentations focused on analyzing issues and problems regarding the provision of water services and sanitation in urban and rural areas. Technology, as well as the solutions provided by it, was highlighted. Furthermore, management and financial models were closely inspected and assessed. A technical visit was organized as part of the thematic week events with large participation of the Bank and client countries.

Week 6 was titled Climate Change and Extreme Events and was held from July 21 through 23. The thematic axes of focus for the week were: Climate Change, and Extreme Events. The week was devoted to discussing the main effects derived from climate change and the main perspectives on mitigating them or adapting ways of life to climate change consequences. Presentations were also related to assessing the water cycle and water availability dynamics and possible modifications as well as their impact on food production, economic growth, and demographic patterns. The sessions concentrated heavily on issues of severe droughts and on providing policy and operational recommendations. Large participation of the Bank and client countries took place in this thematic week (as in the previous week) as a technical visit
was also organized as part of the thematic week events. In addition, the Bank commissioned a background document on water scarcity and climate change. This document was distributed at the Water Tribune and is included as Annex A.2 in the DVD.

**Week 7** was about *Water Economics and Finance* and was held from July 28 through August 1. The focus areas for the week were Water Markets and Financial Solutions for Developing Countries, including the contribution of water infrastructure to growth and development and the relevance of regulation. The main objective of the week was to disseminate, analyze, and assess the implementation of water markets, including the Spanish case, as a tool to allocate water effectively and to debate on the contribution of infrastructure, in particular water, to growth and development, the financial challenge, and regulatory requirements. The specially commissioned background paper on water economics and financing for developing countries is included as Annex A.3 in the DVD.

**Week 8**, held from August 4 through 6, was titled *Water and Society: Education, Communication, and Culture*. The thematic axes of focus for the week were: Education, Communication, and Culture. The debate was concentrated on identifying proactive paths to solve existing issues and problems in the complex relationship of social groups with water resources. This thematic week was organized by the Water Tribune and the WBI and consisted of a series of GDLN sessions.

*Water, Energy, and Sustainability* was discussed during **week 9** from September 1 through 3. The thematic axes of focus for the week were: Water for Energy and Energy for Water, and Non-Conventional Energy Sources. The week aimed at deepening the debate to identify a common agenda in water and energy in three basic areas: sustainability, technology, and policies, with an emphasis on development cooperation.

**Week 10** was the final week of the Water Tribune; titled *New Sources of Water: Reuse and Desalination*, it was held from September 8 through 10. The thematic axes of focus for the week were: Reuse and Desalination. Currently, desalination appears to be a water source that is environmentally sustainable and attractive due to its gradual reduction of costs per unit of volume. At the same time, the options and processes available for the successful reuse of water are growing and multiplying. Discussions centered on technological advances in these areas and in implementing financially and environmentally sustainable projects. Bank participation was limited to a GDLN session.

The Water Tribune attracted around 65 specialists per day from all fields of knowledge. More than 350 lectures featured more than 400 speakers and more than 1,700 experts.

### 1.3 Bank Participation in Expo Zaragoza 2008

The Government of Spain requested that the World Bank be involved and provided funds through a trust fund it established in the World Bank Institute (WBI) for three purposes:

**Creation of a Virtual Pavilion.** WBI implemented a water capacity building program delivered through fourteen Global Development Learning Network (GDLN) sessions. The objective of the Virtual Pavilion was to create a channel between the event and different cities around the world by video-conference in order to bring the debate to the international stage, reaching a global audience and having a global exposure. The Virtual Pavilion gathered around the table a large range of people including policy makers and representatives of private sector, academics, international organizations, and civil society. WBI organized 14 such GDLN sessions during the duration of Water Expo 2008; at each one, participants from three to five countries joined in real-time the debates and dialogues taking place at the Water Tribune auditorium.
Technical Exchange. The World Bank Water Anchor organized two technical visits during thematic weeks 5 and 6 to learn from Spain’s experience in water resource management. The technical visits offered learning in four areas:

- Institutional: how the hydrographic confederations and irrigation associations operate
- Technical: state-of-the-art technologies such as: i) automated real-time information systems on the quantity and quality of water resources and how these information systems are used in flood- and drought-control efforts, ii) desalination of sea water, and (ii) joint management for irrigation of surface water, groundwater, treated wastewater, and desalinated water
- Agronomical and commercial: state-of-the-art technology for joint management of soil, plant, and climate, and for irrigation used to grow and market high-value crops
- Replicability: although Spain’s socioeconomic conditions may differ considerably from those of developing countries, Spain’s experience nevertheless offers valuable lessons for many developing countries because of the similarity in issues they face such as aridity, droughts, floods, etc

Expert Support. The Water Anchor facilitated the participation of Bank staff and representatives from client countries both at the Water Tribune and in the technical exchanges, and provided support in the formulation of thematic documents.

As a result of all these efforts, the Bank and its member client countries had an active role throughout the Water Tribune’s ten thematic weeks. More than 35 Bank staff and representatives of client countries participated as speakers and panelists in approximately 40 percent of the Water Tribune sessions. Among them were seven high-level Bank officials who participated at the opening ceremony of the Water Tribune and at the opening ceremonies of thematic weeks one, three, four, five, six, seven, and nine. Among the panelists from the Bank’s client countries were ministers from Brazil, Colombia, Ethiopia, and Mexico, and water authorities’ high-level officials from Burkina Faso, Niger, and Senegal. A total of 84 videos of these sessions were produced and are available for consultation.³ Thirty-seven (37) countries in all World Bank regions and 25 GDLN centers around the world were connected, bringing the total number of participants to more than 1,700. More information can be found in Annex B of the DVD.

1.4 This Report

This report summarizes the most significant results of this collaborative effort between the Government of Spain and the Bank, looking at i) the contributions and discussions held during the water capacity building program delivered through the GDLN and implemented by the WBI; ii) the experiences discussed during the technical visits; and iii) the knowledge exchanges as a result of the participation of several Bank-supported speakers during the Water Tribune. Drawing from the presentations and discussions of the Water Tribune and the GDLN video sessions, Chapter II highlights the issues and common challenge Spain and many other countries share in moving toward better water resources management. Chapter III discusses the experiences of the two technical visits during weeks 5 and 6 of the Water Tribune. Chapter IV provides a concluding summary and key lessons learned. The report includes a DVD with full texts of specially commissioned thematic documents and the power point presentations prepared by Bank staff and Bank-invited participants to the Water Tribune.

³ Details of these sessions as well as the video clips can be found at http://www.e-waterexpo.net.
This chapter highlights the common challenge the Government of Spain, local Expo organizers, and the Bank have to continue their commitment to effective water resources management as an important means to foster sustainable socioeconomic advancements and poverty reduction in the developing world, above and beyond the emergence of new common challenges like climate variability and change. It examines key issues addressed at Water Tribune and GDLN sessions by drawing on material produced for these sessions, video clips, and Back to Office Reports (BTORs) of Bank staff who participated in Expo Zaragoza 2008 and in the technical visits.

National development is a complex process that encompasses many themes, issues, and actors; water is one of them. But even if water is merely one of several cross-cutting issues within the development process, it is crucial to properly define the role of water toward meeting national socioeconomic goals in a sustainable manner. It is also necessary to motivate decision makers to act in response to the impacts of climate changes of the future, while ensuring that that this does not happen at the expense of remaining disinterested in the many water problems of today. This commitment was evident during the ten weeks of the Water Tribune.

The relationship between water and culture and how societies value water was the focus of the eighth week of the Water Tribune, when four GDLN-based sessions brought together participants from 20 countries in Africa, Asia, and Latin America. The discussion focused on how waste, pollution, and corruption in the water sector can be ameliorated through education and communication. Participants from Benin, Burkina Faso, Costa Rica, Cote d’Ivoire, China, Dominican Republic, Ecuador, Egypt, Ethiopia, India, Indonesia, Kenya, Nicaragua, Palestine, Panama, Senegal, Singapore, Tanzania, Tunisia, Uganda, and Yemen discussed the importance of communicating and learning about the use of water. Societies are connected to water through customs, often religious or spiritual, but they tend to be unaware of the importance of water for their productive activities. Even if there is consciousness about water as a public good, its role as an economic good has often not been valued by society at large. Attitudes and behaviors of societies need to change and become sensitive and conscious of current values to explore prioritized interventions and adopt sustainable lifestyles (GDLN 2008).

2.1 A Renewed Commitment to Improved Water Resources Management

Participants in the culture discussion expressed a number of concerns about water resources management issues. Participants from Palestine stressed the importance of integrated water resources management. The need for more stakeholder involvement in water resources management was underlined by participants from Nicaragua and Ethiopia, including the
empowerment of women to play a more decisive role in water resources management decisions. Participants from Benin, Costa Rica, China, Egypt, India, and Panama focused on the need to make everybody aware of the value of water, not only from the traditional cultural point of view but also from social, economic, and environmental perspectives.

Although there was no specific session about integrated approaches for water resources management and development, the issue was part of presentations throughout the Water Tribune. See, for example, the proposed basic principles underlying a sustainable water resources strategy in Box 2.1. World Bank interventions in the water sector fall into one of four types, depending upon whether they are broad or poverty targeted and whether they are focused on resource development and management or on the delivery of services (Figure 2.1).

**Box 2.1 Principles for a Sustainable Water Resources Strategy**

- Improve management of the resource
- Expand and improve water supply and sanitation services
- Develop more effective irrigation models
- Integrate urban environmental management and urban water management
- Foster multisectoral and integrated approaches for complex infrastructure
- Facilitate global exchange of experiences and knowledge

Source: Abicalil 2008.

**Figure 2.1 Types of World Bank Water Projects**

<table>
<thead>
<tr>
<th>NATURE OF INTERVENTION</th>
<th>AFFECTING WATER</th>
<th>Service Delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>BROAD</td>
<td>Resource Development &amp; Management</td>
<td>Type 3: Breed impacts through water service delivery reforms</td>
</tr>
<tr>
<td>POVERTY TARGETED</td>
<td>Type 1: Broad region-wide water resource interventions</td>
<td>Type 4: Targeted improved water services</td>
</tr>
</tbody>
</table>

Source: Abicalil 2008.
An important conclusion of the Water Tribune (week 3—Water for Life) was that clean water is a development necessity. Water supply and sanitation are public as well as private goods, investment needs are large, and basic service delivery must be part of inclusive development packages. Investments in water-related projects, in a participatory manner and with due consideration of social and environmental variables, provide multiple benefits and are drivers of growth and poverty alleviation. They produce health and education benefits, and environmental and gender empowerment gains; they can help build government track record of credibility and inclusiveness, and in general promote growth.

However, there is a caveat. This does not come without a price (Leipziger 2008). The relationship between growth and poverty reduction has been stressed but also the difficulties of promoting growth through aid development packages in low income countries. The World Bank analysis of some country case studies shows that the annual GDP per capita growth has an influence on the annual rate of poverty reduction (see Figure 2.2). However, an examination of growth in 46 low-income countries shows that, relative to the period 1995–2000, growth accelerated in 28 countries during the period 2000–05 but decelerated in 18, including in three countries that received increased aid (Figure 2.3).

**Figure 2.2 Growth is Vital for Poverty Reduction**

![Graph showing the relationship between annual change in poverty headcount and annual GDP per capita growth](source: Leipziger 2008)

**Figure 2.3 Per Capita GDP Growth in Low-income Countries, 1995-2000 and 2000-2005 (no. of countries)**

![Bar chart showing growth acceleration and deceleration](source: World Bank staff calculations, from Leipziger 2008)
Large investments are necessary, yet public investments in infrastructure are decreasing. A World Bank study of 11 African countries concluded that while public expenditure in health and education as percentage of GDP has increased slightly during the last two decades, the investment in infrastructure decreased from over 4 percent to less than 2 percent of gross domestic product (Figure 2.4). Moreover, all around the globe, investments in water supply and sanitation and wastewater treatment and disposal, although important, are not the only drivers for growth and will be competing for available resources, as illustrated in Table 2.1. In Latin America, for example, the water sector lags behind the transport, telecommunications, and electricity sectors. These figures, however, depend on the level of development that each region had reached by 2008. Not reflected in the table, but also relevant, is that water is also involved in developing the electricity and agriculture sectors.

The main challenge for institutions like the World Bank and other donors is to bend the negative trend in public expenditure and assure that water supply service delivery, as well as other water-related productive services, remain high on the development agenda (GDLN 2008a).

**Shared Waters**

Many countries around the world have opted for planning and managing their water resources within a river basin, catchment, and/or river basin context. However, there are 263 rivers around the world that cross the boundaries of two or more

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**Figure 2.4 Public Expenditure in 11 African Countries (% of GDP)**

![Public Expenditure in 11 African Countries (% of GDP)](source: Leipziger 2008)

**Table 2.1 Annual Investment Needs by Region 2008-2015 at 2005 Prices (% of GDP)**

<table>
<thead>
<tr>
<th>Region</th>
<th>Transport</th>
<th>Telecoms</th>
<th>Electricity</th>
<th>W&amp;S+WW</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>EAP</td>
<td>17</td>
<td>0.4</td>
<td>3.2</td>
<td>0.5</td>
<td>5.9</td>
</tr>
<tr>
<td>ECA</td>
<td>3.1</td>
<td>0.5</td>
<td>2.5</td>
<td>0.3</td>
<td>6.5</td>
</tr>
<tr>
<td>LAC</td>
<td>1.5</td>
<td>0.6</td>
<td>2.0</td>
<td>0.4</td>
<td>4.4</td>
</tr>
<tr>
<td>MENA</td>
<td>3.0</td>
<td>0.9</td>
<td>4.5</td>
<td>0.8</td>
<td>9.2</td>
</tr>
<tr>
<td>SAS</td>
<td>4.0</td>
<td>1.3</td>
<td>4.3</td>
<td>1.7</td>
<td>11.3</td>
</tr>
<tr>
<td>SSA</td>
<td>3.0</td>
<td>1.1</td>
<td>2.8</td>
<td>2.0</td>
<td>8.9</td>
</tr>
</tbody>
</table>

Note: World Bank regions: EAP = East Asia and the Pacific; ECA = Europe and Central Asia; LAC = Latin America and the Caribbean; MENA = Middle East and North Africa; SAS = South Asia; SSA = Sub-Saharan Africa.

Source: Leipziger 2008.
nations, and an untold number of international groundwater aquifers. So, in many parts of the world, the potential for conflict still exists, and parties involved have not yet embarked on the path of assessing incentives for regional cooperation or have not started systematic dialogue for exploration of shared use of water as a unique resource (GDLN 2008a).

At the GDLN and Water Tribune in Zaragoza sessions, as well as in associated virtual sessions, participants shared their concerns and experience in managing transboundary issues, stressing the need for transforming potential sources of conflict into opportunities for collaboration. Experts and key players commented on the African context and formulated recommendations defining steps to identify incentives to get countries and stakeholders together around the dialogue table, to assess the pros and cons of those incentives, and to communicate and negotiate with each other about win-win solutions. Many collaborative efforts have shown that conflict and lack of cooperative management would be expensive, disruptive, and would interfere with efforts to relieve human suffering, reduce environmental degradation, and achieve economic growth (GDLN 2008a).

Regional and national organizations have been and need to be established to build trust among countries and their leaders, to share knowledge and information, and to plan and implement projects sharing benefits and costs. Participants agreed that the development of negotiations skills to prevent conflict is urgently needed, as it is essential to learn to communicate and negotiate with each other to create win-win situations for the parties involved, and called for institution building in the field of “water diplomacy.” A key recommendation of the Water Tribune session on Shared Waters, Governance, Watersheds, Geopolitics, and Water was that countries that share rivers should aim to share both costs and benefits. Emphasizing the perception of mutual benefits motivates dialogue between stakeholders, but negotiated agreements need to be robust, to allow for changes in political and economic contexts. An example of such a robust approach can be found in Senegal; the Senegal River Commission, set up by Mali, Mauritania, and Senegal, develops jointly owned and operated infrastructure to provide energy, irrigation, and navigation benefits through a benefit-sharing mechanism (GDLN 2008a).

The Nile River Basin Initiative, launched in 1991, provides another example of states turning a potential source of conflict into a collaborative enterprise. The Nile Basin is characterized by water scarcity, poverty, a long history of dispute and insecurity, and rapidly growing populations and demand for water. A partnership initiated and led by the ten riparian states of the Nile River—Burundi, Democratic Republic of the Congo, Egypt, Ethiopia, Eritrea, Kenya, Rwanda, Sudan, Tanzania, and Uganda—the Nile River Basin Initiative has brought these States together in an effort to share costs and benefits. Their objective is to achieve sustainable socioeconomic development through the equitable utilization of, and benefit from, the common Nile Basin water resources. The Strategic Action Program adopted by the Nile riparian countries provides the means for translating this shared vision into concrete activities through a two-fold, complementary approach: i) lay the groundwork for cooperative action through a regional program to build confidence and capacity throughout the basin (the Shared Vision Program); and ii) pursue, simultaneously, cooperative development opportunities to realize physical investments and tangible results through sub-basin activities (subsidiary action programs) in the Eastern Nile and the Nile Equatorial Lakes regions (GDLN 2008a).

**Energy**

Hydropower accounts for about 20 percent of the world’s electricity supply and 88 percent of the supply from (non-biomass) renewable resources. Scaling up hydropower is not limited by physical or engineering potential. Organisation for Economic Co-operation and Development (OECD) countries
have exploited over 70 percent of economically feasible potential compared to 23 percent in developing countries. Indeed, 91 percent of unexploited economically feasible potential worldwide is located in developing countries, with one quarter in China. The value of hydro infrastructure in development and poverty alleviation is changing. In addition to its role in bringing electricity to the 2 billion people who lack access, hydropower offers a hedge against rising energy prices and can play an important role in energy trade and regional power pools. The imperatives of water management are also repositioning hydro infrastructure with a growing appreciation of the link between hydrological variability and economic growth, especially in the 263 international river basins in the world. Hydropower infrastructure plays two critical roles in meeting the climate change challenge: i) renewable hydro energy offers an alternative to fossil fuels; and ii) water resources infrastructure can help countries adapt to changes in hydrology (GDLN 2008b).

A decade of learning about environmental and social risks has shifted the definition of sustainable hydropower infrastructure. The World Commission on Dams, follow-up work of the United Nations (UN) Dams and Development Program, sustainability initiatives of both industry and non-industry organizations, and requirements of financing institutions have redefined the standards for environmental and social management. However, hydropower is and will remain risky. Implementing good practices is challenged by lack of capacity in implementing new standards and inherent complexities, and the multi-sector, multi-objective nature of hydropower projects further emphasizes the importance of a strong risk management approach to the sector (GDLN 2008b).

A GDLN session on Water, Energy, and Sustainability explored key themes in moving to sustainable hydropower: i) strategic planning to ensure projects are appropriate and to consider both water management and energy issues; ii) sharing of benefits across a wide range of stakeholders; and iii) managing for uncertainty through adaptive management and contingency planning. There is no “right” answer for these challenges—yet (GDLN 2008c).

Learning from the Spanish Experience: Water Management

Water Resources in Spain

The natural water availability to cover water needs is about 110,116 hm³/year. If there were no streamflow regulation infrastructure (which amounts to a real storage capacity of 56,800 hm³), only 7,220 hm³/year could be used. Groundwater resources are used to supply 70 percent of the urban centers and one third of the irrigated land (approximately one million hectares).

Spain's total land area is 50.5 million hectares (Mha), almost half of which is valuable agricultural area, of which 22.3 Mha (44 percent) is cropland for seasonal agriculture and 3.7 Mha (7 percent) is irrigated cropland. A total population of 45.2 million lives in this territory, to which the almost 50 million tourists who visit Spain every year must be added. Within the electricity sector, hydropower constitutes the leading source of clean and renewable energy and supplies the peak hours of the energy curve, allowing for continuous service. Hydropower represents 10 to 15 percent of electricity output, which accounts for about 3 percent of the end-use energy consumed in Spain. Almost 68 percent of the total demand comes from irrigation; industry and industrial cooling account for approximately 19 percent, and domestic water use the remaining 13 percent (Ortega and Pizarro 2008).

The Spanish Model of Water Resources Management

The “Spanish model" of WRM is the result of a lengthy evolution that began in 1926 with the creation of the Confederaciones Hidrográficas. A
first characteristic to note in this model is the separation between multi-sector and individual sector uses of water (such as municipal water supply, irrigation, hydroelectricity, industrial use, mining use, recreational use, etc). The CHs are in charge of multi-sector water issues, while each sector has created its own institutions for managing the sector uses of water, such as the farmers who are members of the irrigation associations. Another characteristic is that water is now seen as a resource that needs to be protected and managed and not merely used. The present Water Law (Ley de Aguas) assigns water resources management to the general state administration, under a national authority, the Ministry of Environment and Rural and Marine Environments, through the General Bureau of Water (Dirección General del Agua) and the CHs, as basin authorities. The General Bureau for Water is responsible, among other things, for the elaboration of the National Water Resources Plan (Plan Hidrológico Nacional).

For WRM, Spain is divided into thirteen Management River Basins (Cuencas de Gestión, or CGs), each bringing together several natural river basins for management rationalization and reducing costs, which are managed following the principle of the integrality of each natural basin. Each CG has a CH as the basin’s water authority, which undertakes a decentralized, participatory, and comprehensive approach to management of the basin based on the principles of sustainability and efficiency. The functions of the CHs include assigning water concessions and other water administration activities; study, design, construction, and operation of the multi-sector water use infrastructure; hydrologic planning; and setting regulatory fees and tariffs based on criteria of rational water use, equitable distribution of responsibilities and benefits among different water users, and the degree of self-financing of the services. The CHs are public law entities with their own legal persona, distinct from that of the State and with full functional autonomy, but positioned under the Ministry of Environment and Rural and Marine Environments for administrative purposes.

Mitigation and Adaptation to Climate Change

Spain, given its geographical position, is especially vulnerable to climate change and its impact on water resources is being studied by the Water Resources Studies Center (Centro de Estudios Hidrológicos) of the General Bureau of Water of the Ministry of Environment and Rural and Marine Environments. Water resources are very sensitive to increases in temperature and, in Spain, decreases in precipitation. Most critical are the semiarid areas, where future water input may be half of its current volumes according to some estimates. This situation suggests that the climate change variable should be factored into general and sector water policies to plan and implement appropriate adaptation and mitigation measures.

Despite this vulnerability, however, Spain finds itself in a situation that may facilitate adaptation and mitigation. On the supply side, Spain’s rivers are highly regulated and it also has a strong existing program for building desalination facilities. On the demand side, programs such as the Irrigation Modernization Program (Programa de Modernización de Regadíos) are designed to increase efficiency and thus reduce demand. Finally, regarding water resources management as a whole, the CHs have developed and use drought and flood control tools and techniques; they also have a policy to coordinate operation of surface and ground water reservoirs, aimed at controlling the drawdowns as well as the volumes extracted, to ensure reservoir recharge and obtain a safe yield (equilibrium). A participatory process among the different users and a competent water administration is fundamental for this purpose (as an example, the case of the Ebro CH is described in more detail in Chapter III).


**Inter-basin Water Transfers**

The spatial irregularity of precipitation creates both “a dry Spain” and “a moist Spain.” Water is scarce in the Mediterranean areas, which are better suited for agricultural production and where, with the exception of Madrid, most of the population is located, both on a permanent as well as on a seasonal basis. In the rest of the country, resources are abundant. Therefore, the transfer of water between basins in Spain is an option that has been used since the 1930s to correct natural imbalances and several inter-basin water transfers are presently in use. Nonetheless, with increasing ecological awareness and regional autonomy, this option has lately given rise to controversies in Spanish society, becoming a political problem.

**2.2 Water Supply and Sanitation**

Stakeholders from Costa Rica commented that, while water was always made available to meet the requirements of the tourism industry, in many nearby communities, water services are not available 24 hours a day. Although the remarks were intended as a comment on a misdirected sense of values, they also point to the fact that, even in one of the developing countries in Latin America with a high coverage of urban water supply (97 percent), these statistics do not always reveal the quality of the service. The need to improve the quality of the services was also mentioned by other stakeholders, such as those from Panama.

However, in regions such as sub-Saharan Africa, which lags behind other World Bank regions in access to water (56.24 percent of population with access in 2004, compared with the Millennium Development Goal (MDG) 2015 target of 75 percent), it has been reasoned that a low level of service “now” is much better than a higher level of service “tomorrow” (Bengoechea 2008). Similarly, access to a low level of service may represent a great improvement at a much lower price that is affordable for poor people and the level of service can always be improved in the future.

Stakeholders from Tunisia were concerned about access to safe water supply. Coverage limitations reflected by the low number of connections were also mentioned by stakeholders from Kenya. Sustainable access to safe drinking water and adequate sanitation has been recognized as a key factor to improved health, education, and several of the environmental outcomes reflected in the MDGs. But reaching the water supply and sanitation-related goals has proven to be far from easy (Chen 2008). Almost one hundred million people would need to be served each year to reach the safe water supply MDGs (Figure 2.5).

Figure 2.5 *The Challenge to Reach the MDGs, by Region*

![Image of Figure 2.5](image-url)
Most of the people yet to be served live in the sub-Saharan Africa, South Asia, and East Asia and Pacific regions.

Financing remains a major challenge. During the 1990s, there were high hopes that needed increases in financing were going to come from the private sector both domestic and international. Recent trends, however, show that while traditional independent private investment had been increasing, it was not in the water supply and sanitation subsector. Public investment in infrastructure also shows a decreasing trend, and donor financing has been stable at best (Chen 2008).

One of the factors making increased access to water and sanitation difficult is the world’s increasing population and urbanization, as Figure 2.6 shows. During the second half of the last decade, however, a new trend of Public Private Partnerships (PPP) became evident, not only in developed but also in developing countries. Figure 2.7 shows the many ways in which the role of the private sector in water and sanitation has increased.

Although the number of new PPP awards by the World Bank have somewhat decreased in the current decade, the urban population served by private water operators has been

![Figure 2.6 Rural, Urban, and World Population Growth, 1950–2030](image)

Figure 2.6 Rural, Urban, and World Population Growth, 1950–2030

Source: Chen 2008, based on UN population data.

![Figure 2.7 The Changing Face of the Private Sector](image)

Figure 2.7 The Changing Face of the Private Sector

Source: Chen 2008, based on UN population data.
increasing, especially in middle income countries. Overall since 1990, 55 million persons have been served by clearly successful PPP projects, 20 million by projects with mixed outcome but still active, 20 million by expired and not renewed projects, and 25 million by projects that suffered early termination. There is not enough information about projects serving 12 million, and 70 million are to be served by recent projects.

It can be said that water PPP does not appear as a failed proposition for developing countries. A second generation of projects and players is appearing, targeted to specific countries and projects. The so-called traditional operators still exist and are appreciated, but small informal service providers are receiving increasing attention from donors in the context of meeting the MDGs. Both water utilities from developed countries as well as new operators from developing countries are becoming new actors in the new PPP scene, however not everywhere and not for every project, as the following discussion illustrates.

Western and Central Africa have some of the longest experiences with PPPs in developing countries. Cote d’Ivoire had the first such project in 1959; over the last two decades, 15 of the 23 countries in the region have experimented with PPPs, eight for water supply alone and seven for combined electricity and water supply (Fall 2008). These have taken the form of concessions, leasing, management, and performance-based short-term service contracts. Six of these can be considered as successful, two achieved initial improvements, five failed, and two are too early to judge. In Senegal, for example, the reforms initiated by the Government in 1996, with the involvement of a private operator in managing the water subsector through a leasing contract and an ambitious US$450 million investment program, contributed to increasing the population with access to water services in the Dakar area from 80 percent in 1995 to 98 percent in 2004 (85 percent through household connections and 13 percent via standpipes) (Ndaw 2008). In the ten-year period, 1.7 million additional people were served; financial equilibrium was achieved in 2003, with average tariff increases not exceeding 3 percent per year from 1997 to 2003 (Figure 2.8). Average daily hours of service have steadily increased, going from 16 in 1996 to nearly 24 in 2006.

The results for Niger, which is a much poorer country coming from a long period of political instability and a water supply subsector in bad shape, are not as good. In 2006, 64 percent had
access to water services (31 percent access through private connection and 33 percent through standpipes); the average daily number of hours was 18. In five years, the number of people served had increased by 460,000 (Figure 2.9). The subsector was in financial deficit, with a 60 percent bill collection ratio.

Lessons learned from the African experience indicate that successful PPPs have been part of well designed comprehensive subsector reforms, driven by basic concepts of transparency, accountability, autonomy, and incentives. Success occurs when they take a customized approach to the prevailing national context and the particular situation of the subsector. Mixing public and private financing was viewed by the participant as the most pragmatic approach to turn around water utilities (Fall 2008).

Stakeholders in Nicaragua and Palestine were concerned by the lack of economic incentives to regulate consumption and waste. Stakeholders from China and Indonesia concluded that water as an economic good has not been valued by society at large. There is a need to manage the harmony between water as a public good and an economic good. Other participants concluded that water pricing contributes to valuing water and demand management (GDLN 2008d).

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**Learning from the Spanish Experience:**
**Urban Water Management**

Spain, with a population of 45.2 million in 2007, has an urban water supply demand on the order of 4,700 hm³ per year. The average per person consumption is in the order of 290 liters per day, which includes industry and services connected to the municipal networks. Water demand increases in the summer months (July to September); this is more pronounced in the Mediterranean coastal municipalities that draw large numbers of tourists. In municipalities with populations greater than 20,000, most of the water used is from surface water sources (79 percent); approximately 19 percent comes from groundwater and 2 percent comes from other sources (mainly desalination). In the smaller population centers, the ratios between surface and groundwater use are inverse.

According to the Spanish Water Supply and Sanitation Association (Asociación Española de Abastecimiento de Agua y Saneamiento, or AEAS), as cited by Ortega and Pizarro (2008), 40 percent of the population receives water supplied by providers who are public entities, 36 percent from private companies, 16 percent from mixed public-private companies, 7 percent from the local governments themselves, and the remaining percent through other management systems. Private intervention in management, considering both the private and mixed public-private companies, is higher the smaller the population center. Management by public entities increases with the size of the population supplied.

The average unit price of household consumption is higher the lower the level of consumption, and begins to drop as consumption reaches average levels. However, at high levels of consumption, the average price goes up again as a direct result of the application of price brackets that increase with consumption. By population size, the highest average prices are in metropolitan areas, whereas the lowest are for population centers with 50,000 to 100,000 inhabitants. The availability of natural water resources as well as differences in their natural water quality at the source, accounts for variations in the price of water from place to place in Spain, depending on the basin (Ortega and Pizarro 2008).

Figure 2.10 shows, the geographical distribution of the average price in three distinct intervals according to the 2004 survey by the AEAS. The basins of the Balearic Islands, the Canary Islands, and the internal basins of Catalonia and Segura for the most part, have scarce surface water resources and need to recur to high cost sources—groundwater extraction, desalination, or
inter-basin water transfers—and have a price greater than 0.70 Euros/m³. By contrast, in the Coast of Galicia, the basins of the North, the Duero, and the Ebro, with ample surface water resources, the price falls below 0.55 Euros/m³.

2.3 Water Quality and Environment

The abatement of water pollution and conservation of water resource was a common concern of stakeholders from Nicaragua, Ethiopia, Uganda, and Senegal. Urbanization impacts the environment, contributing 60–70 percent of carbon dioxide (CO₂) emissions (Freire 2008); because it is a major source of water pollution both domestic and industrial, and contributes to increased slums and poverty, the standing paradigm has viewed rapid urbanization and the emergence of too-large cities as an undesirable happening. Now, however, cities are recognized for the important role they play in development; no longer viewed as a burden, urbanization is increasingly seen as an opportunity. A new emerging paradigm recognizes that economic growth and change happens with concentration of people in towns and that density is needed for productivity and growth.

The challenge is how to ease the urbanization process while minimizing congestion costs and the impacts on the environment, knowledge, and governance (Freire 2008). A major problem is how to ease the living conditions of millions of people living in slums around the world, as depicted in Figure 2.11. Box 2.2 lists some actions that the World Bank and others are implementing to improve the conditions of slum dweller.

Box 2.2 Water and the Urban Poor
Most slum improvement projects are water and sanitation projects, often accompanied by social components:

- Cleaning water resources in rivers and lakes (for example, in Bolivia, Sao Paulo, Brasilia)
- Helping to create and improve management of water utilities
- Helping to design and negotiate private-public partnerships
- Helping to design economic and rational incentives for subsidy allocation and affordable price systems

Source: Freire 2008.
The integrated approach discussed above is important in addressing urban issues (Figure 2.12). In China, for example, strong economic growth and rapid urbanization have created a serious water and river pollution problem that is a major issue of concern to the government. Investments in wastewater including treatment have been increasing and, since the late 1990s, have outpaced investments in water supply (Figure 2.13). The Government has been developing a series of five-year plans that prioritize issues and problems related to rivers, lakes, regions, cities, and

The Case of China

Figure 2.11 Population Living in Slums

Source: Freire 2008.

Figure 2.12 Integrated Urban Approach

Source: Kolsky 2008.
bays. Mechanisms for consultation/policy dialogue on environment are also being developed.

Environmental protection and improvement is also a World Bank priority in China. The Bank started working on wastewater issues in the late 1980s and its commitment has expanded since the early 1990s. There are 20 ongoing projects and more are proposed for fiscal years 2008 through 2010, working in over 40 cities and half of the 30 provinces. There is a trend in Bank support to move from developed urban centers to less developed cities and regions (Sun 2008).

Despite the advancements achieved, important challenges remain (see Box 2.3). To cope with these challenges, the following have been recommended (Sun 2008): strengthen/reform the institutional setting for wastewater management and integrated basin management; expand the national channels for wastewater financing; strive for cost-efficient wastewater network investments; and promote public private partnerships.

**Box 2.3 Waste Water Collection and Treatment in China: Present and Future Challenges**

- Cost recovery is good, but not yet sustainable.
- Wastewater collection systems are lagging behind treatment.
- Focus is on investment rather than efficiency in private sector participation.
- Utility regulation and management still localized and fragmented.
- Inter-municipal and regional planning of investments is just starting.
- Capacity at lower levels of government is weak.
- Integrated approach to policy study and project preparation and implementation needs to be strengthened.
- Lessons learned need to be disseminated and interventions scaled up.
- Environmental issues are complex: single and multi-sources, point and non-point sources.
- Institutions, investments, and implementation have to be strengthened and coordinated for sustainable development.

Source: Sun 2008.
Five hundred seventeen million people live in the 36 countries of Latin America, 75 percent in urban areas. By 2010, the number of inhabitants in Latin America is projected to reach 600 million, 85 percent of whom will live in urban settings. Four countries (Brazil, 138 million urban inhabitants; Mexico, 73 million; Argentina, 33 million; Colombia, 31 million) host 70 percent of the urban population of Latin America; 33 percent of households are below the poverty line and 128 million persons lack adequate wastewater collection services (Pena 2008).

In Brazil, the largest and most populous country in the region, the coverage of sanitation services increased 3.2 percent between 2001 and 2006 (Pena 2008). This growth, although representative, is low and treated sewage is still one of Brazil’s major challenges. The lack of wastewater treatment causes serious problems such as water pollution and water transmission of diseases. Currently, 73.2 percent of Brazilians living in urban areas have access to full sanitation services. However, 34.5 million people living in urban areas do not.

The need for investment is high and subsidies are deemed necessary by the government. For many years, these grants were focused on the construction of wastewater treatment facilities, but in 2001 the strategy was changed by the National Water Agency (Agência Nacional de Águas or ANA). When launching the Program for Pollution Abatement in Watersheds (Prodes), the focus was to link the release of subsidy financial resources to volumes of effectively treated sewage, instead of construction. This innovative program, also known as “purchase of sewage,” reimburses up to 50 percent of the facility investment cost after the treated wastewater volumes have been achieved (Tribuna del Agua 2008). Quarterly evaluations are made by the service provider and ANA performs periodic auditing to verify compliance with previously agreed management indicators (Pena 2008).

These examples highlight that, although the water pollution problem is global, we do not live in an “average” world. The problems of inhabitants in the mountains of Peru are different from those in slums of East Asia; the risks are different in Asia than in Africa. Therefore, there is a need to act and think locally, in ways that are specific to each context (Kolsky 2008).
Learning from the Spanish Experience: Water Quality and Environmental Safeguards

Water Quality

The CHs are responsible for monitoring water quality in the river basins under their respective jurisdictions by measuring various parameters at groups of stations that are part of the Integrated Water Quality Network (Red Integrada de Calidad del Agua or ICA Network). The main objective of this network is to warn of any anomaly caused by point-specific or diffuse contamination, and to swiftly set in motion, as the case may require, appropriate measures to prevent grave consequences from the contamination. Waste-water discharges are sampled approximately six times per year. Random sampling is also performed and there is self-monitoring by certain industries. Finally, the Navy Guard of the Rural Civil Guard (Guardia Naval de la Guardia Civil Rural—SEPRONA) and other agencies perform surveillance and report any irregular activities and conditions they detect. The 1985 Water Law prescribes that discharges authorized by CHs into public waters are taxed through a discharge fee for protecting and improving the receiving waters. The amount of the discharge fee depends on the pollution load transported by the wastewaters from urban sanitation systems, industrial establishments, and other water quality degrading discharges.

Environmental Safeguards

Sensitivity to environmental issues has been gradually incorporated into watershed management over time. At present, and especially since the 1985 Water Law, a fundamental component of water resources management has been the establishment of ecological flow regimes that make possible the correct functioning, at every river or lake stage, of the riparian ecosystems. An ecological flow is one that ensures maintenance of the hydro-biological and sociocultural heritage of the riparian environment in ways that are compatible with the needs for household water supply and agricultural and industrial uses. An ecological flow allows for the development of the various components of the riparian ecosystem, including the flora and fauna particular to it, the physical-chemical quality of the surface water and groundwater, the dynamic geomorphologic equilibrium of the system, and the particular social, economic, cultural, and landscape values of the river. The ecological flow varies from river to river, and within a given river it depends on the season of the year. The methodology for determining these ecological flows integrates hydrological findings with studies for modeling fish life habitat. Spanish legislation establishes three categories of studies for environmental evaluations of projects which, in decreasing order of detail are: Environmental Impact Study (Estudio de Impacto Ambiental), Environmental Documentation (Documentación Ambiental), and Environmental Data Sheet (Ficha Ambiental). The type of study required by each project depends on its characteristics and on whether it includes natural areas within the protected Natura 2000 network (Red Natura 2000).

2.4 Food Security

Eighty-five percent of the poor in sub-Saharan Africa live in rural areas and depend largely on agriculture for their livelihoods. Agricultural growth is the key driver to poverty reduction and economic improvement and agriculture is the major water user around the world. However, a lack of strategic vision impedes the link that ties agriculture and water development to poverty reduction and growth. This was the topic of discussion of the Water Tribune’s first week, “Land Use Planning and Agriculture.”

Participants sought answers to key questions, such as how to reduce by half the costs of agricultural development and innovative mechanisms for financing and ways to attract
private investments and farmer participation (GDLN 2008e). This was also addressed during other sessions, when Yemen participants expressed that 93 percent of renewable water is used for agriculture without regard for cost or any other economic considerations. On the other hand, in Sub-Saharan Africa, only 3.6 percent of renewable water withdrawals are used for agriculture. If full irrigation potential were developed, this percentage would reach 12 percent. The irrigation situation of Sub-Saharan Africa comprises a broad menu of options and is different from that of Asia or the global irrigation situation (de Jong 2008). Box 2.4 highlights data on irrigated agriculture around the world.

Irrigated areas have been increasing since 1961 in both developing and developed countries (Figure 2.14), but this increased capacity varies across regions. In eight Sub-Saharan African countries (Botswana, Burkina Faso, Kenya, Mali, Mauritania, Niger, Senegal, and Somalia), there is no land with a rain-fed growing period greater than 200 days; these countries cannot meet food demand from

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**Box 2.4 Irrigation around the Globe**

- There are 300 million ha with irrigation infrastructure.
- 90 percent of the systems are used by various farmers in collective arrangement.
- 70 percent of the systems were built with public funds.
- More than 50 percent of the 300 million ha are in need of rehabilitation and 90 percent need investment to modernize them with 21st century technology.
- 40 percent of the systems use groundwater or pumping from surface waters.
- It has been estimated that 50 percent of future food supply will be produced in irrigated areas.
- Large collective irrigation systems allow governments to pursue agricultural policies and sovereign food security.

Source: Contijoch 2008.

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**Figure 2.14 Irrigated Area, 1960–2000, (million ha)**

![Irrigated area expansion 1960-2000](image)

Source: Darghouth 2008.
rain-fed farming only (de Jong 2008). Yet over the last 40 years, only 4 million ha of new irrigation has been developed in Sub-Saharan Africa. Over the same period, China added 25 million ha and India 32 million ha (de Jong 2008). Although in some parts of Asia, such systems are to a large extent publicly developed and managed, this is not the case in other parts of the world (Figure 2.15).

There still is potential for expansion as well as for improvement and for intensification, especially in Sub-Saharan Africa and Latin America (Darghouth 2008). Irrigation potential in Sub-Saharan Africa has been estimated in 39.4 million ha, but only 7.1 million ha (18 percent) is under irrigation. This represents 3 percent of the total farmed area in Sub-Saharan Africa and equals the irrigated area of Mexico, is significantly less than the irrigated area of Iran, and less than twice the irrigated area of Spain (de Jong 2008).

Agricultural water management goes beyond irrigation. It also includes water management of rain-fed agriculture (which includes practices such as water harvesting, flood and spate irrigation, water recession agriculture, soil moisture conservation, and others). In certain developing countries experiencing high population growth, high population pressure in highlands, high level of land degradation, and high inflation of food prices, and where development is linked to rain-fed agriculture, despite good economic performance in recent years, important development challenges persist. In Ethiopia, for instance, agricultural growth has been based on extension of cultivated area; both the agricultural sector and the national economy are highly dependent on rainfall, as illustrated by Figure 2.16.

Agricultural water management also involves drainage and reuse of reclaimed waste, drainage water, and catchment or watershed management. It is integrated to other sectors and cross-cutting areas such as agriculture, rural development, water resources management, and environment (Darghouth 2008).

Agricultural water systems vary greatly depending on climatic conditions, water resource and hydrological regimes, agricultural scheme size, water conveyance systems and distribution methods, on-farm irrigation methods, types of crops, institutional and management setup, just to mention some of the most important factors. Agricultural scheme sizes vary from very large scale to small scale. The water source can be surface or groundwater. The distribution system...
can be collective or individual. The farm plot can go from well drained to not drained at all. Cropping pattern can go from monoculture to diversified. Crops can go from high value such as horticulture to lower value such as cereals; cropping intensity can go from low to high, and so can water productivity (Darghouth 2008).

It has been said that management of water for agriculture is “pro-poor,” since 75 percent of the world’s poor are rural and most are involved in farming (Fernandes 2008). However, poverty headcount is in general greater in rain-fed-agriculture areas than in irrigated areas (Darghouth 2008), making evident the importance of achieving good water management in these areas. In the 21st century, agriculture is still fundamentally important to achieving goals of poverty reduction, economic growth, and environmental sustainability (Fernandes 2008). It also plays an important role in development (Box 2.5).

**Box 2.5 Basic Functions of Agriculture for Development**

- Is a source of food security and livelihood (especially for the poor and in rural areas)
- Integrates risk management and resilience to climate change via better natural resource management
- Is a major driver for growth in countries where agriculture generates a significant share of the GDP

Not all investments in agriculture produce the same effect in all countries. It depends largely on the type of investment and the degree of development the country has achieved. In less developed countries, for example, water infrastructure investments result in greater rates of return than investments in management, but the converse also applies in more developed countries (Figure 2.17).

Figure 2.17 Rates of Return on Investment by Development of Water Infrastructure

Learning from the Spanish Experience: Irrigation

Spain has the largest amount of irrigated land in Europe. Its 3.7 million ha irrigated breaks down as follows: 2,191,000 ha by gravity (59 percent), 886,000 ha by sprinkling (24 percent) and 623,000 ha by localized irrigation (17 percent), making it the second leading country in the world to use this irrigation method, after the United States. Average annual consumption of water for irrigation is on the order of 24,000 hm³ (68 percent of total consumption), which implies an average application of 6,500 m³/ha/year. The source is surface water (2.5 million ha), groundwater (1 million ha), inter-basin water transfers (109,000 ha), return flows (26,000 ha), treated wastewaters (19,000 ha), and desalination plants (2,000 ha).

The water concession is given individually to the land. Therefore, when a farmer sells his land he conveys, along with the property, the water right that is attached to the land. By rule of law, water users who use the same intake or concession must create Water User Associations (Comunidades de Usuarios). When the water is to be used for irrigation, these are known as Irrigation Associations (Comunidades de Regantes or CRs). Currently there are some 6,200 CRs in Spain. These are non-profit associations of all the landowners in an irrigated area who, required by law, autonomously and collectively administer public waters.

The current CRs have their origins in various organizations (brotherhoods, unions, assemblies, guilds) that go back to Roman times and that were developed during the Visigoth period and the period of Moorish domination. These are public-law corporate entities that in turn are part of the CHs. Their governing structure is summarized in Box 2.6.

The irrigators pay their CR for two items: the internal tariff of the irrigation association, and the portion to be paid to the CH. The internal tariff, which covers administrative as well as operations and maintenance costs, is established by the community itself at its General Board. It may take any of several forms. In traditional irrigation it is

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Box 2.4 Governing Structure of the Irrigation Associations in Spain

- The General Board (Asamblea or Junta General), made up of all the users, is the association’s sovereign body. It exercises legislative functions, elects the representatives to the Irrigation Union (Sindicato de Riegos), and approves or disapproves management plans, budgets, etc.

- The Governing Board (Junta de Gobierno) or Irrigation Union (Sindicato de Riegos) is the association’s executive body. Its main function is to supervise and directly carry out the work approved by the General Board, mainly the distribution of water and the maintenance works or upgrades.

- The Irrigation Jury (Jurado de Riegos) is the judicial body that imposes sanctions. Its main function is to arbitrate among irrigators with regard to water use. The purpose is to reach a quick solution to any problems that arise, without having to turn to the courts. The resolutions of the Jury are executive determinations, and may only be reviewed by means of a motion to set aside (de reposición) before the Jury itself, as a prerequisite to filing a contentious administrative action.


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3. The rules for distribution, based on customary law, were transmitted verbally at first, and only later were they set forth in written ordinances (ordenanzas). From these primitive organizations, various institutions were structured over time, from the famous Valencia Water Tribunal (Tribunal de las Aguas de la Vega de Valencia), which has been in existence for more than one thousand years, to the present-day CRs.
common to find tariffs per hectare, based on the different crops. In pressurized irrigation, where it is easier to install meters, the payment is generally by volume of water consumed. In these cases a two-part tariff is quite common: an initial sum depends on the farmer’s area and is independent of the volume consumed; even if he does not irrigate he must pay it. The second sum is proportional to volume, with the possibility of applying different prices by brackets of consumption. Apart from the ordinary tariff, extraordinary tariffs are applied for financing the execution of special works.

2.5 Technology Innovations

Several stakeholders expressed the view that the change needed to achieve sustainable development requires more than a change of values. Participants from Tanzania, for example, stressed the role of technology. Available water resources are coming under stress due to competing agricultural, municipal, industrial, and environmental demands (GDLN 2008c). Population increase, urbanization, industrialization, and ensuing lifestyle changes all contribute to higher demands for clean water and larger production of wastewater, as well as to the expansion of irrigated agriculture.

Water conservation through improved conveyance and water use efficiencies (application efficiency in the case of irrigation) has long been advocated to reduce and optimize the volumes of water used in various economic sectors. However, once water efficiency and demand management programs have reached their limits, development of new water resources is inevitable. This, and factors such as climate change, increase the strategic relevance of spreading supply risks over a mix of water sources, including alternative resources such as saline water and others seen as largely immune to climate change such as water reuse. Improvements in technology and facility design are furthermore raising process performance and reliability, while also reducing unit treatment costs. In this context, desalination and water reuse appear to be reaching the threshold as economically and environmentally sustainable options for a growing range of situations worldwide. Desalination can increase the options for irrigation and potable water supply in certain parts of the world. Water reuse, on the other hand, can augment water resources for non-potable or indirect potable uses, while also affording environmental protection and deferring freshwater development costs. With increasing scarcity pressures and evolving technology costs, the feasibility of desalination and water reuse programs are growing fast, although always subject to complex site-specific feasibility and operational conversion constraints (GDLN 2008d).

Learning from the Spanish Experience: Desalination

Spain’s AGUA Program

The program Actions for Water Management and Use (AGUA: Asociaciones para la Gestión y Utilización del Agua) was created to cover the needs for household water supply and productive activities in areas with limited surface and groundwater resources. Although the program is national in scope, the actions are predominantly located in the Mediterranean basins. The basic objectives of this program are: i) to provide 1,000 hm³ per year of new water resources, fully guaranteed, along the Mediterranean shore from Malaga to Gerona; ii) to improve and modernize an extensive network of supply and irrigation systems; and iii) to provide for the environmental rehabilitation of some emblematic natural areas such as la Albufera, the Ebro delta, and the Mar Menor, as well as a series of river stretches. Some eight million persons and 300,000 ha of irrigated land stand to benefit from this program, whose anticipated investment comes to 4 billion Euros. Half of this new water input comes from
desalination of sea water or brackish water, 20 percent from the re-use of treated wastewater, 15 percent from savings resulting from the modernization of irrigation facilities, and the remaining 15 percent is obtained from both surface waters and groundwater.

The program’s present desalination activities include two plants in operation, five under construction or contracting, ten under tender, and ten under study, public hearings, or preparation, with a total capacity of 640 hm³ per year. The main instrument of the Ministry of Environment and Rural and Marine Environment for developing the program in the Mediterranean basins is the state entity Aguas de las Cuencas Mediterráneas S.A (ACUAMED)⁴, whose purpose is the contracting, construction, acquisition, and operation of all types of water works in the basins of the South; the Segura, Jucar, and Ebro rivers; and the internal basins of Catalonia.

**Desalination versus Inter-basin Water Transfer**

In Spain an intense debate is under way between these two alternatives, which are summarized in the discussion around the most important case, the water transfer from the Ebro River vs. the desalination plants of the Mediterranean. Table 2.2 indicates the costs per cubic meter of each solution.

The desalination cost of 0.522 €/m³ refers to sea water and is an average value corresponding to a desalination plant with a capacity of 50 hm³/year, with an investment of 103 million Euros. Depending on the circumstances, this cost may vary from 0.45 to 0.71 €/m³. In the case of brackish water, the cost depends on the salinity of the water. In Spain, the cost of removing salt from brackish water is in the range of 0.21 to 0.36 €/m³. Table 2.3 summarizes the expected environmental impacts of each approach.

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**Table 2.2 Costs per m³ of Desalination and Inter-basin Water Transfers (€)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Desalination</th>
<th>Ebro Water Transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amortization</td>
<td>0.133</td>
<td>0.200</td>
</tr>
<tr>
<td>Energy</td>
<td>0.240</td>
<td>0.100</td>
</tr>
<tr>
<td>Operation and Maintenance</td>
<td>0.149</td>
<td>0.300</td>
</tr>
<tr>
<td>Compensation fee</td>
<td>-</td>
<td>0.300</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0.522</strong></td>
<td><strong>0.360</strong></td>
</tr>
</tbody>
</table>


**Table 2.3 Summary of Environmental Impacts from Desalination and Inter-based Water Transfers**

<table>
<thead>
<tr>
<th>Desalination</th>
<th>The Ebro Water Transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Greater consumption of energy, therefore greater CO₂ emissions</td>
<td>• Worse water quality.</td>
</tr>
<tr>
<td>• Harm by brine to marine meadows of Posidonia oceanica</td>
<td>• Impact on the Natura 2000 (three river crossings and one space marginally transformed by human activity)</td>
</tr>
<tr>
<td>• Boron content of the desalinated water</td>
<td>• Impacts on the Ebro Delta (accelerates the delta’s regression; penetration of the salt wedge in the river’s channel)*</td>
</tr>
<tr>
<td>• Landscape impact (civil works, electrical lines, etc.) in coastal areas.</td>
<td>• A 900 km long mark on landscape</td>
</tr>
</tbody>
</table>


* http://www.acuamed.es
2.6 Communication

The question of how to communicate about water issues was an important component of the GDLN sessions. One aspect of this involves exchange of information between sources and interested persons, or creating and sharing water knowledge. For example, information about country water resources and use can be found in Google, libraries, through colleagues, in Wikipedia, etc., and all of these sources have pros and cons. In order to capture the benefits of the quick access that Google provides, the variety of sources available through libraries, and the interactive character of personal communications, the World Bank is developing what it calls the Country Topic Overviews (CTOs) through a pilot project using Wikipedia (Schiffler 2008). The CTOs are designed to provide systematic information that everybody can edit under certain controls, information boxes, links to other articles, documents and Websites, and a discussion page. In other words, it is a living document with the additional benefits of low maintenance, low cost, replicability, and high visibility (Schiffler 2008).

Another important facet of communication is between service providers and users of the service. In many countries, the major transition of most utilities in the 1990s was from centralized to decentralized public provision. While utilities have changed in size and nature with decentralization, they face the same challenges as their centralized predecessors. Many utilities are locked in the vicious spiral of weak performance incentives, customers' low willingness and ability to pay, and insufficient funding for maintenance leading to deterioration of assets, while necessary reforms are often blocked by inappropriate political interference. Although considerable attention has been placed on the financial and technical governance of utilities, there is little communication with users and their voice in utility matters is often muted. One consequence is that service providers do not take account of users’ priorities and preferences and the users’ comprehension of the importance of the financial viability of the provider is very low. The utility, then, loses the trust and cooperation of the community that it is supposed to serve. The result is service deterioration, which further alienates users.

The importance of consumer accountability in the urban water supply and sanitation sector is gaining attention. Consumer accountability can be defined as the degree to which public or private service providers of water are accountable to their customers for their performance, their conduct, their use of resources, and policy decisions. It is a specific type of social accountability that is a process where citizens or citizens’ groups work directly to hold power holders to account for their performance and behavior. Recent research has shown that consumer accountability can improve the quality of services by making the providers more accountable to the people they serve. Utilities should account for their actions and resources to their consumers if they expect them to pay for services (GDLN 2008f).

A GDLN session on social accountability was intended to create awareness and exchange know-how on social accountability and the tools used to support social accountability initiatives in the water sector; how utilities, governments, and civil society can initiate social accountability initiatives; and some of the challenges for sustainability of these initiatives. Three case studies were presented: i) a citizen-led initiative in Kenya using Citizen Report Cards in the cities of Kisumu, Nairobi, and Mombasa; ii) a utility-led initiative in the municipality of Puerto Cortes, Honduras; and iii) a government-led initiative dealing with consumer complaints from the Office of the Ombudsman in Peru (van Ginneken 2008).

In Puerto Cortés, Honduras, before the mid-1990s, water services were managed by a national utility. Performance was low and water supply coverage stood at 62 percent. In 1994, the
Municipality of Puerto Cortés acquired control of its drinking water system. In 1999, the municipal water division was corporatized into a municipally owned company, Aguas de Puerto Cortés (APC). Over the years, the Municipality has sold part of its shares in APC, and it now holds 19 percent. Sixty-two percent of the shares are owned by five cooperatives with a collective membership of 11,000 members, such as the cooperative of port workers and the chamber of commerce; 19 percent are owned directly by households. APC engages regularly with users through public meetings as well as surveys to inform the company of user perceptions of its performance. APC has a functioning complaint mechanism, and users can go to the regulator if they are not satisfied with the actions taken by APC. At present, APC has reached water supply coverage of 92 percent of the population. Service has improved from 12 hours a day to continuous 24-hour service. Unaccounted for water has decreased from 50 percent to 30 percent (GDLN 2008f).

In the Peruvian case, when a pensioner saw that he was overcharged for his water, he complained on his next bill, but to no avail. This made him decide to come to Peru’s ombudsman to get help. Since 1996, Peruvians can bring their case to the Ombudsman, who maintains a network of 46 field offices. Problems with utilities are the most frequent complaints. Complaints often deal with intermittent supply or billing issues. Bringing his case to the ombudsman helped to move the utility into action. Although it cannot enforce compliance with its decisions, the resolution of cases is high. Many cases are resolved in less than a week, although some take longer. Through this process, the voices of the poor and the marginalized are amplified and the authorities are put on notice that corruption, incompetence, and an indifferent attitude are not acceptable (GDLN 2008f).

Citizens’ Report Cards are being used in Kenya to strengthen citizen engagement as a means of enhancing public accountability, performance, and responsiveness in the urban water and sanitation sector. The Citizen Report Card is a simple but powerful tool to provide public agencies with systematic feedback from users of public services; they point out areas where service providers are succeeding and areas that need improvement. The citizen report cards on urban water, sanitation, and solid waste services in Nairobi, Mombasa, and Kisumu revealed general consumer dissatisfaction and highlighted inequities suffered by the poor in accessing services and interacting with utilities. The Bank’s Water and Sanitation Program–Africa, which provided technical assistance to develop the report cards, is helping stakeholders in the subsector to apply the report cards in identifying urgent priorities, especially regarding services for the urban poor (van Ginneken 2008; Rop 2007; Thampi 2006).
This chapter concentrates on experiences shared during the two technical visits made by groups of key water resources client stakeholders. The experiences of the technical visits highlighted are the adaptation to changing climatic conditions in the Ebro basin, the efficient use of water use in Almería utilizing both groundwater and desalinated water, and the integrated urban water management system in the Madrid region.

3.1 Adaptation to Changing Climatic Conditions in the Ebro Basin

Strategic Importance of Water for the Socioeconomic Development of the Ebro Basin

The Ebro basin or Hydrographic Ebro Demarcation (Demarcación Hidrográfica del Ebro or DHE) is the largest in Spain, occupies a total area of 85,362 km², 445 km² of which are in Andorra, 502 km² in France, and the rest in Spain. The part in Spain includes parts of nine autonomous communities (comunidades autónomas) and 18 provinces. It has 347 rivers that drain into the Ebro, the main river, which is 910 km long and flows into the Mediterranean forming a delta. More information can be found in Annexes A.1 and A.4 in the DVD.

In the DHE territory, the agrarian sector (with strong irrigation support) remains important, but has been reduced compared to the urban sector and industrial development. Within the DHE, the most important sectors in terms of the water use are examined here.

URBAN AND TOURISM SECTORS

The population of the DHE is 3,086,000 inhabitants (year 2007), essentially determined by the existence of seasonal tourism that is concentrated in the coastal area. Although its influence with respect to water consumption is not relevant, the tourist sector contributes more than 3,000 million Euros in water-related leisure activities. This externality allows the region great present and future potential that must be considered. The tendency of population growth in the coming years indicates that, after 2015, the DHE will have 3.3 million inhabitants, and increase of 6.9 percent since the current population census. In addition to the consumption of the population in the Ebro River basin, water resource transfers provide water to Gran Bilbao, with a population of 800,000, and Campo de Tarragona, which normally has a population of 565,000 inhabitants and twice that during the summer months. Thus the total population supplied with water resources from the Ebro is nearly 5 million inhabitants.

THE AGRI-FOOD INDUSTRY

The agri-food industry is a key production component in the Ebro valley, thanks to the structural changes implemented in irrigation in the
1970s. There an increasing interrelationship among agriculture, livestock farming, and the food processing industry, although this interrelationship does not always take place entirely within the region. Meat production is a particularly powerful agri-food industry that accounts for more than 30 percent of total Spanish meat production.

The gross value added (GVA) of agriculture, livestock farming, and fisheries amounts to 3,170 million Euros (2005), which represents 5 percent of the DHE’s GVA and is 1.8 points above the national average. The sector employs around 121,000 workers, 7.8 percent of all employment in the DHE.

Irrigation is undergoing major modernization and restructuring. Nevertheless, geographic asymmetry exists: whereas the mountainous periphery has been subject to a long process of abandonment of agrarian operations, the Valley of the Ebro generates around one fifth of total Spanish agrarian production.

The irrigated area is around 700,000 ha of effective irrigation and 900,000 ha of concessions. The largest irrigation areas are located on the left bank (Aragón, Gállego-Cinca, Ésera, with the canal de Aragon y Cataluña, and Segre) and along the main course of the Ebro (Canal Imperial de Aragon, Canal de Lodosa, Canal de Tauste, and more recently Canal de Navarra). This productive modification has allowed good adaptation to resource insufficiency. Crop evolution forecasts for the coming years need to take into account the transformation of farming methods and crop types and the possible incentives on industrial or bio-energy crops. Such crops usually have high water requirements, and demand may rise in the future. However, many of these crops are heavily subsidized, a situation that could alter at any time, and farmers tend to react to change with certain parsimony.

ENERGY AND THE INDUSTRIAL SECTOR

The industrial sector in the DHE accounts for 23.0 percent of the total GVA (well above the national average of 15 percent). It employs close to 350,000 workers, which is 22.2 percent of the employed population. Territorially, this industry is concentrated along the Ebro and along a number of highly specialized pockets of industry around middle-sized towns. Nevertheless, the industrial sector’s water demand is moderate. Of Spain’s total energy production, 32 percent of nuclear power, 21 percent of hydropower, and 11 percent of conventional thermoelectric power is generated in the DHE at 3 conventional thermoelectric plants, 4 combined-cycle plants, 2 nuclear plants and 360 hydropower facilities. The energy sector accounts for 1,500 million Euros (2005), 2.3 percent of the DHE’s GVA. The foreseeable future growth in electricity demand throughout Spain could potentially mean an increase in hydropower facilities which, depending on how they are managed, could affect resource availability for other uses, and the possibility of greater water requirements for the cooling of new thermoelectric or combined-cycle power plants.

Climatic and Hydrological Characteristics of the Region

The orographic and morphologic conditions of the DHE territory give rise to different climatic regions, from the high mountain areas in the north to a typically Mediterranean climate at the mouth of the Ebro. Aridity is one of the main climate features in the center of the DHE, precisely where most of the population and economic activity is concentrated. The mean annual precipitation in the Ebro basin over the 82-year period between October 1920 and September 2002 was 622 mm per year. The minimum annual value corresponded to the hydrological year 1949/50, with 452 mm per year, and the maximum annual value was found for the year 1935/36, with 840 mm per year. The 1996 Hydrologic Plan considered inflow series corresponding to the period 1940/41–1985/86. Total inflows in the natural regime stood at 18,217
hm³ per year. The main fluvial network has a length of some 13,000 km, of which 910.5 km correspond to the Ebro itself. The most important tributaries are on the left bank, draining the Pyrenean area which has the highest precipitation and includes a considerable snowmelt component.

**Vulnerability**

Existing statistical studies on precipitation trends in the Ebro basin do not confirm an overall decrease, although in some areas—such as the Segre or Jalón basins—such a trend can be seen in the 1920–2001 period. The most recent statistics (1980–2005) show a lower trend in contributions to streamflow. This reduction has been explained through the augmentation of the basin’s irrigation consumption and also by the intensive use of the groundwater resources that diminish the contributions to base flow. Recent studies also show slight reductions in run-off due to the increased forest surface. On the other hand, a reduction of the nivopluvial inputs of the Pyrenean rivers is noticeable in the combined effect of the temperature increase and the precipitation decrease that causes the monthly streamflow regime to vary and has direct influences on their availability for economic uses. Nevertheless it cannot be assured with absolute certainty that these situations correspond to manifestations of the climatic change. In view of the lack of sufficiently accredited data for the Ebro basin as a whole, the 2027 planning horizon supposes a 5 percent drop in inflows on account of climate change. The Confederación Hidrográfica del Ebro has recently commissioned the University of La Coruña to carry out a study to assess the effect of climate change on water resources in the Ebro hydrographic basin, which is the most detailed study to date on the impact of climate change on water resources in the basin. The analysis addresses several sub-basins and different hypotheses, determining impacts on climatologic and hydrologic components, an increase in the mean temperature from 1.1 to 2.6°C, and reduction in the total flow between 12 and 19 percent (Ortega 2009). The results also show strong space-time variability. The effects of change are most notable in the Ebro’s right-bank basins (which already present water deficits) and in low water flows (which tend to be more severe and to occur more frequently, although this may be attributable not only to the effects of climate change but also to the pressures of growing demands on resources that remain more or less stable).

**A History of Adaptation**

The environmental characteristics of the Ebro River basin have had an important influence in the evolution of the system of water resource use that historically has followed a trajectory of adaptation to the prevailing conditions. From a historical perspective, the establishment of irrigation in the central axis of the river represents an answer to the drought conditions and the necessity to supply food to the population. Prior to the twentieth century, the irrigated territory was reduced mainly to small home plantations near self-supplying small towns, oriented toward specialized horticultural products. Supply to the cities was done in a very precarious way and the industrial uses were limited to mills and other plants to take advantage of the water energy. At the end of the nineteenth century, the crisis enlightened the regenerationist movement that would have great importance in the water resources field and its use for irrigation by means of state interventions in the construction of corresponding infrastructures. This produced three great lines of action in response to the following issues: first, the necessity to approach the water uses of the river basin in an integral manner; second, the capacity for self-management of water on the users side; and third, public investments in hydraulic infrastructures. The first two issues are

6. This figure is based on CEDEX studies carried out to assess the potential impact of climate change on water resources, as cited by Ortega (2009).
addressed by the creation of the CHs, and in the Ebro the constitution of the CHE in 1927.

In response to the third issue, the 1950s and 1960s saw the start of a major building program of hydraulic infrastructures—partly for hydropower generation and partly for irrigation—that aimed to solve Spain’s energy and food deficit. In the 1960s and early 1970s, a structural change took place in the Spanish economy, with a transfer of human resources from the primary sector to the secondary and tertiary sectors. As a result, it became necessary to step up the productivity of the food production sector. This was only possible by extending irrigation, in combination with restructuring agricultural land by means of land plot consolidation measures and intensification of the capital factor. In short, it was necessary to adapt irrigation in order to facilitate the changeover from subsistence farming to market-oriented farming, a trend that continued during the 1980s. Incorporation into the European Community opened the possibility for incorporation into new markets and new economic instruments.

The strategies to adapt to this new situation started to be seen in the early 1990s, in terms of increases in the area dedicated to continental crops or orientation toward specialized production and agro industry. When technology made it possible, the irrigated land was extended to other areas of the river basin, although construction of multiple dams was necessary to do so. These changes were undertaken at the cost of an important modification of the environmental characteristics of the territory, a fact that society has taken consciousness of. The consideration of environmental values in the projects is a consequence of the paradigm change in which the environmental value of water is increasingly recognized, a change that is motivated, as well, by the greater role of urban society in the river basin.

On the other hand, water users, both direct and end users, have been acquiring a greater degree of consciousness with respect to the importance of water and its dependence on climatic variability and change. Participation of direct users has been key in the operation of the CHE, as is evident both in their representation in the community groups associated with the CHE and their involvement in the public participation process for developing the Ebro River’s future hydrologic plan.

CHE currently is implementing a set of adaptation and mitigation measures for the effects of climate change and variability in compliance with the National Climate Change Adaptation Plan, the Spanish Strategy of Climate Change and Clean Energy, the “Alberca” Program, and the European Union Water Framework Directive (WFD) (Ortega 2009). These measures are summarized in Box 3.1.

**Box 3.1 Spain’s Climate Change Mitigation and Adaptation Measures**

- To help guarantee existing water demands, there is a reservoir capacity of around 3,720 hm³. Reservoirs used for hydropower production can store more than 3,900 hm³ of water, which could also be used to satisfy other demands. In addition to this, 970 hm³ of reservoir capacity is currently under construction, the most significant projects being Enciso, Cigudosa-Valdeprado, Lechago, Mularroya, La Loteta, Montearagón, Soto-Terroba dams and the heightening of Yesa and Santolea dams
- Provisional limitation of new applications for exploitation of certain groundwater resources until the completion of work to assess the real situation of these areas and to define what measures need to be adopted
- Modernization of irrigation, reducing the amount of water per unit of production
- “Alberca” program, involving a complete review of existing concessions in order to know the real current situation and subsequently embark upon a process which could release flows for environmental purposes
Box 3.1 Spain’s Climate Change Mitigation and Adaptation Measures cont’d

Water-related Actions Promoted by the National Climate Change Adaptation Plan

• Development of regional climate-hydrology models that provide reliable scenarios of all the terms and processes of the hydrologic cycle, including extreme events
• Development of ecological quality models for water bodies, compatible with the applicable scheme in the Water Framework Directive (WFD)
• Application of the hydrological scenarios for the twenty-first century generated in other sectors highly dependent on water resources (energy, agriculture, forestry, tourism, etc.)
• Identification of the indicators most sensitive to climate change within the applicable scheme in the WFD.
• Assessment of hydrologic management system potential in hydrologic scenarios generated for the twenty-first century
• Development of guidelines to incorporate considerations on the impact of climate change in environmental impact assessment and strategic environmental assessments for plans and projects in the water resources sector

Urgent Measures to be Analyzed in the Basin Plan, in agreement with the exigencies of the Water Framework Directive, including in the Spanish Strategy of Climatic Change and Clean Energy, Horizon 2007-2012-2020

• Establishment of a water control plan: Going beyond the “Alberca” program (review of water use concessions to identify water volumes that could be freed and used for environmental purposes) and of the mass installation of water metering and gauging equipment. Priority shall be given to measures such as modulation and adaptation of concessions in various river basins
• Checks on water management efficiency in irrigation systems and in large industrial and power generation uses. This action should include cooperation agreements between administrations and users
• Modernization plan for irrigation hydraulic infrastructures, paying special attention to the adaptation of internal regulations to facilitate irrigation upon demand. There is a generalized deficit of infrastructures of this type in all the basin’s historical irrigation systems. A preliminary catalogue of actions has been designed in collaboration with the Ebro Basin Federation of Irrigation Communities
• Irrigation modernization plan for the new period 2008–13
• Analysis of the economic, social and environmental feasibility of the 52 new reservoirs envisaged in the current plan but not yet started, and of possible complementary or alternative solutions, their social acceptance, and their territorial interest. The reservoirs included in the current plan have a capacity of 1,048 hm³
• New regulation proposals by public and private promoters after approval of the current basin plan
• Linking of new concessions to minimum internal regulations which guarantee environmental flows at the intake. In existing concessions, fostering of internal regulations linked with modulated extractions to be compatible with environmental flows
• Study of possibilities and fostering of the combined use of surface water and groundwater in order to improve guarantees, minimize costs, and reduce negative impacts
• Water efficiency awareness campaigns related to good management actions
• Investment in water supply and distribution networks in order to replace obsolete and amortized infrastructures

**Flood Control**

Studies conducted in the 1980s on historical floods identified 282 areas with a potential flood risk, classifying their potential for future flooding based on the extent of damage in past floods. To do this, an impact matrix that assigns values to the damage caused by each flood to people and facilities was used; it yielded a coefficient of risk making it possible to rank the areas inventoried. As a result, it was considered that there were 18 maximum risk zones in the Ebro basin, 45 with intermediate risk, and 219 with minimal risk. Of the measures adopted, structural measures stand out, such as head abatement dams, dredging channels, inlets, cut-offs, etc., and management measures, such as land use management, establishment of an insurance system, and the Automatic Hydrological Information System (Sistema Automático de Información Hidrológica or SAIH), which provides information in real time on precipitation and flows that is recorded at a series of points in the basin and makes it possible to anticipate how the flood might be controlled so as to diminish potential damage. This information allowed forecasts to be made for points of interest in the hydrographic network as to the possible evolution of the hydrological/hydraulic situation, as well as decisions about optimal areas for flood control.7

**Drought Management**

The Special Drought Plan developed by the CHE was approved in 2007; it sets the strategies to be followed in dry periods. The Plan: i) establishes the minimum reserves in the reservoirs to ensure household supply as a priority use; ii) sets the objectives for water savings or reduced consumption by the population: reducing hours of service, reducing the water pressure, prohibiting certain uses, etc.; iii) once the reserves are in the reservoirs for supply of the population and other priority uses such as the minimal ecological flow, it (a) establishes amounts available for agricultural uses (irrigation users must use these amounts to make decisions about reducing area planted, maintaining the alternative of traditional crops, reducing the unit amounts or number of times irrigation is applied, etc.); (b) sets the criteria for distributing water among the different zones and collective and private users based on concessional rights; and (c) defines the regulatory and enforcement standards that will be used during the campaign to ensure that no one fails to comply with the guidelines.8

**The Automatic Hydrological Information System of the CHE**

SAIH is a tool for making decisions related to: i) forecasts and activities in the case of floods; ii) overall monitoring of water resources; iii) water quality control; iv) dam security; and v) improving hydrological and meteorological databases. To meet these objectives, a tele-detection measurement network has been installed that captures, processes, stores, and presents the full set of variables measured by the sensors. The SAIH consists of a micro processed telecommunications system for data transmission that includes 98 repeater stations and radiofrequency transceivers at all the control and data concentration points and that allows for the transmission of information to the CPD of Zaragoza. With this organizational structure, construction on the SAIH Ebro began in 1989 and concluded in 1997; in all, some 74.5 million Euros were invested in it. The SAIH Ebro operates 24 hours a day year round.8

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7. Of the expert forecasting systems, special mention should be made of the CAESAR, which provides a flood routing hydrological model and a statistical model. The program, which provides as output the hydrograph and the water-level reading expected in the Ebro River as it flows through Zaragoza, makes it possible to minimize the risk with 24 to 48 hours of lead time.

3.2 Water Use in Almería

The province of Almería, situated in the southeastern sector of the Iberian Peninsula, is the driest area in Europe, with annual rainfall on the order of 200 mm. Average temperatures range from 12°C to 24°C. Two climatic characteristics highly favorable for the production of fruits and vegetables are the more than 3,000 hours per year of sunlight, and the low relative moisture, which prevents the development of fungal diseases.

The province of Almería is home to agricultural production on more than 30,000 ha intensely farmed, dedicated to fruits and vegetables for export, based on the following technological innovations: i) growing under plastic sheets, mainly using the Almería greenhouse model; ii) drip irrigation and joint management of water from different sources (surface, groundwater, rainwater, treatment, and desalination); iii) soil management using the technique of sanding (enarenado almeriense); iv) constant agronomical research into local crops, with a special line for ecological/organic crops; and v) exhaustive quality control of the products. One key factor has been the powerful commercial organization created by the producers themselves, which makes it possible to send the area’s high production volume to markets outside Spain, mainly in the European Union.

The largest greenhouse area is concentrated in the Campo de Dalías. The area’s development began in the 1950s, first making use of groundwater, demand for which grew enormously in the 1960s and 1970s as a result of an increase in the irrigable area, in the development of tourism, and in the growth of the city of Almería. Inadequate management of the aquifers brought about an

Figure 3.1 Almería Corridor

excessive decrease in the piezometric levels, with its subsequent salt water intrusion and deterioration of water quality. In order to recover the aquifer and the water supply for irrigation, a series of complementary measures have been implemented: i) reduction of amounts extracted by 50 hm³; ii) recharge of the aquifer by the levees built in the Sierra de Gador; iii) practices for water saving in irrigation (5 hm³); iv) flow assignment from the Benímar reservoir of 20 hm³; v) reuse of wastewater (5 hm³); and vi) desalination of sea water (20 hm³). The main crops are eggplants, zucchini, string beans, cantaloupe, cucumber, bell peppers, watermelon, and tomatoes. There is growing interest in flower cultivation, especially carnations.

The Almería-type greenhouse is a low-cost structure made of light materials. Plastic is used for the enclosure, and a two-layer cover is used to capture the rainwater for irrigation. Under greenhouses one to two crops per year are obtained. Production is interrupted in June and July, when there is considerable production of fruits and vegetables in other parts of Europe. In those months the land is left to lie fallow, and the next crop is prepared. This type of agriculture is labor intensive, on the order of 700 person-days per year per ha. Investment per ha of greenhouse varies from 180,000 to 300,000 Euros. The gross value of production is 70,000 Euros per hectare. The costs are 55,000 Euros per hectare (current expenditures and amortization) and the profit is 15,000 Euros per hectare. Average water consumption is 5,600 cubic meters per hectare per year, and water productivity is 12 Euros per cubic meter.

A second type of agriculture common in the area is sanding, used by 85 percent of the farmers in the area. The technique of sanding started in 1955. It consists of placing on the land, which is first leveled and the rocks removed, a 1 cm layer of manure and, on it, some 10 cm of siliceous sand. Due to its low specific heat, the sand quickly heats up, and the heat received is transmitted to the lower layers, such that the root zone heats up, intensifying microbial activity; differences of temperature of up to 4°C are obtained between a naked and sanded soil. The sand, in addition, reflects a large part of the energy, increasing the ambient temperature of the greenhouses, and facilitating photosynthesis. Another advantage is breaking the capillary rise of the water in the soil-sand interface, keeping the soil moist. The sand also prevents excessive compaction of the surface of the soil due to being stepped on or for other reasons.
The World Bank technical visit focused on two CRs, the western Sol Poniente CR and the Irrigation Area of the Campo de Nijar.

The western Sol Poniente CR\(^9\) has 1,800 ha and 1,454 community members, and makes use, as a community, of six wells, whose water is mixed with water from the Beninar reservoir. The CR has five reservoirs for regulation and one network of piping that takes the water, under pressure, to each user, who uses it on demand. The CR has recently completed: i) an irrigation modernization program, which includes modernized hydrants and implementation of a system for remote management of meters, valves, soundings, and reservoirs; and ii) the implementation of an Irrigator Advisory Service. These improvements brought about a 16 percent savings of irrigation water. Current average consumption is 6,150 cubic meters per hectare at an average cost of 0.18 Euro per cubic meter.

The Irrigation Area of the Campo de Nijar is an example of joint management of groundwater and desalinated water, with some 8,200 ha of greenhouses under irrigation, and 1,826 users. The area’s development was begun in the 1970s using groundwater, building a series of wells approximately 200 meters deep; a users’ group was established for each well called the Agrarian Processing Company (Sociedad Agraria de Transformación or SAT). The expansion of the irrigated area and the resulting overexploitation of the aquifer created problems of deteriorating water quality, which resulted in many farmers capturing the rainwater that falls on the greenhouses, mixing it with the well water. Nonetheless, this solution proved insufficient, so the administration was asked to build the Carboneras desalination plant. In 1999, the farmers created the Nijar Users Community (Comunidad de Usuarios de Agua de la Comarca de Nijar or CUCN\(^10\)) to use the desalinated water. The average cost of the water is on the order of 0.34 Euro per cubic meter, which represents some 1,900 Euro per hectare. This high cost is a limitation on the use of the desalinated water on crops that are not highly profitable. In the case of the Campo de Nijar, however, that cost can be assumed by the farmers, since it is on the order of 3 percent of the production costs or 13 percent of profits.

The Desalination Plant at Carboneras

The Carboneras desalination plant (IDAM Carboneras), which started operations in 2005, is a sea water desalination plant with inverse osmosis technology and a treatment capacity of 120,000 m\(^3\)/day (42 hm\(^3\)/year), open sea water intake, and 12 membrane frames. Foreseeing a future expansion, the civil works have been based on twice the treatment capacity. This work is completed by pipes that deliver water to the various users. The plant was concluded in 2005 and its operation, for a 25-year period, is entrusted to a temporary union of private companies. The plant’s nominal output of 120,000 m\(^3\)/day of desalinated water, with less than 400 parts per million (ppm) of TDS and a conversion factor of 45 percent, presupposes sea water consumption of 266,667 m\(^3\)/day, 146,667 m\(^3\)/day of which returns to the sea as brine, with a concentration of salts approximately twice that of the sea water. The brine is released in the channel for discharge of water used for cooling from the Central Termica Litoral power plant, mixing it with the water discharged by the thermal plant, resulting in a lower-temperature, lower-salinity mix, not affecting the meadow situated around the discharge point.

The desalinated water is used as follows: i) irrigation for farming in the Campo de Nijar, with 27 hm\(^3\)/year; ii) household supply, with 15 hm\(^3\)/year for the Campo de Nijar and the municipalities of the eastern coast in the province.

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of Almería; and iii) the industrial use of small amounts, less than 1 hm$^3$/year, which corresponds to water income to the thermal power plant Central Termica Litoral, situated alongside the desalination plant, mainly to produce the steam needed for the turbines.

**The Feasibility of Using Desalinated Water**

Almería is Spain’s driest province and, paradoxically it is also Europe’s most intensively irrigated land with production worth 2,275 million Euros during the two-year period 2007–08. Almería’s economic development is staggering. Between 1994 and 2002, Almería’s GDP nearly quadrupled relative to the regional and national averages. This growth has been driven by intensive agriculture for horticultural products and more recently by a rapidly developing tourism sector.

Domestic and agricultural water demands are exceeding the natural environment’s capacity to balance water abstractions through natural recharge of surface water reservoirs and aquifers. Various studies and authorities argue that Almería’s present rate of water consumption is incompatible with natural recharge, and, without steps to increase water supplies and/or reduce water demands, these long-term annual deficits cannot be sustained. A combination of factors explains why Almería’s water demands reached this condition and continue to rise: a) evolution of agriculture production, b) a long-standing problem of uncertainty concerning available water resources, c) water tariffs often based on consumption and typically small compared to a grower’s other operating expenses, d) the land area under irrigation in Almería is increasing, and e) a growing urban population and tourist development are placing increasing demands on available water resources and competing with the agricultural sector for existing and future water resources.

Water has been a vital ingredient in Almería’s economic development. In recent years, Spain has undertaken a fundamental shift in policy from large inter-basin transfers to desalination as a means to meet present and anticipated water deficits. In this context, desalination has been seen as a logical and relatively quick solution to meet provincial needs. Desalination provides Almería independence from climatic influences (such as drought and climatic change), providing confidence for investors. The emphasis on desalination, however, is not immune from environmental criticism.

In the literature, desalination costs are described mainly for industry and drinking-water uses, although for high-value intensive agriculture use, such as Almería’s agriculture, they are within the range. For large plants (more than 5,000 m$^3$/day) seawater distillation plants presents production costs that range from 0.75 to 1.1 Euro/m$^3$. In the case of reverse osmosis applied on seawater, the production costs are more than 0.80 euro/m$^3$ for small plants (up to 500 m$^3$/day), between 0.75 and 1.1 euro/m$^3$ for medium plants (500–5,000 m$^3$/day), and less than 0.75/m$^3$ for large plants. On the other hand, reverse osmosis applied on brackish water implies a production cost less than 0.4 Euro/m$^3$. Current trends show that distillation costs are falling because of economies of scale (large plants), while reverse osmosis costs are decreasing more rapidly because of new technology developments, competition, and economies of scale. In any case, experts recommend that each specific case be studied carefully before selecting the desalination technology.

Although local market conditions will determine the most suitable desalination technology for each zone, it is clear that the reduction in desalination costs per unit of production reached by reverse osmosis plants will generate worldwide implementation of this membrane system to produce desalinated water, mostly for water supply in water scarce areas or in high value tourism developments. For general irrigation purposes however, long-term solutions would still require good management of existing water resources, both surface and groundwater, due to
the cost increase that the use of desalinated water would impose. However, in zones with structural water deficit, as is the case in southeast Spain and the Mediterranean river basin in general, water desalination systems (particularly those based on reverse osmosis) appear to be a technically and economically viable alternative. This is especially valid in zones that produce high-value crops such as Almería. The gross production value of high-value crops for exports in Almería, such as fruits and horticultural products, covers the costs of desalinated water used in irrigation of these products. However, it is important to point out that Almería’s total agricultural production is not economically feasible with the exclusive use of desalinated water. The cost of using only desalinated water for total production is 2,800 €/ha on the average while agricultural rents in Almería are 1,500 €/ha on the average.

By extending the natural boundaries of the river basin to include the conceptually limitless capacity of the Mediterranean, desalination provides the very real potential for aquifer recovery. However, aquifer recovery will only be possible with effective pricing to ensure that desalinated water is affordable relative to conventional resources. This will be achieved by a combination of subsidizing the price of desalinated water to consumers relative to conventional water resources, or raising the price of conventional water resources in line with the real cost of desalination.

Although authorities emphasize the environmental compliance of desalination plants, the government’s policy commitment to desalination is not immune from environmental criticism. Despite improvements in the efficiency of reverse osmosis technology, desalination still requires large amounts of energy. Energy costs are the second highest cost component after the amortization costs of the facilities themselves and are between 15.5 and 20.1 percent of the desalted water costs. For example, in the Canary Islands, seawater desalination accounts for 14 percent of all energy demands. The desalination facility at Carboneras consumes 500,000 kWh per day. This energy requirement represents approximately one third of Almería’s electrical energy consumption. By choosing desalination instead of large inter-basin transfers, the government is exchanging very tangible and immediate forms of environmental impacts (that can be readily quantified) for the less tangible (and perhaps less accountable) environmental impacts of additional energy production.

Political will to comply with energy emission targets (Spain is a signatory to the Kyoto Protocol to the United Nations Framework Convention on Climate Change) may change to the point that the real cost of producing the energy needed to provide desalinated water may rise and so lose the competitive advantages over alternative water sources. Technological innovation may provide alternative and cheaper sources of energy. For example, given Almería’s climate, it has huge potential for solar energy desalination facilities and European Union–funded field trials are being conducted in Almería to investigate the technical and economic limitations. However, solar desalination is not yet developed at an economical level to compete with existing reverse osmosis desalination and remains, at present, better suited to small-scale facilities.

Desalination technology developments have also taken place in other areas around the world. Reverse osmosis technology is also used in other regions around the world as well as in Spain, including the Gulf (Saudi Arabia, Kuwait, Oman, and United Arab Emirates), where energy consumption is not a critical factor due to excess oil production and desalination has developed using thermal processes. The region has become the world leader in desalination over a few years, in terms of production volume. Likewise, there are also similar models in different parts of the world, such as in Egypt, different areas of the Caribbean, and many arid and costal zones around the world, such as Cyprus (Dekelia or Limassol), the United States (Tampa), Chile (Antofagasta), Philippines
(Cebu), Singapore (Tuas), Morocco (Layounne), and Algeria, among others. The reason is very simple. Nowadays, desalination is a viable technology that not only guarantees a continuous supply but also has a production cost that, although it varies from location to location, has become a competitive option in many coastal areas. Nearly all international projects (with exceptions due to the technical specifications of the project such as the intakes, pumps, or local financing) operate at about 0.6 to 0.8 Euros per cubic meter, which includes the investment for plant construction and the operation of the plant over its life cycle (20–30 years).

3.3 Background to the Ebro Valley and Almería Visits: Economic and Financial Considerations

Some background to the Ebro Valley and Almería technical visits is helpful in examining the two models of water resources management (Donoso 2009). Additional information is also included in Annex A.5):

- In 2005, Almería’s GDP was approximately 13,200 Euros per hectare, while Ebro’s GDP is 7,900 Euros per hectare. Spain’s GDP is approximately 16,000 Euros per hectare.

- A comparison of agricultural, livestock, and fisheries production values of Ebro Valley and Almería with those of Spain, France, Belgium, and Denmark, shows that:
  - While the agricultural, livestock, and fisheries production value of Ebro represents a significant percentage with respect to that of Belgium and Denmark, it is less significant with respect to Spain’s or France’s agricultural, livestock and fisheries production value.
  - Almería’s agricultural, livestock, and fisheries production represents 46.0, 39.7, 5.0, and 3.7 percent of the agricultural, livestock, and fisheries GDP of Belgium, Denmark, Spain, and France, respectively, in the period 2000–05. This is a lower percentage of these countries’ agricultural, livestock, and fisheries GDP than Ebro Valley.

- The annual infrastructure investments are shared by basin organisms or Confederaciones Hidrográficas and by the General Bureau of Water (Dirección General de Aguas). The CHs invested a total of 10,510 million Euros in 2003, while the General Bureau of Water invested 13,643 million in the same year. The General Bureau of Water has significantly reduced the amounts invested; its 2002–03 investment was 85 percent of its 1997 level. In the Ebro Valley, the basin organism’s share of investments has increased from 4.6 percent of the total in 1997 to 43.5 percent in 2003.

- The share of the investments made by the basin organisms in the Andalucía Mediterranean basin increased from 4.9 percent in 1997 to 96.0 percent in 2003, although the amount invested averages 12,800 million Euros each year, because the amount the General Bureau of Water invested declined substantially during the period 1997–2003. Between 2002 and 2003, for example, the amount invested by the General Bureau decreased 89 percent, going from 21,218 million Euros to 2,233 million. In this context, the basin organisms invested a total of 54,127 million Euros in 2003, while the General Bureau of Water invested only 2,233 millions.

- Regarding cost recovery, a comparison between the Ebro Valley and the Andalusia Mediterranean basin shows that:
  - The Ebro Valley has a total irrigation cost of

11. Since there is no available information for the Almería proper, the Andalucía Mediterranean Basin figures are presented as proxies. It should be noted, however, that Almería is a region of Andalucía and thus the data must be interpreted accordingly.
175.4 million Euros and total irrigation income of 156.1 million Euros, resulting in a cost recovery ratio of 80 percent. In the Andalucía Mediterranean basin, the total irrigation cost is equal to 12.5 million Euros and the cost recovery share is 92.1 percent.

– Regarding payment for irrigation services, in the Ebro basin they reach 62.2 million Euros while the total costs of the services equal 67.2 million Euros. Consequently, the subsidy is 4.9 million Euros. In the Andalucía basin, the total payments for services equal 250.5 million Euros, covering almost 100 percent of the services costs.

– With respect to the recovery share of surface water extraction, storage, and transportation costs, the Ebro Valley shows a total cost of 34.2 million Euros and a total income of 24.9 million Euros. Consequently, the Ebro’s cost recovery share is 72.8 percent. In the Andalucía Mediterranean basin, the total costs are 21.5 million Euros and the cost recovery share is 50.0 percent.

• The irrigation methods used in the Ebro and Almería basins differ (Table 3.1). In the Ebro, the main irrigation method is gravity, while in Almería it is localized (drip). In large part, this reflects different agricultural production systems: in Almería, the greenhouse production is predominant, while Ebro has more open field production systems.

• Most areas irrigated by flood systems have an average irrigation efficiency of 51.3 percent when it is inadequately implemented and 78.7 percent when adequately implemented. Drip irrigation systems have 94 percent efficiency (Donoso 2009).

3.4 Canal de Isabel II: Comprehensive Water Cycle Management

Canal de Isabel II is one of the oldest utilities in the world. Unlike many, it manages the full water cycle. It started in 1851 with the transport of water from the Lozoya River to Madrid by a 70 km canal that was named “Canal of Isabel II” honoring the Queen to serve a Madrid population of 220,000 inhabitants. It became a public utility in 1977; today it is a profitable public holding that belongs to the Madrid regional autonomous government (Comunidad de Madrid), serving nearly six million people.

Canal de Isabel II provides comprehensive water cycle management throughout the Madrid region: water collection, purification and quality surveillance, transport, distribution, wastewater purification, sanitation, and managed reuse of some of the purified water for secondary supply uses. Organizationally, Canal de Isabel II is under the office of the vice-president of the Comunidad.

Since the rivers within the Comunidad have very limited dry season flows, Canal has built one storage reservoir after another. Unlike other urban regions, the Comunidad de Madrid has the advantage of having all of its water sources, both surface and groundwater, within the limits of its

<table>
<thead>
<tr>
<th>Basin</th>
<th>Sprinkler</th>
<th>Gravity</th>
<th>Localized (Drip)</th>
<th>Other Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ebro</td>
<td>19</td>
<td>69</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>Almería</td>
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<td>23.50</td>
<td>74.67</td>
<td>0.28</td>
</tr>
</tbody>
</table>

Source: Donoso 2009.

12. This Section is from Ortega and Pizarro (2008), Canal de Isabel II (2006), and Canal de Isabel II (2008).
own jurisdiction. The company distributes a total of 620 hm³ of water per year, for which it uses two sources: surface waters from seven rivers in the Guadarrama mountains (stored in 14 reservoirs with a total capacity of 946 hm³) and groundwater extracted from the main two aquifers in the Madrid region (using 81 facilities distributed in six well fields, capable of delivering a nominal flow of 5m³/s). Canal also operates four small diversion dams. Despite the rapid increase in population that the Comunidad has experienced in recent years—basically due to immigration—it has been possible to meet growing demand thanks to continuous awareness campaigns promoting efficient use of water.

The water is treated at 11 treatment plants, with a maximum treatment capacity of 43.5 hm³ per day; the oldest plant became operational in 1967. Although the quality of the water obtained is excellent and regulations on drinking water are amply complied with, Canal de Isabel II is gradually refurbishing the treatment plants, incorporating more advanced treatment processes such as active carbon filters, and increasing the capacity. In these plants, raw water is subjected to a series of linked processes depending on the characteristics of the water to be treated. The usual sequence in that process is pre-oxidation, coagulation or flocculation, sedimentation, filtration, neutralization, and final disinfection.

The distribution network managed by Canal de Isabel II has large conduits, regulating tanks, and elevating stations. The large conduits are essential in guaranteeing water flow conveyance in the central part of the region during peak consumption periods. Linked in the form of a ring, these conduits connect the large canals running from the Lozoya-Jarama rivers with those from the Guadarrama-Alberche rivers providing redundancy to the system. In a region like Madrid, water consumption undergoes strong fluctuations according to the time of day, on weekends, and during major events. In order to adapt the supply to the daily fluctuations, Canal de Isabel II has 22 large-capacity regulating tanks with a total capacity of 2.6 million cubic meters. In addition, the utility company has 240 smaller-capacity tanks.

Canal de Isabel II has 18 elevating stations, and the network it manages has a total of 14,136 km of conduits with diameters between 50 millimeters and 2 meters. Of this total, 4,000 km correspond to the city of Madrid. The objective of Canal de Isabel II is to achieve a network in which none of the pipes is older than 25 years, which requires the renovation of hundreds of kilometers of pipeline each year.

Canal has 30 automatic surveillance stations (ASSs) installed at the outlet of the water treatment plants, large regulating tanks, and important junctions in the supply distribution system. After sampling and analyzing the water, the ASSs send the results in real time to the main control centre in the head offices through its in-house communications network. Canal de Isabel II has also implemented a remote control system for permanent monitoring of the hydraulic network, which comprises more than 11,640 measuring instruments situated throughout the region. This system provides real-time data on the hydraulic situation of the utility’s network, quality of the water, groundwater availability, purification plants, and other installations.

As a public institution, Canal has entered into inter-administrative agreements with all the local governments in the Comunidad. In 2006, Canal de Isabel II was entrusted with the technical and commercial management of the purification and sewerage services in the Madrid municipality, with a total of 3,500 km, plus 43 other municipalities that add another 485 km to the network. Practically 100 percent of the wastewater in the Comunidad has secondary treatment, using 146 wastewater treatment plants using all types of technology. A series of treatment stations are being outfitted for tertiary treatment, so as to produce some 40 hm³/year of wastewater of
adequate quality for re-use in the irrigation of 6,000 hectares of parks and gardens that are fully automated and managed from a central control, sports facilities, and street cleaning. Canal also operates seven mini hydro plants that produce 54 million Kwh, mostly for its own use through a 250 km network that distributes the energy to its principal installations.

One of Canal’s objectives is to recycle as much waste as possible, such as treatment plant sludge. Canal has implemented a Self-Control Plan which allows it to verify the efficacy of the measures and mechanisms implemented to guarantee both a reduction in hazardous waste production and its correct management, in compliance with legal requirements. Not including the purification installations of the Madrid municipality, Canal de Isabel II also manages 313 hectares of green areas, of which 193 hectares are landscaped.

The continental climate that affects the Comunidad de Madrid means that it faces recurrent droughts. To address this situation, Canal has created the so-called “Drought Office,” which administers resources as efficiently as possible based on existing reserves. For the time being, restrictions on human consumption have never been implemented, but there have been restrictions on the irrigation of parks and public and private gardens. Due to an awareness-raising campaign, “Súmate al reto del Agua” (Join the Water Challenge), consumption decreased by 9.3 percent relative to 2005, to 553.2 hm³, similar to the 1990 level despite an increase in population. According to the Hydrological Plan of the Tajo River basin, in whose territory the Comunidad is situated, when reserves are greater than 60 percent, Canal is required to release water to maintain the ecological flow of the rivers. This geographic area is fundamentally urban; since the agriculture sector is such a minor element, there are no conflicts over the distribution of water resources between these sectors.

Pricing varies by consumption levels and seasonality as well as by types of users as a strategy to foster rational use and efficient consumption of water in order to adapt consumption needs to the supply system’s capacity and reach an adequate economic and financial balance in the provision of the service. The pricing system ensures the sustainability and value of the service by progressively adapting the purification price to costs.

Canal created the position of Customer Ombudsman in 2001 to act as mediator between the consumers’ complaints and the company. All customers who have filed a claim and do not receive a reply within a maximum period of two months or who are not satisfied with the reply they receive, can request ombuds services.
Bank participation in Expo Zaragoza 2008 was a mutually beneficial experience. On the one hand, it allowed for representatives from the client countries to get a first-hand look at Spain’s long and rich history of water management and how participatory institutions like the hydrographic confederations of the “Spanish Model” have helped to meet water demands and to cope with climatic variability. On the other hand, the participation of Bank staff and representatives of client countries enriched the experience exchange among the many participants in the Water Tribune. Additionally, the video sessions organized by the World Bank Institute with the participation of Global Development Learning Network centers around the world contributed to making Expo Zaragoza a truly world-wide event.

4.1 A Common Challenge

On the one hand, water-related problems are becoming more acute as a result of both increasing population and growing demands for various uses of water. Various stakeholders’ interests conflict, and competing demands for water supply and sanitation, energy and food production, as well as other uses such as navigation, are occurring at the same time that water quality is deteriorating. On the other hand, evidence is growing that climate change is already occurring and given its transversal effect, climate change impacts on water resources will affect the overall economy. As a result, current water-related problems (in terms of water scarcity, quality deterioration, frequency of droughts and floods) will become more acute. Despite the uncertainties with climate change and its impacts on the hydrological cycle, water managers are encouraged to incorporate climate change into current water resources planning in the context of vulnerability assessment and risk management to improve water resources management.

Overall management of water resources requires a system that allows for active participation from users, as well as a system in which reliable, user-friendly, hydrological information that monitors the stocks and flows of water plays a key role in resolving various conflicts of interests. The Spanish river basin organizations have been able to play a critical role in sustainable water resources management, but it is clear that these institutions cannot become functional and efficient from one day to the next. They have evolved over several decades. Also, it is not sufficient to establish a river basin organization with a strategic vision, normative and financial autonomy, and decision-making structures with stakeholder involvement. It is also necessary that these organizations give solutions to the immediate socioeconomic problems being faced and have strong support from central and subnational governments and the private sector for their long-term strategy. This acquires special relevance in the management of shared water resources, where the sharing of benefits is somewhat new and is now being explored and considered among neighboring countries.
**Water Supply and Sanitation**

About the best approach for extending the benefits of safe and reliable water supplies and adequate sanitation to the greatest number of people in the world, much has been said, written, and discussed. Significant advances have been achieved. Many efforts toward restructuring and modernization of the water supply and sanitation subsector have been made and the roles of both the public and the private sectors have gone between both extremes of the pendulum swing. Nevertheless, eliminating or minimizing the gap in water access seems to elude even the best efforts, and there is no clear path in sight, although public-private partnerships seem a viable option. The general pragmatic conclusion is that more is better than less, but little is better than nothing and efforts should continue.

Regarding water and sanitation utilities, one aspect that merited discussion was that of user accountability as a means to an end. Such accountability can trigger reform processes in the relationship between citizen and state and service providers, creating a favorable environment for finding sustainable development solutions. It seeks a subtle objective of instilling and maintaining appropriate cultures within utilities, and increasing the satisfaction and building the trust of the users, as well as enhancing users’ ability to interact with the utility effectively.

**Energy**

Emerging global dynamics are rewriting the role and value of hydropower in development. Increasingly, its potential contribution to a complex web of energy security, water security, and regional integration are being recognized. As part of that web, hydropower is a readily accessible core element in mitigating and adapting to climate change. The sector’s burden of risk is both real and perceived. The international community has made good progress in managing many risk issues, particularly in environment and social inclusion, but confidence remains fragile and implementation is challenged by weak capacity and institutions. Scaling up hydropower is not limited by physical or engineering potential. Rather, the challenges lie in defining hydro’s strategic role in each country/basin and bringing adequate resources, knowledge, and skills to realizing its value. Finally, focusing on policy discussions, integrating across players, and facilitating good practices can assist in scaling up public and private investments.

**Food Security**

Irrigation has an important role to play in addressing food security. However, it is not sufficient to promote and support the use of improved irrigation technologies to increase efficiency in the use of water for irrigation and productivity of irrigation water. It is also necessary to have strong institutions for allocating and managing water resources, for controlling water use, and for imposing sanctions; to provide technical assistance in the adoption of improved technologies and use of water; to facilitate provision of commercialization services to help reduce transaction costs and access markets; and to improve irrigation infrastructure to ensure more reliable supplies at the farm level. Irrigation system modernization needs to focus on both physical and operational aspects. Good water level control and communication facilities are essential to good irrigation management. In particular, there is a need for good water balance assessment, good understanding of internal system processes, and high flexibility in water delivery arrangements. At the same time, it is important not to lose sight of the fact that agricultural water management goes beyond irrigation, including water management of rainfed agriculture, which produces the bulk of the world’s agricultural production.\(^\text{13}\)

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13. Of the 1.5 billion hectares of cropland worldwide, 82 percent is rainfed (FAO 2006). In developing countries, rainfed agriculture accounts for 60 percent of agricultural production (World Bank 2006).
Technology Innovation

Water scarcity is increasing in many parts of the world due to growing populations, greater per capita water demand, and diminishing freshwater sources (a result of drought conditions, desertification, and other ecosystem degradations). Desalination was previously regarded as a prohibitively expensive solution, but dramatic cost reductions have led potential customers to view it more favorably. Technological innovations have greatly increased the energy efficiency of the desalination process and reduced operation costs. Desalinated water is becoming more competitive for urban uses and could be put to conjunctive irrigation use provided there is a high value user (such as tourism) that can be utilized for cross subsidies. In general, however, the cost of desalinated water is still too high for full use of this resource in irrigated agriculture, with the exception of intensive horticulture for high-value cash crops such as vegetables and flowers (mainly in greenhouses) grown in coastal areas. Reverse osmosis is the preferred desalination technology because of the cost reductions driven by improvements in membranes in recent years.

4.2 Highlights of the Spanish Experience

The Ebro Hydrographic Confederation (CHE) territory presents notable morphologic and climatologic variability. Its most important characteristic, in terms of water use, is the existence of an extremely arid central area (along the Ebro valley) with soils potentially suitable for agricultural development. Effective cooperation between the public and private sectors, particularly in irrigation financing, has been a key factor in the development of large water-related infrastructure in the Ebro basin as well as in Almeria, where technological progress and innovations have been greatly motivated by water scarcity.

The irrigation sector is the main user of water. It has been a dynamic sector that defined water policy during the last century, by emphasizing public sector construction of infrastructure and providing farmers with an unlimited supply of water at a low price for farmers. Since the 1970s, the irrigation sector has provided an efficient response to structural changes in markets by diversifying production and integrating new activities. Irrigation modernization plans allow further adaptation of the sector, responding to the need for more technical farming methods to achieve additional cost savings and helping to calm tensions arising from society’s greater environmental awareness and the perception that irrigators use water resources badly. The effect of the financial cost of modernization on farm economies remains to be seen, although it is foreseeable that a larger proportion of the modernization costs will come from public administration budgets.

Although the potential effects of climate change on available water resources in the CHE territory are yet to be determined, steps are being taken to extend supply guarantees, both by increasing regulatory capacity and by improving water management and allocation systems. In the formulation of the Hydrologic Plan, decision making has been reinforced by a broad process of public participation that has achieved greater awareness among the general public (including direct users) of the consequences of climate change and greater acceptance of the proposals.

Almeria provides an example of the socioeconomic problems that can be encountered in semi-arid areas with groundwater aquifers that can be easily exploited. Although the construction of desalination plants and their excellent management is a step in the right direction to reduce pressure on the aquifer, an integrated approach to managing groundwater, desalination water, and surface water is badly needed for reducing overexploitation. The Almeria model provides small farmers with technical assistance at three levels (at the farm, to meet European Union phytosanitary regulations, and for marketing purposes) and can provide interesting lessons for
projects in other countries that merit being reviewed in greater detail.

A demand management approach following criteria set out by the European Water Framework Directive could be used to improve water use efficiency in both Ebro Valley and Almería province. The relatively low water prices do not align the economic incentives and foster wastefulness in a market in which the resource is rationed and has a quota assigned by the water administration. Agricultural water prices could be maintained below prices paid by other users or could be increased to solve serious scarcity problems. The latter scenario will have negative effects on farmers’ rents that may require compensation. It is important to note, however, that Almería’s GDP is almost double that of the Ebro Valley. Regarding cost recovery, the Ebro Valley has a cost recovery share of 89 percent; in the Andalucia Mediterranean basin, the cost recovery share is 92.1 percent.

Also worth mentioning is the bold step taken by the Spanish government in pledging its commitment to desalination as a means to balance water budgets in the Spanish Mediterranean, but other nations may need to proceed with caution before adopting the Spanish policy. Investment costs are huge and may only be sustainable if the added economic prosperity this water affords a region in the long term is sufficient to offset the project funding. Moreover, desalination may provide tangible environmental benefits over inter-basin transfers as a means of meeting water deficits, but their energy requirements and waste discharges cannot be ignored. A parallel commitment to water demand management through water tariffs is prudent to encourage recovery of degraded natural water reserves.

The Canal de Isabel II is noteworthy among water supply and sanitation utility models for its comprehensive water cycle management throughout the Madrid region, providing water collection, purification and quality surveillance, transport, distribution, wastewater purification, sanitation, and managed reuse of some of the purified water for secondary supply uses. Another feature of interest in this utility is the position of Customer Ombudsman, created in 2001 to act as mediator between the consumers’ complaints and the company.
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Practical Solutions to Water Challenges: Learning from the Spanish Experience