IWMI
Working
Paper

177

Sticks and Carrots: Managing Groundwater Over-abstraction in La Mancha, Spain

Alvar Closas, François Molle and Nuria Hernández-Mora

IWMI
International
Water Management
Institute

USAID
FROM THE AMERICAN PEOPLE

CGIAR
RESEARCH
PROGRAM ON
Water, Land and
Ecosystems

Working Papers

The publications in this series record the work and thinking of IWMI researchers, and knowledge that the Institute's scientific management feels is worthy of documenting. This series will ensure that scientific data and other information gathered or prepared as a part of the research work of the Institute are recorded and referenced. Working Papers could include project reports, case studies, conference or workshop proceedings, discussion papers or reports on progress of research, country-specific research reports, monographs, etc. Working Papers may be copublished, by IWMI and partner organizations.

Although most of the reports are published by IWMI staff and their collaborators, we welcome contributions from others. Each report is reviewed internally by IWMI staff. The reports are published and distributed both in hard copy and electronically (www.iwmi.org) and where possible all data and analyses will be available as separate downloadable files. Reports may be copied freely and cited with due acknowledgment.

About IWMI

IWMI's mission is *to provide evidence-based solutions to sustainably manage water and land resources for food security, people's livelihoods and the environment.* IWMI works in partnership with governments, civil society and the private sector to develop scalable agricultural water management solutions that have a tangible impact on poverty reduction, food security and ecosystem health.

IWMI Working Paper 177

Sticks and Carrots: Managing Groundwater Over-abstraction in La Mancha, Spain

Alvar Closas, François Molle and Nuria Hernández-Mora

International Water Management Institute

The authors: Alvar Closas is Researcher - Groundwater Management and Policy, and currently Acting Office Head, Middle East and North Africa (MENA) region, at the International Water Management Institute (IWMI), Cairo, Egypt; at the time of writing, François Molle was Principal Researcher and Office Head, IWMI, Cairo, Egypt, under a seconded appointment from the Institut de Recherche pour le Développement (IRD), France; and Nuria Hernández-Mora is an independent researcher based in Spain.

Closas, A.; Molle, F.; Hernández-Mora, N. 2017. *Sticks and carrots: managing groundwater over-abstraction in La Mancha, Spain.* Colombo, Sri Lanka: International Water Management Institute (IWMI). 42p. (IWMI Working Paper 177). doi: 10.5337/2017.218

/ groundwater development / groundwater management / groundwater extraction / groundwater irrigation / aquifers / wetlands / ecosystems / water law / water rights / water governance / water rates / water policy / water users / environmental management / agricultural policy / public participation / socioeconomic development / decision making / incentives / legal aspects / regulations / river basins / resource depletion / wells / Spain /

ISSN 2012-5763
e-ISSN 2478-1134
ISBN 978-92-9090-859-3

Please direct inquiries and comments to: *IWMI-Publications@cgiar.org*

A free copy of this publication can be downloaded at
www.iwmi.org/Publications/Working_Papers/index.aspx

Acknowledgements

The authors acknowledge the support provided by José Ramón Aragón Cavaller (Guadiana River Basin Agency), Enrique Calleja (former President, Plan Especial del Alto Guadiana [PEAG]), Alberto Fernández Lop (World Wide Fund for Nature [WWF], Spain) and Elena López-Gunn (ICATALIST) during the various exchanges and communications established during this research study. Also, the valuable comments and suggestions provided by two reviewers and Ian Makin (Interim Deputy Director General, International Water Management Institute [IWMI]), which helped to improve the content of this paper, are gratefully acknowledged.

Project

This work was undertaken as part of the *Groundwater governance in the Arab world: Tacking stock and addressing the challenges* project

Donors

This research study was funded by the following:

Middle East Bureau, United States Agency for International Development (USAID), under the terms of the *Groundwater governance in the Arab world: Taking stock and addressing the challenges* project, Award AID-263-IO-13-00005

Disclaimer

The opinions expressed in this publication are those of the authors and do not necessarily reflect the views of the International Water Management (IWMI) or the United States Agency for International Development (USAID) or the United States government.

Contents

Acronyms

AEP	Agro-environmental Plan
AEMET	Agencia Estatal de Meteorología
ALBERCA	Actualizacion de Libros de Registro y Catalogo
ARYCA	Actualización de Registros y Catálogos
ASAJA	Asociación Agraria de Jóvenes Agricultores
BOE	Boletín Oficial del Estado
CAP	Common Agricultural Policy
COAG	Coordinadora de Organizaciones de Agricultores y Ganaderos
EC	European Commission
ESYRCE	Encuesta sobre Superficies y Rendimientos de Cultivos
EU	European Union
GWUA	Groundwater User Association
INE	Instituto Nacional de Estadística
IWMI	International Water Management Institute
MAGRAMA	Ministerio de Agricultura, Alimentación y Medio Ambiente
MENA	Middle East and North Africa
PEAG	Plan Especial del Alto Guadiana
PP	Partido Popular
PSOE	Partido Socialista Obrero Español
RBA	River Basin Authority
RBMP	River Basin Management Plan
SEO	Sociedad Española de Ornitología
UPA	Unión de Pequeños Agricultores y Ganaderos
USAID	United States Agency for International Development
WFD	Water Framework Directive
WWF	World Wide Fund for Nature

Foreword

This paper is part of a wider research initiative undertaken by the International Water Management Institute (IWMI) and funded by the United States Agency for International Development (USAID), with the aim of addressing the challenges posed by the unsustainable use of groundwater in the Middle East and North Africa (MENA) region (For more information, visit the website http://gw-mena.iwmi.org). Groundwater over-abstraction is a phenomenon also threatening the sustainable economic and social development of the countries on the southern side of the Mediterranean, and the control and management of over-abstraction has become a clear challenge for policy-makers, managers and academics in the region. This broader research exercise presents different governance problems and challenges that exist around the world in relation to groundwater, and informs potential future management and policy pathways in the MENA region.

Semi-arid and arid countries are more likely to (over)exploit their groundwater resources. Northern and southern Mediterranean countries have many common climatic and agricultural features, and they all face dramatic increases in the use of groundwater for irrigation. The paper analyzes, through a political and historical lens, the different groundwater regulatory tools, laws and regulations, community actions and institutional structures put in place in Spain in order to curb groundwater over-abstraction. This paper arises out of the necessity to examine, at various scales, existing cases of groundwater regulation and management, so that policy solutions and mitigation measures to the groundwater crisis may be found.

Despite different socioeconomic and political contexts, the example of Spain can provide a deeper understanding of the challenges countries in the MENA region face when it comes to reducing groundwater abstraction. This is due to the fact that the sequence of policies attempted and implemented in the country bears resemblance to similar attempts to regulate groundwater abstraction made by other states in the region. The challenges faced by governments and communities can provide relevant insights on how to enforce regulations or understand legal barriers to policy implementation, which are all relevant and important lessons for other countries. Reflecting on a wealth of background stories and experiences will also provide a richer understanding and diversity of insights to these problems. Lessons also indicate potential solutions or - more often than not - flag the dangers or irrelevance of certain standardized, or seemingly desirable, policies. The gravity and complexity of the situation caused by groundwater over-abstraction requires a systematic and wide-ranging approach building on existing knowledge and practices in and beyond the region, so that innovations in groundwater regulation and legislation can be found and the groundwater depletion trend averted.

Summary

Since the 1970s, groundwater-fed irrigation has sustained the social and economic development of La Mancha, Spain. Without much initial regulation and control, groundwater resources and aquifer levels decreased dramatically, threatening agriculture and also highly valuable groundwater-dependent wetland ecosystems. This paper presents a historical analysis of the different policy tools used to manage and regulate groundwater abstraction in the Western Mancha aquifer after Spain approved its 1985 Water Law. It analyzes, in chronological order, the evolution of the panoply of control and management instruments introduced by the state to counter the resource depletion trend. The case presented here is paradigmatic due to the variety of policy tools applied, and its attempted implementation at various political and administrative levels. The interplay between sticks and carrots used in La Mancha shows the necessity for regulatory bodies to complement soft management approaches based on incentives with the threat of sanctions and limitations. However, as this case study shows, each policy modality has its legal and practical loopholes, which can be negotiated and exploited by groundwater users to their own advantage. Moreover, the costs of most measures, if they are to be implemented fully, can also be financially prohibitive.

The paper also studies the distribution of decision-making power and how local dynamics and individual behaviors are linked to higher level regulations and policies and their impacts on groundwater management, with an emphasis on the effectiveness and limitations of these tools. Thus, the lack of effective law enforcement, fragmented political realities and a difficult legal transition towards well licensing are all problems that remain unresolved. The political instrumentalization of water management in La Mancha, and the lack of trust and dialogue between users and the state, have created a stalemate detrimental to improving groundwater management. The recuperation of water table levels starting in 2010 seems to be linked to aquifer recharge, following an unprecedented wet cycle rather than the effectiveness of the policy tools.

1. INTRODUCTION

Groundwater over-abstraction is a vexing issue in many parts of the world and exercising control over it is a clear challenge for policy-makers, managers and academics alike. There are both limited success stories and a large diversity of physical, institutional and cultural contexts, making it difficult to draw lessons or derive recommendations across the board. Many policy instruments have been devised to manage and control groundwater abstraction. They include supply augmentation and demand management options as part of a panoply of sticks and carrots that can be implemented by a wide range of players such as governments and management regulatory agencies. Sticks are regulatory instruments acting as disincentives of certain actions with potentially punitive consequences, economic or otherwise (e.g., quotas limiting groundwater abstraction, tariffs, sanctions, well closure). Carrots are used to regulate actions through positive incentives usually in the form of economic support (e.g., subsidies, water rights buyback programs). 'Sermons' are considered a third type of policy tool, a voluntary instrument attempting to influence people's behavior through the transfer of knowledge, and communication of arguments and persuasion (Bemelmans-Videc 1998; Turnpenny et al. 2015). Against this backdrop, this paper will review a range of policy instruments applied to groundwater management and regulation in the Upper Guadiana Basin in Spain. In order to further illustrate the process of policy making, the paper will also examine the distribution of decision-making power and how local dynamics and individual behaviors are linked to higher level regulations and policies and their impacts on groundwater management.

Spain is a largely semi-arid country notable for the importance of surface water and groundwater resources in its economy, for its highly developed water storage capacity and for the high number of wells, which is estimated to be between 1 and 2 million (De Stefano et al. 2015; Llamas and Garrido 2007). It offers a rich history of policies that have been implemented in order to control groundwater use. Of its 699 water bodies underlying approximately 70% of the country, 232 are at risk of not fulfilling the environmental indicator standards established by the European Union (EU) Water Framework Directive (WFD) (IGME 2012; De Stefano 2013).[1] Among those, the Western Mancha aquifer, located in the Upper Guadiana River Basin, stands out in the literature as an iconic example of the problem of sustaining both irrigated agriculture and environmental needs. This paper looks at the history of groundwater use and policies in the past 30 years as applied in the Western Mancha aquifer. It also draws generic lessons from the diversity of regulations that have been implemented, the interplay between stick and carrot instruments, and how legal loopholes can be negotiated and exploited by groundwater users. The paper concludes with reflections on the power and capacity of the state to reorder groundwater regulation and management.

2. THE GROUNDWATER FEVER IN LA MANCHA

2.1 Characterization of the Western Mancha Aquifer

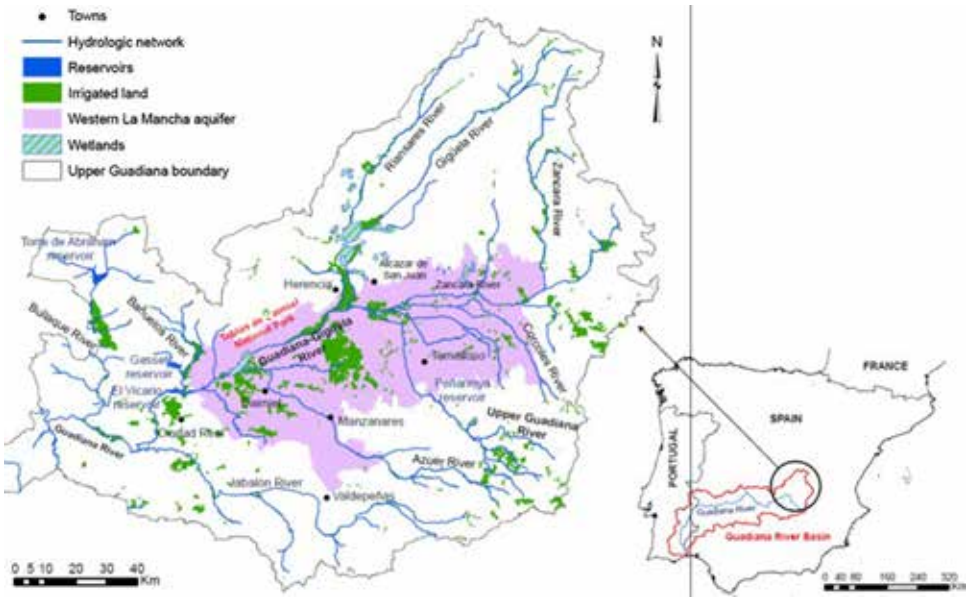
The Mancha region, in south central Spain, presents a unique example of a semi-arid region where intensive groundwater use has helped transform a largely poor rural economy into a vibrant and economically viable region. In an area where surface water resources are scarce, irregular and not

[1] The good status of groundwater bodies is defined quantitatively and qualitatively by the WFD (Directive 2000/60/EC) approved in 2000. Good quantitative status is achieved in terms of the WFD when "the level of groundwater in the groundwater body is such that the available groundwater resource is not exceeded by the long-term annual average rate of abstraction" (European Commission, Directive 2000/60/EC, Annex V, WFD).

readily available, the development of the region's rich groundwater resources starting in the 1970s has made this economic change possible.

The geographical area of La Mancha is administratively located in the autonomous community of Castilla-La Mancha. The climatic conditions of La Mancha are semi-arid, with hot and dry summers and short winters, and an annual average rainfall of 415 mm (Martínez-Santos et al. 2008). The Western Mancha aquifer, with an extension of 5,500 km^2, is part of the Upper Guadiana sub-basin, which has an area of 16,130 km^2. This sub-basin is part of the Guadiana River Basin, a 60,256 km^2 transboundary basin shared by Spain and Portugal (Figure 1).

FIGURE 1. The Western Mancha aquifer.



Source: Varela-Ortega et al. 2011.

The Upper Guadiana River Basin is drained by the Guadiana River and its tributaries, in what constitutes a highly interconnected network of rivers and streams, wetlands and aquifers. A set of four aquifer systems that are hydrologically connected underlie the upper basin: the Western Mancha (*Mancha Occidental*), the Campo de Montiel, the Sierra de Altomira and Mancha de Toledo aquifers. The Western Mancha aquifer is the main aquifer, both in terms of areal extent and groundwater storage capacity. The River Basin Management Plans (RBMPs) approved in compliance with the WFD divided the Western Mancha aquifer into three groundwater bodies: Western Mancha I, Western Mancha II and Rus-Valdelobos (the latter including a small area that was not previously part of the Western Mancha water body).

Morphologically, the Western Mancha region is characterized by a gentle topography, with altitudes ranging between 600 and 700 meters above sea level (masl). The topography together with the geological characteristics of the region are responsible for the poorly defined surface drainage system, the interconnectedness of surface water and groundwater resources, and the network of wetlands that lace the area and create a unique humid ecosystem.[2] Historically, wetlands and lakes

[2] This humid ecosystem was given the name 'The Humid Mancha Ecosystem', a network of lakes, riverine wetlands, karstic shallow lakes, tables (formed by the confluence of river overflow and groundwater discharge resulting in the shallow flooding of about 1 meter deep of large areas) and more recently artificial lakes and ponds dotting the Mancha landscape.

covered 25,000 ha, or about 1% of the Upper Guadiana River Basin, the natural discharge area for the entire upper basin (Cruces et al. 1998). Their uniqueness in comparison to other riverine wetlands was due to the mix of water sources: highly mineralized water from the Záncara and Cigüela rivers mixed with the less saline groundwater emerging from the Western Mancha aquifer. In 1981, the entire Humid Mancha Ecosystem – a 400,000 ha wetland-rich region − was designated a United Nations Educational, Scientific and Cultural Organization (UNESCO) Biosphere Reserve (ibid.) The reserve includes the Tablas de Daimiel, an international wetland and a National Park protected by the Ramsar Convention since 1982, which is fed with water from the Western Mancha aquifer and the Guadiana and Cigüela rivers (IGME n.d.a, n.d.b; Martinez Cortina et al. 2011; Mejías Moreno 2001; Mejías Moreno et al. 2012).

Prior to the transformation induced by the extension of irrigation in the 1970s and 1980s, dryland cereals and vineyards were the primary crops together with sheep rearing. From the late 1970s onward, irrigation spread and crops with high water demands, such as corn, sugar beet and alfalfa, started to predominate. In the peak of the irrigation era by the mid-1980s, between 105,000 and 135,000 ha were being irrigated from the Western Mancha aquifer (López Gunn and Hernández-Mora 2001).

The socioeconomic importance of agriculture, and of irrigation in particular, in the Western Mancha is underscored by the land tenure structure in the area. Small to medium-sized farms predominated during the time of expansion of groundwater use, with 44% of the farms being less than 5 ha in size and 82% less than 20 ha (López Sanz 1998). While landownership concentration has occurred between 1999 and 2009, especially in dryland farming, irrigated land property continues to be fragmented, with average farm sizes of 9.17 ha/farm (Confederación Hidrográfica del Guadiana 2016a, 2016b). As a result, any restriction on groundwater use has wide social and economic implications and can be highly contentious.

2.2 Groundwater Development and Use in the Western Mancha Aquifer

In 2013, groundwater supplied 22% of the total water demand in Spain with agriculture being its main user (73% of the total groundwater demand) (De Stefano et al. 2013). In La Mancha, the rapid development of groundwater abstraction occurred between the 1960s and 1970s, when farmers tapped into the Western Mancha aquifer with increasingly powerful pumps in order to extract larger groundwater volumes and reach deeper layers, resulting in aquifer drawdown (Closas 2014).

This ‘silent revolution’ (Fornés et al. 2005) occurred, however, not only as a result of the private initiative of farmers driving groundwater development with modern boreholes, but also with state-led colonization and resettlement policies in areas such as La Mancha,[3] coupled with irrigation subsidies which helped sustain the groundwater-fed irrigation boom (Closas 2014). Along with market demand for cash crops, agricultural subsidies and a loose regulatory regime of groundwater abstraction rights, this state-fuelled and farmer-led ‘green revolution’ brought about significant drawdowns in aquifer levels in the Western Mancha and neighboring Campo de Montiel aquifers. It also caused the environmental degradation of the groundwater-dependent Mancha Húmeda Biosphere Reserve. As a result of groundwater level drawdowns, the Tablas de Daimiel National Park underwent a reduction in its naturally inundated area from 1,800 ha in the 1960s to as little

[3] In the 1950s, the state built three colonization areas in La Mancha with new irrigation works and two towns: Llanos del Caudillo and Cinco Casas. The newly irrigated Peñarroya area used surface water from a neighboring 47.5 million cubic meter (Mm^3) storage capacity dam to irrigate 8,176 ha. The irrigated areas of Llanos del Caudillo and Cinco Casas used groundwater wells to irrigate around 2,000 ha (Closas 2013, 2014).

as 15 ha in 2009. This also led to some graphic instances of burning peat in 1988 and, again, in 2009 within the National Park and near the iconic '*Ojos del Guadiana*' springs.[4]

Intensive groundwater use for irrigation in the Western Mancha, aggravated by drought periods in the mid-1970s, mid-1990s and again during the period 2005-2009, resulted in significant water table drawdowns (MMA 2008a; Mejías Moreno et al. 2012). Mejías Moreno et al. (2012) distinguished four phases in the evolution of groundwater levels and abstractions in the Western Mancha. Between 1980 and 1995, there was an uncontrolled expansion of groundwater abstraction for irrigation, with over 650 Mm^3 being pumped annually against an estimated average annual natural recharge of 230 Mm^3 per year (Bromley et al. 2001; IGME n.d.a, n.d.b; Varela-Ortega 2007). This resulted in average water level drawdowns of 1.8 m/year until 1988 and up to 2.3 m/year until 1995, coinciding with the peak of the drought period. As a result, aquifer levels deteriorated, reaching a record low in 1995-1996, with, for example, 43 m below the surface measured at the *Ojos del Guadiana* (Figure 2). Aquifer storage decreased by an estimated 3,790 Mm^3 during that time. Between 1995 and 2000, aquifer levels recuperated (on average, 2.5 m/year) due to higher precipitation and lower pumping volumes in response to the *Wetland Program* implemented in the region (see section 4), resulting in an estimated aquifer storage recovery of 1,750 Mm^3. Between 2000 and 2009, groundwater levels responded to the evolution of precipitations since abstractions were stable at fairly high levels throughout that period. Over 1,000 Mm^3 were lost from aquifer storage. Starting in December 2009, the combination of an exceptionally wet cycle, which culminated in 2013 with the wettest year since records began at the *Ojos del Guadiana* springs in 1988,[5] together with new policy initiatives, resulted in the most significant recuperation in groundwater levels, with average annual increases of water table levels of 6 m/year until 2011 (Figure 2) and a recuperation of storage of about 2,000 Mm^3. The iconic *Ojos del Guadiana* springs, which had dried out in 1983, reappeared in 2010 (Confederación Hidrográfica del Guadiana 2010). As will be discussed below, some critical voices (Martínez-Santos et al. 2008; WWF 2012) have suggested that such a recovery is due to exceptional rainfall and not the result of state-sponsored groundwater recovery plans.

3. REGULATING GROUNDWATER ABSTRACTION RIGHTS

3.1 Historical Groundwater Abstraction Regulation and Reform Attempts in 1985

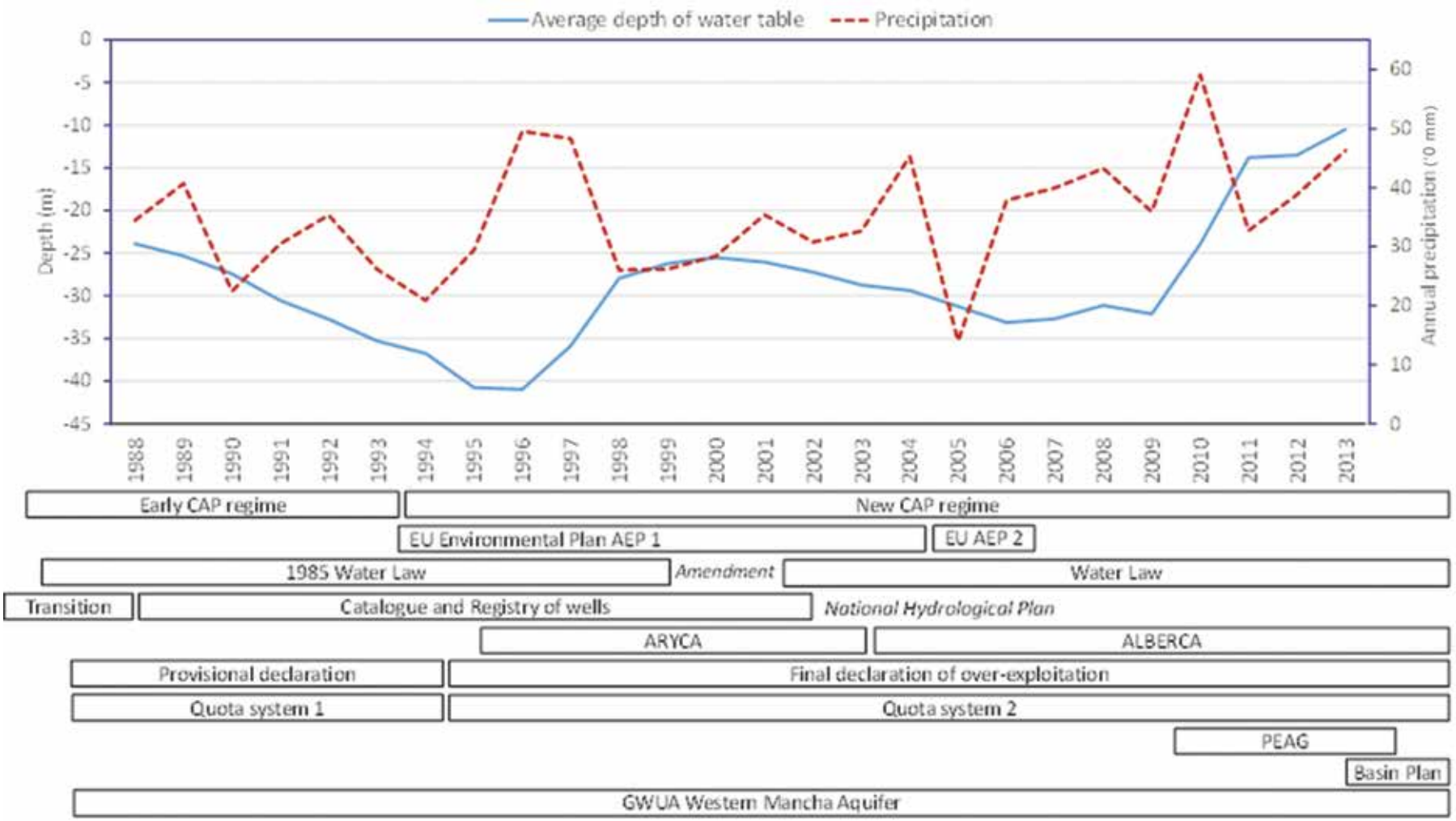
During most of the twentieth century, groundwater abstraction rights in Spain were linked to landownership. The 1879 Water Law granted private groundwater rights to landowners as a way to sustain private property and increase the profitability of groundwater abstraction ventures. This had been sought by the bourgeoisie after the liberal revolutions in Spain during the nineteenth century[6] to secure investments in property (Closas 2013).

[4] Located around 12 kilometers northeast of Daimiel, the 'Ojos del Guadiana' (Eyes of the Guadiana) springs are a natural water surfacing phenomenon caused by the combination of a depression of the terrain in the center of the Western Mancha aquifer and a naturally high water table discharging into the surface.

[5] See Bórnez Mejías (2014) for a study of the piezometric evolution during this period. Also, see data published regularly by the Centro de Interpretacion del Agua y los Humedales Manchegos - "Nuevos datos avalan recuperacion del Guadiana", December 13, 2013. Available at http://www.tablasdedaimiel.com/Noticia/6078/nuevos-datos-avalan-la-recuperaci-n-del-guadiana (accessed June 21, 2016).

[6] The liberal movement started in 1812 with the first constitution promulgated in Spain during the War of Independence between Spain and France (1808-1814), and continued during the nineteenth century through different liberal revolutions and conservative counter-revolutions until restoration of the monarchy in 1875.

FIGURE 2. Policy chronology, average precipitation and evolution of aquifer levels.



Sources: Data on groundwater levels - Centro de Interpretación del Agua, Daimiel, Spain; average monthly precipitation measured at the Ciudad Real weather station for series 1988-2010 and 2013 – Agencia Estatal de Meteorología (AEMET), and for series 2011-2012 – Instituto Nacional de Estadística (INE).

Notes: CAP: Common Agricultural Policy; EU: European Union; AEP: Agro-environmental Plan; ARYCA: Actualización de Registros y Catálogos (Actualization of Registries and Catalogues of Abstractions); ALBERCA: Actualización de Libros de Registro y Catalogo (Actualization of Registry Books and Catalogue); PEAG: Plan Especial del Alto Guadiana (Special Plan for the Upper Guadiana); GWUA: Groundwater User Association. Average annual depth of the water table measured at the groundwater abstraction well for Daimiel's public water supply, located near the *Ojos del Guadiana*. Average precipitation measured for the province of Ciudad Real.

In 1934, a new decree stipulated that a permit issued by the Ministry of Mines was needed once the well had been drilled or dug, but only as a method of registering the well and not to control or limit groundwater abstraction (ibid.). Despite the 1934 regulation, wells in Spain continued to be drilled without permits. The weak enforcement of the 1934 decree was due to the fact that it did not supersede higher level laws (e.g., the 1879 Water Law) and in instances of conflict, the Supreme Court of Spain recognized in many occasions the protection of non-registered wells, reverting in its judgment to the primary private nature of groundwater (Moreu Ballonga 2002).

The reform of this system of groundwater abstraction rights only came in 1985 when a new law was approved in the context of wider political and socioeconomic changes. After 40 years of dictatorship and centralized government, a democratic system was established in 1975. Seventeen Autonomous regions (*Comunidades Autónomas)* gradually assumed administrative powers in matters related to health, education, agricultural, environmental and land use policies. In terms of water management, the 1985 Water Law established that, when a river crosses more than one autonomous region, a central government-backed River Basin Authority (RBA) (*Confederación Hidrográfica*) has management and planning responsibilities (Box 1). The Guadiana River Basin is shared between three Spanish autonomous regions (Castilla-La Mancha, Extremadura and Andalucía) and Portugal, and is managed by the Guadiana RBA. When the river basin remains within an autonomous region, it is that region's government that is responsible (Hernández-Mora et al. 2014).

Box 1. River Basin Authorities (RBAs) in Spain.

The increasing conflicts around the distribution of political and management powers between RBAs, as branches of the central government in Madrid, and new regional governments – Autonomous Communities – created after 40 years of centralizing dictatorship, also helped fuel the water allocation conflict between users and the state. RBAs that manage interregional river basins are functionally dependent on the Ministry of Agriculture, Fisheries, Food and the Environment[7]. However, their complex organizational and institutional structure integrates the state, the different autonomous regions within the river basin, and a representation of different permitted users (irrigators, and users of urban water supplies and hydroelectricity). Environmental protection interests are only nominally represented (Varela-Ortega and Hernández-Mora, 2010). The autonomous regions within the basin are present in the Governing body of RBAs *(Junta de Gobierno),* their Consultative Council *(Consejo del Agua),* and the Competent Authorities Committee, created in 2007 to coordinate the sectoral policies of the regional governments with water planning and management goals.

RBAs and their functions evolved from a focus on the development of infrastructure projects without a real river basin management approach to a growing emphasis on integrated water resources management and planning, which started after the 1985 Water Law (AEVAL 2010) and, more clearly, during the process of implementation of the WFD that started in 2004. Amidst this increasing institutional and political complexity with the decentralization of political power to the autonomous regions, RBAs have managed to retain control over the management of interregional river basins with insufficient regional participation (Del Moral Ituarte and Hernández-Mora 2016; Font and Subirats 2010). RBAs, which are funded through user fees and transfers from the central government and European Union cohesion funds, are largely underfunded. This is a situation that has been accentuated over the past few years because of the profound economic and budgetary crisis in Spain, causing a weakening of their role as planners and regulators (Font and Subirats 2010).

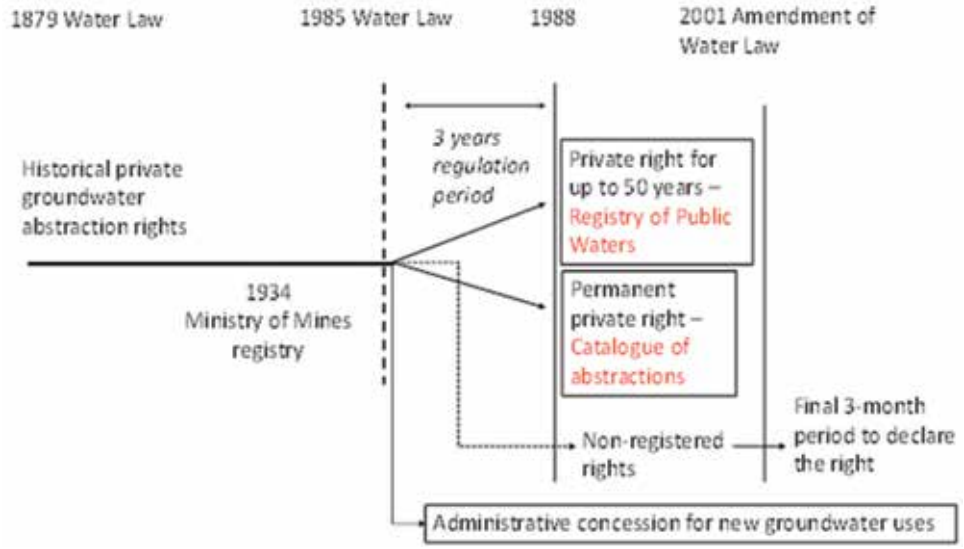
[7] In Spain, environmental issues, in general, and water responsibilities, in particular, have been under different ministries over time. In this paper, we refer to the ministries as they were called when decisions were made or relevant documents published that are mentioned here. In 1993, in response to increasing environmental concerns, the name of the Ministry of Public Works was changed to Ministry of Public Works, Transportation and the Environment, thus incorporating environmental issues into a ministerial title for the first time. In 1996, the Ministry of the Environment was created incorporating water management and planning responsibilities. In 2008, it was merged with the Ministry of Agriculture and renamed: Ministry of Environment, Rural and Marine Affairs. In 2011, the ministry was once again renamed as the Ministry of Agriculture, Food and the Environment.

The 1985 Water Law also changed the regime of groundwater abstraction rights from one that was private to public. Water (including aquifers) was declared a 'public domain', and the state would regulate and control groundwater abstractions via concessions for all users (except wells withdrawing less than 7,000 m^3/year) issued by RBAs (Closas 2012). The original aim of the law was to also bring all groundwater rights to a common same status, by transforming historically acquired private groundwater rights into concessions after a transitional period (Moreu Ballonga 1996).

The 1985 law required any new groundwater users to obtain administrative concessions and, in order to avoid expropriation claims, gave owners of preexisting wells two options. The first option was to register their historical rights in the Registry of Public Waters as a "temporary private water right." This option granted users a temporary state of private ownership for an additional 50 years until 2035. After this period, these users would be given priority by the state to receive an administrative concession to continue enjoying their right to groundwater use. The second option was to remain in the private property regime indefinitely by registering the rights in the Catalogue of abstractions (Private Waters). In either case, a modification of the originally declared characteristics of the well or groundwater volumes abstracted (location, depth or abstraction capacity) automatically extinguished the preexisting right and required users to request a new concession granted by the RBA. Theoretically, the incentive to register historical groundwater rights in the Registry of Public Waters was the 'administrative protection' granted by the state as contemplated in the water law, which would last as long as the concession lasted. All groundwater users had to prove that they were abstracting water prior to the enactment of the Law, by presenting proof of groundwater use before 1985. This point, however, led to significant administrative chaos as neither the law nor subsequent ministerial regulations specified what document could be used as proof of use before 1985.[8]

The law gave groundwater users 3 years to register their rights through either of these two options (Figure 3). If groundwater users had not declared their rights after this period, they would automatically be considered as part of the Catalogue. The decision by the state to maintain the

FIGURE 3. Evolution of private groundwater abstraction rights in Spain.



[8] In some cases, a simple note signed by the mayor was accepted. In other cases, the registration certificate from the Ministry of Mines or the land property title stating that the estate was being irrigated prior to 1986 along with the property deeds (Hernández-Mora 1998; Ruiz Pulpon 2007) were accepted. The process caused confusion regarding the administrative procedures to be followed by well owners and the legal appeals to the different verification tools used by the state, causing a backlog which lasted for years.

option of private groundwater abstraction rights was designed to avoid the need to financially compensate users for the loss of their private right (Cabezas Guijarro and Sánchez 2012), as dictated by Article 33 of Spain's constitution, in case the state would privatize or limit access to a good or property (ibid.). Some groundwater users saw, in this formulation, a way to maintain private ownership of their rights and an exit door to the legal imbroglio caused by the new water law (Llamas et al. 2001). Still, many other groundwater users were uncertain about the meaning and extent of the 'administrative protection' promised by the state, as well as by having to choose between the Catalogue or the Registry without knowing exactly the advantages of each of the options (Requena and Garcia 2010). *Partido Socialista Obrero Español* (PSOE) (the Spanish Socialists Workers' Party), in power at the time, was mainly involved in supporting this change in ownership of groundwater abstraction rights (from private to public), an alleged 'nationalization' of natural resources, which would have meant large compensations to private right holders. The main opposition party (*Partido Popular* [PP], the conservative People's Party), however, considered this measure to be unconstitutional as it would infringe on private property, individual rights and liberties (BOE 1985). Even though PP filed an appeal to revoke the application of the water law, the Constitutional Tribunal[9] considered that the 1985 Water Law did not infringe individual rights, as the Constitution did not grant the right of private property in absolute terms (Moreu Ballonga 2002). What was then instituted was a 'hybrid system' where, in theory, most groundwater abstraction rights would eventually migrate to the public Registry (Elena López-Gunn, Senior Researcher, Water Observatory, Botin Foundation, pers. comm., May 12, 2014).

A combination of lack of information given by the state, lack of trust of groundwater users vis-a-vis the Guadiana RBA, and the fact that many wells had not been registered with the Ministry of Mines in spite of the 1934 requirements, resulted in only an estimated 10 to 20% of all private groundwater abstraction rights being registered in the Registry and only 8% in the Catalogue (Fornés Azcoiti et al. 2005). The balance remained unregistered and liable to penalties from the RBAs. The reluctance from groundwater users to relinquish formal historical rights, coupled with the politically controversial enforcement of these regulatory measures by the state and the lack of public funds, led to a situation where hundreds of thousands of wells remained in legal limbo, outside the regulatory framework established by the 1985 Water Law (Moreu Ballonga 2002).

Delays in the registration process due to a last minute rush in application submissions, together with unclear regulatory guidelines and insufficient resources in RBAs, meant that, in most cases, well registrations did not start until 1991. The resulting administrative deadlock helped sustain a generalized sense of distrust and impunity among farmer groups (Martínez-Santos et al. 2008). The situation of the Guadiana RBA was no exception. The new legal measures were undermined by logistics as the submission of an additional 12,000 applications for permits for groundwater abstraction rights, on the last day of the registration period in 1988, overwhelmed and crippled the Guadiana RBA (Closas 2013; Fornés et al. 2005).[10]

3.2 Subsequent Regulatory Attempts of Groundwater Abstraction

In an effort to regularize the situation of groundwater rights, the government launched two consecutive ambitious programs for interregional river basins: the Actualización de Registros y Catálogos (ARYCA) (Actualization of Registries and Catalogues of Abstractions) and the

[9] The highest court in Spain in charge of dictating whether laws are constitutional or not.

[10] As studied by Closas (2013), the majority of registrations for groundwater rights at the Guadiana RBA came from the province of Cuidad Real in La Mancha. This happened at the end of the 3-year period, concretely on the December 31, 1988.

Actualización de Libros de Registro y Catalogo (ALBERCA) (Actualization of Registry Books and Catalogue). ARYCA was envisioned as a census of groundwater abstractions in the *White Book on Groundwater* released in 1994 by the Ministry of Public Works, Transportation and Environment (MOPTMA and MINER 1994). It intended to clarify the legal status of groundwater use in Spain by: (i) completing the registration process of the thousands of wells previously declared for inscription in either the Registry or the Catalogue; and (ii) inventorying and registering non-declared abstractions, thus identifying potential illegal wells (i.e., those drilled after 1985 without an administrative concession) (ibid.).[11]

The *White Book on Water* released in 2000 (MMA 2000) described the implementation of the ARYCA program as 'discouraging', due to the slow registration process and its limited budget. The results of the program in 2002 showed an estimated number of 433,576 wells in Spain were declared: 43% had been registered; 13% were being processed; and the remaining 188,139 registrations were still pending. However, these estimates did not include wells in interregional river basins, i.e., those basins that are managed by autonomous regions and which include several intensive water-use areas such as the Balearic Islands and the coastal basins of Andalucía or Catalonia. According to MMA (2000), the total number of wells in Spain is closer to one million, and it is around two million according to Llamas et al. (2001). As a result of the limited success of the ARYCA program, the 2001 National Hydrological Plan (Law 10/2001) introduced a final three-month deadline for groundwater users to register their rights in the Catalogue of Private Waters, which essentially represented a closure of the catalogue after that period.[12]

The ALBERCA program that followed in 2002 aimed to streamline and homogenize the permit registration process in the Registry of Public Waters in every RBA, characterizing existing uses (including georeference and type of use), and modernizing the Registry via computerization and digitalization to make information available online. According to the Ministry of Agriculture, Food and the Environment, requests for 566,316 registrations for both surface water and groundwater rights had been submitted to the ALBERCA program as of January 2013, of which 466,272 were being processed. Eighty percent (80%) of these (415,420) were groundwater use rights (MAGRAMA 2012a). In 2010, in its assessment of RBAs, data provided by the Spanish Agency of Evaluation and Quality stated that around 46% of all well regularization files in Spain had been processed and resolved (AEVAL 2010).

The process of registration of groundwater rights in the Western Mancha aquifer was also long and contentious. According to unpublished data from the Guadiana RBA (Hernández-Mora and López-Gunn 2003), in 2001, 17,563 rights had been registered in the Western Mancha aquifer covering a 133,149 ha irrigated area, and over 7,000 requests were pending. Martínez-Santos et al. (2008) estimated that nearly 40,000 wells exist in the Western Mancha aquifer and only 17,000 had been registered at the Guadiana RBA in 2008. So, no significant progress had been made. Furthermore, based on data from the ALBERCA program, the Guadiana RBA estimated that there were 52,408 ha of illegally irrigated land in 2008 (i.e., without registered permits) (MMA 2008b). It was not until the Special Plan for the Upper Guadiana Basin (*Plan Especial del Alto Guadiana* [PEAG]) was launched in 2008 (see section 5 below) that a clear picture of existing groundwater use in the Western Mancha aquifer was publicly available.

[11] The Registry is not closed, as new concession requests are still being submitted for both surface water and groundwater use. Section C of the Registry, which includes the 'temporary private rights', cannot include registration requests made after 1988. However, section C continues to be updated as pending requests are processed (78,157 as late as 2012 according to MAGRAMA [2012a]).

[12] For groundwater uses existing prior to 1985 and for aquifers declared 'over-exploited', the only way to recognize groundwater abstraction rights after that deadline was to go via the judicial system and obtain a court ruling, which, in some cases, could mean resorting to the Supreme Court and spending 8 to 12 years in various courts proving the ownership of the groundwater abstraction right (Fornés et al. 2005).

4. STICKS AND CARROTS TO CONTROL GROUNDWATER ABSTRACTION

Over the years, different policy measures have been put in place in the Upper Guadiana Basin using a combination of incentives and regulations to curb groundwater abstraction and recover the groundwater-dependent wetland ecosystems. Different administrations have taken part in the development, funding and implementation of the various measures (the Guadiana RBA, the Autonomous region of Castilla La Mancha, the central government and even the European Union) with different degrees of success.

4.1 The "Stick" of the Guadiana River Basin Authority and the 1985 Water Law

The 1985 Water Law allowed the state to declare aquifers as 'over-exploited[13] and, as a result, entrusted RBAs with the power to enforce emergency regulatory regimes limiting groundwater abstraction. In the case of the Western La Mancha aquifer, a provisional declaration of over-exploitation was approved in 1987. In compliance with the declaration of over-exploitation, the Guadiana RBA approved the first annual groundwater abstraction regime *(Régimen de Explotación)* for the aquifer in 1991. This included: (1) volumetric restrictions for individual wells; (2) prohibition to drill new wells; (3) freezing all new groundwater abstraction concessions; and (4) obligation to create a community of groundwater users with the purpose of overseeing the implementation of the newly established emergency abstraction regime (Closas 2013; Hernández-Mora 1998). However, groundwater abstraction limitations were only imposed on the users that have registered their wells in the Registry of Public Waters or in the Catalogue, as illegal wells were not known or identified. These restrictions would remain in place as long as the declaration of over-exploitation lasted.

The 1991 groundwater abstraction regime (quota system 1), put in place by the Guadiana RBA, established maximum irrigation quotas calculated on the basis of what it called normal consumption *(consumo normal)*, set at 4,278 m^3/ha/year.[14] Maximum pumping quotas were modulated in relation to the amount of land being irrigated, which ensured that as the irrigated area increases, the amount of water allocated per hectare decreases: a 5-ha farm would be able to use its total groundwater allocation (i.e., 4,278 m^3/ha) whereas a 20-ha farm would only be allowed to use 2,352 m^3/ha, and a farm of 100 ha would be limited to using only 1,375 m^3/ha (Figure 4) (Closas 2013). Farmers growing vines had a limited allocation of 2,000 m^3/ha/year.

In spite of these measures, and in view of the continuing depletion of the Western Mancha aquifer, the Guadiana RBA tightened the quota regulation. In 1994, the Western Mancha aquifer was legally declared definitively over-exploited *(declaración definitive de sobreexplotación)* and a new groundwater exploitation regime had to be approved by the RBA. This regime established a new maximum allowable pumping quota (quota system 2) of 2,000 m^3/ha for all users, land owned and crops, except for vine, which was given a new maximum allowance of 1,500 m^3/ha (Varela-Ortega 2007). These quotas were intended to be modified annually according to evolving climatic and demand conditions.

The 1985 Water Law also gave the Guadiana RBA enforcement authority to control groundwater use and impose sanctions for illegal wells and excessive abstractions, although this authority was significantly sustained from the outset by a lack of staff for monitoring and control (AEVAL 2010).

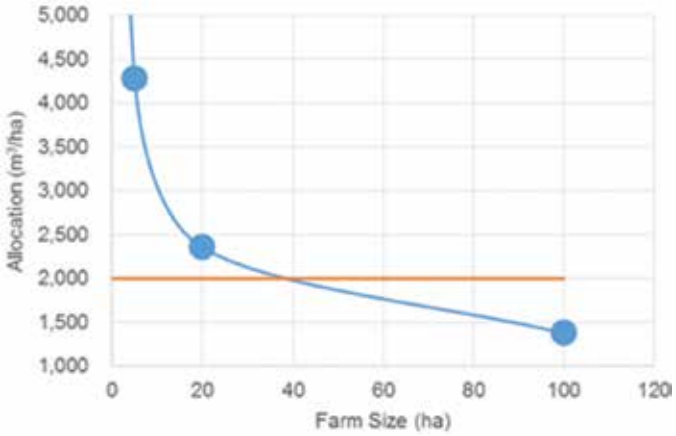
---

[13] Under the 1985 Water Law and its developing statutes, RBAs could declare an aquifer over-exploited when groundwater pumping exceeded annual average recharge rates, when existing uses were at risk, when groundwater quality was deteriorating or when groundwater levels were experiencing continuous declines. The legal declaration of over-exploitation allowed RBAs to impose limits on groundwater abstractions and develop annual management plans. Additionally, users in a legally declared over-exploited aquifer had to organize themselves into user communities to facilitate collaboration with the RBA.

[14] The estimated normal consumption of 4,278 m^3/ha/year consisted of an average estimate based on the existing irrigated area, types of crops, and abstracted volume of groundwater resources in 1985 (José Ramón Aragón Cavaller, Guadiana River Basin Authority, pers. comm., August 1, 2016).

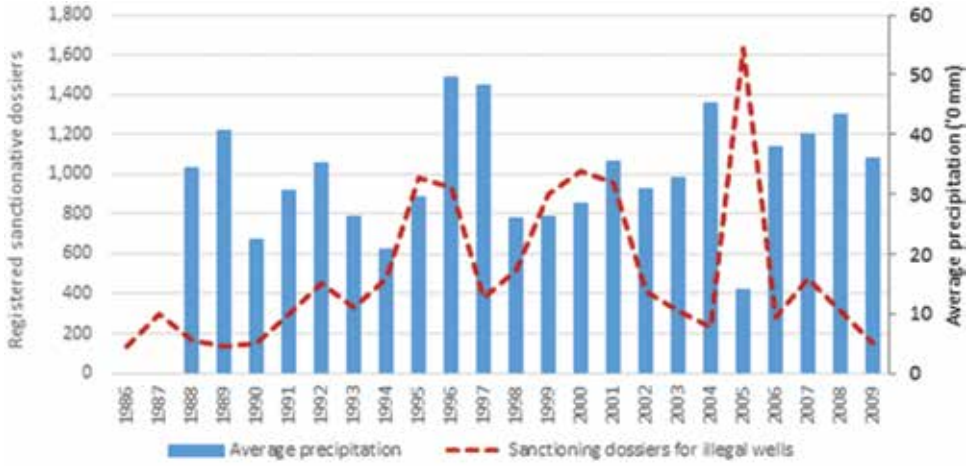
Sanctions ranging from EUR 3,000 to EUR 30,000 per farmer were put in place for violations of the emergency groundwater abstraction regime (López-Gunn 2003). The installation of meters commenced in 1996, with farmers covering the installation costs (ibid.). Since not all wells had meters installed, groundwater abstraction was also monitored via so-called 'consumption tables' based on groundwater consumption estimates for different crops established by the Regional Agricultural Center (Elena López-Gunn, Senior Researcher, Water Observatory, Botin Foundation, pers. comm., May 12, 2014). The RBA also used remote sensing to assess groundwater use and identify plots with excess water use. RBA river agents (*guardería fluvial)* conducted on-site inspections and oversaw extractions, but there were only four agents to cover an area of 5,500 km^2 (López-Gunn 2003). When river agents were instructed to seal a well following a certified violation, they would be accompanied by the police in order to avoid conflict with farmers. The enforcement powers of the Guadiana RBA were all the more critical during drought episodes as shown in Figure 5, with peak sanctioning periods coinciding with important decreases in average precipitation (in the periods 1992-1994 and 2004-2005).

FIGURE 4. Water allocation by farm size.



Source: Closas 2013.

FIGURE 5. Registered sanctions at the Guadiana River Basin Authority and yearly precipitation in La Mancha (1986-2009).



Sources: data on registered sanction dossiers from AEVAL 2010; and average precipitation measured at the Cuidad Real weather station for series 1988-2010 and 2013 from Agencia Estatal de Meteorología (AEMET) and for series 2011-2012 from Instituto Nacional de Estadística (INE).

Notes: The dashed line refers to illegal wells without licenses. Yearly precipitation is calculated as the average of accumulated monthly precipitation for every given year.

4.2 The "Carrot": Agro-environmental or Wetlands Plans (1992-2005)

It was estimated that the limitations on groundwater use imposed by the abstraction regime would result in a 25% reduction in the workforce directly involved in agriculture. As a result, farmers, and their associations, demanded compensatory measures from the state (Rosell and Viladomiu 1997). Furthermore, in spite of having invested in new harvesting machinery to cultivate and harvest corn (a water-intensive crop), the low allocations imposed by the new abstraction regime prevented farmers from cultivating and they demanded compensation (Lourdes Viladomiu, Associate Professor of Applied Economics, Autonomous University of Barcelona, pers. comm., June 16, 2014). According to Varela-Ortega (2007: 332), "the drastic reductions in the allowable quotas led to considerable social unrest and to free-riding behavior in the form of illegal drilling of wells and excessive abstraction."

In 1992, the first Agro-environmental Plan (AEP1), known locally as the Wetlands Plan or *Plan de Humedales,* was set up with the goal of reducing total groundwater abstractions from the Western Mancha aquifer to 240 Mm^3 per year, by compensating farmers willing to stop or reduce groundwater pumping (Rosell Foxà 2001). The Plan was proposed by the Spanish government (jointly by the ministries of Agriculture and Public Works) and the regional government of Castilla-La Mancha to the European Commission following the declaration of over-exploitation of the aquifer in 1987 and during a very serious drought affecting La Mancha in the early 1990s. It was meant to alleviate the burden on farmers of the measures approved in 1991. The proposal also aimed to take advantage of the 1992 reform of the Common Agricultural Policy (CAP), which approved funds for member states to support agro-environmental projects that would induce farmers to reduce water use and preserve natural ecosystems (Regulation CEE 2078/1992) (Rosell and Viladomiu 2000; Lourdes Viladomiu, Associate Professor of Applied Economics, Autonomous University of Barcelona, pers. comm., June 16, 2014). Given the deterioration of the Tablas de Daimiel National Park, Spain combined its (urgent) need for funds to compensate farmers with the necessity to protect the endangered ecosystem (Lourdes Viladomiu, Associate Professor of Applied Economics, Autonomous University of Barcelona, pers. comm., June 16, 2014).

AEP1 established three levels of reduction in pumping volumes in relation to an estimated average consumption of 4,200 m^3/ha/year (similar to the 4,278 m^3/ha/year "normal" consumption estimated by the groundwater abstraction regime) (Hernández-Mora 2002): 50%, 70% and 100%. Payments were established per hectare of irrigated land (Varela-Ortega 2007). The European Commission provided 75% of the funds and Spain's central government contributed 12.5%. The regional government of Castilla-La Mancha added the remaining 12.5% and was in charge of implementation. The first phase of the program was approved for a five-year period (1993-1997), with a total budget of EUR 96 million (Hernández-Mora 2002).

Participation in the plan was voluntary. Since the monetary compensations per hectare largely offset income losses resulting from the abstraction regime, which is estimated at around EUR 200-250/ha (Rosell and Viladomiu 1997; Varela-Ortega 2007), farmers responded positively (Table 1). Rosell and Viladomiu (1997) estimated that, in the Western Mancha and Campo de Montiel aquifers, 2,652 farmers had joined AEP1 by 1995, representing 85,410 ha of irrigated land and savings of 298 Mm^3 (51% of total volumes recognized by the Guadiana RBA at the time according to AEVAL [2010]) (Table 1). However, AEP1 did not include irrigated areas with groundwater abstraction rights not recognized by the Guadiana RBA, i.e., either registered in the Catalogue or the Register (Rosell and Viladomiu 1997).

The estimated reduction in total volumes of groundwater abstracted was calculated in relation to the average consumption established by AEP1 (4,200 m^3/ha/year). Accepting a reduction of

TABLE 1. Total surface area participating in the compensation program for the reduction of irrigation in the Western Mancha and Campo de Montiel aquifers.

Year	Participating hectares	Total theoretical savings (Mm^3)
1993	57,973	182.39
1994	74,853	235.97
1995	85,410	298.19
1996	85,834	302.16
1997	85,838	310.00
1998	85,020	Not available
1999	61,127	Not available

Sources: Hernández-Mora (2002) with data for the period 1993-1996 from Rosell and Viladomiu (1997); data for the period 1997-1999 from the Department of Agriculture, Fisheries and Nutrition, Castilla-La Mancha regional government (unpublished data).

50% was, therefore, almost equivalent to the quota of 2,000 m^3/ha imposed by the abstraction regime for vine, or the 2,352 m^3/ha for a 20-ha farm (quota system 1). Therefore, funds from the EU program were in fact being used to pay farmers to comply with the law. Furthermore, large farms with lower allocations under the 1991 abstraction regime (1,375 m^3/ha) could adopt the 70% reduction option of AEP1, which gave them a right to pump similar volumes (1,200 m^3/ha) and entailed larger payments, thus once again being compensated for complying with existing restrictions.

With the imposition of the stricter pumping quotas (2,000 m^3/ha maximum) by the RBA after the definitive declaration of aquifer over-exploitation in 1994 (quota system 2), the number of farmers joining AEP1 increased. By 1997, an area of almost 86,000 hectares was under cultivation and water abstraction was reduced by 60% (about 300 Mm^3), exceeding the program's objective of 255-270 Mm^3 per year (Varela-Ortega 2007). The five-year AEP was extended until 2003. However, under quota system 2, AEP1 was essentially paying farmers to 'break the law', since AEP1 calculated payments based on the initial estimated "normal volumes" of 4,200 m^3/ha/year established by the initial 1991 groundwater abstraction regime (quota system 1) and not on the revised and much lower emergency abstraction limits (quota system 2) from 1994. In fact, the 50% and 70% pumping reduction options of AEP1 exceeded the maximum pumping volumes established in 1994.

The AEP was substantially modified in 2003 (AEP2) to adjust it to the revised abstraction quotas established in 1994 (Table 2). In response to a request from the European Commission, AEP2 only included two options: 50% and 100% reductions in abstraction of the lower groundwater allocation established by quota system 2 (2,000 m^3). The elimination of the 70% option was due to the fact that it had been difficult to discriminate the amount of water savings achieved by each of the different reductions, and limiting the program to only two saving alternatives simplified water accounting (José Ramón Aragón Cavaller, Head of the Area for the Management of the Environment, Guadiana River Basin Authority, pers. comm., August 1, 2016). Additionally, payment levels depended on farm size in order to reduce the positive bias toward large farms that was incorporated in AEP1. The incentives for farmers to join the program were thus reduced, since compensations now barely covered the income loss resulting from the reduction in groundwater abstraction. As a result of the lack of interest from most farmers and the lack of results of the second phase of the program, it was abandoned in 2005 (Varela-Ortega 2007; Martínez-Santos et al. 2008).

TABLE 2. Evolution of compensatory payments from the AEPs in the Western Mancha aquifer.

Reduction in water consumption (%)	First phase (1993-2002)			Second phase (2003-2007)	
	1993	1997	2001	2006	
				ha	EUR/ha
50	156	164	179	1-40	209
			40-80		125
			>80		63
70	258	271	296		
100	360	379	414	1-40	518
				40-80	311
				>80	155

Source: Varela-Ortega 2007.

Notes: In AEP Phase 1, payments are independent of farm size; in AEP Phase 2, payments are modulated according to farm size.

4.3 The Role of European Agricultural Policy Support

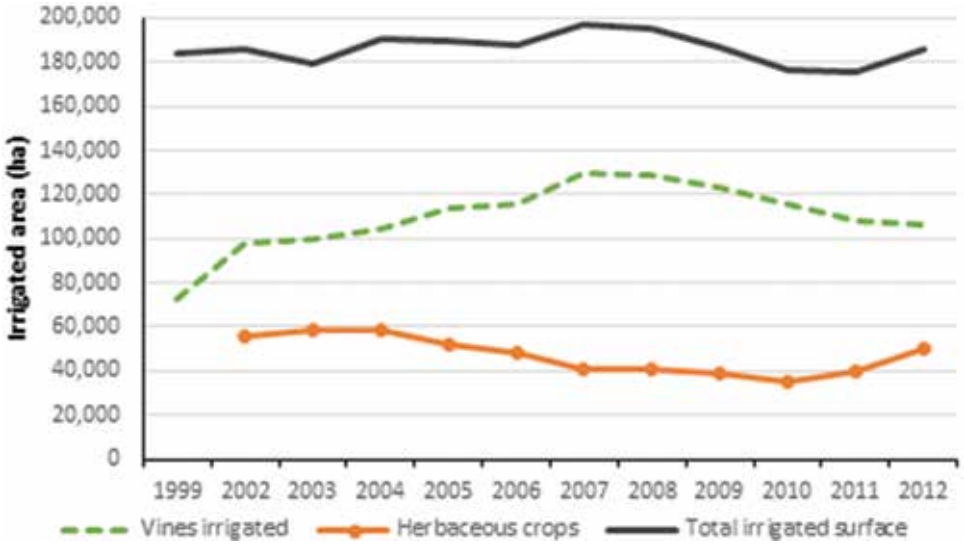
The contradictions between European environmental programs and the CAP[15] meant that, while environmental programs were trying to reduce groundwater stress, agricultural funds were incentivizing groundwater abstraction with subsidies for irrigated agriculture and water-intensive crops such as corn, beetroot and alfalfa (Martínez-Santos et al. 2008). EU subsidies for agriculture in Spain continued after the two major CAP reforms in 1992 and 2003. After 2003, although most agricultural subsidies were unified under one single farm payment decoupled from agricultural production, coupled subsidies were maintained for specific crops such as grapes. In Spain, most of these subsidies supported the production of grapes for wine resulting from the 1999 reform of the European Common Market for Wine (Sanjuan 2013). In La Mancha, the increase in irrigated vineyards during the 1990s and 2000s, and the conversion of rainfed vines to irrigation, were linked to specific funds allocated for the modernization of agriculture and the receipt of EU subsidies linked to production (ibid.). Specific subsidies and restructuring programs, and crop conversion for vines, included start-up costs for cultivation (removal of rocks, soil preparation, land leveling, plant disinfection and treatment) (Ruiz Pulpon 2013; Sanjuan 2013). In the autonomous region of Castilla-La Mancha, although a mixture of coupled and decoupled subsidies still existed in 2009, coupled subsidies for wine production represented the majority of European funds received (over 90% of CAP funds went for the production of grapes alone) (Ruiz Pulpon 2013).

These subsidies and restructuring programs for vineyards also had a perverse effect as they represented an incentive to switch from rainfed cultivation to drip irrigation, leading to an increase in the total irrigated area cultivated with vines and therefore increased groundwater consumption. In addition, most of the new grapes are grown on ‘espaliers’, a type of cultivation technique with drip irrigation requiring more water than conventional vines on the ground (between 2,000 and 3,000 m^3/ha) (Ruiz Pulpon 2013; Sanjuan 2013). In total, irrigated vines increased from 72,000 ha in 1999 to almost 130,000 ha in 2007, representing 66% of the total irrigated area in the province

[15] The Common Agricultural Policy (CAP) is the European Union agricultural policy that included a series of incentive programs to support European farmers (price intervention, trade regulations, production quotas, intervention prices, agricultural subsidies).

of Ciudad Real, where the largest part of the aquifer is located (Figure 6).[16] Between 2003 and 2009, the regional government of Castilla-La Mancha invested around EUR 65 million per year in the transformation of vineyards; with the Western Mancha aquifer representing the highest concentration of espalier grapes, at 41% of the total cultivated area in 2013 (ibid.).

FIGURE 6. Irrigated areas in the province of Ciudad Real (1999-2012).



Sources: data from Encuesta sobre Superficies y Rendimientos de Cultivos (ESYRCE); Ministerio de Agricultura, Alimentacion y Medio Ambiente (MAGRAMA) (available at http://www.magrama.gob.es/es/estadistica/temas/estadisticas-agrarias/agricultura/esyrce/resultados-de-anos-anteriores/default.aspx - accessed April 7, 2014).

Note: Herbaceous crops include cereals, legumes, forage crops, industrial crops and vegetables.

4.4 Technological Fixes for Groundwater Governance Challenges

Infrastructure projects to prevent further degradation of the Las Tablas de Daimiel National Park were also implemented during the 1980s and 1990s. In 1988, a regeneration plan was put forward to artificially maintain the water levels in the wetland by building two small dams that would retain water inside the designated national park area (Álvarez-Cobelas et al. 2008; Castaño-Castaño et al. 2008; Cirujano et al. 1996). In addition, a 150-km canal from the Tagus-Segura Water Transfer (*Trasvase Tajo-Segura*) to the Ciguela River, a tributary of the Guadiana, was completed in 1994 and this allowed the transfer of a maximum of 50 Mm^3/year from the Tajo River to the National Park. This interbasin water transfer proved to be a technological fix for the intensive use of groundwater and the environmental degradation in La Mancha.[17] In 2009, this infrastructure proved essential when an emergency transfer of 20 Mm^3 to the wetland was approved by the Council of Ministers. The transfer was needed especially due to a dry summer which caused the combustion of underground peat in some

[16] As also shown in Figure 6, the decrease in irrigated vines after 2007 could be due to the globalized financial crisis after 2008. This would explain the recess in global wine demand in international markets as well as the increase in production from other countries, thus reducing the dependency on Spanish grapes. Additionally, the liberalization of the wine market in the EU after 2008 as well as market deregulation have been quoted as drivers affecting the decrease in wine production (Barco Royo and Navarro Pérez 2012; Fernández Portela 2013).

[17] The state's centralizing hydraulic mission (more supply-driven water policies and infrastructure) and the so-called 'hydrological solidarity' between regions in Spain have been the two main drivers for the approval of interbasin water transfers in the country (Font and Subirats 2010; Hernández-Mora et al. 2014; Swyngedouw 2014). The largest interbasin water transfer operating in Spain today transfers up to 600 Mm^3 per year from the central Tagus River Basin to the Segura River Basin in southeastern Spain.

areas of the wetland (Closas 2013). However, the transfer also had the unintended consequence of destroying the Cigüela riparian wetlands, because the bed of the Cigüela River had been dredged in order to enhance the efficiency of water transfers to the Tablas de Daimiel wetland (Cruces et al. 1998).

4.5 Would Water Pricing Policies Work in La Mancha?

Water pricing is considered a major instrument for demand management, internalization of externalities via cost recovery, and water conservation (Molle and Berkoff 2007). Although water pricing policies have not been adopted in La Mancha, Varela-Ortega (2007) tried to assess what the impact of such policies would be in groundwater abstractions from the Western Mancha aquifer through modeling of the impact of volumetric tariffs on irrigated farms.

Varela-Ortega (2007) used two types of farms common to the Western Mancha aquifer - the extensive large farm and the more intensive medium-sized farm. Results show that water demand is reduced progressively when prices increase, but differs between the two types of farms. Water demand is more inelastic in the more intensive farms "as higher productivity permits to absorb increased water use costs without drastically changing the cropping pattern towards less water-demanding crops or to rain-fed farming" (Varela-Ortega 2007: 343). The model also shows that a water tariff of EUR 0.054/m^3 would produce the necessary incentives to reach average groundwater abstraction levels compatible with aquifer recharge. With this tariff, acting as a negative incentive to abstract groundwater, farm income is reduced by 23% in the aggregate. However, for water pricing to work, wells should be monitored volumetrically, something which, given the previous experience of well regulation, would be difficult to achieve in La Mancha. As discussed in section 5, the Special Plan for the Upper Guadiana included funding mechanisms and agreements with Water User Associations (WUAs) to install water meters in permitted wells, but this had limited impact.

5. THE LATEST CARROT: THE SPECIAL PLAN FOR THE UPPER GUADIANA BASIN AND THE PURCHASE OF GROUNDWATER RIGHTS

The critical situation of the basin and the need to comply with the newly approved EU WFD prompted the inclusion of a requirement for the development of a Special Plan for the Upper Guadiana Basin *(Plan Especial del Alto Guadiana* [PEAG]) as part of the 2001 National Hydrologic Plan approved by the conservative Popular Party government. A first draft of the plan emphasized the regularization of unregistered wells and was presented in December 2003, but this was rejected by the Castilla-La Mancha autonomous region's socialist government. An alternative proposal was then put forward by the regional government more in line with the WFD goals. However, after a surprise win by the socialist party in the March 2004 national elections, the incoming national government negotiated a new PEAG proposal together with the agricultural lobby organizations, national environmental groups and the regional government of Castilla-La Mancha.[18] The new proposal was presented in 2006 and finally approved in January 2008, after 22 different drafts.

[18] These organizations involved with the PEAG included (i) Asociación Agraria de Jóvenes Agricultores (ASAJA), a more conservative farmer union whose position toward the PEAG during this period changed from outright opposition to finally approving and defending it; (ii) other farmer unions representing smaller farmers (Coordinadora de Organizaciones de Agricultores y Ganaderos [COAG] and Unión de Pequeños Agricultores y Ganaderos [UPA]); and (iii) groundwater user associations. Local environmental groups do not have a strong presence in the region despite the existence of the Tablas de Daimiel Wetland National Park. The environmental groups considered as the main stakeholders in the negotiation process are all national-level environmental nongovernmental organizations (NGOs) (e.g., World Wide Fund for Nature (WWF), Sociedad Española de Ornitología (SEO)-BirdLife). The government appointed a PSOE (socialist party) nominee from the area as new President of the Guadiana River Basin Authority in 2004 to lead the negotiations for the PEAG. In 2008, he became the president of the Consortium for its implementation.

The approved plan included a series of activities for the socioeconomic restructuring of the region and strengthening public participation procedures (López-Gunn et al. 2013; Varela-Ortega 2007). At the time, the seriousness of the depletion of the aquifer had garnered national and international attention. On June 14, 2008, UNESCO threatened to cancel the status of the Humid Mancha as a biosphere reserve and gave the Spanish government until 2011 to regenerate the wetland ecosystem, or it would no longer be considered a protected reserve (Closas 2013).

In 2008, the socialist government was reelected. However, while the 2004-2008 legislature had been characterized by a significant push to align water policy in Spain with the EU WFD, the reelected government changed its focus toward more agriculture-friendly environmental policies.[19] At the same time, the Castilla-La Mancha regional government, still under socialist rule, emphasized its defense of agricultural interests over the achievement of environmental objectives. Evolution in the implementation of the PEAG has to be understood in this political context.

The PEAG, which targeted the entire Upper Guadiana including the Western Mancha aquifer, was managed by a consortium comprised of the state, via the Ministry of Environment, Rural and Marine Affairs, and the regional government of Castilla-La Mancha. It was to be implemented between 2008 and 2027, and had been conceptualized as an umbrella plan integrating the various measures and programs developed in the past, as well as new initiatives (Calleja and Velasco 2011). The PEAG aimed to achieve the sustainable management of the aquifer through a combination of measures, most significantly, by acquiring 130 Mm^3 of water rights between 2008 and 2015 via the purchase of private groundwater abstraction rights and concessions through a 'public water bank' (*Centro de Intercambio)* (López-Gunn et al. 2013), and by extending the policy of land purchase around the Las Tablas de Daimiel National Park initiated in 2000. Through the PEAG, the state would buy groundwater use rights through public acquisition offers and via this public water bank. Up to 30% of the acquired rights would be reassigned to professional farmers without legal water rights, or to other priority uses defined by the Government of Castilla-La Mancha. This was particularly significant in the Western Mancha aquifer, where no new concessions could be granted since the provisional declaration of over-exploitation in 1987. The remaining 70% of purchased water was designated to improve aquifer levels, with an environmental target that a minimum of 35 Mm^3/year would reach the Tablas de Daimiel National Park before 2027 (WWF 2012).

The PEAG also outlined a series of complementary measures, including an environmental plan for habitat recovery, improvements in water use monitoring and control, support to water user associations, and outreach and education programs targeted at the farming community and the general public in the Upper Guadiana. The latter included training courses, funding for research programs at the regional university, educational programs in schools, and seminars and conferences, among other activities. The PEAG had an original dedicated budget of almost EUR 3 billion. This was complemented by over EUR 2 billion from other programs (both EU and nationally funded) for investments in wastewater supply and treatment, socioeconomic development programs and efficiency improvements in irrigation for the 2008-2027 period (PEAG 2008c). However, it was never fully funded and only partially implemented.

[19] The new government merged the Ministry of the Environment with the Ministry of Agriculture to create the Ministry of the Environment, Rural and Marine Affairs. The new secretary of the environment and water came from the agroindustrial and farming union sectors - "Josep Puxeu ha sido nombrado Secretario de Estado de Medio Rural y Agua", April 18, 2008 (available at http://www.soitu.es/soitu/2008/04/18/info/1208543580_909450.html - accessed February 10, 2015). Environmental groups opposed this merger and denounced the shift away from a commitment to environmental conservation and a realignment with farmers' interests - "Greenpeace denuncia el desguace del Ministerio de Medio Ambiente", April 12, 2008 (available at http://www.greenpeace.org/espana/es/news/2010/November/greenpeace-denuncia-el-desguac/ - accessed February 10, 2015).

Groundwater abstraction rights were procured by the state though six public offers of acquisition, three before the approval of the PEAG and three after it was approved (Table 3). In those procurements, the PEAG did not distinguish between private or public rights as long as the rights were registered. Purchase prices ranged between EUR 3,000-10,000/ha for herbaceous crops and EUR 3,000-6,000/ha for vineyards per declared hectare (recognized by the RBA) (Cabezas Guijarro and Sánchez 2012).[20]

TABLE 3. Public procurement of groundwater abstraction rights in the Upper Guadiana Basin.

Date	Total budget (EUR)	Applied budget (EUR)	Offers acquired (#)	Total affected hectares	Total volume purchased (Mm^3)
November 2006	600,000	487,275	4	59	0.210
April 2007	10,000,000	9,445,300	35	1,061	4.434
September 2007	30,000,000	12,344,196	79	1,282	5.322
September 2008	11,950,000	11,945,342	85	1,256	5.292
March 2009	20,000,000	19,919,000	140	2,011	8.405
November 2009	11,950,000	11,648,574	83	1,200	5.400
Total	84,500,000	65,789,687	426	6,869	29.063

Source: Cabezas Guijarro and Sánchez 2012.

Interested farmers without groundwater rights could apply to the Guadiana RBA for an abstraction concession. Concessions were granted after the review of interested applicants, and farmers were selected based on several factors: farm size (average of 10 ha), age (between 18 and 40 years old), professional status, and the requirement that agriculture was the main source of income (José Ramón Aragón Cavaller, Head of the Area for the Management of the Environment, Guadiana River Basin Authority, pers. comm., June 17, 2014; Requena and Garcia 2010).

Having sold water rights, farmers would have to keep the land under dryland farming (Elena López-Gunn, Senior Researcher, Water Observatory, Botin Foundation, pers. comm., May 12, 2014; PEAG 2008a, 2008b). Within a month after the sale, well owners would have to remove pumping equipment and other machinery, as well as close and seal the wells (Requena and Garcia 2010). Once this had been verified, the RBA would register the changes in the Registry of Public Waters or the Catalogue of Private Waters, the Registry of Property, and the Real Estate Cadastre (ibid.). Farmers could also sell a part of the abstraction rights from their wells, in which case the RBA would monitor the meter installed in the well in order to identify the actual groundwater consumption and limit the remaining abstraction right to what was allowed (Enrique Calleja, former President of Consorcio del Plan Especial del Alto Guadiana (PEAG), pers. comm., June 26, 2014). The RBA did not allow users with remaining rights to expand the irrigated area, even if the farmer stated that it would be done with less groundwater use per hectare (established at 1,500 m^3/ha for vine and 2,000 m^3/ha for other crops in the groundwater abstraction regime) (Enrique Calleja, former President of Consorcio del Plan Especial del Alto Guadiana (PEAG), pers. comm., June 26, 2014). What was allowed, however, was the 'concentration of groundwater abstraction

[20] The PEAG only purchased groundwater rights, not land. The price was established by the Guadiana River Basin Authority after "a comprehensive review of market prices and assessing the difference in production of one hectare of irrigated land and that of dry farming." The study considered an initial groundwater allocation of 1,500 m^3/ha for each land plot, and also differentiated between vine crops and non-vine crops. The range in prices responded to different types of cropping patterns, farm sizes, proximity to the National Park, etc. (Ferrer Matvieychuc and Martin de la Cal 2009).

rights' on smaller irrigated areas, depending on the crops,[21] monitored in theory by the RBA and the various Communities of Groundwater Users (providing information to the RBA) via water meters and field visits (Enrique Calleja, former President of Consorcio del Plan Especial del Alto Guadiana (PEAG), pers. comm., June 26, 2014).

In order to improve monitoring and control of groundwater use, the PEAG envisioned investing over EUR 223 million for the installation of water meters in the Upper Guadiana. As a first (and eventually last) step, the Guadiana RBA signed a memorandum of understanding with the groundwater user association (GWUA) in the Western Mancha aquifer, the General Community of Groundwater Users of Aquifer 23 (Enrique Calleja, former President of Consorcio del Plan Especial del Alto Guadiana (PEAG), pers. comm., June 26, 2014). In the agreement, the RBA agreed to provide EUR 7 million to install 2,700 water meters that could transmit information electronically to the water user associations and the RBA. Previous efforts to control groundwater abstractions dated back to the implementation of the Wetlands plan, when EUR 6.6 million had been invested to install 1,700 well meters in farms that were receiving AEP subsidies (Cabezas Guijarro and Sánchez 2012). In any case, not all wells have meters installed and on-site visits by officials have been infrequent, with no noticeable increase in visits by guards from the RBA to the farms having relinquished their rights (Alberto Fernández Lop, Water and Agriculture Program, WWF Spain, pers. comm., June 27, 2014).

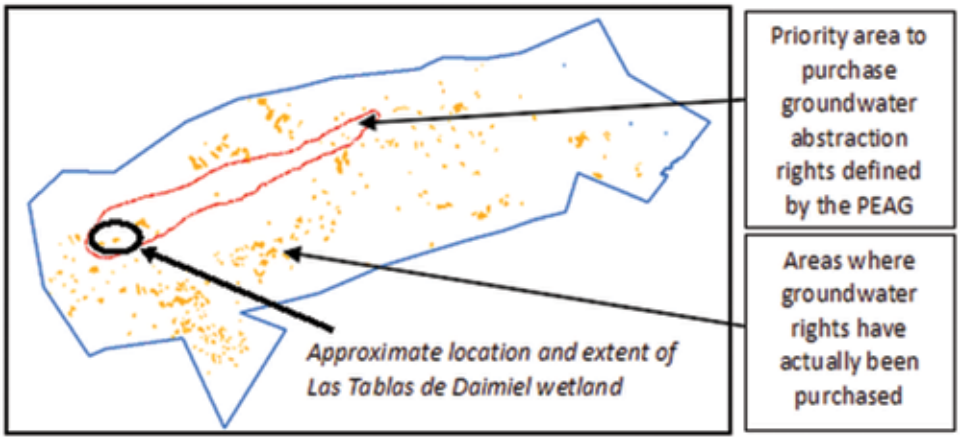
The purchase of water rights, which was meant to be the principal activity of the PEAG, helped regularize the use of water for vine cultivation (to which most of the new water rights accrued) and incorporate many informal irrigators into the water rights system (with 15,700 ha regularized out of a target of 17,510 ha) (José Ramón Aragón Cavaller, Head of the Area for the Management of the Environment, Guadiana River Basin Authority, pers. comm., June 17, 2014). This was done by purchasing water rights from farmers that were mainly irrigating cereals, and reallocating these rights to other users to irrigate more economically productive crops such as vine (López-Gunn et al. 2013). In terms of funds, the PEAG disbursed almost EUR 66 million for the purchase of groundwater rights (only 10% of the initial budget component allocated specifically for the purchase of rights) (Fernández Lop 2013). In other words, the state extended a big 'carrot' to illegal well owners, whereby a water right – purchased by the state – would be transferred to them (at no cost) with the additional possibility, in the case of vines, to receive subsidies for 'technology improvements and modernization' (such as drip irrigation) and shifts to higher-value vine varieties. Of course, for this to happen, such recipients had to declare their illegal wells.

Irregularities were found in the implementation of the measure to reduce the volume of groundwater abstraction from the Western Mancha aquifer via the public procurement of groundwater rights. Although the PEAG established rules aimed at controlling the sale of groundwater rights with proven abstraction at least 3 years before the sale (checked and tested by members of the RBA) (Ferrer Matvieychuc and Martin de la Cal 2009), WWF (2012) found that 83% of the rights purchased by the government had not been used for 5 years prior to the sale (Figure 7). Despite the critical need for monitoring, the RBA did not assign more human resources to monitor meters or to visit plots. There were instances of meter tampering or direct sabotage, and although many User Communities knew who was abstracting more water than allowed, they rarely reported them to the RBA (Alberto Fernández Lop, Water and Agriculture Program, WWF Spain, pers. comm., June 27, 2014).

In addition, WWF (2012) highlighted that 95% of the rights procured were located outside the priority area designated for purchase (the area around the National Park of the Las Tablas de Daimiel

[21] As an example, a farmer having sold half of his groundwater rights and cultivating 20 ha of melon, would only be allowed to plant 10 ha, even if his remaining rights were sufficient to cultivate the 20 ha (Enrique Calleja, former President of Consorcio del Plan Especial del Alto Guadiana (PEAG), pers. comm., June 26, 2014).

FIGURE 7. Groundwater abstraction rights purchased outside the designated areas.



Source: Fernández Lop 2013.

Wetland) (Figure 7). Farmers within the designated priority area were often reluctant to sell (Alberto Fernández Lop, Water and Agriculture Program, WWF Spain, pers. comm., June 27, 2014). As a result, after the second public acquisition offer, rights were purchased from wells that did not comply with the pre-established conditions and with the only requirement that they should have water in them. Farmers willing to sell their water rights were often retired or not farming anymore for a variety of reasons (ibid.).

The initial PEAG agreement with the regional government of Castilla-La Mancha established that only 30% of the rights acquired would be transferred to the Junta de Castilla-La Mancha in order to be reallocated for 'social uses' (i.e., allocated to users without abstraction rights). In 2010, this requirement changed and most acquired rights were used to regularize illegal abstractions (Requena 2013). In response to demands by the Junta de Castilla-La Mancha, the PEAG consortium processed and passed over 4,000 application files to the Guadiana RBA for granting of new concessions to irrigate vines, thus allocating 100% of effective purchased rights (around 13.5 Mm^3)[22] to users with wells without permits. Farmers that benefited from this measure received the concession at no cost. According to Requena (2011), 81% of the rights purchased by the PEAG were reallocated to non-authorized users, thus becoming a de facto regularization of previously illegal groundwater abstraction. This limited the amount of purchased rights designated for aquifer recovery. The actual volume of water left to the environment (i.e., not allocated to another farmer) amounted to 9% of the total volume originally expected for that purpose (ibid.).[23] Additionally, some of the rights purchased continued to be used after the sale (around 8%). In an even more striking case, rights were purchased from 212 ha of land in farms within the legally defined 'public water domain', i.e., public lands that should not have been farmed at all (WWF 2012).[24] The outcome of the water rights purchase program was, therefore, mixed. While it served to appease social tensions surrounding illegal groundwater uses, it did not achieve the original environmental goals (aquifer recovery) that justified its operation and financial costs.

[22] While 29 Mm^3 were purchased on paper, the decision had been made to only consider the "effective rights", i.e., the water that could be effectively used according to the Groundwater Management Plan. Thus, only 13.5 Mm^3 could be reallocated.

[23] As pointed out by López-Gunn et al. (2013: 264), the indirect water savings of this measure could potentially amount to more than the originally allocated environmental flows in the PEAG, as users consuming newly allocated water rights "will no longer consume their initial (illegal) use (since their new water footprint will correspond to part of the purchased rights they received) and therefore this initial water footprint also goes to the environment."

[24] The state purchased groundwater rights from farms in the vicinity of the *Ojos del Guadiana*, which, being dry for almost 20 years, had been privately farmed. Some of these farmed lands were actually located in the old Guadiana riverbed and therefore defined by the 1985 Water Law as part of the 'public water domain' belonging to the state (the public water domain of rivers is defined as the river course and a stretch of land of 100 m on each side – Article 6, Royal Decree 1/2001 of July 20, 2001, approving the revised 1985 Water Law) (WWF 2012).

In addition, due to Spain's economic crisis after 2008, the lack of funds and political support for the PEAG from the newly appointed team at the Ministry of the Environment, Rural and Marine Affairs resulted in a very slow start for the PEAG. Political changes after the 2011 general elections, and the advent of a conservative government with a different approach to water management compared to the previous socialist government, resulted in a change of direction in national water management policy. This represented the end of the PEAG's siren song and its plans to invest over EUR 5 billion from the state budget and EU funds for its various activities until 2027 (PEAG 2008c; Calleja and Velasco 2011; López-Gunn et al. 2013). A "Liquidating Director" was appointed in July 2013 to close the PEAG management consortium.[25] The new Guadiana River Basin Management Plan, approved in December 2013, resulted in the de facto dissolution of the consortium and its integration within the new river basin plan.[26]

Critical voices, such as some communities of irrigators in La Mancha and environmental groups, consider this new RBMP as the 'death' of the PEAG, which was a plan that took many years to agree upon and approve. In their view, the RBMP was devoid of any new measure to attain its environmental goals (a priority for environmentalists) or further regularize illegal wells (a priority for farmer groups).[27] However, other interest groups, such as the president of ASAJA, one of the main farmers' unions in La Mancha, stated that "organizations that do not work, such as the Special Plan for the Upper Guadiana, the sooner they are removed, the better."[28]

6. USER PARTICIPATION IN GROUNDWATER MANAGEMENT IN LA MANCHA

The 1985 Water Law reaffirmed a long-standing tradition of user participation in surface water management. Under the 1879 Water Law, water user participation was understood in Spain as the right of every irrigator to establish self-governing institutions for the common management of water for irrigation. When the first RBAs were created in the 1920s, irrigators and hydroelectricity users were part of their boards and committees from the outset (Del Moral Ituarte and Hernández-Mora 2016). The 1985 Water Law continued this practice and water users with permits (irrigators, hydroelectricity users and domestic water users) have an active presence as voting members within the formal structure of RBA's decision-making councils and boards (López-Gunn 2003; Varela-Ortega and Hernández-Mora 2010). Groundwater users were also included after the 1985 reform (Fanlo Loras 2007). In the case of the Upper Guadiana, groundwater users dominated decision-making boards. The influence of the agriculture sector on management decisions exceeds their role in the RBA's management boards, since they are also able to influence the development of

[25] Boletin Oficial del Estado (BOE), 'Resolucion de 19 de Julio de 2013, de la secretaria de Estado de Medio Ambiente, por la que se publica el Convenio de colaboración con la Junta de Comunidades de Castilla-La Mancha, para la disolución y liquidación del Consorcio para la gestión del Plan Especial del Alto Guadiana'. Available at http://www.boe.es/diario_boe/txt.php?id=BOE-A-2013-8530 (accessed March 3, 2014).

[26] The Draft Strategic Environmental Assessment of the Guadiana River Basin Management Plan stated that, 'there had been a multitude of requests to revise and modify the PEAG, highlighting the demand to eliminate the consortium, its rules, and the bigger budgets (purchase of rights and environmental restoration); introduce new management systems and consider introducing external resources. At the same time, it is also requested that the regularization of abstractions and the purchase of rights continue" (MAGRAMA 2012b: 31).

[27] Laverdad. es "Acusan al Nuevo plan hidrológico de 'enterrar' el Plan del Alto Guadiana", December 18, 2012. Available at www.laverdad.es/albacete/v/20121218/provincia/acusan-nuevo-plan-hidrologico-20121218.html (accessed March 4, 2014).

[28] La Tribuna de Ciudad Real "Cospedal y Barato abogan por enterrar el plan del Alto Guadiana", December 18, 2011. Available at www.latribunadeciudadreal.es/noticia.cfm/Local/20111218/cospedal/barato/abogan/enterrar/plan/alto/guadiana/0A1C50CF-9F59-F430-F8FEACDA917AEB43 (accessed March 11, 2014).

water management policies and plans through the political strength of farmer associations and their political influence vis-à-vis the regional government of Castilla-La Mancha.

In Spain, collective action for groundwater management has been developed by user initiatives through different organizational and institutional formats both public and private, reflecting the diversity of types of groundwater rights (López-Gunn et al. 2013). The first collective groundwater management organization was created in 1976 in the Delta del Llobregat (Barcelona) (*Comunidad de Usuarios del Delta del Llobregat*). Since then, 19 other GWUAs have been created with only three following the prescriptions of the 1985 Water Law, which requires GWUAs to be created in aquifers that are declared as over-exploited (ibid.). The other GWUAs emerged spontaneously due to users' self-interest, as a reaction to drought, or in most cases, as a reaction to the potential loss of private rights that would follow from the possible declaration of aquifer over-exploitation by the state (Rica et al. 2012).

In the Western Mancha aquifer, the creation of GWUAs[29] started within municipal boundaries following the 1987 provisional declaration of over-exploitation (Hernández-Mora 1998). Their size varied according to the number of hectares for irrigation declared by its members, ranging from 35,000 ha and 1,431 members such as the GWUA of Alcázar de San Juan, to the GWUA of Bolanos de Calatrava with 2,800 ha and 342 members (López-Gunn and Hernández-Mora 2001; Varela-Ortega et al. 2006). A 'General Community of Irrigators of Aquifer 23' ('*Communidad de Regantes del Aquifero 23'*)[30] was created in 1996 after the final declaration of over-exploitation of the Western Mancha aquifer in 1994. The creation of this General Community was a compulsory measure under the 1985 Water Law, which stated that, in case of a legal declaration of aquifer over-exploitation, users would have to organize themselves into a Community of Users. The main objective of this Community was to implement the new emergency regime of groundwater abstractions triggered by the declaration of over-exploitation.

The General Community operates as a federated organization, integrating the 20 GWUAs from the 20 different municipalities in the aquifer and representing around 17,000 farmers using groundwater within the Western Mancha aquifer (López-Gunn 2003). During the creation of the General Community, rivalries between farmers' leaders from different GWUAs for the presidency of this overarching organization led to the split of the farming community into two different groups, one in the western part of the aquifer and another in the eastern part (López-Gunn 2012). This resulted in the spontaneous creation of a separate user association for the Eastern Mancha aquifer, which encompassed seven municipal GWUAs. However, they continued to be (reluctant) members of the umbrella General Community.

Individual GWUAs appeared as self-driven movements at the municipal level during the 1990s, as users tried to avoid the top-down mandate granted to the General Community of groundwater users derived from the water law and the declaration of over-exploitation of the aquifer, as well as a generalized feeling of mistrust towards the state (Cabezas Guijarro and Sánchez 2012; López-Gunn 2012). Irrigators relied on local GWUAs as a response to the long process of establishment of the General Community (it took 9 years for the General Community to be created), and a lack of clear leadership within the General Community due to internal fights between farming elites for its control (López-Gunn 2012).

---

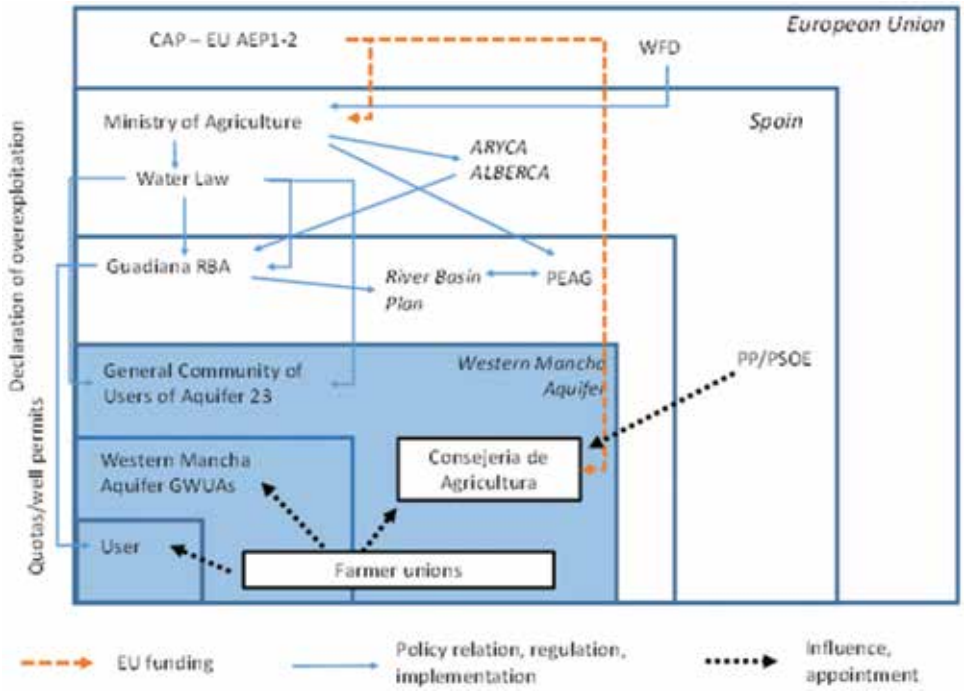
[29] The existence of irrigation communities was already regulated for surface water users in the original 1879 Water Law. The 1985 Water Law codified their existence once again and extended it to groundwater users. It also established that their organization and normal operations are to be internally regulated via Statutes or Ordinances once drafted and approved by the users themselves and submitted to the River Basin Authority for final approval (Del Campo Garcia 1996). These irrigation communities are considered 'public corporations' under Spanish Civil Law, and attached to the different RBAs. They are granted internal management autonomy, and have to regulate the representation and participation of water users in its governing bodies (ibid.). The role of the individual GWUA in La Mancha is to safeguard the interests of their members vis-à-vis the RBA, and ensure the implementation and control of the groundwater abstraction regime under the declaration of over-exploitation of the aquifer (Diaz Mora 2014). The GWUA can also establish agreements and partnerships with the RBA in order to receive technical and financial support for effective control of the groundwater abstraction regime and respect the groundwater rights (ibid.).

[30] The name of this General Community of Irrigators, which remains unchanged, has kept in its name the previous designation of the Western Mancha aquifer as 'Aquifer 23'.

In order to facilitate their organization and consolidation, the GWUAs relied on municipal governments and existing agricultural organizations such as agricultural chambers of commerce and farmer unions (Cabezas Guijarro and Sánchez 2012). As a result, many GWUAs were captured in the 1990s by already established and influential farming unions, and they effectively became lobbying organizations looking for subsidies rather than effectively managing groundwater (López-Gunn 2012). This process of elite capture also prevented GWUAs from developing from the bottom up or to gather internal legitimacy amongst its constituents (ibid.). The co-opting of these associations by local elites and union representatives was reinforced by frequent meetings with members (formal and informal in bars and cafes or as part of cooperatives), shared office spaces and joint billing procedures (López-Gunn 2012). The strong social bonds at the town level, however, undermined the federation of communities, as inter-village relationships tend to be based on historical animosities and rivalries which lead to mistrust between users from different villages (López-Gunn 2012; López-Gunn and Martinez-Cortina 2006).

Rent-seeking behavior and political clientelism of farmers in the Western Mancha aquifer also appeared as an unintended result of the original five-year European AEP in 1993. The plan helped to consolidate municipal-level GWUAs, but it also made them dependent on regional and European funds (Rosell and Viladomiu 1997). For several years, the fees paid by farmers to the user associations for the management of the AEP were their only source of income (Hernández-Mora 1998). As a result of the new funds and subsidies, the purpose for these associations was to manage and apply for European funds while regional governments were expected to support farmers via subsidies. This created a reciprocal relationship of political support tied to funds, and votes from the user associations and farmer unions (López-Gunn 2012) (Figure 8).

FIGURE 8. Actor interactions and policy relations regarding agriculture, irrigation and the implementation of groundwater regulation policy in La Mancha.



Notes: ALBERCA: Actualización de Libros de Registro y Catalogo (Actualization of Registry Books and Catalogue); ARYCA: Actualización de Registros y Catálogos (Actualization of Registries and Catalogues of Abstractions); CAP: Common Agricultural Policy; EU: European Union; AEP: Agro-environmental Plan; PEAG: Plan Especial del Alto Guadiana; GWUA: Groundwater User Association; PP: Partido Popular (Popular Party); PSOE: Partido Socialista Obrero Español (Spanish Socialists Workers' Party); RBA: River Basin Authority; WFD: Water Framework Directive.

In 2016, the situation of the individual GWUAs was precarious, as they relied solely on low member fees to finance their operations. Additionally, the division of the Western Mancha aquifer into three groundwater management bodies after the approval of the 2013 Guadiana RBMP implies that the organization of existing GWUAs has to realign itself with the new management boundaries. This jeopardizes the existence of the General Community of Users of Aquifer 23 (according to the law, there has to be one general user community per designated aquifer unit) as well as the future of the individual GWUAs, as some of them overlap two of the newly created aquifer subunits.

7. DISCUSSION AND CONCLUSIONS

In Spain, different types of sticks and carrots have been used by the state to attempt to regulate, control and limit groundwater abstraction for irrigation (Table 4). The example of the Western Mancha aquifer is a valuable case study due to the variety of policy tools applied and implemented at various political and administrative levels, coupled with the serious degradation of the aquifer underlying the plains of La Mancha and of highly valued groundwater-dependent ecosystems.

In most cases, well registration is the first step taken by the states, as it is obvious that it cannot manage a collection of wells of which the characteristics and even the existence are unknown. Yet, this case study illustrates that (this is a lesson often learned the hard way) registration is undermined by a logistical nightmare which exposes the substantial time needed and the high costs involved in such an undertaking (which must include field visits to check the accuracy of declarations). The experience with the strict quotas imposed in 1987 in the Guadiana Basin illustrates that the mere use of such a stick instrument (i.e., the limitation of pumping volumes) is unlikely to be successful, as it generates free riding and deviant behavior that are close to impossible to check and politically costly to curb; and is not sustainable because of the high political costs associated with the social unrest caused by such measures. Quotas can be expressed by limits in terms of volume, irrigated area or volume per area to cap use. Each modality comes with its loopholes that are exploited by farmers to their own advantage. The costs of monitoring are also found to be much higher than expected despite the use of remote sensing and meters, and constant monitoring of what is happening on the ground was found to be beyond the capacity of the state.

The establishment of the AEP, largely funded by the EU, clearly illustrates that earlier stick-only policies, whereby users were asked to reduce abstraction with the risk of losing their groundwater allocation based on their historical rights, do not work. The European AEPs were designed at a moment when the stick policy of the imposed quotas was translating into high political costs. Environmental objectives and policies – and EU financial support - were used to reduce these political costs by offering financial compensation to farmers willing to curb groundwater use.

The transfer of historical private abstraction rights to public water use concessions can also open the door to future conflicts between users and the state (Closas 2012). As this case study shows, the inherited fuzzy and confusing legislation regarding the regularization of historical groundwater abstraction rights, which caused an initial discomfort amongst users, remains one of the main reasons for the lack of trust of groundwater users towards the state. Despite different programs, since the early 1990s, to rectify this lack of control and finalize an inventory of wells and rights in Spain, results have been partial and inconsistent. This is due to the difficulty of applying the rules on the ground, lack of funding and challenges obtaining farmers' cooperation, as well as a lack of political will due to the high social and political costs of enforcement and control measures by the state (De Stefano and López-Gunn 2012). Additionally, as De Stefano and López-Gunn (2012) stated, net benefits from agriculture based on the unauthorized use of groundwater outweigh the negative consequences to the user (e.g., water table drawdowns, higher energy costs, potential sanctions).

TABLE 4. Groundwater management policies adopted in the Western Mancha aquifer.

Policy implemented	***Carrots***	***Sticks***	***Outcomes***
Well registration (1985-2012) Aiming to register historical rights through either a public water concession (Registry of Public Waters) or recognition of a private right (Catalogue of Private Waters)		***Threat that unregistered well rights could be affected and rights revoked***	It has taken almost 30 years to complete the well registration process. Some illegal wells still remain today and some pump more water than they should
Declaration of over-exploitation and emergency abstraction regime (temporary in 1987 and final in 1994)	***Community of groundwater users established***	***Abstraction quotas by hectare (varying with some size)*** ***Freezing of new wells and deepening limitations*** ***Sanctions***	Access to water is reduced or controlled unilaterally Political agitation, meter tampering Transformed into lobbying groups; clientelism
AEP1 (1992-2001) Establishing water quotas fixed at 50%, 70% and 100% reduction of original 1987 groundwater abstraction regime	***Compensation payments to reduce groundwater abstractions for irrigation based on original 1987 abstraction volumes***		85,838 ha of irrigated land and 310 Mm^3 of water saved in the first 5-year phase (1992-1997), with farmers adopting the scheme, farm income gains and aquifer recovery
AEP2 (2001-2005) Fixed at 50% and 100% reduction of 1994 groundwater abstraction regime	***Compensation payments to reduce groundwater abstractions for irrigation based on new abstraction volumes after 1994***		Low implementation of the program due to reductions based on already low water allocations. Compensation payments not sufficiently attractive for farmers
PEAG (2007-2013) Purchase of water rights by the River Basin Authority and allocation of these rights to new users and the environment	***Public purchase of groundwater rights from users by the state*** ***Allocation of purchased rights by the state to priority users without rights***		Regularization of illegal wells, meter tampering Irregularities in the purchase and exchange of rights (wells not in use, outside the designated purchase area, etc.)

(Continued)

TABLE 4. Groundwater management policies adopted in the Western Mancha aquifer (Continued).

Policy implemented	*Carrots*	*Sticks*	*Outcomes*
	SERMON* ***Outreach and education program***		Underfunded and only partially implemented
Vine restructuring and modernization program	***Subsidies for improving irrigation techniques and vine variety shifting (from dryland to irrigated and toward more productive varieties)***		Increase in irrigated area due to substitution of dryland vines to irrigated vine varieties
Pricing policies (hypothetic)		***Water tariff***	Affecting farmers' income and uneven impact due to farm size and water demand elasticity. Measure would also require volumetric monitoring, which would be hard to achieve.

Note: * Sermons are a type of policy tool defined as "attempts at influencing people through the transfer of knowledge, the communication of reasoned argument and persuasion" (Bemelmans-Videc 1998: 11).

The use of legal sticks by the state, such as sanctions via the control and prosecution of illegal wells, needs to be accompanied by concrete actions on the ground financially supported by government agencies. This has been tried by the Guadiana RBA and the Special Plan for the Upper Guadiana (*Plan Especial del Alto Guadiana* [PEAG]), but the politicization of water management in La Mancha, and the lack of trust and dialogue between participants and the state were detrimental to improving groundwater management. The PEAG ended when the funds from the government (the carrots) dried up. Further political struggles and a change of government killed the plan altogether.

This case study also highlights the potential perverse effects of subsidies and government aid programs for agriculture or technology improvements, such as drip irrigation, which are promoted at great state expense as a water-saving solution. However, under some conditions, these can lead to an increase in overall water consumption through intensification or expansion. Another commonplace conclusion is that demand side policies alone are seldom sufficient to reverse over-exploitation, and a panoply of parallel regulatory and management tools are invariably required. Simulations suggested that demand management tools such as pricing, which could help achieve the required environmental objectives, may be impractical because of the reduction in farm income that would result, especially in more extensive farms, eventually pushing some farmers out of business. Such policies, based on volumetric management of water, are also very hard to implement because of the difficulty to monitor groundwater use in a large number of independently operated wells.

The present case study also shows the policy contradictions between European and national programs incentivizing (irrigated) agriculture, and seeking to protect the environment at the same time. It also shows how, in the name of higher productivity, 'modernization' policies result in the expansion of vine cultivation and higher evapotranspiration, reducing the return flow to the aquifer and therefore compromising the very environmental objectives pursued. The contradictions between the WFD aiming at protecting environmental flows and the state of water bodies on the one hand, and the CAP which seeks to protect agricultural production in Europe on the other continue, although they have been attenuated.

The experience with the PEAG program showed how environmental and social objectives are mobilized to justify large cash injections by the government and how these were hijacked by farmers with illegal wells, exploiting the loopholes in a poorly executed plan. The state experimented with a water banking system as a key measure of the PEAG, shouldering the full cost of buying back rights from some farmers. The aim of this measure was to restore aquifer levels and wetland ecosystems, and reallocate 30% of the water to others abstracting water illegally. The original environmental objectives were gradually forgotten during the implementation of the program, because of lobbying by farmer groups and a weak environmental constituency in the region. The state ended up transferring 100% of effective water rights procured to other farmers, thus paying for granting of legal use to those who had breached the law. The program even included the possibility to buy and transfer partial rights, whereby legal farmers could retain part of other abstraction rights. This flexibility resulted in high monitoring and enforcement costs, opening the door to opportunistic strategies. The program was bedeviled by several irregularities, such as farmers selling the rights of wells which were not used any longer, and the state buying rights from farmers outside the designated priority area, and even from some who had illegally encroached on public land. This also points to a big gap between the regulations established by the state and its capacity to enforce them on the ground, whether due to a lack of means or a combination of political power struggles between local communities, governments and corrupt practices.

Despite the existence of GWUAs in La Mancha, the lack of devolution of management powers to user communities and their financial difficulties and small budgets paralyzes their activities

and adds to the lack of common purpose between users. Additionally, while the 1985 Water Law has provisions for the establishment of a General Community of water users in aquifers declared as over-exploited, the expectation that such water user groups would help enforce state regulation on the ground is naive. As may have been expected, they are not prepared to inflict stick-like regulation onto themselves and become lobbying groups which try to influence policy making in their favor. The powers of the ad hoc General Community of users created by decree are also limited due to member fragmentation and internal political pressures. Furthermore, individual GWUAs have been captured by elites, with some powerful members of local farmer unions having skillfully exploited windows of opportunity to join their boards, and organize and control these associations.

The history of groundwater management policy in the Upper Guadiana provides several crucial lessons with regard to the weakness of the state in implementing different types of groundwater management policies. Conventional approaches suggest that, in order to address the problem of groundwater over-abstraction, strong regulation, clear legal frameworks, and negative and positive incentives are needed. However, as the case study reviewed in this report shows, a strong regulatory framework on paper is necessary but not sufficient. The lack of law enforcement, fragmented political realities, and a not-so-easy legal transition towards well licensing are all problems faced not only by Spain but also by other countries in Europe and around the Mediterranean (Closas and Molle 2016).

Part of the weaknesses of these tools and frameworks can be attributed to the logistical nightmare commonplace in groundwater management, with huge costs for installing metering and enforcing regulation due to the large number of independent users. Part of the weaknesses can also be attributed to the strength of regional and local politics, exemplified in the case of the Upper Guadiana RBA by the hijack of the PEAG's objectives by the regional government of Castilla-La Mancha in contravention with the goals of the River Basin Agency. Additionally, the alignment of groundwater user communities to agricultural interests and local politics undermined the establishment and mandate of the state-sponsored groundwater management association, the *Communidad General de Usuarios del Acuifero 23*, supposed to oversee the implementation of the emergency groundwater abstraction plan amongst local groundwater irrigation communities.

In spite of the limited success of the above-mentioned policy tools on the recovering of water table levels since the provisional declaration of over-exploitation of the Western Mancha aquifer in 1987, hydrological data from 2012 indicated that groundwater levels have been recovering (Figure 2). However, even though the Guadiana River started flowing again into the Las Tablas de Daimiel Wetland in November 2012 (Mendez 2012), some critical voices (e.g., WWF 2012; Martínez-Santos et al. 2008) have warned that such recovery is not the result of state-sponsored recuperation plans but due to exceptionally good rainfall periods. In other words, the observable shifts in the multi-year groundwater storage levels in the Western Mancha aquifer would seem to be indicative of aquifer recharge following precipitation (recovering 2 years after the rainfall events). This suggests that this aquifer recovery has less connection with the policy instruments used, masking once again the complex reality of groundwater over-abstraction in La Mancha and the relative importance of state policies hitherto.

One general conclusion from the overall story outlined in this report is that failure is linked to opportunistic (groundwater users) and lax (official) behaviors. However, merely recommending that actors should act differently does not carry much weight. It is easier (yet useful) to identify what does not work rather than asserting what should be done and how; since what should be done is predicated upon local socioeconomic, institutional and political contexts. However, some

general conclusions can be derived from the Western Mancha aquifer experience that may have wider application:

- The implementation of conventional state policy instruments (quotas, pricing, licensing, bans, etc.) faces clear limitations; officials generally tend to overestimate the weight of their regulation and often fail to anticipate how they will be weathered down when applied locally. Policy instruments should not be implemented without a clear analysis of the costs and means involved, notably in terms of plain logistics.
- Policy solutions have to be kept simple when groundwater monitoring and control are not possible. The counterpoint is well illustrated by the PEAG's complicated buy-out programs, whereby users could not only sell their groundwater abstraction rights but could also sell a portion of their rights. However, the sealing of wells from owners selling the right is hard to ensure, and the reallocation of portions of groundwater rights implies accurate monitoring of water use, something clearly more difficult to undertake. Predictably, this 'flexibility' option gave way to malpractices and was clearly beyond administrative capacity.
- While it is apparent that state-only, top-down regulation has clear limits, no co-management of groundwater has been possible in the case study presented. Whether forced, or by their own will, farmers have organized in lobbying groups rather than co-managing the resource. They have successfully exploited political bipartisanship at the national level, hijacked and circumvented policies on the ground, and drawn benefit from inconsistent EU policies. This, so far, has proved much more beneficial to farmers than merely conforming to state injunctions. Contrasting experience in the nearby Eastern Mancha Province, where groundwater users have rather successfully organized and collaborated (Hernández-Mora and López-Gunn 2003; López-Gunn 2012), suggests that two important constraints need to be overcome:
    - The size of the Western Mancha aquifer and the number of users is unmanageable. Contrary to the law which suggests that a federation of users at the aquifer level is a key objective, the aquifer and the users need to be subdivided into manageable and hydrologically meaningful units. This calls for a breaking of municipal associations and forced reorganization along hydrologically consistent boundaries (with some tolerance to reduce the number of municipalities concerned). Management units must then be modeled hydrologically to establish pumping limits that reflect their impact on the aquifer, in general, and the wetland, in particular; and management bodies (or districts) must be made responsible for enforcing these limits. Incentives to organize can come from a tangible threat to reduce quotas uniformly and toughen enforcement.
    - Forced acceptance begets adaptiveness and proactive behaviors if, once limits (sticks) have been accepted, they are paralleled with compensation/help (carrots) extended when hydrologic conditions dictate a reduction in abstraction. These may include temporary (or permanent) buy-out of entitlements, subsidies to move to less water-intensive crops, or interbasin surface water transfers.
- It is abundantly clear that 'politics' consistently outweighed policies. The multiple levels of decision making and the antagonistic objectives/interests (whether economic or political) of farmers, user communities, the General Community, the regional government, the river basin organization, the national level, political parties, and finally the EU (Figure 8) do not converge toward the same goal. Changing this state of affairs is an issue that is, of course, much further than what can be envisaged from the sole point of view of the water sector.

- The case study also shows that carrots given to offset sticks can be counterproductive and even worsen the problem, because (i) farmers have been paid to break the law (which seriously undermines the authority of the state); (ii) the reduction in abstraction achieved was only temporary; and (iii) some measures were unsound (such as the subsidies given to grape cultivation, which fueled intensification and extension, and eventually water consumption). Sticks should be brandished and then (moderate) carrots extended to those who *comply with the constraints*. Otherwise nothing is gained at the end in terms of controlling over-abstraction.
- It was apparent that gaps in EU policies have been exploited. Such policies influence the wider environment that shapes the economic behavior of groundwater users. Coherence of sectoral policies should, therefore, be achieved at the EU level in order to reinforce, rather than undermine, national policies.

REFERENCES

AEVAL (Agencia Estatal de Evaluacion de las Politicas Publicas y la Calidad de los Servicios). 2010. *Evaluación de la gestión y funcionamiento de las confederaciones hidrográficas*. España: Agencia Estatal de Evaluacion de las Politicas Publicas y la Calidad de los Servicios, Ministerio de la Presidencia, Gobierno de España. Available at www.aeval.es/comun/pdf/evaluaciones/E17-2009.pdf (accessed October 21, 2014).

Álvarez-Cobelas, M.; Sánchez Carrillo, S.; Cirujano, S.; Angeler, D.G. 2008. Long-term changes in spatial patterns of emergent vegetation in a Mediterranean floodplain: Natural versus anthropogenic constraints. *Plant Ecology* 194(2): 257-271.

Barco Royo, E.; Navarro Pérez, M.C. 2012. *Factores de cambio en el mercado internacional del vino en un scenario de crisis*. Comunicacion V Premio Jose Luis Sampedro. Available at http://xivrem.ujaen.es/wp-content/uploads/2012/05/29-R-041M111.pdf (accessed February 5, 2015).

Bemelmans-Videc, M.L. 1998. Introduction: Policy instrument choice and evaluation. In: *Carrots, sticks and sermons: Policy instruments and their evaluation*, eds., Bemelmans-Videc, M.L.; Rist, R.C.; Vedung, E. New Brunswick, USA: Transaction Publishers. Pp. 1-18.

BOE (Boletin Oficial del Estado). 1985. Sesion plenaria num. 187, Martes 12 de Marzo de 1985, Diario de Sesiones del Congreso de los Diputados, II Legislatura, Num. 187. Available at www. congreso.es/public_oficiales/L2/CONG/DS/PL/PL_187.PDF (accessed March 11, 2014).

Bórnez Mejías, K. 2014 *Evolución hidrogeológica de la masa de agua subterránea mancha occidental I: Inventario, génesis y clasificatión de los colapsos del terreno*. MSc thesis, Universidad de Málaga, España.

Bromley, J.; Cruces, J.; Acreman, M.; Martínez, L.; Llamas, M.R. 2001. Problems of sustainable groundwater management in an area of over-exploitation: The upper Guadiana Catchment, central Spain. *International Journal of Water Resources Development* 17(3): 379-396.

Cabezas Guijarro, I.; Sánchez, J.O. 2012. *Las comunidades de usuarios de aguas subterráneas en la mancha occidental : Una propuesta de reforma*. Facultad de Economía y Empresa, Universidad de Zaragoza, España.

Calleja, E.J.; Velasco, M. 2011. *Plan Especial del Alto Guadiana: Un reto, una oportunidad*. VII Congreso Ibérico sobre Gestión y Planificación del Agua "Ríos Ibéricos + 10. Mirando al future tras 10 años de DMA", February 16-19, 2011, Talavera de la Reina, España.

Castaño-Castaño, S.; Martinez-Santos, P.; Martinez-Alfaro, P.E. 2008. Evaluating infiltration losses in a Mediterranean wetland: Las Tablas de Daimiel National Park, Spain. *Hydrological Processes* 22(26): 5048-5053.

Confederación Hidrográfica del Guadiana. 2010. *Informe técnico. Análisis de la aparición de cuerpos de agua en el cauce del río Guadiana en la zona del molino de Griñón y denominados « nuevos ojos »*. Expediente investigación EI – 11/2010. España: Confederación Hidrográfica del Guadiana, Ministerio de Medio Ambiente, y Medio Rural y Marino. Available at www. chguadiana.es/corps/chguadiana/data/resources/file/informacion_interes/informe_Final_Daimiel_Molino_Grinon-Nuevos-ojos.pdf (accessed March 11, 2014).

Confederación Hidrográfica del Guadiana. 2016a. *Anejo 3 – Análisis de la rentabilidad de los cultivos de la demarcación hidrográfica del Guadiana*. 2º Ciclo de planificación hidrológica 2015-2021. España: Confederación Hidrográfica del Guadiana. Available at http://planhidrologico2015.chguadiana.es/corps/planhidrologico2015/data/resources/file/documentos%20DMA/art5-6/Art5_Anejo_3.pdf (accessed June 21, 2016).

Confederación Hidrográfica del Guadiana. 2016b. *Plan hidrológico de la parte Española de la demarcación hidrográfica del guadiana.* Available at http://www.chguadiana.es/?corp=planhidrologico2015&url=61 (accessed on September 13, 2015).

Cirujano, S.; Casado, C.; Bernués, M.; Camargo, J.A. 1996. Ecological study of las Tablas de Daimiel National Park (Ciudad Real, central Spain): Differences in water physico-chemistry and vegetation between 1974 and 1989. *Biological Conservation* 75(3): 211-215.

Closas, A. 2012. Annex 6: Groundwater management and governance in Spain and Jordan - Spain. In: *Managing the invisible: Understanding and improving groundwater governance*, eds., Wijnen, M.; Augeard, B.; Hiller, B.; Ward, C.; Huntjens, P. Water papers. Washington, DC: The World Bank. Pp. 136-138.

Closas, A. 2013. *Burning water - The state, irrigation technology and the production of scarcity in Spain.* PhD Thesis. School of Geography, University of Oxford, UK.

Closas, A. 2014. Norias, boreholes, and the role of the state during the groundwater 'silent revolution' in La Mancha, Spain. *Hydrogeology Journal* 22(5): 1179-1192.

Closas, A.; Molle, F. 2016. *Groundwater governance in the Middle East and North Africa.* IWMI Project Report No. 1. Groundwater governance in the Arab world. Cairo, Egypt: International Water Management Institute (IWMI).

Cruces, J.; Fornés, J.; Casado, M.; de la Hera, A.; Llamas, M.R.; Martínez Cortina, L. 1998. El marco natural: Agua y ecología [The natural environment: Water and ecology]". In: *De la noria a la bomba. Conflictos sociales y ambientales en la cuenca alta del río Guadiana,* eds., Cruces de Abia, J.; Hernández, J.M.; López Sanz, G.; Rosell, J. Bilbao: Editorial Bakeaz. Pp. 15-130.

Del Moral Ituarte, L.; Hernández-Mora, N. 2016. Nuevos debates sobre escalas en política de aguas. Estado, cuencas hidrográficas y comunidades autónomas en España. *Ciudad y Territorio: Estudios Territoriales* XLVII(190): 1-21.

De Stefano, L. 2013. Easier said than done? The establishment of baseline groundwater conditions for the implementation of the Water Framework Directive in Spain. *Water Resources Management* 27(7): 2691-2707.

De Stefano, L.; López-Gunn, E. 2012. Unauthorized groundwater use: Institutional, social and ethical considerations. *Water Policy* 14: 147-160.

De Stefano, L.; Martinez-Cortina, L.; Chico, D. 2013. An overview of groundwater resources in Spain. In: *Water, agriculture and the environment in Spain: Can we square the circle?*, eds., De Stefano, L.; Ramon Llamas, M. London: Taylor and Francis Group. Pp. 87-104.

De Stefano, L.; Fornes, J.M.; Lopez-Geta, J.A.; Villarroya, F. 2015. Groundwater use in Spain: An overview light of the EU Water Framework Directive. *International Journal of Water Resources Development* 31(4): 640-656.

Del Campo Garcia, A. 1996. *Spanish irrigators communities*. 2nd Meeting of the Interim Board of Governors, World Water Council, Granada, Spain, July, 1996.

Diaz Mora, J. 2014. *El papel de las comunidades de usuarios en la gestión de las aguas subterráneas*. XIII Congreso Nacional de Comunidades de Regantes de Espana, Palos de la Frontera, May 12-16, 2014. Available at www20.gencat.cat/docs/DAR/DE_Departament/DE02_Estadistiques_observatoris/27_Butlletins/02_Butlletins_ND/Fitxers_estatics_ND/2014_fitxers_estatics/0139_2014_MA_Regadius_RegsRolComunitats.pdf (accessed August 5, 2014).

Fanlo Loras, A. 2007. Confederaciones hidrográficas. In: *Diccionario de derecho de aguas*, coord., Embid, A. Madrid: Lustel. Pp. 426-447.

Fernández Lop, A. 2013. *El fiasco del agua en el alto guadiana.* IX Seminario Internacional: Transparencia y concesiones, Fundacion Marcelino Botin, Enero de 2013. Available at http://www.fundacionbotin.org/89dguuytdfr276ed_uploads/Observatorio%20Tendencias/Sem%20NACIONALES/10%20sem%20nacional/10%20sem%20nac-6%20TEXTO%20alto%20guadiana.pdf (accessed February 5, 2015).

Fernández Portela, J. 2013. La evolución reciente del sector vitivinícola internacional. *GeoGraphos* 4(39): 173-194.

Ferrer Matvieychuc, G.; Martin de la Cal, M. 2009. *Los instrumentos de mercado y la recuperación del estado cuantitativo de las masas de agua subterráneas. Experiencias comparadas de las cuencas del Jucar y del Guadiana*. Master's thesis, Master de Gestion Fluvial sostenible y gestión integrada de aguas superficiales y subterráneas, Universidad de Zaragoza, España.

Font, N.; Subirats, J. 2010. Water management in Spain: The role of policy entrepreneurs in shaping change. *Ecology and Society* 15(2): 25.

Fornés, J.M.; de la Hera, A.; Llamas, M.R. 2005. The silent revolution in groundwater intensive use and its influence in Spain. *Water Policy* 7: 253-268.

Fornés Azcoiti, J.M.; de la Hera Portillo, A.; Llamas Madurga, R. 2005. La propiedad de las aguas subterráneas en España: La situación del registro/catálogo. *Ingeniería del Agua* 12(2): 125-185.

Hernández-Mora, N. 1998. *El papel de los usuarios en la gestión del agua en el acuífero de la Mancha Occidental: Oportunidades ante una situación de conflicto y carestía (The role of users in the management of groundwater resources in the Western Mancha aquifer: Opportunities in the face of conflict and scarcity)*. Acta del Congreso Ibérico sobre Gestión y Planificación de Aguas, (Communications in CD ROM), Zaragoza, September 14-18, 1998.

Hernández-Mora, N. 2002. *Groundwater management in Spain: Local institutions for collective management of common pool resources: An analysis of three cases from La Mancha.* MS thesis, Gaylord Nelson Institute for Environmental Studies, University of Wisconsin-Madison, USA.

Hernández-Mora, N.; López Gunn, E. 2003. La gestión colectiva de las aguas subterráneas en La Mancha. In: *Conflictos entre el desarrollo de las aguas subterráneas y la conservación de los humedales: La cuenca alta del Guadiana,* eds., Coleto, C.; Martínez Cortina, L.; Llamas, M.R. Madrid: Fundación Marcelino Botín y Mundi-Prensa.

Hernández-Mora, N.; Del Moral, L.; La Roca, F.; La Calle, A.; Schmidt, G. 2014. Interbasin water transfers in Spain: Interregional conflicts and governance responses. In: *Globalized water: A question of governance,* ed., Schneider-Madanes, G. Dordrecht: Springer. Pp. 175-194.

IGME (Instituto Geologico y Minero de Espana). n.d.a. Identificación y caracterización de la interrelación que se presenta entre aguas subterráneas, cursos fluviales, descargas por manantiales, zonas húmedas y otros ecosistemas naturales de especial interés hídrico. Demarcación Hidrográfica 040 Guadiana Masa de Agua Subterranea 040.007 Mancha Occidental I. Ministerio de Ciencia e Innovacion, Ministerio de Medio Ambiente y Medio Rural y Marino, Instituto Geologico y Minero de Espana. Available at http://info.igme.es/SIDIMAGENES/147000/984/147984_0000002.PDF (accessed June 20, 2016).

IGME. n.d.b. Identificación y caracterización de la interrelación que se presenta entre aguas subterráneas, cursos fluviales, descargas por manantiales, zonas húmedas y otros ecosistemas naturales de especial interés hídrico. Demarcación Hidrográfica 040 Guadiana. Masa de Agua Subterranea 040.006 Mancha Occidental II, Ministerio de Ciencia e Innovacion, Ministerio de Medio Ambiente y Medio Rural y Marino, Instituto Geologico y Minero de Espana. Available at http://info.igme.es/SIDIMAGENES/147000/984/147984_0000001.PDF (accessed June 20, 2016).

IGME. 2012. *Las aguas subterraneas en la planificacion hidrogeologica*. Madrid: Instituto Geologico y Minero de Espana.

Llamas, M.R.; Fornés, J.M.; Hernández-Mora, N.; Martínez Cortina, L. 2001. *Aguas subterráneas: retos y oportunidades*. Madrid: Fundación Marcelino Botín.

Llamas, M.R.; Garrido, A. 2007. Lessons from intensive groundwater use in Spain: Economic and social benefits and conflicts. In: *The agricultural groundwater revolution: Opportunities and threats to development*, eds., Giordano, M.; Villholth, K.G. Wallingford: CABI. Pp. 266-295.

López-Gunn, E. 2003. The role of collective action in water governance: A comparative study of groundwater user associations in La Mancha aquifers in Spain. *Water International* 28(3): 367-378.

López-Gunn, E. 2012. Groundwater governance and social capital. *Geoforum* 43: 1140-1151.

López-Gunn, E.; Hernández-Mora, N. 2001. La gestión colectiva de las aguas subterráneas en La Mancha: análisis comparativo. In: *La economía del agua subterranea y su gestión colectiva*, eds., Hernández-Mora, N.; Ramón Llamas, M. Madrid: Fundación Marcelino Botín. Pp. 405-473.

López-Gunn, E.; Martinez-Cortina, L. 2006. Is self-regulation a myth? Case study on Spanish groundwater user associations and the role of higher-level authorities. *Hydrogeology Journal* 14(3): 361-379.

López-Gunn, E.; Dumont, A.; Villarroya, F. 2013. Tablas de Daimiel National Park and groundwater conflicts. In: *Water, agriculture and the environment in Spain: Can we square the circle?*, eds., De Stefano, L.; Ramon Llamas, M. London: Taylor and Francis Group. Pp. 259-267.

López Sanz, G. 1998. Humedales y agricultura de regadío: El caso de la Cuenca alta del río Guadiana. *Agricultura y Sociedad* 86: 249-272.

MAGRAMA (Ministerio de Agricultura, Alimentación y Medio Ambiente). 2012a. *Agricultura, alimentacion y medio ambiente en España 2012*. Memoria Anual de actuaciones, Ministerio de Agricultura, Alimentacion y Medio Ambiente, Madrid. Available at http://www.magrama.gob.es/es/ministerio/servicios/publicaciones/09-II-E-Agua_tcm7-286711.pdf (accessed February 27, 2015).

MAGRAMA. 2012b. *Propuesta de memoria ambiental del Proyecto de Plan Hidrologico de la Cuenca del Guadiana parte Espanola de la demarcación hidrográfica*. Madrid, Badajoz: Ministerio de Agricultura, Alimentacion y Medio Ambiente. Available at www.magrama.gob.es/es/agua/temas/planificacion-hidrologica/memoria_ambiental_phguadiana_tcm7-233705.pdf (accessed October 19, 2014).

Martinez Cortina, L.; Mejias Moreno, M.; Diaz Munoz, J.A.; Morales Garcia, R.; Ruiz Hernandez, J.M. 2011. Cuantificacion de recursos hídricos subterráneos en la cuenca alta el Guadiana. Consideraciones respecto las definiciones de recursos renovables y disponibles. *Boletin Geologico y Minero* 122(1): 17-36.

Martínez-Santos, P.; De Stefano, L.; Llamas, M.R.; Martínez-Alfaro, P.E. 2008. Wetland restoration in the Mancha Occidental Aquifer, Spain: A critical perspective on water, agricultural and environmental policies. *Restoration Ecology* 16(3): 511-521.

Mejias Moreno, M. 2001. *Contribucion al conocimiento hidrogeológico de la unidad hidrogeológica 04. 04 (Mancha Occidental). Analisis de la evolución piezometrica*. Tomo XXIV, VII Simposio de Hidrogeologia Asociacion Espanola de Hidrogeologia Subterranea, Mayo 2 - Junio 1, 2001, Murcia, Spain. Pp. 91-106. Available at http://aguas.igme.es/igme/publica/sim_hidro_Murcia/tomo%20XXIV/06.pdf (accessed June 20, 2016).

Mejías Moreno, M.; López Gutiérrez, J.; Martínez Cortina, L. 2012. Características hidrogeológicas y evolución piezométrica de la Mancha Occidental. Influencia del periodo húmedo 2009-2011. *Boletín Geológico y Minero* 123(2): 91-108.

Mendez, R. 2012. *El alto guadiana vuelve a corer*. El País, November 13, 2012. Available at http://sociedad.elpais.com/sociedad/2012/11/12/actualidad/1352755578_374586.html (accessed January 25, 2013).

MMA (Ministerio de Medio Ambiente). 2000. *Libro Blanco del Agua en España*. Madrid: Ministerio de Medio Ambiente (MMA).

MMA. 2008a. *Plan Especial del Alto Guadiana. Documento de síntesis*. Available at www.chguadiana.es/corps/chguadiana/data/resources/file/PEAG/0_DOC_SINTESIS.pdf (accessed February 5, 2015).

MMA. 2008b. *Anejo II. Informe de aprovechamientos sin aval*. *Plan Especial del Alto Guadiana*. Confederacion Hidrográfica del Guadiana. Available at www.chguadiana.es/corps/chguadiana/data/resources/file/PEAG/7_A_II_APROV_SIN_AVAL.pdf (accessed March 11, 2014).

Molle, F.; Berkoff, J. 2007. Water pricing in irrigation: The lifetime of an idea. In: *Irrigation water pricing: The gap between theory and practice*, eds., Molle, F.; Berkoff, J. Wallingford: CABI. Pp. 1-20.

MOPTMA (Ministerio de Obras Publicas, Transportes y Medio Ambiente); MINER (Ministerio de Industria y Energía). 1994. *Libro blanco de las aguas subterráneas*. Madrid: Secretaría General Técnica del Ministerio de Obras Públicas, Transportes y Medio Ambiente.

Moreu Ballonga, J.L. 1996. *Aguas públicas y aguas privadas*. Barcelona: Bosch Casa Editorial S. A.

Moreu Ballonga, J.L. 2002. Los problemas de la legislación sobre aguas subterráneas en España: Posibles soluciones. In: *Papeles del proyecto Aguas Subterráneas*, ed., Ramón Llamas, M. Santander: Fundación Marcelino Botín. Pp. 15-68.

PEAG (Plan Especial del Alto Guadiana). 2008a. *II Situacion actual socioeconómica y ambiental, Memoria Tecnica*. Anexo 7: Plan Especial del Alto Guadiana. Avialable at http://www.chguadiana.es/corps/chguadiana/data/resources/file/PEAG/7_II_2_ANALISIS_HIDROGEO.pdf (accessed June 20, 2016).

PEAG. 2008b. *Programa de modernización y desarrollo agrario, Memoria Tecnica*. Anexo 7: Plan Especial del Alto Guadiana. Available at http://www.chguadiana.es/corps/chguadiana/data/resources/file/PEAG/PROG_MODERN_DES_AGRARIO.pdf (accessed June 20, 2016).

PEAG. 2008c. *Presupuesto*. Anejo 8: Plan Especial del Alto Guadiana. Available at http://www.chguadiana.es/corps/chguadiana/data/resources/file/PEAG/PROG_MODERN_DES_AGRARIO.pdf (accessed June 20, 2016).

Requena, R. 2011. *El Centro de intercambio de derechos de uso del agua en el Alto Guadiana*. [The trading centre for water use in the Upper Guadiana], 6th National Seminar on Formal Water Markets in Spain, Water Observatory, Botín Foundation, June 27, 2011.

Requena, R. 2013. *Plan Especial del Alto Guadiana. Pasado, presente, y futuro (Estudio especial del consorcio para la gestión del Plan Especial del Alto Guadiana y las técnicas para reordenar los derechos de uso de agua en el ámbito del PEAG)*. Thesis, Master en Investigacion y Especializacion en Derecho de Recursos Naturales, Universidad de Zaragoza, España.

Requena, R.; Garcia, D. 2010. *El Plan Especial del Alto Guadiana*. Master thesis, Master de gestion fluvial sostenible y gestión integrada de aguas superficiales y subterráneas, Universidad de Zaragoza, España.

Rica, M.; López-Gunn, E.; Llamas, R. 2012. Analysis of the emergence and evolution of collective action: An empirical case of Spanish groundwater user associations. *Irrigation and Drainage* 61(S1): 115-125.

Rosell Foxà, J. 2001. Aspectos económicos de la utilización de las aguas subterráneas en La Mancha. In: *La economía del agua subterranean y su gestión colectiva*, eds., Hernández-Mora, N.; Ramón Llamas, M. Madrid: Fundación Marcelino Botín. Pp. 181-201.

Rosell, J.; Viladomiu, L. 1997. El programa de compensacion de rentas por reduccion de regadios en Mancha Occidental y Campo de Montiel. *Economia Agraria* 179: 331-350.

Rosell, J.; Viladomiu, L. 2000. The wine regime. In: *CAP regimes and the European countryside*, eds., Brouwer, F.; Lowe, P. Wallingford: CABI Publishing. Pp. 137-154.

Ruiz Pulpon, A.R. 2007. *Tipologia territorial de la agricultura de regadío en los municipios de la cuenca hidrográfica del Guadiana*. PhD Thesis, Universidad de Castilla-La Mancha. Toledo: Consejo Economico y Social de Castilla-La Mancha.

Ruiz Pulpon, A.R. 2013. El viñedo en espaldera: Nueva realidad en los paisajes vitivinícolas de Castilla-La Mancha. *Boletín de la Asociación de Geógrafos Españoles* 63: 249-270.

Sanjuan, Y. 2013. La politica agraria comun en el Alto Guadiana : evolucion de recursos hidricos y de cultivos. *Cuadernos de Investigacion Geografica* 39(2): 359-389.

Swyngedouw, E. 2014. 'Not a drop of water…': State, modernity and the production of nature in Spain, 1898-2010. *Environment and History* 20(1): 67-92.

Turnpenny, J.; Jordan, A.J.; Benson, D.; Rayner, T. 2015. The tools of policy formulation: An introduction. In: *The tools of policy formulation: Actors, capacities, venues and effects*, eds., Jordan, A.J.; Turnpenny, J.R. Elgaronline. Pp. 3-29.

Varela-Ortega, C. 2007. Policy-driven determinants of irrigation development and environmental sustainability: A case study in Spain. In: *Irrigation water pricing: The gap between theory and practice*, eds., Molle, F.; Berkoff, J. Wallingford, Cambridge, Massachusetts: CABI. Pp. 328-346.

Varela-Ortega, C.; Blanco, I.; Carmona, G.; Esteve, P. 2006. *Field work report in the Upper Guadiana Basin (Spain)*. Prepared under contract from the European Commission, Contract no. 511179 (GOCE). Available at http://www.newater.uni-osnabrueck.de/deliverables/D175b%20(II)%20NW_D1.7.5b(II).pdf (accessed August 1, 2016).

Varela-Ortega, C.; Hernández-Mora, N. 2010. Institutions and institutional reform in the Spanish water sector: A historical perspective. In: *Water policy in Spain*, eds., Garrido, A.; Llamas, M.R. London: CRC Press. Pp. 110-125.

Varela-Ortega, C.; Blanco Gutierrez, I.; Swartz, C.; Downing, T.E. 2011. Balancing groundwater conservation and rural livelihoods under water and climate uncertainties: An integrated hydro-economic modeling framework. *Global Environmental Change* 21(2): 604-619.

WWF (World Wide Fund for Nature). 2012. *El fiasco del agua en el alto Guadiana*. Available at www.wwf.es/?22540/WWFdenuncia-la-compra-pblica-de-agua-fantasma--en-el-Alto-Guadiana-por-66-millonesde-€ (accessed January 16, 2013).

IWMI Working Papers

177 *Sticks and Carrots: Managing Groundwater Over-abstraction in La Mancha, Spain.* Alvar Closas, François Molle and Nuria Hernández-Mora. 2017.

176 *Adapting Aquifer Storage and Recovery Technology to the Flood-prone Areas of Northern Ghana for Dry-season Irrigation.* Seth Owusu, Olufunke O. Cofie, Paa Kofi Osei-Owusu, Vincent Awotwe-Pratt and Marloes L. Mul. 2017.

175 *Public Participation in Environmental Impact Assessment of Hydropower Plants in Nepal: A Context-specific Approach*. Jon Munch-Petersen. 2017.

174 *Smallholder Irrigation Schemes in the Limpopo Province, South Africa.* Barbara van Koppen, Luxon Nhamo, Xueliang Cai, Mary Jean Gabriel, Mosibudi Sekgala, Sydney Shikwambana, Khathu Tshikolomo, Shalon Nevhutanda, Boshomane Matlala and David Manyama. 2017.

173 *Agro-climatic and Hydrological Characterization of Selected Watersheds in Northern Ghana.* Davie M. Kadyampakeni, Marloes L. Mul, Emmanuel Obuobie, Richard Appoh, Afua Owusu, Benjamin Ghansah, Enoch Boakye-Acheampong and Jennie Barron. 2017.

172 *Mapping Irrigated Areas in the Limpopo Province, South Africa.* Xueliang Cai, James Magidi, Luxon Nhamo and Barbara van Koppen. 2017.

171 *Multiple Uses of Small Reservoirs in Crop-livestock Agro-ecosystems of the Volta River Basin with an Emphasis on Livestock Management.* Augustine. A. Ayantunde, Mawa Karambiri, Viviane Yameogo and Olufunke O. Cofie. 2016.

170 *An Assessment of Integrated Watershed Management in Ethiopia*. Gebrehaweria Gebregziabher, Dereje Assefa Abera, Girmay Gebresamuel, Meredith Giordano and Simon Langan. 2016.

169 *Methods to Investigate the Hydrology of the Himalayan Springs: A Review*. Pennan Chinnasamy and Sanmugam A. Prathapar. 2016.

168 *Measuring Transboundary Water Cooperation: Learning from the Past to Inform the Sustainable Development Goals*. Davison Saruchera and Jonathan Lautze. 2015.

167 *Review of Hydro-economic Models to Address River Basin Management Problems: Structure, Applications and Research Gaps*. Maksud Bekchanov, Aditya Sood and Marc Jeuland. 2015.

IWMI provides free access to all its publications.

Visit

www.iwmi.org/publications/index.aspx

Postal Address
P O Box 2075
Colombo
Sri Lanka

Location
127 Sunil Mawatha
Pelawatta
Battaramulla
Sri Lanka

Telephone
+94-11-2880000

Fax
+94-11-2786854

E-mail
iwmi@cgiar.org

Website
www.iwmi.org

IWMI is a CGIAR Research Center and leads the: CGIAR RESEARCH PROGRAM ON Water, Land and Ecosystems

ISSN: 2012-5763
e-ISSN: 2478-1134
ISBN: 978-92-9090-859-3