Chapter 1

Introduction

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1 INTRODUCTION

The world's water problems are due to bad governance, not to physical water scarcity. This book is inspired by this statement and explores whether it holds true in a specific country, Spain, where climatic conditions - Spain is one of the most arid countries of the European Union - could lead to the assumption that water problems are due to physical water scarcity. In order to do so, this book builds on *Water Footprint and Virtual Water in Spain* (Garrido *et al*., 2010), where the Water Observatory of the Botín Foundation focused on one of the pillars of good governance – accurate data and information – and estimated how much of the resource is available, how much is used, what for, and the extent of its economic productivity. The previous book provided an analysis of the water footprint of Spain and explored the role of trade in relation to the movement of virtual water – virtual water trade – in and out of the country. Some of its main conclusions are particularly significant due to their policy relevance and potential implications:

- 10% of the consumption of freshwater from rivers and aquifers produces around 90% of the economic value of Spanish irrigated agricultural production.
- Spain imports water-intensive but low economic value products (mainly animal feeds and agricultural commodities), and transforms them into high-value export goods (mainly meat and elaborated products).
- Changes in virtual water trade cushion and respond to drops in agricultural supply caused by droughts.
- Green water (i.e. rainwater stored in the soil) has a very important share of Spain's water consumption. This is normally neglected by governments in traditional statistics and also in most national and river basin plans.
- The economy of water in Spain is very different now than it was 30 years ago, and current tensions around water often have little to do with old arguments and rationales centred on water scarcity.

The book of Garrido *et al.* (2010) was a breakthrough in understanding the relationship between the consumptive use of water and food production in Spain. However, some important aspects could not be treated with appropriate detail, both in terms of knowledge on water uses and also in terms of the complex factors that determine water policy and water-related decisions. In terms of knowledge of water uses, the following issues remained untouched or incomplete and are now addressed in the present book:

- The role of groundwater in the Spanish water sector and the economic value of its use in irrigated agriculture.
- The externalities of the economic uses of water, including agricultural diffuse pollution and the impact of water management decisions on the environment.
- The relevance and challenges associated with water uses in the urban, tourism and industrial sectors.
- The possible impacts of climate change on Spanish water resources and sectors.
- Other issues related to water in connection with energy, water institutions and collective management, and water footprint of specific basins, land uses and products.

Regarding the factors that determine water-related decisions, the book by Garrido *et al.* (2010) showed that a rational reallocation of water – based on economic considerations – could contribute to solving many of the problems of water scarcity (which is interpreted as an imbalance between demand and supply), but concluded that there are other crucial elements, beyond mere economic arguments, that need to be included in the *equation* of good water governance. As pointed out by the Declaration of the UNESCO World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) on the conditions for the good governance of water resources, a key goal is reaching an equilibrium between the utilitarian and intangible values of water resources. Those *intangible* elements often determine the result of the equation, and if ignored or underestimated can sometimes bring water management to a deadlock.

The growing need for maintaining Spain's natural capital is added to the *equation* in the present book, as well as the human component: people that have needs, wishes, (vested) interests, aspirations, social and cultural considerations. This book thus takes a step forward in showing a more complex picture – probably closer to reality – of water governance in Spain.

2 STRUCTURE OF THE BOOK

In this book the reader will find chapters that contribute to shedding light on each of the elements of the *equation* of good water governance. Chapters are grouped into five sections (Table 1).

Section I (Political framework and institutions) characterizes the context of water governance in Spain. It starts by exploring what the concepts of water and food security mean for Spain (Chapter 2). It then outlines the main legal, administrative and economic elements that influence water management after the approval in year 2000

Table 1 Book structure.

Water, agriculture and the environment in Spain: can we square the circle?	
Section I: Political framework and institutions • Water and food security framework • Legal, economic and administrative setting • Politics and institutions	
Section II: Metrification of water uses • Spain's extended water footprint • Groundwater resources • Guadalquivir water footprint • Guadiana water footprint • Olive oil and tomato water footprint	Section III: Looking at the environment and sector uses • Forests' water consumption • Diffuse agricultural pollution • Urban and industrial uses • Water-energy nexus • Potential impacts of climate change
Section IV: Possible mechanisms/enabling conditions • Water markets • Modernization of irrigation systems • Collective action in groundwater • Participation and transparency	Section V: Case studies • Las Tablas de Daimiel National Park • Irrigated agriculture in the North-west of Doñana • The Canary Islands

of the European Union (EU) Water Framework Directive (WFD) (Chapter 3). Finally, Chapter 4 delves into the political and institutional issues that determine water decisions, how current institutions hinder the governability of water resources, and some potential venues for institutional reform.

Section II (Metrification of water uses) deals with metrification, which is undertaken calculating the extended water footprint (EWF) of the main water sectors at different scales. Chapter 5 sets the scene for this calculation by defining key concepts and showing the advantages and limitations of this approach in pursuing Integrated Water Resources Management (IWRM). Chapter 6 focusses on the metrification of water uses at the national level, by updating and upgrading the knowledge of water uses and their economic value, as provided in Garrido *et al*. (2010). Likewise, Chapter 7 presents the most updated data available on groundwater, the hidden half of *blue water* (surface and groundwater) and provides figures on the economic value of groundwater use in agriculture. The EWF is also applied to two river basins, the Guadiana and the Guadalquivir (Chapters 8 and 9), and to specific agricultural products (olive oil and tomatoes, Chapter 10), showing the added value of using this tool with a high level of data resolution.

Section III (Looking at the environmental and other sectorial uses) explores some of the challenges set by economic water uses, especially in terms of impacts on natural resources. Chapter 11 analyses how much water forests consume to maintain their ecological functioning, and how changes in land use and land cover impact water availability downstream. Chapter 12 presents the problem of diffuse water pollution due to agricultural activity, which is probably one of the most difficult and significant challenges for water sector over the next decades. Chapters 13 and 14 look at challenges related to urban water use and the water-energy nexus, showing the strong linkages between urban, energy and agricultural water uses. Finally, Chapter 15 provides

an up-to-date picture of research findings on the potential impacts of climate change on water resources in Spain, how this could affect many water-dependent sectors and the different adaptation and mitigation options available.

Section IV (Possible mechanisms and enabling conditions) offers a closer look at specific mechanisms that are often portrayed as effective tools to solve the jigsaw of good water governance: water markets (Chapter 16), transparency in water management (Chapter 17), collective action in groundwater management (Chapter 18), and improved water use efficiency (Chapter 19).

Section V (Case studies) presents three specific cases where the socio-economic, political and environmental dimensions of water governance interact and lead to different challenges and opportunities for water management: Las Tablas de Daimiel National Park in the Guadiana basin (Chapter 20), an intensively irrigated agricultural area in the north-west of the Doñana National Park, in the Guadalquivir basin (Chapter 21), and the Canary Islands (Chapter 22).

3 BOOK'S MAIN FINDINGS

3.1 Political framework and institutions

Spain has a long, well-known, and globally acknowledged history in water management and planning, which has emerged in many ways as a response to its geographic location and climate. Water scarcity has been a regular and defining element for all Mediterranean countries and has triggered innovation throughout history, both in institutional terms and in water infrastructures, as adaptation measures to reduce risk. Looking to the future – at the start of the 21st century – Spain, like other countries across the world, will have to identify what water and food security mean for its domestic policy and also as part of a wider European and global international system, since this has important implications on water resource use, agricultural policy and the environment.

Water and food security are tags widely used nowadays, although these terms can hide very different meanings, depending on the countries' socio-economic context. Chapter 2 explains that in Spain, since production and market access is largely guaranteed, food security at the domestic level is closely linked to guaranteeing food safety and nutrition. In this context, the book shows how globalization has contributed to a shift in the dietary habits of Spanish consumers, with changes to the standard Mediterranean diet to include higher meat and processed food consumption, and a drop by half in the intake of cereals, legumes, fruits and vegetables. This dietary shift has been largely facilitated by globalization and virtual water imports from third countries. The book highlights some of the unexplored trade-offs, for example in terms of potential reduced food security due to poorer diets and also impacts from virtual water imports into third countries. In this context, Spain is also part and parcel to ongoing negotiations and debates over global food security, as a partner of one of the largest trading blocs in the world – the European Union – which is currently part of key agricultural food trade regulations in the Doha round of the World Trade Organization.

Although the concept of water security is relatively young, around a decade or so, in many ways it has been implicit in Spain's history from the onset. This is reflected in the development of both water infrastructure and institutions to deal with the inherent

Mediterranean climate variability, with Spain being the fourth country in the world in number of large dams, with over 1,200 reservoirs that can store over 55,000 million m^3. This is also linked to a provision under water planning to include protection against extreme events, principally floods and droughts. In the past two decades, two new aspects of the concept of water security have been introduced, which refer, on the one hand, to the ability to *increase* domestic water security through the virtual water embedded in food imports (Allan, 2002; Guodong, 2003); and on the other hand a renewed emphasis on the importance of ensuring the good health of water-related ecosystems. These, in turn, would then secure all dependent activities and most water-related ecosystem services.

In this context, the concept of water security is strongly linked to the good status of aquatic systems, which is the basic goal of the European Water Framework Directive. Chapter 3 discusses how the WFD represents a *before and after*, a turning point for traditional Spanish water policy. The implementation of the WFD has marked a clear *road map* on the aim and the process to be followed, an aim fixed on the achievement of water good status as a primary planning and management objective; and a means due to a required and prescribed process of public participation in the elaboration of river basin plans. This has marked a quiet revolution for Spanish water policy planning and organizational *status quo*, catapulting environmental priorities to a more prominent role. This, however, has to be somehow integrated with the traditional planning framework and the *ethos* of meeting existing demands. A half-hearted attempt to introduce an as yet timid economic analysis of water services and a greater interest in water demand management are two additional implications. As explained in the book, the achievement of the WFD objectives faces several challenges and uncertainties that are technical, financial and political in nature. In this context, to a large extent, the successful implementation of the WFD may well lie in strengthening the link between land use and water management, and the institutional structures that facilitate co-responsibility and full cooperation between the central government and the regional administrations, which hold responsibilities for land use management and agriculture.

The book also identifies and discusses a series of key blocks for institutional reforms, namely, the legal and institutional framework, existing economic incentives, the organisational structure of the current water administration system, and procedures and paradigms for water policy and planning. Chapter 4 identifies areas where it is simply a case of making better use of existing policy instruments, by making these more efficient and effective. This includes strengthening the implementation of the current norms, increasing transparency in cost recovery, and reinforcing budgetary control and oversight. However, in some cases institutional efficiency and effectiveness simply will not suffice, and deeper structural reform might be needed. This is where there is currently a tension between what is politically feasible and issues of political will and skill. Politician will act if carried along or pushed by public support and at present there is a clear de-synchronization when in some ways *bad* water management is good politics. Thus a deeper *water democratization* is ultimately underpinned by a healthy and active civil society that has access to relevant information, and can act as a final check on the system to have a stronger overall accountability from all water institutions to achieve a transformative process of water policy and planning. Politicians will make good water management a priority when pushed by civil society.

The remainder of the book details illustrative examples that highlight how metrification can help shed new light on old problems, to provide a catalytic effect on facilitating change, both in terms of making existing institutions more responsive to change and also in being capable of introducing deeper institutional reforms, if necessary. In this context, political frameworks and institutions face both old and new challenges related to water and food security, which needs an effective and functional overall legal framework for water management and effective, accountable institutions. The *politics of water* should be part of a healthy democratic process where it is no longer the political rents associated with water that determine decisions, but rather the politics of water become part and parcel of a healthy process of water governance and negotiation.

3.2 Metrification of water uses

In this book the quantification of water consumption and its economic value has been undertaken mainly using the concept of the water footprint, which is an indicator of human appropriation of water resources that looks at both the direct and indirect water use of a consumer or producer (Hoekstra, 2003). It includes three components: blue water (referring to surface and ground water), green water (defined as the rainwater stored in the soil) and grey water (referring to pollution). The latter concept of grey water is an interesting, although complex and controversial concept. The water footprint combined with other socio-economic and environmental indicators is a tool that provides a transparent and multidisciplinary framework for informing and optimizing water policy decisions, and ultimately can help to achieve a more integrated water resource management.

In this book, the metrification of water uses, using the water footprint coupled with socio-economic and environmental data, has been applied at multiple scales: to the country as a whole, considering all types of water sources (Chapter 6); focusing specifically on groundwater (Chapter 7); at the river basin level (Guadiana and Guadalquivir, Chapters 8 and 9); and down to some particular products such as tomato and olive oil (Chapter 10).

Chapter 6 shows that, like in the rest of the world, agriculture is the main water user sector in Spain, while the urban and tourist uses represent a very small percentage of consumptive uses (Table 2). Nevertheless, the political weight of urban water supply is great due to its importance to public health and the general well-being of the population. The social and economic importance of urban and industrial sectors implies that drought cycles should not compromise the reliability of water supply,

Table 2 Consumptive blue and green water use and associated socio-economic aspects (year 2010).

Activity	*Consumptive use (hm^3)*	*GDP (M€)*	*Workforce (%)*
Agriculture & livestock	38,990 (84%)	26,000 (2.5%)	4.2
Urban water supply	4,042 (9%)	4,000 (nil)	(nil)
Industry	3,251 (7%)	123,000 (11.8%)	14

Source: Garrido *et al.* (2010), INE (2012). [hm^3 = cubic hectometre = million m^3 = 10^6 m^3].

because agricultural water use can be significantly curtailed at low or moderate costs to society, through e.g. virtual water imports.

As it is common in agriculture, green water holds the largest share of Spanish agricultural water consumption. This sector has experienced significant changes over the last 25 years, like changes in crop production that are giving blue water consumption an increasing importance, especially in the fastest growing sectors like vineyards and olive groves. On the contrary, the water footprint of the animal sector is turning *greener*, as the imports of rain fed-produced feedstuff have increased significantly. Nowadays, the intensive livestock sector in Spain relies primarily on imports from Brazil, Argentina, France, UK and USA, where livestock feeds are grown mainly under rain fed conditions.

Spain's agricultural trade has also grown significantly in volume and value during the last 15 years. The economic value of exports increased more than that of imports, but the total volume of traded virtual water followed an opposite path. The volume of virtual water[1] (VW) imported is mainly associated with cereals and oilseeds based on green water, and is significantly larger than the exported VW, composed increasingly of animal products and olive oil, in addition to the more traditional and stable exports of fruits and vegetables.

In the context of water management in Spain, groundwater plays a strategic role. As in most arid and semiarid countries, during the last half century the *silent revolution* of groundwater use has produced significant socio-economic benefits. Nonetheless, often limited attention has been paid to groundwater, due to a mix of professional bias, neglect and corruption (Llamas *et al*., 2001). The EU WFD planning process has implied important advances in the knowledge of groundwater resources and their use in Spain. However, data on groundwater resources in some cases are still incomplete and a comprehensive official overview of groundwater resources (and their uses) is missing.

As a first estimation, Chapter 7 reports that Spain's groundwater demand is about 7,000 million m^3/year, mainly for agriculture (73% of the total demand), followed by urban uses (21%). The development of intensive groundwater use, with little planning and control by the water authorities, has contributed to the degradation of this strategic resource. At present only 54% of the Spanish groundwater bodies are in good status[2], due to intensive aquifer exploitation or pollution. Full implementation of the WFD provides an opportunity to reduce this deterioration, and indeed water authorities expect to increase[3] to 80% the percentage of groundwater bodies that will be in good status by 2027, which marks the end of the WFD implementation process.

To understand the economic significance of groundwater uses, Chapter 7 also analyses the differences between the apparent economic value of crops irrigated with groundwater and surface water. Previous studies in Andalusia showed that groundwater irrigation was economically more productive than surface water irrigation. This

1 The virtual water of a product or service is the volume of freshwater used to produce the product or service, measured over its full production chain (Hoekstra, 2003).

2 41% of the groundwater bodies are in poor status. Currently, the status of 5% of the groundwater bodies is still under study.

3 Less stringent objectives have been established for 3% of the groundwater bodies, while for 17% of the the groundwater bodies there are no sufficient data to predict their status by 2027.

was attributed to a series of factors, chiefly its resilience to long dry spells, and it was thought this would be applicable also to other regions in Spain. Data obtained for the whole country and presented in this book seem to question this idea, with no clear correlation found between the source of water and the apparent water productivity in irrigated agriculture. This is an issue that merits further analysis, combining local and country-wide data to refine the calculations.

The calculation of the extended water footprint of specific river basins (Guadiana and Guadalquivir) yields closer insights into water uses. In Garrido *et al.* (2010), the authors looked in detail at the Guadiana basin. In Chapter 8 a similar approach is carried out for the Guadalquivir basin. The innovative aspect of the water footprint analyses in these two river basins is the separate analysis of both green and blue water consumption and the associated economic value, using the economic productivity indicator at the basin and sub-basin scales. In the case of the Guadalquivir river basin, blue and green water consumption for direct human use (agriculture, urban and industrial supply), and the green water consumption by forest uses (forests, shrublands, grassland, etc.) have also been considered. The analysis of the water demand by forest ecosystems, closely related to land use changes, is an issue of growing importance.

In both the Guadiana and Guadalquivir river basins, agriculture is the main water consumption sector, accounting for 95% and 93% of the total blue and green human water footprint, respectively. The economic productivity analysis shows that better water management could be reached through reallocation of water resources between the different uses. This reallocation may occur without social conflict with farmers since the quantities of blue water required for specific high-value uses (for example thermo-solar energy production, vegetable production, tourism) constitute a small amount of the current total blue water use. At the same time, the competent authorities should promote a win-win solution, facilitating farmers a change towards more productive and less polluting production techniques.

The tomato and olive oil product-level analysis looks not only at green and blue water consumed, but also at pollution aspects and the associated economic value of water uses. The study confirms the importance of a detailed water footprint supply chain assessment in the case of agricultural-based products, since these represent most of the green, blue, and grey water footprint, thus emphasizing improved agricultural management as fundamental to improving water management. Water accounting in the agricultural sector shows significant differences in results depending on the database, assumptions (e.g. spatial-temporal), and methods used. The main lessons learnt from these discrepancies is that the methods for estimating the water footprint of crops and products are prone to a cascade of errors, mainly when applied at a larger regional scale. Therefore, results from water footprint calculations have moderate accuracy, in line with most hydrological data.

3.3 Looking at the environment and sector uses

Administering an increasing water demand under changing environmental conditions represents a major challenge for managing water resources in a semi-arid country like Spain. Recent water planning documents in several river basins have reported a reduction of 10–20% of available water resources during the second half of the 20th century (Chapter 15). In some of these basins (Duero, Guadalquivir, Guadiana and

Jucar) mean annual precipitation has also decreased in the last six decades between 2–8%, while in other basins, like the Ebro and the Inner Basins of Catalonia, precipitation reduction has not been as significant. Despite the natural variability of the Mediterranean climate, these trends seem to be pointing to a potential transition towards a new climatic situation – as a possible signal of climate change – where annual rainfall is decreasing, thus decreasing naturally available water resources. Nevertheless, the observed runoff reduction cannot be explained by the reduction in precipitation alone. Ongoing changes in land use and land cover, and the increasing water abstraction rates, are also important drivers for the observed reduction in available blue water resources (Lorenzo-Lacruz *et al.*, 2012).

Looking at the future, a recent official report (CEDEX, 2011) forecasts that the observed trend in runoff reduction is likely to continue during the 21st century, especially in the southern, most water-stressed basins. This book argues that, whilst acknowledging the need for water authorities to adopt a precautionary approach to consider the potential intensification of current hydrological regimes, predictions have to be studied carefully because uncertainties remain high as forecasts have considerable error intervals.

Although this book does not address these phenomena in detail, Chapter 15 discusses how rates of droughts and extreme rainfall events have increased since the 1950s in different regions across Spain, although no significant trend has been observed at national scale. In the mean- and long-term scenarios an increase in droughts and in extreme rainfall events in much of Spain is forecast, especially in the central and eastern basins (CEDEX, 2011). However, uncertainty is high.

A reduction in water availability, coupled with an increase in temperature and extreme events, is likely to have major consequences for water-dependent sectors. Efforts are needed in the implementation of adaptation measures such as the development of drought resistant crops, improved forest management to enhance forest's resilience, or the establishment of institutional mechanisms such as a review of existing water rights and allocation, while others focus more on *hard infrastructure*, like improved drainage. Nevertheless, if climate change is considered as an effect rather than a cause, more efforts need to be made in searching for mitigation measures, and in this respect agriculture and urban areas in Spain will have a major role to play.

An important adaptation measure in Spain to climate change not yet explored in detail is how forest management can help to optimize the water cycle and the provision of runoff downstream. In fact, as mentioned earlier, the reduction in blue water resources observed across different basins in Spain cannot be explained only by a decrease in the precipitation regime. One potential driver of the reduction in runoff could be the observed increase in forest cover across large areas of the Spanish territory. According to official data (MAAM, 1996; 2006), forest area in Spain has increased by approximately 1.5 million ha. In this respect, Chapter 11 provides a first estimation of the major green water requirements of main forest uses, including forests, shrubs, agro-ecosystems and pastures. The preliminary results reveal phenomena seldom considered in the WFD and with great potential importance for water planning in Spain: forests consume four times more water than the whole of the Spanish agricultural sector (not including livestock) and use 39% of the mean annual Spanish rainfall. This proportion can increase up to 42% during droughts. Land use changes, and to a large extent an increase of forest cover linked to land abandonment and

afforestation programs, seem to have a great impact on water resources in Spain, as these appear to have reduced national blue water resources by up to 4% since the 1980s. The magnitude of these reductions is especially relevant in those regions which are most water-stressed. Nevertheless, these results need to be assessed more in detail, foremost because current official sources of land use and land cover data (e.g. CORINE Land Cover project, Crop and Land Use Map) report different trends of forest evolution in Spain over the last decades, making it difficult to ascertain the real impacts changing forest area has had over the last years on national water resources. Overall, integrating land and forest management into water planning might be a cost-effective solution to optimize the supply of water in catchments, even though efforts still need to be placed on how to use water more efficiently and for a better management of water demand. Such integration would also highlight the possible negative *co-effects* that climate change mitigation afforestation programs could have from a water perspective.

A major environmental concern for Spain and most European countries is the problem of diffuse pollution caused by agriculture (Chapter 12). Nitrate pollution is a major issue in areas where intensive cropping and livestock (mostly from pig farms) occur. The use of chemicals in agriculture and livestock rearing does not differ from other European countries, although the inherent climate and soil conditions of Spain explain the differences in terms of application rate and types of chemicals used. Fulfilling the mandates on water quality from European Directives poses specific technical and also administrative coordination problems due to the different authorities responsible, on the one hand for water resources, and on the other for the environment at national and regional levels. Many aquifers and the related springs and surface water bodies will not reach good status by 2015, as required by the WFD. This means that new terms will have to be negotiated and new strategies will need to be carefully defined, taking into account technical, economic, social and administrative elements of intervention. Most work done so far deals with nitrate pollution, vulnerable zones and good agricultural practices, but there is also the issue of salinity pollution due to the evapoconcentration effect, when irrigation water is originally of poor chemical quality, something not rare in Spain. Pesticides and emergent pollutants in groundwater and the related surface water are being studied, since they may impact the quality of drinking water, but applied results are still in the early stages.

The water-energy nexus (Chapter 14) has become a relevant issue for Spain's sustainability standing and prospects. A key aspect stemming from the analysis of the water-energy nexus is the importance of the increasing use of energy in the irrigation sector. Since 2002, Spain is deeply involved in a process of modernization of its irrigation systems, with the aim of saving water, which leads to the unintended consequence of increasing energy consumption in agriculture. This came along in parallel with the reform of the electricity sector, which resulted in an increase in electricity costs to farmers by 80%. Moreover, from a water-energy perspective, unless there is a low initial water use efficiency (around 50%), modernization may not be the best option for increasing water availability. Desalination or reclaimed water may be a better suited alternative from the point of view of efficient resource use.

On the side of water for energy, the book highlights that the energy sector is mostly a non-consumptive one. The analysis of seven scenarios of electricity production for

year 2030 with different technology mix suggests that the largest decrease in (non-consumptive) water use is achieved when more renewable energy systems and less nuclear energy are present in the technology mix.

The analysis of the water-energy nexus also links with urban and industrial water demand and the associated reclaimed water production, which is an important challenge in the European Union. The careful use of the potential efficiencies in the water-energy nexus could become an economic option, with the added advantage of providing an economic use for a raw material like wastewater. Extending the wastewater treatment system to include tertiary treatment all over Spain would account for 3% of the water-related electricity consumption or 0.2% of the total Spanish electricity demand.

Chapter 13 delves into challenges of urban and industrial water uses beyond electricity demand for water supply and treatment. The spectacular urbanization and population growth occurred over the past six decades affects the hydrological cycle and increases the complexity of sustainable water management. In this context, the steady increase in the deterioration of water quality due to urban, industrial and agricultural pollutants represents a huge challenge for urban supply, since it requires increasingly more expensive and sophisticated treatments to make water potable. Overall, the response to water pollution has been satisfactory although with three weak points: most of the investment in wastewater treatment was paid by EU funds that have now ended; most small cities and rural settlements still do not treat their grey water, and water prices are subsidized. Spain has some 200,000 km of water supply pipes, around 70,000 km of sewers and about 5,000 water treatment plants. An important part of these assets is or will soon become old, and revenues from current urban water treatment tariffs do not fully allow maintaining or replacing them. Thus, the decrease in the flow of EU funds and the current economic crisis are likely to mark a turning point from subsidies to full urban water cost recovery.

To face the upcoming challenges related to urban and industrial water supply a cultural change is needed, in particular for the major players – ranging from decision-makers to all stakeholders – so that they truly have an integrated approach to water problems. For this to happen these actors have to be trained to address problems from a broader perspective, and the general public has to be educated to value long-term policies, even when sometimes these require unpopular decisions in the short term. Other key elements to face urban and industrial water use challenges are the integration of water policies with other environmental policies (e.g. land use, energy), passing all the costs of water services to users (and reinvest the resulting revenues in the water system), progressively renewing water infrastructures, maintaining the commitment to provide a good quality supply, and improving knowledge and research to continue making progress in technology.

3.4 Possible mechanisms and enabling conditions

Based on the book's multiple angles of metrification, the adaptive reallocation of water rights among existing users or new emerging users is key to finding solutions to current tensions within the water sector and between human water uses – mainly agriculture – and the environment. Water trade and market mechanisms are often discussed as a possible way of facilitating that reallocation. In 1999, following the

example of California and other countries, the Spanish Government decided to relax the Water Act of 1985 so that public water concessions could legally be traded to other users. Chapter 16 reviews the Spanish water market regulation established in the 1999 Water Law reform and overlooks on the type of exchanges that took place between 2004 and 2008, when market exchanges were more frequent due to a dry spell. While exchanged amounts were not very significant in absolute terms, those that involved inter-basin transfers raised most of the concerns. The main concerns are related to the effects of altering the timing and location of water abstraction, as well as changing the place and volume of the return flows of the traded water. For example, trading water belonging to downstream users from the head of a basin to another basin implies that the traded resource will not be available for other users and for in-stream flows on its way to the sea. Moreover, often much of the water associated with a water right is not abstracted or, if it is abstracted, it is not really consumed and returns to the basin, to be used by other users. In terms of implementation, this book outlines legal, political and economic constraints that hinder the growth of water trading in Spain, and lists a number of desirable elements to make them more efficient, environmentally friendly and legitimate.

Groundwater is a strategic resource during dry spells and in areas where no or limited surface water resources are available. Groundwater management may also play a significant role in adaptation to potential impacts of climate change. In Spain, as in most arid and semiarid countries, during the last half century an intensive use of groundwater for irrigation has occurred, providing stupendous socio-economic benefits (Shah, 2009). Nevertheless, due mainly to the fact that this intensive development has been done with little planning and control by water authorities, some problems, mainly environmental ones, have occurred. Since 1985 the Spanish water law developed measures to regulate and control abstractions by declaring an aquifer overexploited, yet these measures in most cases have failed to achieve control of groundwater uses and ultimately to improve the quantitative and qualitative status of the resource, as required under the WFD. As an answer to this situation of mismanagement, there have been spontaneous user-led initiatives, to develop a range of collective action institutions. These young groundwater collective institutions have increasingly focused on reducing water users' risk through the development of a portfolio of water resources, yet leaving some questions unanswered on the overall resilience of the system to intensive groundwater use. Nevertheless, the Spanish experience on these collective institutions to manage groundwater may be very useful for many other countries which have also developed an intensive use of groundwater.

The improvement of water efficiency is one of the pillars of the *Green Economy* and the modernization of irrigation systems represents a facet of this move towards a more efficient use of water. The irrigation modernization programme implemented in Spain during the past decade is possibly the largest in terms of surface area and investment in the whole of Europe and one of the largest in the world (Chapter 19). It is often presented as the flagship for the achievement of sustainable development in the water sector. This plan was a state-led effort to increase water efficiency in irrigation and generate water savings at plot and basin levels, particularly to reduce water stress during drought periods. Chapter 19 shows some evidence that estimated water savings have not been achieved, and that in some cases the increase in water efficiency

application may have entailed an expansion of active irrigated land and/or some crop changes, leading potentially to a higher overall local irrigation water consumption. However, there are other unintended consequences and in some cases co-benefits in terms of reduced used of fertilisers due to fertirrigation, and better traceability and control of water use due to technological improvements. Yet the lack of reliable and consistent information on the actual aggregated consequences of this large public investment programme highlights the need for a detailed assessment of the outcomes and logic of the modernization process.

All the mechanisms presented in this subsection underscore that public access to data about water management and a stronger involvement of stakeholders in decision-making and implementation of policies is needed. Although the implementation of the WFD requirements is contributing to improving transparency and participation, in Spain the tradition of public accessibility to data and public participation in management decisions is still rather poor. Chapter 17 provides an assessment of these two *enabling conditions* for good water governance and presents results of an assessment of information transparency by the Spanish river basin authorities. In general, there is evidence that the transparency of the Spanish water agencies is slowly improving. Nonetheless, there is still a long path ahead for having all the relevant information available, especially in relation to water use and management, and water-related contracts and tenders. The most compelling challenge is possibly ensuring the reliability and the consistency of the information made available by the public administrations. Another key issue is making the information accessible to different target audiences by adapting information to different levels of interest and technical capacity.

3.5 Case studies

Some of the mentioned dimensions of water governance and the daunting task of balancing agricultural water uses and the maintenance of ecosystems are presented in different case studies, which show the difficulties and opportunities of working on specific contexts: Daimiel, Doñana, and the Canary Islands. The three case studies focus on groundwater resources in different regions of Spain, analysing the challenges and opportunities for improved water management and the implications of water use for the economy and the environment. This includes the pressures and impacts that human activity has caused on some unique areas close to important wetlands of the Guadiana basin (Las Tablas de Daimiel wetlands, Chapter 20) and Guadalquivir basin (Doñana wetlands, Chapter 21). The analysis of the situation in the Canary Islands (Chapter 22) gives an interesting view of the strategies adopted in a water scarce region.

In these three Spanish cases a spectacular increase in groundwater development for irrigation has taken place during the last half-century, carried out mostly by the private initiative of thousands of modest farmers in the pursuit of significant economic benefits. However, the chaotic nature of groundwater development, coupled with the attitude of many water policy-makers towards groundwater, has sometimes resulted in a series of unwanted environmental effects, such as water table depletion, groundwater quality degradation, land subsidence, or ecological impacts on aquatic ecosystems.

Since half a century ago, wetlands have changed from wastelands to almost sacred ecosystems all over the world. The concern for the topic and the analyses of many cases of wetland degradation by human actions, mainly by groundwater abstraction, has increased during the last decades in Spain. Two emblematic cases are presented in this book: the development of irrigated agriculture close to the National Park of Las Tablas de Daimiel, a UNESCO Reserve of the Biosphere, and the appearance of an intensively irrigated strawberry-producing area in the north-west of the Doñana National Park, a Ramsar site.

In the case of Las Tablas de Daimiel, the strain between nature and socio-economic development is far from being resolved. The consequences of intensive groundwater abstraction have been particularly severe in the groundwater dependent wetlands of Las Tablas de Daimiel National Park. In fact, in 1994, the Guadiana River Basin Authority declared the aquifer feeding these wetlands legally over-exploited. The last attempt of regulation, the Special Plan for the Upper Guadiana, aimed at reorganizing the water rights structure and reducing extractions to obtain water for ecological flows to Las Tablas de Daimiel. However, the financial cost has conditioned its full implementation. The challenge is to change the current agricultural model towards a more balanced model which aims to allocate water more equitably between all users, including the Biosphere Reserve. In the case of water in arid environments, which face strong competition between users, moving away from current trade-offs (and stand-offs between sectors) requires identifying win-win solutions.

In the strawberry-producing area of Doñana, problems are more recent and the consequences of intensive irrigation, while less spectacular (relative to the Daimiel area) in terms of water table reduction, can also be clearly traced in the transformation of land use and the degradation of groundwater quality. During the past decade, the increase in water abstractions has to some extent been limited through improvements in water efficiency, using improved irrigation technology and the enforcement of administrative constraints to the expansion of irrigated lands and tourist resorts. However, the complex nature of the resource system, the presence of unlicensed groundwater extractions, unsolved issues of land ownership, and a fragmented institutional structure hinder the achievement of long-lasting solutions.

Chapter 22 presents a summary of the characteristics of the Canary Islands archipelago. In a certain way, its hydrological and socio-economic characteristics suggest the need for a reconsideration of the prevailing ideas on the evaluation of water scarcity in the region. Indeed, this archipelago, with a water availability ratio around 300 m^3/year *per capita* should be in a catastrophic situation if it is analysed through the prism of traditional water scarcity indicators. Indeed this water availability ratio is well below the 500 m^3/year *per capita* threshold considered as an extreme water scarcity situation according to these types of indicators. The Canary Islands are in the lowest quartile among the Spanish regions in per capita terms, and yet the islands have not suffered in the last half century any serious economic and social problems. This has been possible mainly thanks to two factors: a) the intensive use of groundwater and the existence of privately managed water markets, and b) the desalination of sea water. Nevertheless intensive use has had a strong impact on the hydrology and social consideration of water in the archipelago, which varies from island to island, according to their specific characteristics. This leads once again to consider a broader perspective to analyse what is meant by sustainable development.

4 ISSUES THAT ARE NOT INCLUDED IN THIS BOOK

This book does not address a number of important topics related to water in Spain. Some relevant aspects have not been covered or are only considered at a preliminary level. This was due either to data not being available at the time this book was completed, or that their collection and study needed time, additional effort or an expertise that was not at hand. Some of these issues are:

- How food security is considered in Spain by the different Autonomous Communities that form the State, and how this agrees with the European Union policies, from the point of view of water resources.
- How droughts influence water policy and food security in Spain and the European Union. Spain is subject to recurrent, severe meteorological and hydrological droughts that affect people, economy and political life. These conditions vary across the territory, with differences between the Mediterranean area and the rest of the country, between the north and the south, including the archipelagos, one Atlantic and the other Mediterranean. The subject has been considered in a recent paper (Estrela & Vargas, 2012).
- How the Common Agricultural Policy (CAP) of the European Union affects water resources use in Spain, and what the future prospects are. This has an effect on the world's food trade and virtual water transfers. The CAP has driven agricultural water uses, sometimes promoting water demand, other times indirectly curtailing it. There has been no comprehensive study to estimate the net impact of the CAP on water use and water pollution. However, based on the available literature one could claim that hitherto the CAP has not had a positive impact on agricultural water use in Spain. Not including this major driver in this book is justified by the fact that a lot of uncertainty still exists about the details of the CAP for 2014–2020, especially about those issues related to irrigated agriculture.
- How the political divisions in Spain, where autonomous regions have responsibility for territorial resources and environment conditions, affect water use, including internal virtual water trade. This requires putting together regional goals and responsibilities, and central government policies, including energy use, environmental objectives and land-use planning.
- The costs and the economics related to water quality in agriculture, human supply and industrial production. These have to be considered taking into account actions (from no action to full commitment) to manage natural water quality (which is poor in some cases), contamination due to hydrodynamic changes induced by water use, and pollution, with special emphasis on that due to agriculture and feedstock, but also due to mining. This evolves over time, especially in groundwater, where the appearance of changes is delayed after some pressure is introduced.
- A wider set of case studies. The Guadiana and Doñana case studies are broadly studied from an agricultural point of view, yet water quality aspects are not fully addressed. A few study cases could be added, such as the Plana de Castelló, the lower Júcar and the Río Verde, but these would need additional time and effort. One of the best studied cases is the Llobregat basin, and especially its lower part,

a main source of water to Barcelona's metropolitan area. This basin is dominated by urban and industrial water supply and involves diverse water sources and activities, which include water transfers from other basins, artificial recharge of the aquifers, advanced river water treatment, seawater desalination, waste water reclamation and the integrated use of aquifers in the framework of all water resources. There, water quality is an important issue (Custodio, 2012).

- Food production and its security not only refer to agriculture and feedstock, but to fisheries and other production in open water. Considering open sea fisheries is out of the scope of this book, but other aspects have a close relationship, such as fish and algae production in rivers and lakes, estuaries and deltas, and in the littoral sea affected by continental surface and groundwater discharge. Water policy and food production have an important influence, but are poorly known components.
- A more detailed, basin-scale assessment of the role of land use and land cover changes in the observed reduction of runoff and the analysis of the potential trade-offs of carbon mitigation measures like afforestation from a water management perspective.
- The assessment and valuation of the multiple ecosystem services supplied by Spain's water-dependent ecosystems to reveal the socio-economic importance of securing water bodies and the need to recognize nature as a full water user.
- The analysis and further development of the different methodologies used in the water footprint assessment at river basin level in Spain.
- A more precise picture of groundwater in Spain (e.g. based on the 2009 Agrarian Census), which is necessary to: a) achieve a good status of surface and groundwater bodies; b) to be able to enforce the Water Code; c) to know the manpower and economic means that require the Water Authorities to cope with these issues, and to negotiate with farmers' lobbies.

5 CONCLUSIONS AND RECOMMENDATIONS

The results of this book can be summarized stating that currently in Spain, as in other semi-arid countries, water problems are not due to physical water scarcity but rather to poor water governance and significant inertia and resistance to evolving and adapting to the present challenges. Based on the results obtained at different scales it seems clear that there is room to improve the allocation of water resources at a moderate cost. This cost comes in the form of foregone agricultural production, primarily products with large blue water footprint and low economic value per cubic metre. This might be achieved without producing social disturbances or triggering scarcity of staple foods. However, it is necessary to take into account that agriculture plays a very important role from the standpoint of landscape, biodiversity and rural life, and that any changes in land use affect the whole human and natural systems. Thus, any transition needs to be undertaken keeping in mind indirect impacts and intangible values associated with land and water uses.

Spain has experienced drought cycles for centuries. Its institutions have evolved and become more complex, flexible and diverse. Some flexibility was introduced with water markets since the Water Law was reformed in 1999, but exchanged volumes

so far have been small, highly concentrated in some areas and far from the volumes that would perhaps need to be reallocated in the future. Current environmental degradation shows that ecosystems must be better preserved and ecosystem services boosted. An important opportunity will be to release significant amounts of blue water currently used in producing low-economic value products back to nature and to more competitive sectors, especially if climate change predictions are confirmed.

In Spain, 90% or more of consumptive uses of water for human activities are due to agriculture. International experience shows that farmers' lobbies are extremely powerful and it is almost impossible to achieve sound water and agriculture policies without their collaboration: it is necessary to look for win-win solutions. Farmers have to increase their economic productivity (*more cash per drop*) and also ensure that farming practices become less polluting and compatible with natural ecosystems, that is, the maintenance of *more care for nature*. Today it is a fairly widespread opinion that the former can be achieved with relative ease thanks to continuing advances in agricultural technology. Achieving the second objective does not seem so easy, although the future CAP for 2014–2020 is exploring options to promote greener payments. The current movement driven by the United Nations toward a *Green Growth* may also help.

Water quality related aspects are less developed since information sources in Spain are scarcer and less comprehensive studies are available, shadowed by the high pressure on water quantity that is common in arid and semi-arid countries. This has to be further developed in future publications since it is becoming increasingly relevant, particularly for the agricultural sector, which plays an important role as a polluter and also as a sector susceptible to significant improvements.

Technological advances during the last decades clearly show that most current problems can be solved with means that were unthinkable only twenty years ago. These means are mainly related to the international food (virtual water) trade made possible by modern food storage and transportation systems, the membrane technology, the intensive use of groundwater (but better planned and controlled), and remote sensing techniques as a tool for water and land use monitoring. Moreover, advances in communication technology (mobile phones, Internet) can contribute to increasing the general information transparency and stakeholders' participation in decision-making processes. These are in our view the main findings of the book, and those that have received most attention in many of its chapters.

The rational allocation of water to uses that are considered to be of high value to society – be it economic, social or environmental – would help in reframing the idea of physical water scarcity. Nonetheless, water reallocation among users or from users to nature is far from simple. Similarly, initiatives portrayed as the solution to the water governance *jigsaw*, such as water trade, improved water use efficiency, users' collective action and public participation, are not free from difficulties and shortcomings. However, knowing the economic value of water uses helps dilute the idea that having water is automatically followed by thriving societies and opens the possibility to shift water debates from rights ("water is mine for historical reasons") to needs ("I need water for covering these needs") and from needs to sharing benefits ("how can I cover these needs").

In Spain water has often been used as a political weapon (Llamas, 2005; López-Gunn, 2009) and, as matter of fact, during the past decade water policy issues have

significantly influenced the vote in several regions and have led to tensions between regions, between regions and the State government, and among stakeholders. In the last five years several influential people have advocated that, to temper this political factor in Spanish water policy, it might be necessary to have a political agreement – a Water Pact – between the main political parties based on a shared vision of the future of water in Spain. Having transparent data on available water resources and their uses seems a sensible first step to create awareness of the great changes in the water paradigms that have occurred in the Spanish and global water context. The following step is moving away from nested positions on water, towards the achievement of this Water Pact.

Our work is motivated precisely to provide results and findings that always come with some qualification as to their reliability and trustfulness. Some of our findings are robust, some others subject to further scrutiny. And yet, with all the caveats that our own results and those of others may have, there are reasons to be optimistic about water policy in Spain. We believe this book offers enough evidence to support the contention that a number of crucial measures could make a difference to water policy in Spain. The social and economic costs require a careful and sensible implementation process, yet in our view are affordable and possible.

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