GROUNDWATER GOVERNANCE IN EUROPE

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Groundwater governance in the Arab World

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Foreword

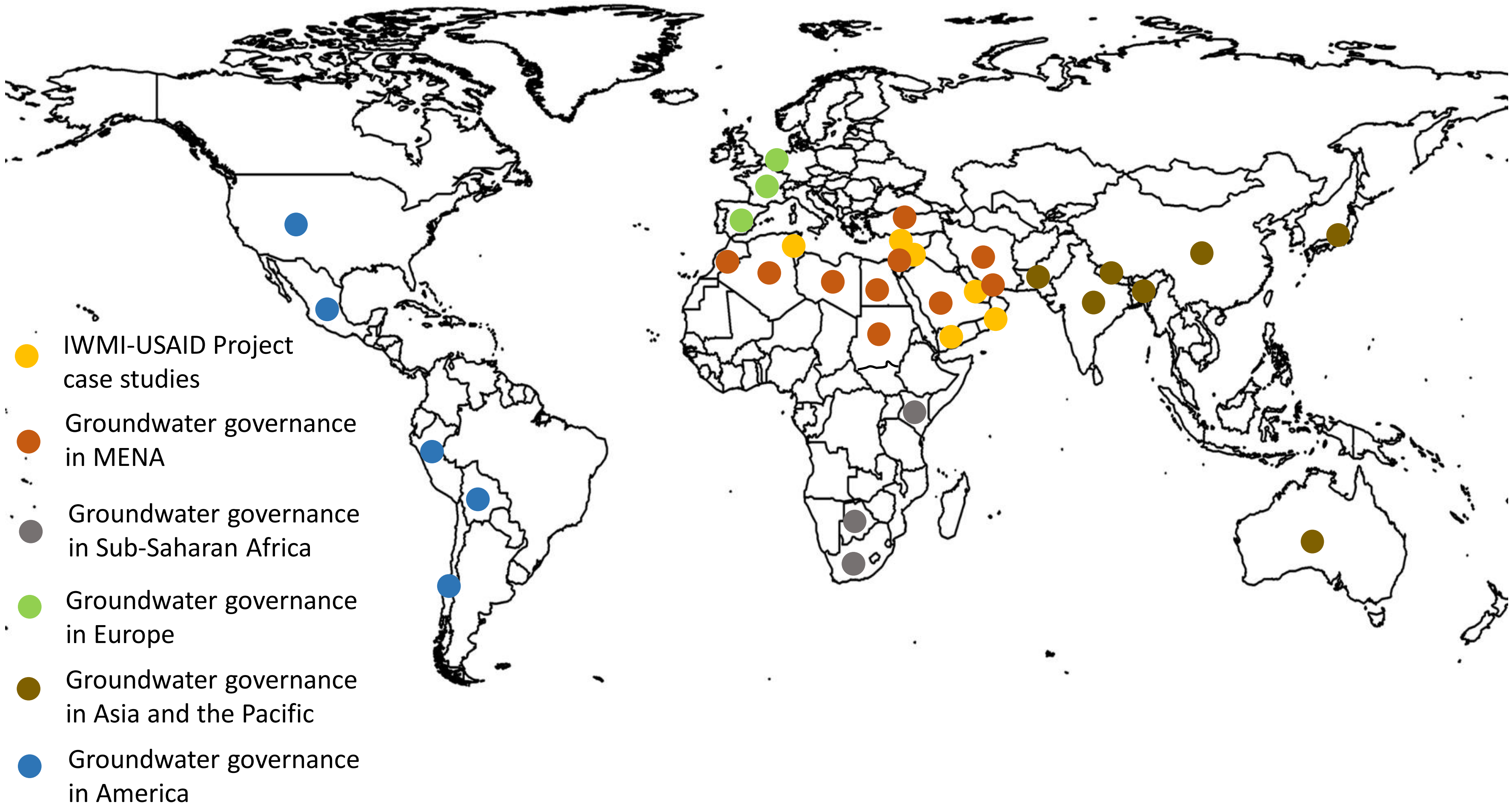
This report on groundwater governance in Europe is part of a series of five regional reports arising from a research initiative undertaken by the International Water Management Institute (IWMI) and funded by USAID aiming to address the challenges posed by the unsustainable use of groundwater in the Middle East and North Africa (MENA) region (Figure 1). Groundwater over-abstraction is a phenomenon 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 is aimed at presenting different governance problems and challenges that exist around the world regarding groundwater and inform potential future management and policy pathways in the MENA region.

The reason for this report on groundwater governance in Europe arises out of the necessity to examine, at various scales, existing cases of groundwater regulation and management so that policy discussions, effective solutions, and mitigation measures to the groundwater crisis may be found. This report brings to the attention of the MENA region the policy and regulatory experience of groundwater in a few selected countries in Europe so that relevant policy and management lessons can be drawn from this case. The countries reviewed in this report are Spain, France, the European Union, and Denmark. The report analyses, through a political, regulatory, and historical lens, the different groundwater regulatory tools, reflecting on the different laws, regulations, community actions, and institutional structures found in the different countries in order to curb groundwater over-abstraction.

Although this report does not attempt to be exhaustive as it is based on existing and accessible literature, it aims to go further than what has been presented until now and address the intrinsic challenges faced by current groundwater policies whilst offering a number of analytical and factual elements on groundwater governance presented in an original way. Semi-arid and arid countries are understandably more likely to (over)exploit their groundwater resources. Mediterranean countries have many common climatic and agricultural features and they all face dramatic increases in the use of groundwater for irrigation. Lessons drawn from the situation in for instance other arid areas with different political economies, can potentially be very relevant as they may indicate potential solutions or -more often than not- flag the dangers or irrelevance of certain standardized, or seemingly desirable, policies. The examples presented here can provide a deeper understanding of the challenges countries in the MENA region face when it comes to reducing groundwater abstraction, echoing some of the attempts to regulate groundwater abstraction made by states in Europe.

The results and failures faced by governments and communities can also represent relevant insights when it comes to enforcing regulation or understanding legal barriers to policy implementation, 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, what worked and did not work. The gravity and complexity of the situation require 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.

Figure 1. Project case studies and cases reviewed for the project



1 Groundwater regulation in the European Union

1.1 Main groundwater management challenges in Europe[1]

Europe presents a large variability of groundwater use and consumption. Though water scarcity in European countries tends to be localized, competition between demands and users is increasing. Southern countries experience a more continuous general decrease in supply, while countries to the north, enjoying more groundwater per capita endowment (Dosi and Tonin 2001). In Southern Europe, the largest single user of water is agriculture, with 80 percent of all water consumption, compared to an EU average of 24 percent. Groundwater represents 18 percent of the total water use in Spain, going up to 43 percent in Greece and 54 percent in Portugal (EASAC 2010). This is in stark contrast with Northern and Central Europe, where agriculture is mainly rainfed and the principal use of groundwater is for drinking.

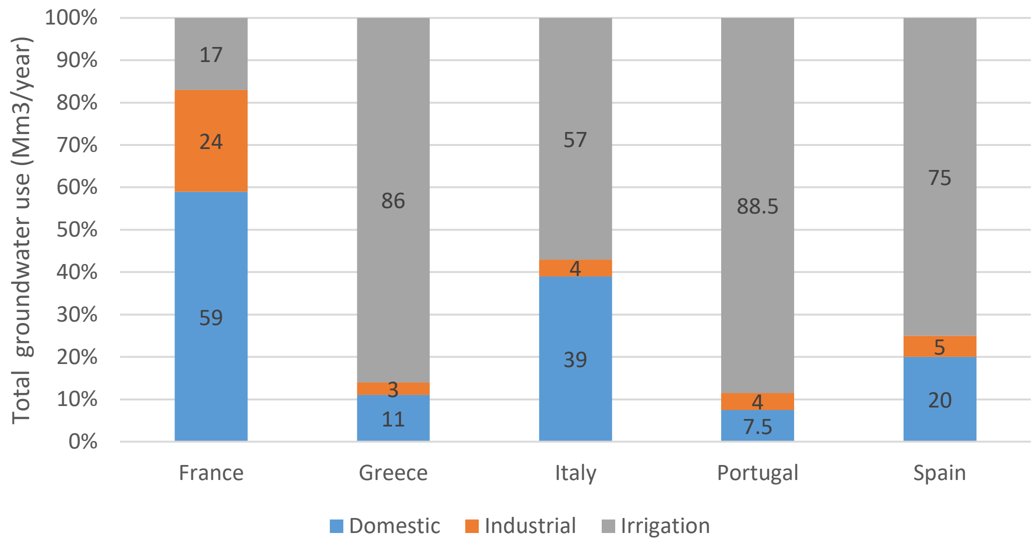
The use of fertilizers and pesticides in agriculture arising from industrialized farming is an issue in most countries, with diffuse pollution representing the major problem for groundwater in countries like France and Denmark. Traditional pollution of groundwater bodies from agriculture is a common problem across Southern Europe, mostly due to the historical uncontrolled use of fertilizers. Some countries (e.g. Greece) face additional pressures on some aquifers arising from the conflict over the allocation of groundwater for different users (tourism vs. agriculture). This is also causing seawater intrusion in certain areas, as tourism is particularly concentrated in coastal areas in the South of Europe. Countries have developed wellhead protection areas for drinking water supply, but these have not been properly enforced in the past (e.g. France, where extended protection perimeters are needed in rural areas, it is known that mayors will protect their fellow-farmers and electorate by seeking delays in the declaration procedures) (Barraqué and de Marsily 2010).

For years not all EU policies have moved in the same direction, as the overall objectives of the CAP policy (Common Agricultural Policy) which incentivized and financially supported intensive farming and groundwater abstraction, was at odds with environmental and sustainable development objectives (Chilton and Smidt 2013). Added to this, the short span of the political vision of decision makers (based on their political terms in office) is often incompatible with the needed timeframe to consult, legislate, and develop sound management practices and enforcement of rules (ibid.).

One of the main concerns amongst the Southern European Union members regarding groundwater is the rapidly increasing number of users, leading in many parts to “a significant unregulated community of users”. This phenomenon affects the accuracy of current estimates of abstraction volumes and can create “a significant social and political obstacle that has to be overcome if good management of aquifers is to be achieved” (EASAC 2010a: 1). The regulation of wells, shows considerable differences across Europe, with monitoring and enforcement varying according to the region and country. This causes a lack of knowledge on total groundwater use, number of illegal abstractions and boreholes, detailed data on groundwater quality changes (including saline intrusion), and economic data on groundwater costs and prices.

[1] Source: EASAC 2010a except when stated otherwise.

Figure 2. Uses for groundwater in Southern European countries (in Mm3/year)



Source: Based on data from EASAC 2010a.

1.2 The Water Framework Directive and groundwater

Groundwater regulation and management in the European Union is done via a series of directives, aimed at harmonizing the legal structures of the different countries, which will be incorporated into every member's legislation and regulatory framework, after being approved by the country's parliament. The most important directive, the year 2000 Water Framework Directive (WFD), is an over-arching piece of legislation aiming to "harmonize existing European water policy and to improve water quality in all of Europe's aquatic environments" (Kaika 2003: 314). This piece of legislation requires that all country members ensure that all surface waters are in good chemical and ecological status and groundwater bodies are in good status by 2015. Programmes and plans to achieve the status required are to be included in river basin management plans, which were due to be sent to the European Commission by 2009.

In order to implement the WFD, a few steps have to be taken by the member states such as defining and characterizing the state of all water bodies; identifying the various pressures for these water bodies; evaluating the impacts of these pressures on the ecological health of the body, and come up with specific measures for implementation, in order to reach a good status by 2015, and finally perform cost-efficiency analyses of the different measures (Hernandez-Mora et al. 2007). The WFD introduced water management at the river basin level, and also incorporated the 'polluter pays principle', and promotes public participation with their representation in national and regional level water bodies.

These programs of measures should be included at the level of the River Basin Plans, due to be sent to the Commission by 2009, after being debated and discussed amongst stakeholders and users. This caused difficulties and some countries (especially in the south of Europe) had to ask for an extension of the deadline (to 2021 or 2027). In some cases where water bodies cannot achieve the WFD goals, countries will have to present the reasons and circumstances for the lack of achievement of the objectives, and they will be subject to consultation with stakeholders (EASAC 2010a).

The WFD initially required all member states to identify groundwater bodies, as well as protected areas and habitats depending on groundwater; identify anthropogenic pressures, quantify them, and develop management plans for their long-term sustainability (as part of the river basin plans) by the end of 2004. This was expected to be completed by the end of 2009 with a review planned in 2015 and then every six years. A programme of measures to achieve the environmental goals of the WFD (e.g. abstraction control, prevention of pollution) was to be established by the end of 2009 and operational by the end of 2012 (Quevauviller 2005).

1.3 Negotiating the WFD

Negotiations for the WFD were fraught with conflict between the different European institutions. Additionally, NGOs involved in the process of amending the WFD in 1998 before it was approved raised their concerns about the 'voluntary compliance' of the directive, as it was up to the member states to define what was meant "by terms like 'significant change', 'low level impacts' or 'good water status' the directive and annex effectively allowed MS [member states] governments to opt out of any of the provisions of the directive they did not like. In other words, the NGOs were alert to what they saw as the danger of allowing the new directive to replace the obligations of existing directives with a more relaxed regulatory regime, which would allow member states voluntary compliance rather than the legal obligations" (Kaika 2003: 317).

During this process, the Council of Ministers was concerned that it would lose legislative powers if the approval of the WFD took too long and the Treaty of Amsterdam was adopted in the meantime (giving the European Parliament more legislative powers, rather than the consultative role it previously had) (Kaika 2003). However, when the draft was passed to the Parliament after the approval of the Council of Ministers, "it became clear that the body as a whole was very sympathetic to the aspirations of the environmentalists" and that there were "real and substantive disagreements between the Parliament and the Council of Ministers over the content of the directive and its pace of implementation" (Kaika 2003: 318).[2] As a result, the Parliament tried to delay the reading of the draft so that the WFD would not be considered until the Amsterdam Treaty had come into force in May 1999.[3]

Conciliatory talks took place however between the Parliament, the Commission, and the Council of Ministers in January 1999 (Kaika 2003). These talks were successful in as much as they were able to establish some trust and contacts allowing for the draft to be red in February 1999. A large number of amendments was however made in Parliament, most of them overturned by the Council in March 1999, going back to their original position from June 1998 (ibid.). When the draft was then returned to the Parliament in December 1999 it had however a reinforced position of co-decision with the Council, following the newly approved Amsterdam Treaty (ibid.). The Environment Commission of the Parliament made however some concessions (such as dropping the demand for full-cost pricing and called for the 'adequate contribution' to cost recovery for water services and the provision of incentives for the rational use of water (ibid.). The delay over conciliation talks during most of 2000 put pressure on the Parliament and Council as, if during the six weeks given for this second round of talks an agreement was not reached, under EU decision-

[2] Some of these disagreements had to do with the idea of full-cost pricing for water. The ministerial agreement over the draft in June 1998 rejected the idea of economic pricing for water. The council of ministers was also criticized for placing the interests of the private water industry above those of conservation as it relaxed the demanding timescales proposed (it allowed derogations of up to 34 years instead of 12 years as proposed by the Commission) (Kaika 2003).

[3] This would have resulted in the WFD being passed in co-decision between the Parliament and the Council of Ministers. This meant that the Parliament would have had the same legislative powers as the Council, therefore with added negotiating powers and potential veto. Not all members of the European Parliament were in favour as members from the South of Europe (representing agricultural interests), also opposed the idea of having full-cost pricing for consumers (Kaika 2003).

making rules, the whole directive would be abandoned. A final agreement was reached in June 2000 with concessions from the Parliament (ibid.).[4]

1.4 Implementing the WFD

The application and transposition of this legislation into each of the EU countries has suffered some delays in some cases, mostly due to internal legislative processes, poor tradition of stakeholder consultations and a lack of coordination and development of river basin plans (EASAC 2010a). Except for the Autonomous Community of Catalonia, Spain for example had not reported any other River Basin Management Plans to the Commission at the time of the assessment in 2012. Moreover, tensions between regions and with the central government have had an important impact on the content of river basin plans, with delays in the consultation and participation process (De Stefano et al. 2013). A judgment from the European Court of Justice against Spain on this issue in 2013 declared that Spain had failed to fulfil its obligations under the WFD, ordering Spain to pay for the costs of the legal procedure.[5]

More generally, at the European level, the required inclusion of stakeholders in the process of drafting these river basin plans has delayed the process, and certain groundwater bodies and countries have had to apply for extensions of the deadline (6 to 12 years). Alternatively, some groundwater bodies might never achieve the required quality status. In such cases, the circumstances have to be presented clearly to the Commission and the proposal for mitigation plans needs to be subject to consultation with stakeholders. This problem is amplified as in some cases methodological heterogeneity in data gathering means that obtaining consolidated data on groundwater uses is difficult (ibid.). Regionally, the implementation of the WFD in the countries of the South of Europe has been seen as difficult due to a lack of a tradition of public participation in policy decision making as well as the fact that consumptive use of water for irrigation represents around 80 percent of all uses, therefore making the process of participation and conciliation more complex due to the large number of such users (as individual farmers) (Hernandez-Mora et al. 2007).

In France, groundwater monitoring following the WFD is done at the River Basin level, with quantitative monitoring in all basins, transposed in 2010 following the WFD specifications. This network is designed to determine the availability of groundwater resources. Even though there are national recommendations, the methodology to pollutant trends has “no national method established” and each River Basin Authority “uses the method that best suits the specific characteristics of its water bodies” (EC 2012d: 21). Additionally, there was no methodology to define the acceptable threshold value exceedances reported in 2012 (ibid.). Methodologies for trend assessments and starting points for trend reversals were also often missing, probably due to the fact that these assessments were not compulsory in the first management plans for river basins (ibid.).

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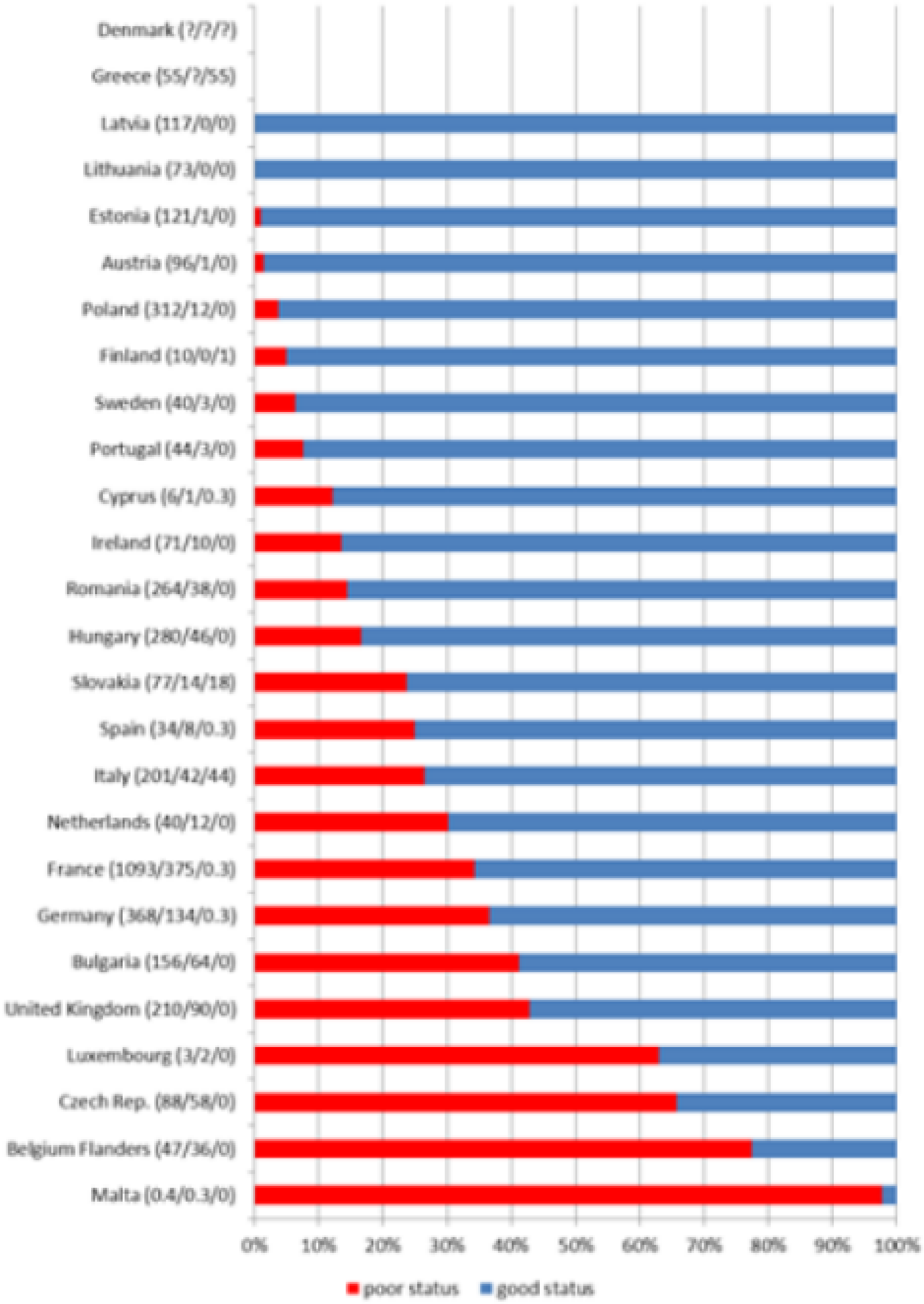
[4] In terms of polluting substances, a revised shortened list was agreed; obligations for discharges; the implementation schedule revised at 15 years and not 10; and the principle of ‘cost recovery’ whereby countries would have to take it ‘into account’ and ensure adequate incentives for the efficient use of the resource by 2010, with an additional opt-out clause making it possible for member states to completely ignore this requirement (Kaika 2003).

[5] Judgment of the Court (fifth chamber), 24 October 2013, Failure of a Member State to fulfil obligations – Environment – Directive 2000/60/EC – Framework for Community action in the field of water policy – Transposition of Articles 4(8), 7(2), 10(1) and (2) of and sections 1.3 and 1.4 of Annex V to Directive 2000/60 – Intracommunal and intercommunal river basins – Article 149(3) of the Spanish Constitution – Supplementing clause, http://curia.europa.eu/juris/document/document.jsf?text=river%2Bbasin%2Bwater%2Bdirective&docid=143545&pageIndex=0&doclang=EN&mode=req&dir=&occ=first&part=1&cid=456036#ctx1 (Accessed 25th February 2015).

In Italy, the central government merged all major and minor basins into 14 different water districts (EASAC 2010b). District authorities, responsible for the application of the principles of the WFD replaced basin authorities (ibid.). The reorganization of the water sector aimed at establishing a governing institution of equal relevance for each district, but what actually happened, was a process that reinforced in a different way, the fragmentation of competencies and responsibilities between ministries, districts, and regional levels (ibid.).

Figure 3. Percentage of groundwater bodies in good and poor chemical status (2012)



Source: EC 2012a.

The chemical status of groundwater bodies in Europe was assessed as good in almost 59 percent of groundwater bodies, (Figure 3) whereas the quantitative status was assessed as ‘good’ in 90 percent (ibid.).[6] Nearly all river basins where groundwater bodies failed to reach a good quantitative status (91 percent) reported that the registration of abstractions and a need for prior authorization of abstractions were the main measures adopted in order to tackle groundwater over-abstraction (EC 2012b). Additionally, 23 percent of river basin plans reported that financial incentives, pricing policies for sustainable use (charges, fines, taxes for water abstractions) were in place (ibid.). However, it would seem that state sovereignty was not overridden as according the WFD these conditions could be allowed following Article 4.7 of the Directive: “Member states can fail to achieve good groundwater or ecological status or potential or prevent deterioration of the status of a water body because of modifications to the water body, if these modifications are adequately justified, all corrective measures are implemented, there is overriding public interest and the goal cannot be satisfied in other ways because of technical infeasibility or disproportionate costs.”

1.5 The Groundwater Directive

An agreement for a ‘daughter directive’ concerning groundwater in the EU was reached in October 2006 and adopted in 2007. A first proposal for such a directive had been presented in 2003 but it took several readings by the European Parliament and discussions between the Council, the Commission, and the Parliament for a final version to be eventually agreed upon and published in December 2006 (Crowhurst 2007). This directive aimed at clarifying some of the objectives of the WFD regarding groundwater, in particular the identification of pollution trends and control (article 17.1 of the WFD). The WFD specifically addresses the quantitative status of groundwater, but does not deal with the chemical status of groundwater (ibid.). The scope of this new directive was therefore broadened following the demands of the European Parliament with the aim to protect groundwater “against pollution and deterioration and not only ‘against pollution’, as the Council had proposed in its common position” (Crowhurst 2007: 203). This ‘groundwater directive’ also listed the criteria pollutants and thresholds for groundwater pollution and clarified the meaning of ‘good chemical status’ (EASAC 2010a).

Previously, Directive 80/68/EEC from 1980 regulated the protection of groundwater against pollution. The main aim of this directive was to provide a framework to protect groundwater from the direct or indirect introduction of high priority pollutants (List I) and other types of pollutants (List II) into groundwater to avoid pollution (Quevauviller 2005).[7] The implementation of this directive faced difficulties due to an “absence of clear information on background groundwater quality levels in the zone affected by discharges, and of quality objectives on the basis of which deterioration may unambiguously be identified” (Quevauviller 2005: 91). Additionally, this first directive was considered to be “needlessly complex and weak”, weakened also by a series of authorization procedures and derogation clauses (Thomas 2009: 277). Afterwards, in 1991, the Nitrate Directive introduced a groundwater action value of 50 mg per litre for maximum nitrate

[6] Good quantitative status is achieved when groundwater levels are such as the available groundwater resource is not exceeded by the long term annual average rate of abstraction (EC 2012b).

[7] List I pollutants include substances posing carcinogenic or mutagenic properties in or via the aquatic ecosystem, mercury and its compounds, cadmium, mineral oils, hydrocarbons, and cyanides. For List I substances direct discharges are prohibited and indirect discharges need to be authorized after a thorough investigation on a case-by-case basis. List II pollutants include substances which could have a harmful effect on groundwater, in particular metals and its compounds (e.g. zinc, copper, nickel, chrome, lead), toxic or persistent organic compounds, inorganic compounds of phosphorus, fluorides, ammonia and nitrites. Direct discharges of List II substances have to be limited and appropriate measures have to be taken to limit any indirect discharges. An authorization after a thorough investigation needs to be issued for direct discharges or disposal or tipping (Quevauviller 2005).

concentration and a new European authorization procedure was approved for pesticides, establishing the obligation to keep groundwater free from pesticides (Cunningham et al. 2006).

A ministerial seminar held in 1991 recognised the need for further action in order to avoid the long-term deterioration of groundwater resources (quantity and quality) by the year 2000 (Quevauviller 2008). To that effect a ministerial declaration was issued, stressing the objective that sustainability should be implemented through an integrated approach taking account of groundwater resources as a whole (ibid.). Subsequent requests made by the Council in 1992 and 1995 in the form of resolutions recommended the implementation of the declaration and the revision of Directive 80/68/EEC (ibid.). A proposal by the Commission to the European Parliament and the Council followed in 1996 calling for an action programme for Integrated Protection and Management of Groundwater (adopted on the 25th of November 1996). This programme provided a framework for national action programmes, implementation and review, as well as clear procedures for the regulation of abstraction of freshwater and for quality and quantity monitoring (ibid.). Later, the WFD of 2000 took the 1996 action programme into account "and was set to complement the Directive 80/68/EEC by stipulating that member states should implement the measures necessary to prevent or limit the input of pollutants into groundwater and to prevent the deterioration of the status of all bodies of groundwater" (Quevauviller 2008: 91).

The 2006 Directive on the Protection of Groundwater against Pollution and Deterioration (Directive 2006/118) implemented Article 17 of the WFD, providing criteria for assessing and restoring groundwater quality. As a 'daughter directive' of the WFD, this Groundwater Directive operates "within the structure of an existing body of legislation governing water policy as a whole" (Thomas 2009: 274). Even though the WFD established quantitative requirements it did not include specific provisions on chemical status (Quevauviller 2008). The WFD seeks a 'good groundwater chemical status' but this target was to be achieved following this new Directive by monitoring of groundwater pollution, establishing criteria for assessing the good status of groundwater bodies and setting specific EU-wide limits to pollutants (nitrates and pesticides particularly) and by delegating regulatory authority and responsibility to member states (Thomas 2009). In the WFD however delays were expected for groundwater with the possibility to extend the 2015 deadline given slow groundwater recovery times and high costs in de-polluting groundwater. For groundwater there was also an envisaged 'lower objective' in the WFD for the 'good chemical status' owning it to technical infeasibilities and disproportionate costs, or in case of exceptional natural events, a temporary deterioration of the good status could be envisaged (EASAC 2010a).

States are also required to take specific actions to reverse any upward trend in groundwater pollution presenting "a significant risk of harm to the quality of aquatic ecosystems or terrestrial ecosystems, to human health, or to actual or potential legitimate uses of the water environment" (Article 5(2), cited in Thomas 2009: 280). Thus, member states must "bring into force the laws, regulations and administrative provisions necessary to comply"[8] with the Directive and implement a program of measures following the WFD (at minimum) however, they also may adopt an alternative 'starting point for trend reversal' if: "1) an earlier starting point is necessary to cost-effectively prevent or mitigate detrimental changes to groundwater quality or; 2) detection of an upward trend in a particular pollutant is impossible at seventy-five percent of the

[8] Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration, Page 25, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:372:0019:0031:EN:PDF (Accessed 26th October 2015).

quality standard or threshold value or; 3) the characteristics of an upward trend indicate that a later starting point for reversal would still allow the most cost-effective prevention or mitigation of harmful changes to groundwater quality" (Thomas 2009: 281).

For Cunningham et al. (2006), the Groundwater Directive brought clarity in regulation and complemented the WFD as it established criteria for assessing groundwater chemical status with two separate pollutant limits (for pesticides and nitrates). Many other pollutants are required to be limited according to specific threshold values set by the state members (although more rigorous standards are to be developed if existing standards are not sufficient to meet WFD objectives). Quality standards for nitrates and pesticides are defined at the European level. For pesticides, the Groundwater Directive introduced the standard of 0.1 micrograms per litre for an individual substance and 0.5 micrograms per litre for the total concentration of pesticides. Quality levels for nitrates were set up at 50 mg per litre in all groundwater bodies (Cunningham et al. 2006).

Table 1. Main dispositions and timeframe for the application of the Groundwater Directive

Year	*Main dispositions*
2007	New Groundwater Directive
2008	- Identification of the baseline level for the trend assessment of the groundwater status in groundwater bodies (average value of pollution concentration for monitoring purposes, defined as the baseline level) - Assessment of the groundwater status - Establishment of threshold values for pollutants by member states
2009	- New programmes of measures ensuring the prevention of input of hazardous substances (specific pollutants listed by the directive) and limitation of other pollutants according to best environmental practice - Identification of new pollution trend in groundwater bodies - Transposition of the Groundwater Directive must be finalized (March 2009 the latest) - Commission report about national threshold values - River Basin Management Plans must publish threshold values for groundwater bodies
2012	- Commission report on the implementation of the WFD should include an evaluation of the functioning of the Groundwater Directive in relation to other environmental legislation
2013	- Review of the Groundwater Directive (every six years after that) - Repeal of the Groundwater Directive 80/68/EEC from 1980
2015	- Window to amend Annexes from the Groundwater Directive in light of scientific and technical progress (and every six years after that)
2027	- Good chemical status is achieved in groundwater bodies at the latest (unless exemptions apply and are justified owing to slow natural recovery progress)

Source: Based on Cunningham et al. 2006.

1.6 Additional implementation gaps

The European Commission assessment in 2012 of the Groundwater Directive (EC 2012a) stated that even though there was a low percentage of groundwater bodies reported to be unknown, there were shortcomings for most member states regarding groundwater monitoring and methodologies to assess the status and pollution trends, "making the results of the groundwater chemical status assessment questionable" (EC 2012a: 23). Additionally, the Groundwater

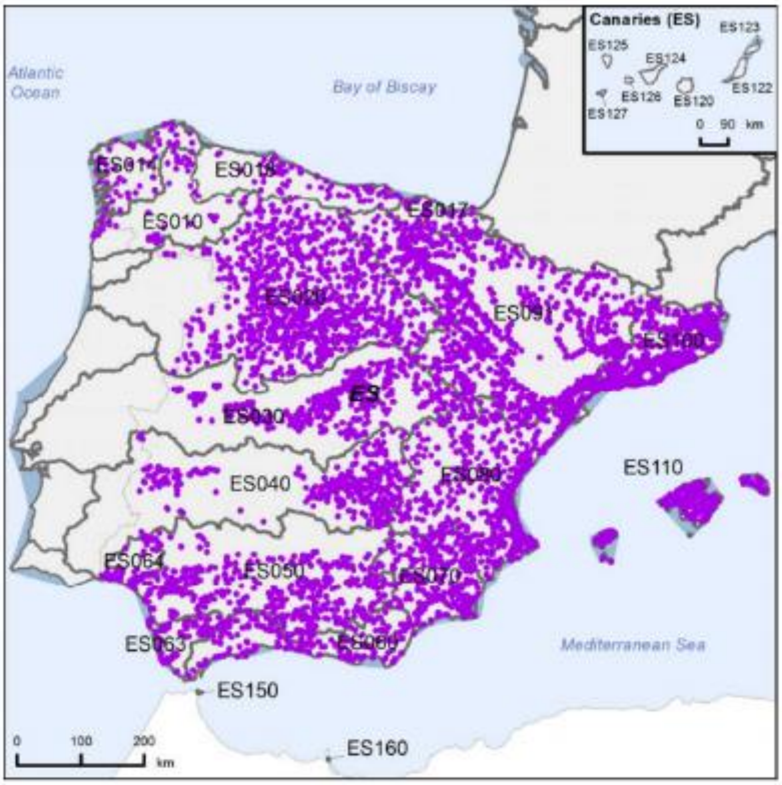
Directive, according to Thomas (2009: 282), does not impose "uniform standards applicable throughout Europe. Instead, the Groundwater Directive coordinates methods for establishing standards based on local conditions, delegating to individual Member states the significant responsibility for regulating contaminants." During the negotiations for the groundwater directive, it was recognized that a uniform approach across Europe would not be "appropriate because of the very different circumstances in different parts of the EU" (EASAC 2010a: 5). This caused a lack of uniformity in the application of the 2006 Groundwater Directive and limitations of the legal transposition of the directive in member states (EASAC 2010a).

In Denmark for instance, according to the European Commission (EC 2012c), the basis for assessing the quantitative status of groundwater bodies is weak (it is only done by the water supply works and utilities). Any groundwater body with contaminants exceeding the set standards for drinking water is abandoned and monitoring is stopped, making it hard to analyse pollution trends. The number of monitoring stations is not consistent according to the European Commission (different figures for national reports and for the EU assessment). Monitoring of protected areas used for drinking water is done by the water suppliers and after treatment.

In Southern European countries (e.g. Spain, Greece), River Basin plans still lack information required, and present data gaps regarding water bodies (EC 2015a, 2015b). In Spain, information required has not been identified in the screening assessment (e.g. the result of the public consultation and its integration in the Basin Plans). In Spain, monitoring information (specifically on groundwater quality and quantity) is not always fully consistent and budget cuts since 2010 have affected the implementation of monitoring programmes (EC 2015b). Also in Spain, the high percentage of water bodies with unknown status adds to the information gaps on the status and implementation of the directives (on average 10 monitoring stations exist per groundwater body in Spain, more so in the areas with intensive abstraction – even though there are 4 river basins, two of which with high intensity water use, and 11 groundwater bodies with a lack of quantitative monitoring) (ibid.).

Other than monitoring and data gaps, in Greece the European Commission's report on the implementation of the WFD in 2014 stated that a better regulation of groundwater licensing was needed (e.g. a review of the regulatory framework; updating the regulation standards regarding minimum and maximum limits of water volumes for irrigation; ban on new construction of groundwater wells in certain cases) (EC 2015a). Following this point on regulation, in Spain even though the water legislation includes the possibility to declare an aquifer overexploited and control groundwater abstractions via an 'emergency regime of abstractions', the implementation of this measure is not compulsory and used at the discretion of the River Basin Agency (in some Basins, despite a serious situation of over-exploitation, the Basin Agency continues to issue concessions for abstractions in groundwater bodies in poor quantitative status) (EC 2015b).

Figure 4. Groundwater monitoring stations in Spain (2014)



Source: EC 2015b.

2 Groundwater regulation and protection in Denmark

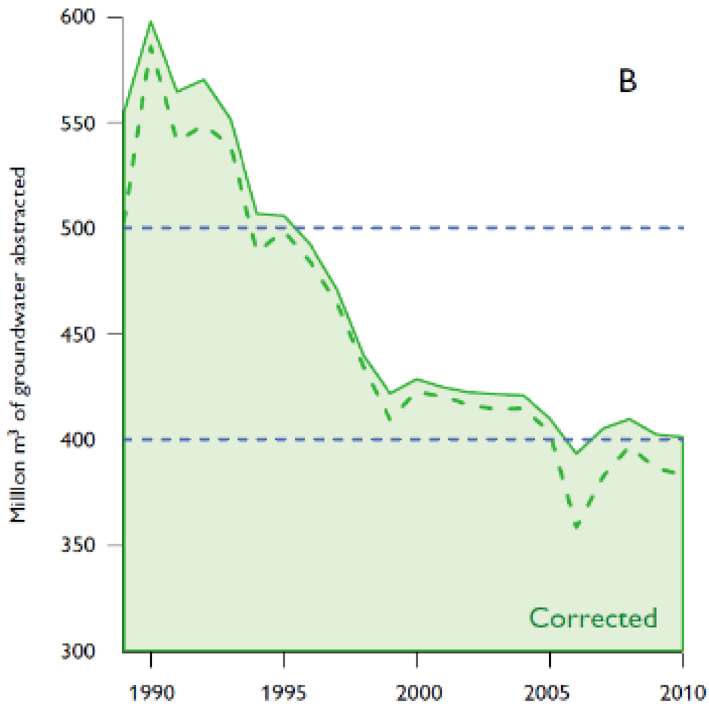
2.1 Groundwater management and regulation in Denmark

2.1.1 Groundwater use in Denmark

Groundwater is the predominant source of water supply in Denmark (accounting for up to 99 percent of its total water supply) (ECOTEC 2001). Aquifers in Denmark usually consist of either unconsolidated sands and gravels or fractured limestone and chalk (Hansen et al. 2012). Drinking water in Denmark is produced in around 2,500 utilities through waterworks and plants (until the mid-1970s there were 5,000-6,000 utilities, merged for rationalization and cost savings), abstracting around 400 Mm3 of groundwater per year (Figure 5) (Jørgensen et al. submitted; Sørensen and Møller 2013). The high demand of groundwater in highly densely populated areas such as the capital, Copenhagen, causes stress on water resources (Figure 6).

Historically, Denmark evolved as a farming society and still today two thirds of the country remain cultivated (Jørgensen et al. submitted). Crops are however predominantly rainfed and groundwater is only used as a supplemental resource during dry periods and therefore groundwater requirements for irrigation vary significantly at the regional level and between years (ibid.). The national average of groundwater use for agriculture varies from 25 to 40 percent of the total groundwater abstraction. Domestic uses take between 55 and 75 percent and industrial less than 10 percent (ibid.). In Denmark, groundwater abstraction licenses are time-limited and can be renewed usually through a 30-year cycle (for irrigation it is 15 years). They can however be cancelled in case of severe impacts of abstraction on the environment (ibid.).

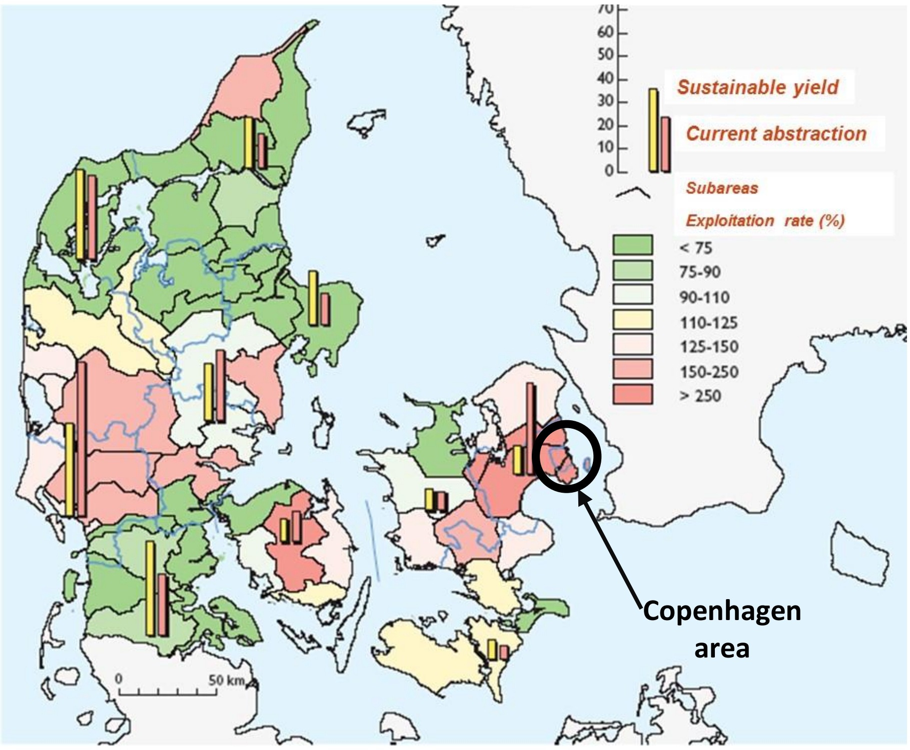
Figure 5. Total groundwater abstraction in Denmark



Source: Sørensen and Møller 2013.

As described by Jørgensen and Villholth (2015, pers. com.), the municipality renews licences by inspecting the wells and applying the regulation on construction and maintenance (drilling companies have to be certified by the Ministry of Environment, ensuring also that drilled wells are known and entered into the national well database). Most municipalities issue licences of 1,000 m3 per hectare per year for wells but can issue smaller abstraction permits if the surrounding areas can be affected by groundwater drawdown. Licenses also set maximum abstraction volumes per hour (m3/hour). Farmers also have to report abstraction volumes annually back to the municipalities (often licenses request that groundwater levels are logged into the database before and after the irrigation season). New or renewed licenses require the installation of meters and municipalities can set up rules regarding the choice of meters. For agricultural uses, municipalities will carry out regular controls to the farms (visits are however conducted in a good atmosphere as municipalities seek to be in dialogue with users, acting "more as advisors than inspectors). Besides, every farmer is in contact with a local agricultural advisory company that – although run on a private basis, funded by the farmers themselves – will also check that things are in accordance with laws and regulations as this is the best for the farmer" (Jørgensen and Villholth 2015).

Figure 6. Groundwater abstraction in Denmark (2003)



Source: Henriksen 2009.

2.1.2 Regulation and management of groundwater in Denmark

Groundwater started being regulated in Denmark in 1926 with the Water Law. This law defined that groundwater ought to be distributed via rights based on the water balance with the idea that abstraction was not to exceed the amount of infiltration of precipitation into the aquifer (Thorn and Conallin 2005). Ministerial oversight and protection of groundwater started in Denmark in the 1970s with the creation of the Ministry of Environment. The legislation enabled the creation of 14 regional authorities and the development of regional groundwater management strategies.

The Water Supply Act of 1978 gave rights to counties to allocate water rights (surface and groundwater). Water rights granted can only be for 30 years and if surface water flows are affected, counties can fix a minimum base flow in streams and re-distribute water rights based on this new level. Counties are also required to determine groundwater interest areas and rate them on a high-low priority scale (ibid.). The development of action plans for catchment areas is also a requirement of the 1978 Water Supply Act. They have to define which areas are vulnerable to pollution and where and what additional measures are necessary for the protection of groundwater (Abildtrup et al. 2012).

The Environmental Goals for Water and International Protection Sites Act of 2003 further regulated groundwater management as it defined 13 water management districts, regrouping different catchment areas in the country (with 385 groundwater bodies) aiming to set the framework for the protection of surface and groundwater as established by the Water Framework Directive. Each district would need a water management plan extending over a period of 6 years and addressing issues such as basin analysis, locations of the protected areas, areas of drinking water interest, and general environmental goals for the protection of surface and groundwater.

In 2007 a municipal reform in Denmark merged municipalities, resulting in a drop from 271 to 98 municipalities. Counties were also reformed and from 13 counties, Denmark ended up with 5 regions. As part of this reform, municipalities also took the responsibility from the counties to manage water resources (including abstraction licensing). Following this trend, groundwater protection "has changed from being a national responsibility to becoming a more locally embedded task" (Petersen and Jørgensen 2012: 49).

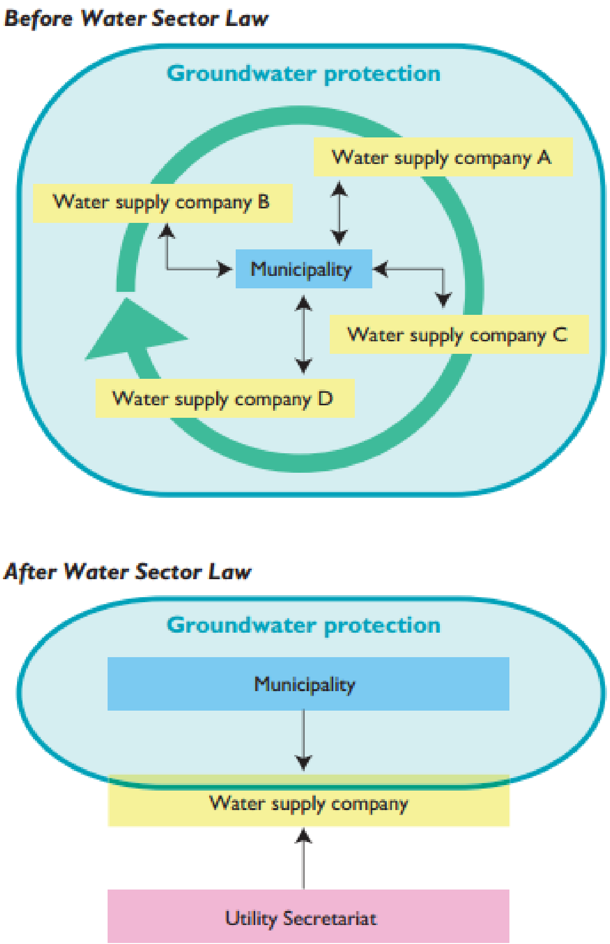
A reform of the water law in 2009 had the purpose of privatizing the water supply sector (into not-for-profit corporations) (Figure 7) (Petersen and Jørgensen 2012). A new regulatory body was also introduced (the Utility Secretariat) to enforce price ceilings on drinking water (ibid.). The level of groundwater pollution in Denmark however required continuous measures to strengthen groundwater protection, and some water supply corporations actively engaged in financing groundwater protection activities (48 percent of the 75 largest Danish water supply companies, using between 1 and 25 percent of the annual turnover – including afforestation, agreements with farmers, quality studies, etc.) (ibid.).[9]

Water utilities in Denmark can establish arrangements with farmers and compensate them for changing their land use practices. Water utilities use this mechanism when they face a risk of pollution of water resources by agricultural land use. Agreements can range from restrictions on the use of pesticides, reduced use of fertilizer and manure, and re-forestation. A compensation is paid by the utility to the farmer. These arrangements are contemplated in the Danish Water Supply Act of 1998. The act also allows water utilities to purchase agricultural land in vulnerable areas "provided an action plan for the protection of groundwater has been approved by the regional authorities" (Abildtrup et al. 2012: 171). Abildtrup et al. (2012) found 18 water utilities or supply companies having engaged through this type of process with farmers. In the event that the farmer rejects a reasonable offer for compensation in these areas, compulsory purchase (expropriation) is contemplated by the law. This type of purchase has to be carried out in cooperation with the local municipality (ibid.).

With this seemingly fragmented management structure between different administrative and political levels (state/county/municipality), hydrologic consistency is ensured through task sharing between the different levels. According to Jørgensen and Villholth (2015, pers. com.), the state's laws and regulations set out overall water management plans. Municipalities then have to cooperate to reach these goals. In order to implement the plans, "municipalities have a number of tools – like cancelation of licenses (happens extremely rarely) or reduction of licenses (happens more often, especially when the license is not used fully – and there is a fee for each abstracted m3 […]), forcing the abstracting body to move wells (happens from time to time for water supply utilities), imposing farmers to establish wetlands for nitrate reduction – for which the farmers are compensated)."

[9] The new Water Law however might limit these activities as the price review is done for individual water companies and for different price ceilings (these activities were before funded through an up to 2 percent tariff of the total water price per cubic metre) (Petersen and Jørgensen 2012). However, it would seem that this new legal framework does not provide the necessary structure for the continuation of these activities, as the tax and tariff system funding these activities is not in accordance with the law (ibid.).

Figure 7. Framework for groundwater protection in Denmark before and after the 2009 water reform



Source: Petersen and Jørgensen 2012.

2.2 The supply of groundwater to the greater Copenhagen area[10]

The supply of drinking water for the greater Copenhagen area from the Kornerup Catchment in the Lejre area west of Copenhagen began in the 1930s. The city was growing and needed more water for its industry and water had to be brought from areas outside the municipality of Copenhagen. In 1936 the Ministry of the Interior allocated the rights for groundwater to the city of Copenhagen from the Lejre area, estimated based on the water infiltration levels in the area. Groundwater found there was artesian and the location of wells was placed near the streams (where the well head pressure was the highest). This allowed the abstraction of 18.3 Mm3 of groundwater, with 16 Mm3 allocated to Copenhagen and the remaining 2.3 Mm3 to be used locally by the water works in the municipality and industry. The initial approval also restricted the maximum amount of drawdown in wells (from 4.5 metres to 11.5 metres for 130 wells in seven different sites).

Since groundwater abstraction began, residents have observed a reduction of surface water flow in the area and localized drying up (in the summer) of streams and wetlands. This indicates that

[10] Section based on Thorn and Conallin 2005 unless referenced otherwise.

groundwater became heavily abstracted and was affecting the groundwater base flow to surface water bodies. Initial concerns were already expressed by some inhabitants of the area, fearing that groundwater abstraction would cause the drying up of some rivers. The Copenhagen Water Supply provider agreed to establish an artificial spring emptying into the River Ledreborg to provide the stream with some 'base flow'. This caused an almost immediate effect on the groundwater hydraulic head in the area (groundwater pressure at an observation well fell from 32m to 25m in two months). This was followed by a reduction of stream flows and in some instances, the drying up of streams upstream of some of the abstraction sites.

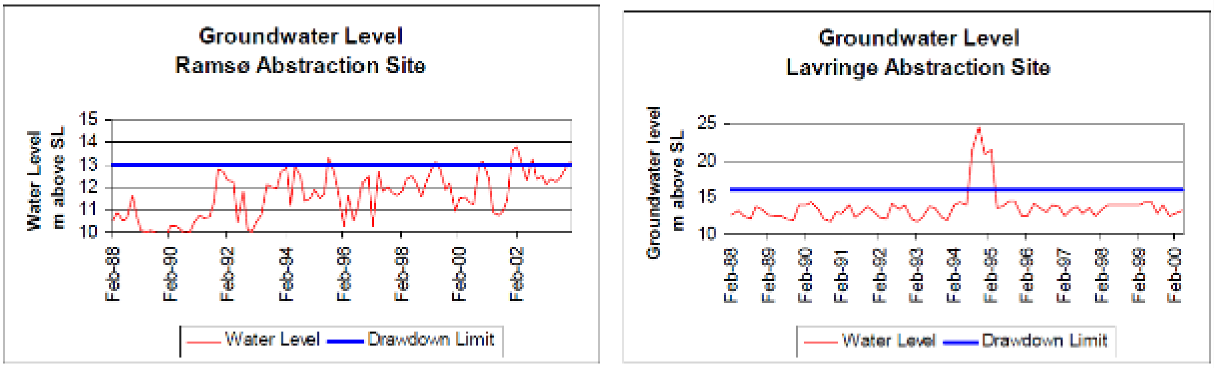
Seeing the effects of groundwater abstraction on surface water, the government sponsored the creation of a Commission with the mandate to study the relationship between precipitation and groundwater recharge, surface water flows, and evapo-transpiration in order to create a water balance for the area. The work of this commission took place between 1939 and 1952, concluding that the Copenhagen Water Supply provider had overestimated groundwater recharge into the aquifer and that there was only 50 percent of recharge actually taking place from the original calculations. In spite of these conclusions, there was no change to the abstraction regime until the late 1980s, with the authorities permitting (or not knowing) that the legal limits for groundwater abstraction were being exceeded. The city of Copenhagen would apparently have been granted preferential treatment when it concerned water rights. This is illustrated by the fact that some municipalities around Copenhagen ended up purchasing water from the Copenhagen Water Supply provider because they no longer had the rights to the water within their municipal boundaries.

In the 1970s however a change in groundwater management happened, with more attention being paid to the effects caused by groundwater abstraction on surface waters. Additionally, in the 1970s the administrative and legal powers to grant concessions for water rights were moved from the central government to the local counties. This meant that the Copenhagen Water Supply provider had to renegotiate its rights with Roskilde County (even though it never exceeded the amount allocated, the hydraulic head levels had been consistently lowered year after year). Fearing political repercussions however, Roskilde County renegotiated in 1980 the same conditions as initially granted in 1936 (to be renegotiated 30 years later, in 2010). Changes in well location, abstraction rates, or well repairs would have to be approved by the county. In the 1970s too, researchers put forward ideas to recover stream flows (particularly during the summer) but they were never applied. Some of these projects consisted of directly pumping groundwater into the stream, moving the location of the well fields away from the streams, or to build water reservoirs in order to release water into the streams during the summer.

In 1985, the first real effort to develop a groundwater management plan for the city of Copenhagen was released. The plan placed a strong emphasis on wetland protection and sensitive areas, stating that groundwater abstraction would not be allowed if it had a negative impact on declared sensitive areas. The plan recommended the reduction of groundwater abstraction levels and the direct pumping of groundwater into the River Lavinge to increase its base flow.

In 1988 the first reductions of groundwater abstractions were agreed upon by Roskilde County and the Copenhagen Water Supply provider (from 3.2 to 1.8 Mm3 per year at one of its well field stations). The abstraction level of 1.8 Mm3 was reached in 1995. A similar agreement was reached for another pumping station for the reduction from 2.2 Mm3 to 1.2-1.4 Mm3 per year. Further reductions in other pumping stations during the 1990s were also caused by aging infrastructure and sea water intrusion into the wells (one pumping site was shut down in 1999 and some wells were closed due to too high levels of chloride from sea water mixing into the wells). In spite of these reductions, water levels still exceeded the maximum allowed drawdown (Figure 8). With hydraulic head improving, they were not able to recover and continued under the legal level allowed.

Figure 8. Groundwater levels and drawdown limits in two abstraction sites for Copenhagen



Source: Thorn and Conallin 2005.

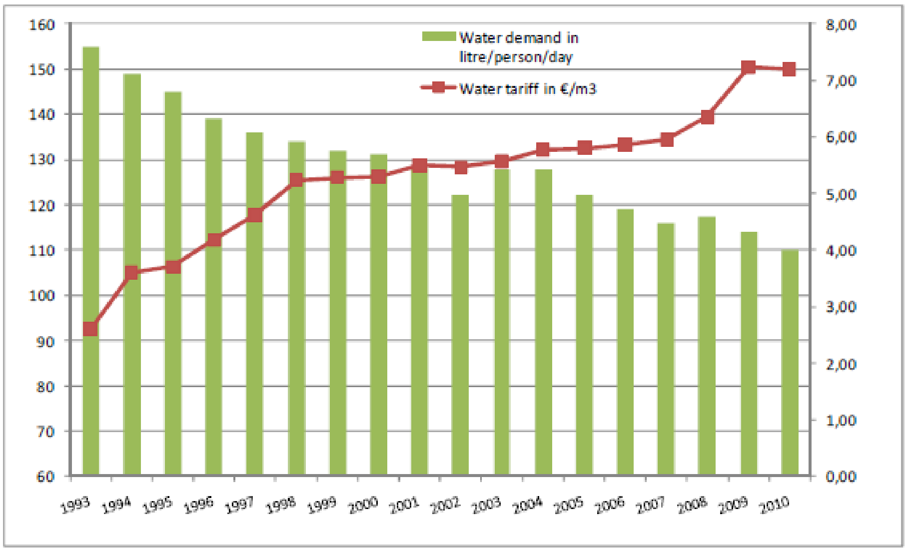
Given the reduction in abstraction capacity with the closing down of wells due to salinity problems, the Copenhagen Water Supply provider requested a new permit to Roskilde County to abstract an additional 800,000 m3 per year to replace the wells that had to be closed. The permit was issued by the county in 2002 but the Danish Society for the Conservation of Nature appealed to the Danish Environmental Protection Agency in 2003 on the basis that the abstraction of such volume would impact the streams and ecology of the area. The County as well as the Environment Protection Agency commissioned studies on these effects. As seen above, the concern for river flows had already led to a reduction in groundwater abstraction in 1992 and in 2003 no new groundwater abstraction permits were allocated and current permits not renewed (Thorn and Conallin 2006). Results in 2006 studied by Thorn and Conallin (ibid.) remained inconclusive however as to the impact of groundwater abstraction on local ecology and fish life, as fish populations that should have been sustained by river flows saw a decrease between 1997 and 2005 in spite of decent river base flows. This is likely due to other factors such as dissolved oxygen, temperature, sedimentation or pollution affecting the streams (ibid.).

2.3 The water supply tax in Denmark

It has been said that pricing water schemes in Denmark provide the right incentives to reduce household water use (EEA 2013). Since 1992 urban water prices in Denmark have been established on a cost-recovery basis aimed at recovering the economic cost (through user charges) and environmental costs (through taxes). All urban uses are metered and water consumption is volumetrically charged. Since its introduction, 2004 water prices rose 54 percent and is believed to be associated with a substantial decrease in urban water demand (ibid.). The 30% reduction in per capita consumption in the past 20 years (alongside an increase in prices of 80% in actualized values[11]), however, has been observed all across Europe and it is not clear how much is due to better appliances and to other factors such as pricing and awareness raising.

[11] The increase in price corresponds roughly to a hike in the water bill of an average family from 0.9% to 1.6% of its revenue (Danish Ministry of the Environment n.d.)

Figure 9. A 30% reduction in water demand in Denmark over 20 years



Source: COWI 2013.

When the water supply tax was introduced as part of a 'green-tax' reform, it was implemented gradually through successive tax increases (one Danish crown per year – around 0.13 EUR) between 1994 and 1998 (EEA 2013). The tax applies to households and industries but does not apply to the agricultural sector (as irrigation is self-abstracted and is not supplied through the water supply network) (ibid.). However, the tax applies to individual wells in rural areas used for drinking water purposes.

Value Added Tax (VAT) charged at 25 percent is also imposed on the tax (ECOTEC 2001). An innovative financial mechanism introduced through this tax is that the tax is imposed on water delivered to customers. However, if metered amounts delivered are less than 90 percent of the quantity abstracted by the water supply company the latter is subject to the remaining tax. This is an important incentive for companies to repair leakages (ibid.).

Water savings due to the tax were not foreseen by the government, resulting in lower revenue forecasts (25 to 30 percent of the expected revenue in the first four years) (ECOTEC 2001). Between 1989 and 1998, total water consumption in Denmark decreased from 360 Mm3 to 266 Mm3 although half of that reduction happened before the introduction of the water tax and additional charges (ibid). This relativizes the results claimed earlier by other sources as to the widespread success of this measure (EEA 2013). Additional reasons for the success and broad support of active groundwater protection could be the long tradition of public participation in decision-making and planning process (Jørgensen et al. submitted; Thomsen et al. 2004). Interest organisations are involved in the process of drafting groundwater protection zones in Denmark (since 1998) and plans once drafted, have to be presented at public meetings with the possibility to submit comments and at the government level, the strategy was also supported by all major political parties (Thomsen et al. 2004). Additionally, a study showed that Danes are willing to pay for clean drinking water, even up to the double of what was charged in 2005 (Hasler et al. 2005 in Jørgensen et al. submitted).

The water supply tax is collected directly from the annual water bill. Taxes on individual wells supplying drinking water in rural areas are collected by the municipality (ECOTEC 2001). The main aim of the tax was to reduce household water consumption. This contributed to changing consumers' behaviours. The installation of water saving devices in households (e.g. water saving taps) reached 45 percent of households and 39 percent of households in 2001 had already installed low-flush toilets (ibid.). Also, as an example of the Danish mentality, as Jørgensen and Villholth (2015, pers. com.) put it, "farmers are of course usually not satisfied with restrictions making their farming more difficult or less efficient, but most farmers are also interested in not harming the environment, and there is a lot of compensation possibilities even from the EU system".

2.4 Water pollution and the pesticide tax

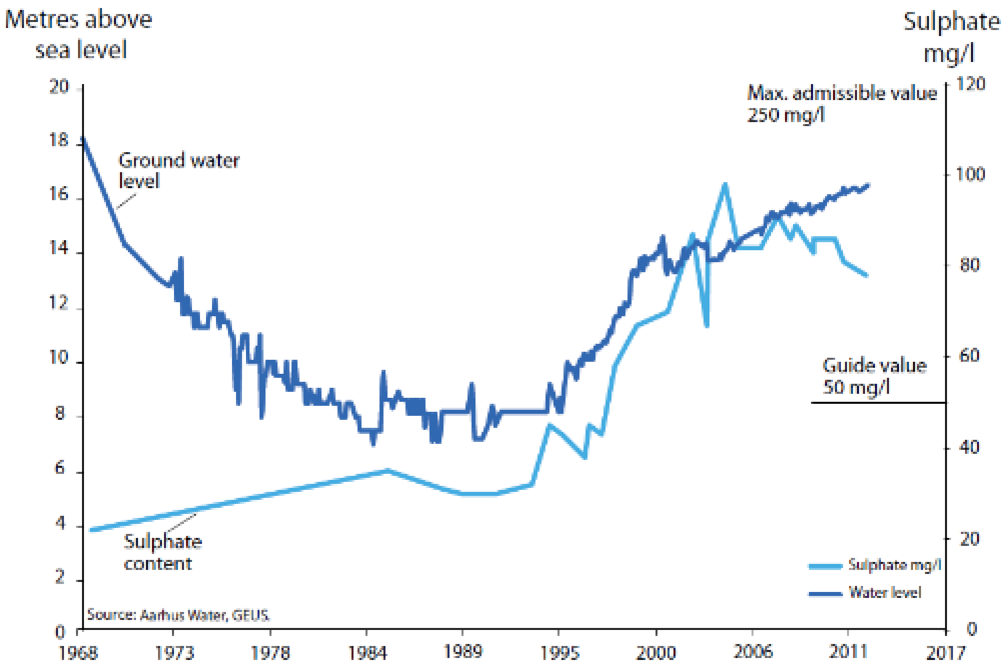
2.4.1 Water pollution in Denmark

Diffused-source pollution from Denmark's large agricultural sector has historically been one of the main risks affecting water resources in the country (two thirds of the country are farmed) (Jørgensen et al. submitted). Given the fact that drinking water quality has always been very high and delivered through the water supply with limited treatment, the risk associated with high pollution levels remains important. Despite several decades of regulation, policies, and controls, concentrations of nitrate in groundwater in approximately 48 percent of monitored groundwater bodies studied by Hansen et al. (2012) across the country, were still higher than the allowed drinking water standards of 50 mg per litre. According to these authors, 33 percent of monitored groundwater areas shows an upward trend in nitrate concentration (Hansen et al. 2012). Due to pollution, availability began to decrease in the 1980s and as a result, groundwater resources deemed safe to be abstracted, were reduced. The water balance in the main island of Denmark (Zealand) was affected, interfering with base flow in rivers and lakes (ibid.).

According to a report from the European Commission on the implementation of the Water Framework Directive in Denmark (EC 2012e: 5), "the basis for assessing quantitative status of groundwater bodies is weak". Despite having a relatively high density of monitoring stations for surface water, groundwater monitoring is only done by the water supply works and any groundwater body "exceeding drinking water standards (e.g. nitrates and pesticides) is abandoned, and monitoring is stopped" (ibid.). There has also been a decrease over the previous years in the number of monitoring stations for groundwater (from 858 in 2007 to 636 as reported by the European Commission in 2012) (ibid.). This is also due, according to Jørgensen et al. (submitted), to a dwindling number of skilled professionals at the Danish Environment Protection Agency (many of whom left during a structural reform in 2007) and low demand for new science-based knowledge (ibid.).

Figure 10 shows the evolution of groundwater abstraction and the increasing levels of sulphate at a pumping water station in Beder, Denmark (in Jutland, mainland Denmark) (Thomsen et al. 2013). The abstraction yield had initially been estimated using traditional hydrogeological analyses, causing the over-estimation of groundwater resources and following water table level decreases after pumping began in 1968 (ibid.). A new calculation of the potential yield to be abstracted led to the reduction by 35 percent of the allowed abstraction levels in 1990 and the subsequent increase in water table levels (ibid.).

Figure 10. Groundwater abstraction and increasing levels of sulphate (Beder, Denmark)



Source: Thomsen et al. 2013.

2.4.2 The pesticide tax

In 1996 Denmark approved the Pesticide tax aimed at reducing pesticide residues in crops, water courses, lakes and groundwater and thereby reducing the negative impact on health. The objective of the tax was to reduce pesticide consumption in Denmark between 5 and 10 percent. However, the tax rate was doubled in 1998 and the new objective became a reduction of 8 to 10 percent. The main concern reflected in this tax is that there is a preference in Denmark for drinking untreated water. There is therefore a high 'willingness to pay' for unpolluted groundwater for drinking water supply (Hasler et al. 2005). The introduction of this tax reflected a failure of previous policy attempts to reach the aim of the pesticide policy and the general move at the time towards green tax reform "shifting the tax burden from income taxes to environmental taxes" (Ministry of Taxation 2001 in Pedersen et al. 2011: ii).[12] Data from 2005 showed that 27 percent of monitoring wells contained pesticides and/or metabolites and that 10 percent exceeded the Maximum Admissible Concentration for drinking water. In 2010, pesticides were still detected in 25 percent of all tested active abstraction wells (Petersen and Jorgensen 2012).

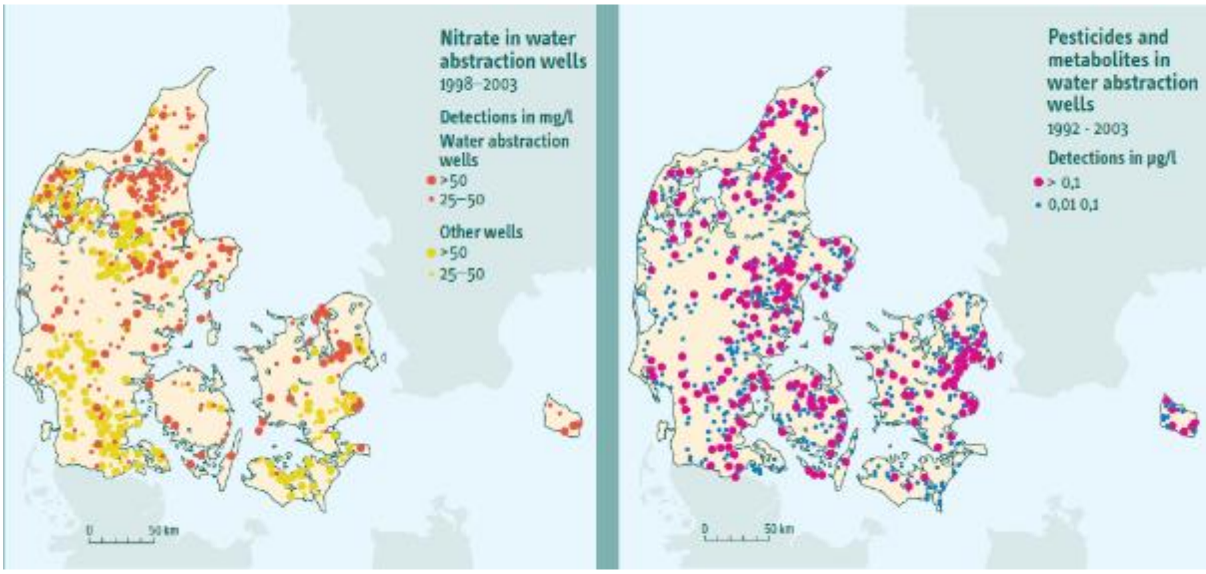
The tax was levied on sale prices and charged to manufacturers and importers who incorporate it into the retail price. Additionally, all manufacturers and importers are obliged to register with the tax authorities and taxed products have to be marked with a special label. According to Pedersen et al. (2011) however, a study comparing a baseline scenario without the tax (1994 levels) and the real effects of the tax concluded that the tax had had a very small effect on pesticide consumption at best. Pesticide levels in water were not reduced to the expected results predicted ex ante (1.7

[12] However, in connection with the EU Water Framework Directive, the pesticide tax had to be redesigned in order to reflect the environmental damage caused by pesticides and pollution and not the sale price of the product (Pedersen et al. 2011).

of Treatment Frequency Index down from 3.5 in 1996) (Pedersen et al. 2011)[13] (see the experience of the Netherlands in the box below).

According to the Danish Ministry of the environment (n.d), "In the period 1991-2005, 1,306 wells were closed as water supply abstraction wells, solely due to content of pesticides or degradation products (metabolites) and approximately 100 wells are still closed every year due to pesticide contents". Moving wells to better areas is still a central management option in the face of overall resilient levels of pollution.

Figure 11 Nitrate and pesticide concentrations in abstraction wells in Denmark (2005)



Note: the Maximum Admissible Concentration (MAC) for drinking water is 50 mg/l, found in 16 percent of monitoring wells. For nitrates, 75 percent of abstraction wells do not contain nitrates (less than 1 mg/l). Source: Aue and Klassen 2005.

[13] TFI represents the number of applications of pesticide in cultivated areas per calendar year (Pedersen et al. 2011).

Box 1. Groundwater tax in the Netherlands[14]

Taxes are part of the array of policy tools (in this case sticks) that can be used as regulation mechanisms to control groundwater abstraction by users. In the Netherlands, a 'groundwater tax' was introduced by the national government in 1994 and was presented as a 'win–win green' tax promising to reduce financial distortions in the water bill. However, as opposed to what the government said, the poor design of the tax increased distortions by taxing a narrow base of drinking water companies reliant on groundwater and interfered with groundwater management programs funded by an existing provincial groundwater fee. Due to their political influence, a desire to minimize transaction costs and the inability to tax the conjunctive use of groundwater and surface water, farmers were mostly exempted from the tax. The drinking water companies using groundwater that were affected by the tax transferred the additional cost onto their customers, dampening the demand for drinking water and causing business users to revert to self-supply or to other drinking water companies not affected by the groundwater tax. Thus, the tax became an anti-competitive burden for the companies and made it very unpopular amongst users. The Dutch national government ended up revoking the tax altogether for being fiscally inefficient and environmentally unhelpful in December 2011.

3 Groundwater management and regulation by the state in Beauce, France

3.1 Groundwater regulation instruments in France[15]

Following the 2006 Water Law, groundwater management regulation in France relies on three main instruments: 1) a series of regulations related to the declaration of wells and the volumetric control of abstractions; 2) an environmental tax system; and 3) a series of mechanisms to prevent abstraction during periods of water shortage.

Wells have to be declared and registered as well as fitted with meters. The declaration is compulsory for wells deeper than 10 metres (for any use) (Figure 12). Health legislation also demands that wells located within the protection area of drinking water supply are to be registered. Wells for private water supply (defined as abstracting less than 1,000 m3 per year) have also to be declared at the town hall. The declaration of wells is however not sufficient for wells abstracting more than 10,000 m3 per year as the well owner also has to obtain an authorization which includes the amount of groundwater allowed to be abstracted. The owners of wells abstracting more than 200,000 m3 are required to submit an impact assessment when they apply for the authorization.

Even though the non-declaration of a well can result in a fine of up to 15,000 Euros, many wells according to Montginoul and Rinaudo (2013) are not declared when they are drilled. According to estimations by these authors, around 5 to 10 percent of wells have been declared in the Languedoc Roussillon Region (ibid.). This is partly due to a lack of resources from the state (water police non-operational) as well as a lack of awareness by the users. This type of regulation also relies on the principle of self-control by users.

The state can also declare areas where well drilling is forbidden (so-called 'Resource Preservation Areas') or limited (called 'Allocation Areas', or in French 'Zone de Repartition des Eaux'). In forbidden areas, new wells are not allowed and in limited areas, new wells will have to be

[14] Source: Schuerhoff et al. 2013.

[15] Based on Montginoul and Rinaudo 2013.

approved by the *Prefect* and an impact study will have to be submitted (for wells abstracting more than 8 m3 per hour). All wells must have a meter installed and for those abstracting more than 10,000 m3 per year (7,000 m3 per year in 'Allocation Areas'), abstraction volumes will have to be declared to the Water Authority so that the environmental tax on groundwater abstraction can be calculated. Drilling companies are neither regulated nor controlled.

The use of an environmental tax according to the 2006 Water Law aims at internalizing the externalities linked with the abstraction of groundwater. The tax represents 0.02 Euros per m3 and 0.03 Euros in 'Allocation Areas'. The use of groundwater for agriculture benefits from discounts (on average one cent cheaper than the other uses, as studied by Montginoul and Rinaudo in three major basins where agriculture represents the largest user).

The state can also establish abstraction restrictions and bans (declared by the *Prefect*). Abstraction can be limited or banned for a specific period of time, subject to the evolution of aquifer levels. Different piezometric levels are defined by the Water Law in order to track the evolution of water levels (surveillance level, alert level, crisis level, and increased crisis level). The state can also declare a total volume allowed to be abstracted from an aquifer and allocated between uses. It is defined following piezometric levels, historical records, and in some cases groundwater modelling. The volume to be abstracted is then allocated individually through quotas (usually in relation to consumption needs or irrigated area). As will be described for the case of the Beauce Aquifer, farmers may also be allowed to carry over part of their un-abstracted volumes for the following years.

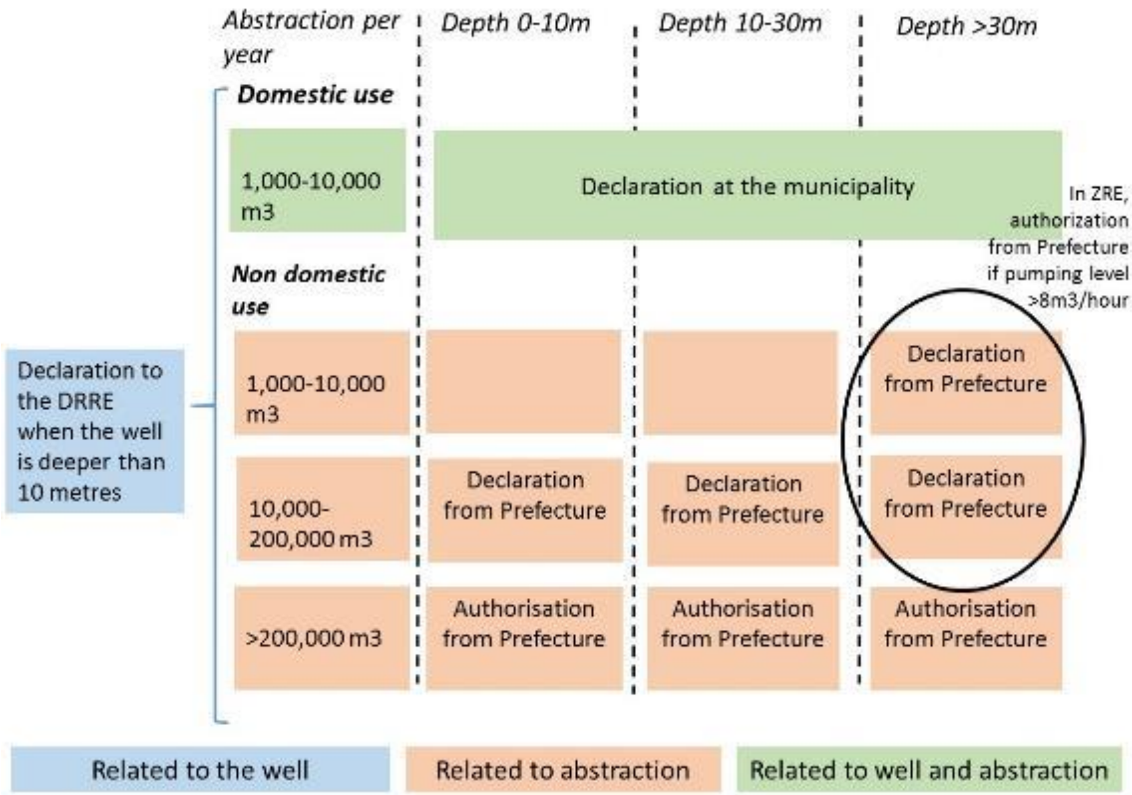
At the local level, there are two instruments used to manage groundwater: 1) the SAGE; and 2) the aquifer contract. Aquifers are managed through a SAGE, a planning instrument developed to achieve the objectives of a river basin plan related to groundwater. The aquifer contracts are voluntary action programs aimed at balancing groundwater resource use amongst the users of an aquifer. They are signed for 5 years between all stakeholders (governor, state, local authorities, municipalities, trade unions, etc.) (BRL ingenierie and AFD 2015). With this contract, all parties commit themselves to undertake the necessary studies and actions in order to put in place a balanced groundwater abstraction regime. The agreement between the parties is technical and also financial but has no regulatory scope or intent (ibid.).

Table 2. Groundwater regulation instruments in France

Type of instrument	***Instrument used***
Control of wells and abstractions	Registration of wells
Control of abstractions	Abstraction authorizations
	Installation of flow meters
	Declaration of limitation and abstraction bans in specific areas
	Definition of a total abstraction volume for an aquifer and individual quotas for users
Pricing incentives	Environmental tax on abstractions

Source: Based on Montginoul and Rinaudo 2014.

Figure 12. French regulation for well registration



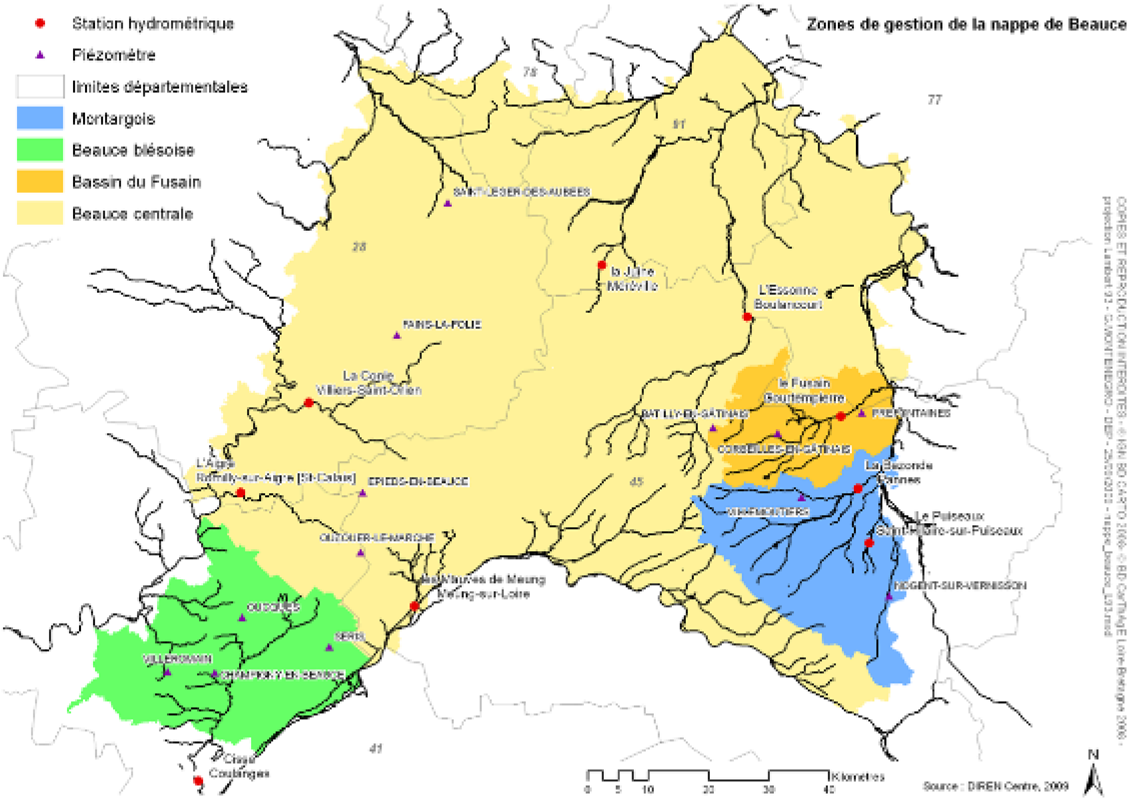
Note: ZRE = 'Zone de Répartition des Eaux'.
Source: BRL ingenierie and AFD 2015.

3.2 The Beauce Aquifer

The Beauce Aquifer in Central France is a calcareous aquifer shared between 6 different '*departements*' and 2 administrative Regions in France (Centre and Ile-de-France), has an area of around 10,000 square kilometres and a natural storage capacity of 20,000 Mm3 (Figure 13) (Petit 2009). Agriculture is the main user of groundwater (around 420 Mm3 per year) and groundwater is abstracted for irrigation through 2,138 wells in around 3,600 farms (declared since 1993 and registered in a database) (Chauvet 2014, pers. com.; Lejars et al. 2012).

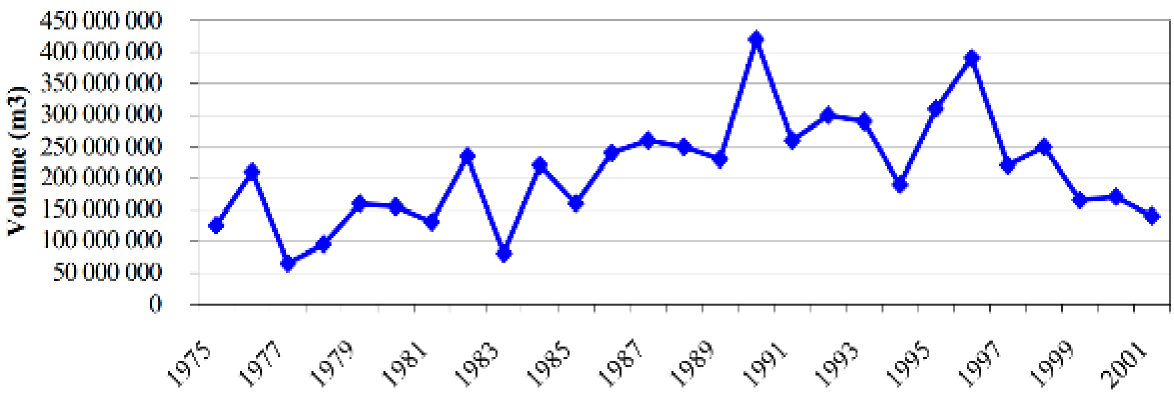
The irrigated area in the Beauce increased by 50 percent between 1988 and 2000, mainly driven by cash-crops in the summer (Lejars et al. 2012). The irrigated area of the basin represents 26 percent of the total basin area (SAGE 2002). In 2000, large farms with more than 100 hectares represented 38 percent of the total cultivated area and since 1977, the number of these large farms increased by 70 percent (ibid.). Linked with this increase in irrigated area, groundwater abstraction has also increased although abstraction volumes in Beauce shows an irregular evolution between 1975 and 2001 (Figure 14), linked, in particular, with factors such as weather variations (e.g. droughts) and market demand for crops (ibid.).

Figure 13. The Beauce Aquifer, France



Source: http://www.donnees.centre.developpement-durable.gouv.fr/nappe_de_beauce.htm (Accessed 6th May 2014).

Figure 14. Groundwater abstraction volumes in Beauce (1975-2001)



Source: SAGE 2002.

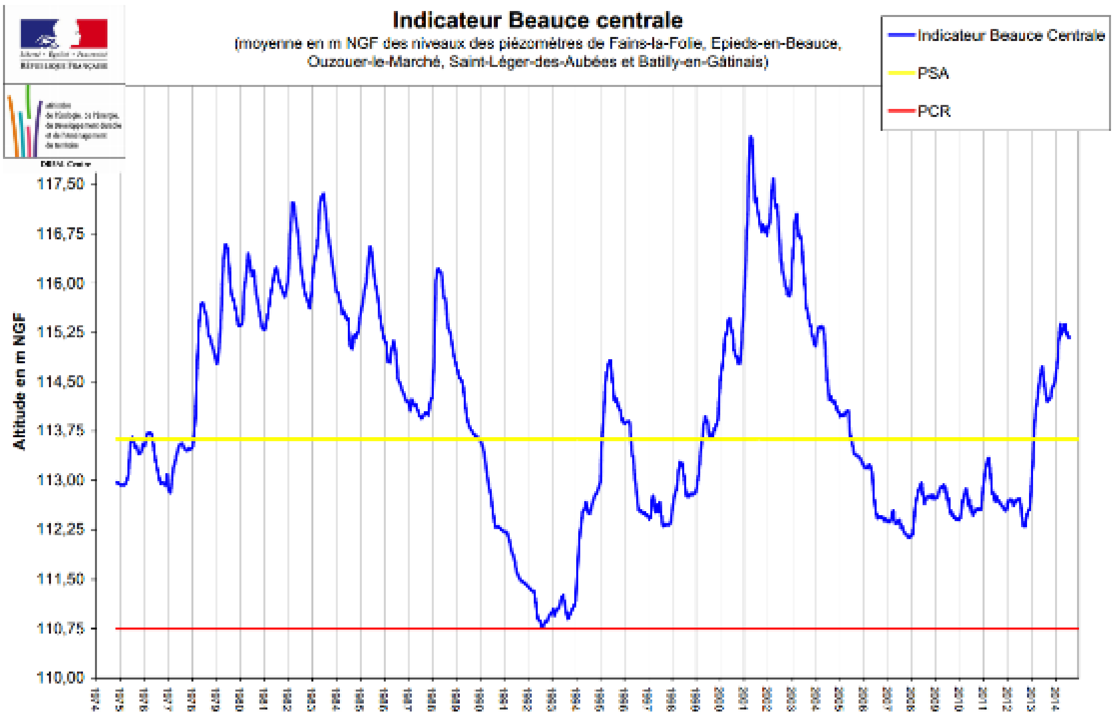
3.3 A groundwater abstraction plan for the Beauce Aquifer

According to Petit (2009), the management of the Beauce aquifer has followed a double process with, on the one hand, the strengthening of the role of the state through qualitative and quantitative monitoring of the aquifer and the use of regulatory tools (authorizations, quotas, abstraction sectors), as well as economic instruments (fees on withdrawals) and also participative instruments (the local water commission). On the other hand, the role of the community of users has also been reinforced by the development of participative structures and a partial transfer of management to the users themselves (ibid.).

The concern for the conservation of the Beauce Aquifer, France, started in the 1990s when the wetland of la Conie, fed by the high water table of the aquifer, started to recede as a result of the increase in irrigation during a series of droughts between 1989 and 1992. An association for the protection of the ecology and environment of la Conie complained to the state between 1995 and 1997 about the weakness of the measures put in place to limit irrigation (Petit 2009).

In March 1995 an agreement called 'Beauce Aquifer Charter' ('*charte nappe de Beauce*'), was signed between the administration and irrigators' representatives. The charter allowed to put in place limiting volumetric measures for groundwater abstraction for irrigation following an aquifer monitoring system and the establishment of three alert thresholds: 1) alert threshold 1 (S1) = 106.8 meters (corresponding to the level of the aquifer in April 1978-89); 2) alert threshold 2 (S2) = 105.6 meters (corresponding to the level of the aquifer in December 1976); alert threshold 3 (S3) = 103.9 meters (corresponding to the level of the aquifer in January 1994) (Figure 16) (Petit 2009). These thresholds were established in order to maintain environmental flows for the rivers in the basin (Deruyver 2014, pers. com.). One should note that the environmental impacts of a water drawdown is very sensitive and management rules are expected to keep the water table within a range of 3-4 m only.

Figure 15. General piezometric levels for the Beauce Aquifer and alert thresholds (1974 to 2014)



Source: Centre Développement Durable, http://www.donnees.centre.developpement-durable.gouv.fr/Hydrogeologie/indicateur_beaucecentrale.pdf (Accessed 25th August 2014).

With the management plan of the aquifer, no restrictions were to be put in place between alert thresholds 1 and 2. In any other case, groundwater abstractions were limited to the prohibition to irrigate for 24 hours during certain days of the week for all crops. Between alert thresholds 2 and 3, limitations were extended to 48 hours per week if aquifer levels continued to decrease for cereal crops but maintained for 24 hours per week for the rest of the crops. Below alert threshold 3 limitations have to be negotiated. These limitations were unevenly approved and changed from one administrative *Department* to another (Petit 2009).

The area and boundaries for the management of the Beauce Aquifer were established by an inter-prefectural decree in January 1999 and the Local Water Commission was established after long negotiations (Petit 2009) by prefectural decree in November 2000, consisting of 76 members with 39 local authorities, 19 representatives of water users (e.g. agricultural chambers, associations of irrigators) and 18 other representatives from other state departments. The different actors worked in groups and submitted their consensual decisions to the Local Water Commission. The Local Water Commission then adopted the rules through a majority of votes, with a widespread abstention from farmer representatives (Deruyver 2014, pers. com.).

In 1999 the water management plan re-used the principle of thresholds but also introduced a new system of abstraction quotas and established the total annual average for volumetric abstractions for irrigation at 420 Mm3 (as the maximum allowed abstraction level for a very favourable year). With this new water management plan, a more flexible system of restrictions was put in place allowing each irrigator to be assigned a total volume to be abstracted from the aquifer. The administration was then able to calculate the abstraction volume for each irrigator based on a series of coefficients (both individual and for the municipality – between 0.9 and 1.1) and according to the utilized agricultural area of each farm plot. This system took into consideration: the level of the aquifer at the beginning of the irrigation period; the location of the irrigator and the type of terrain it occupies; and the number of hectares to be irrigated. In some administrative units (Department of the Loiret) each farm plot also has a cap on abstractions of 20,000 m3 per farm. In Seine-et-Marne, different coefficients are established according to the type of crops or other agricultural activities (vegetable crops had a coefficient of 1.5 and chicken and rabbit farms had a coefficient of 1, same as maize, beetroot, and flowers) (SAGE 2013).

The flexibility of this system of quotas comes from the fact that irrigators would be able to manage their own abstraction volumes, and be able to shift a portion of water non-consumed to the following year (up to 20 percent) or to exceed the allocated amount by 20 percent (knowing that the irrigator will have to take account of the excess the following 2 years and adjust the abstraction volume accordingly). If quotas are exceeded by more than 20 percent then the administration will deduct the entire excess from the irrigators' abstractions the following year (Petit 2009).

These measures however were abandoned in 2007 with the new integrated river basin plan, as they were considered to go against 'an effective management of the resource', especially under stress conditions (e.g. a low winter groundwater recharge followed by a dry spring) (Deruyver 2014, pers. com.).

After the characterisation of the sub-basins in Beauce in 2007 with the new integrated water resources plan for the river basin, a distinct indicator for each of the four newly defined sub-basin units (Beauce Centrale, Blesois, Montargois basin and Fusain basin) was put in place. Being operational since 2010, at the beginning of every irrigation season, warning and crisis levels are established, in order to limit the overall level of abstractions (see Table 3 for 2013) or to stop irrigation during 24 or 48 hours per week (Petit 2009).

The Local Water Commission for Beauce adopted its latest management plan on the 15th of September 2010, following consultations between the 15th November 2010 and the 15th June 2011. During these consultations, 975 municipal assemblies and other stakeholders were consulted, of which 88 percent were in favour and 9 percent were against. As part of the local water commission in Beauce, 5 agricultural chambers were represented of which 3 voted against, one in favour and one expressed some reservations (Département d'Eure-et-Loir et al. 2012). The main demand from the agricultural chambers (which represented the interests of irrigators in Beauce) is the reintroduction in the management plan of 'flexible volumetric management rules and a threshold for the differences in abstraction coefficients between the different sectors in the aquifer'. During these negotiations, the Agricultural Chamber of Loire et Cher specifically asked for a 3 to 4 percent abstraction allowance over the limit that could act as a safety buffer in order to cover the difference between the allocated abstraction volume for each irrigator and the indicators for the volumes measured every year in the Beauce aquifer (ibid.). The demands from the irrigation communities participating at the initial consultation phase, referred to the fact that irrigators do not use all of the allocated volumes and also mentioned, during the consultation phase, that the volumes allocated for irrigation are lower than the volumes needed for all the crops (ibid.).

3.4 New groundwater abstraction rules

The groundwater management rules for the Beauce stipulate various piezometric crisis levels below which only drinking water supply and ecological requirements can be fully met. The maximum volume to be abstracted by irrigation was revised in 1999 and was set at 420 Mm3 – a reduction from 525 Mm3 or 20 percent of allowed abstraction volume (Golaz and Girard 2011), defined as the most favourable abstraction conditions in which all piezometric levels are above the established crisis levels for all geographical sectors in the aquifer. Besides agriculture, the established abstraction volumes for drinking water supply is 125 Mm3 and 40 Mm3 for industry and other services.

The annual volume allowed to be abstracted for irrigation is defined each year based on the level of the aquifer at the end of winter. To assess the level of the aquifer at the end of winter, groundwater levels on the 1st of April and the 1st of March are used as a basis. The annual volume to be used as reference is then calculated as the average of the three following days after these two established dates. The comparison of this calculated average level with the specific management thresholds is then used to determine the different allocation coefficients for each sector.

Following the establishment of the groundwater volume in the aquifer, the different management thresholds established in 1999 were also modified and made more restrictive (Table 3 and Figure 16 and Figure 17). As explained before, this type of volumetric management is controlled by a series of coefficients used to calculate how much water each user can abstract (according to the type of crop and surface irrigated). These '*seuils de gestion*' (management thresholds) are to be checked every year in order to determine the level of abstraction for each user and for the entire aquifer.

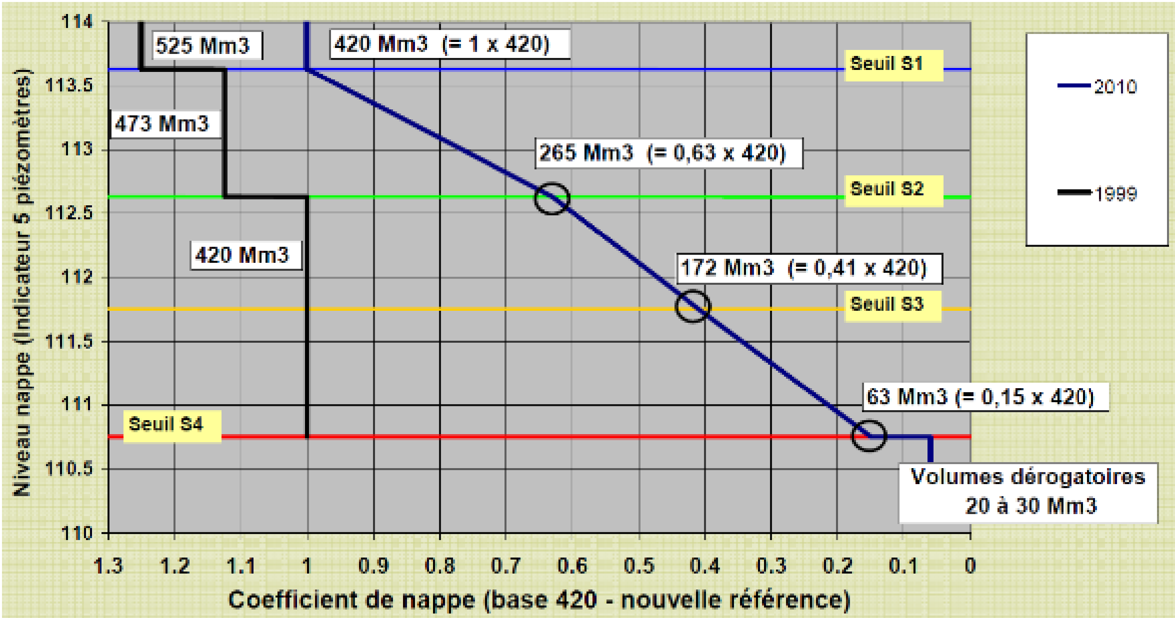
Given the frequency and intensity of previous hydrological crises, the allocation of abstraction coefficients can be revised if needed. The various management parameters and allocation levels would have to be revised in order to preserve the effectiveness of the mechanisms of volumetric management and also to mitigate the impact of these hydrological shortages. According to the management plan, any modification of the maximum allocated groundwater abstraction volumes for irrigation will not affect established river flows even in sub-basins with groundwater abstractions higher than the average (affecting 288 municipalities) (SAGE 2013).

Table 3. Groundwater abstraction volumes for the Beauce Aquifer

Secteur de gestion	Beauce centrale	Beauce Blésoise	Bassin du Fusin	Montargois
Volume de référence par secteur	326,3 Mm³ répartis comme suit : Eure-et-Loir.......133,6 Loir-et-Cher.......20 Loiret...............134,1 Seine-et-Marne..............13,8 Yvelines..............4,8 Essonne...........20,0	43,2 Mm³	28,8 Mm³ répartis comme suit : Loiret............22,6 Seine-et-Marne.6,2	21,7 Mm³
Seuils de gestion	S1: 113,63 m NGF S2: 112,63 m NGF S3: 110,75 m NGF	S1: 106,00 m NGF S2: 104,78 m NGF S3: 103,00 mNGF	S1: 89,00 m NGF S2: 87,40 m NGF S3: 84,50 m NGF	S1: 106,50 m NGF S2: 106,20 m NGF S3: 103,60 m NGF
Coefficients d'attribution (1)	Supérieur à S1 : 1 S2 : 0,63 S3 : 0,15 Entre S1 et S2 puis S2 et S3 : variation linéaire du coefficient	Supérieur à S1 : 1 S2 : 0,63 S3 : 0,15 Entre S1 et S2 puis S2 et S3 : variation linéaire du coefficient	Supérieur à S1 : 1 S2 : 0,63 S3 : 0,43 Entre S1 et S2 puis S2 et S3 : variation linéaire du coefficient	Supérieur à S1 : 1 S2 : 0,63 S3 : 0,15 Entre S1 et S2 puis S2 et S3 : variation linéaire du coefficient

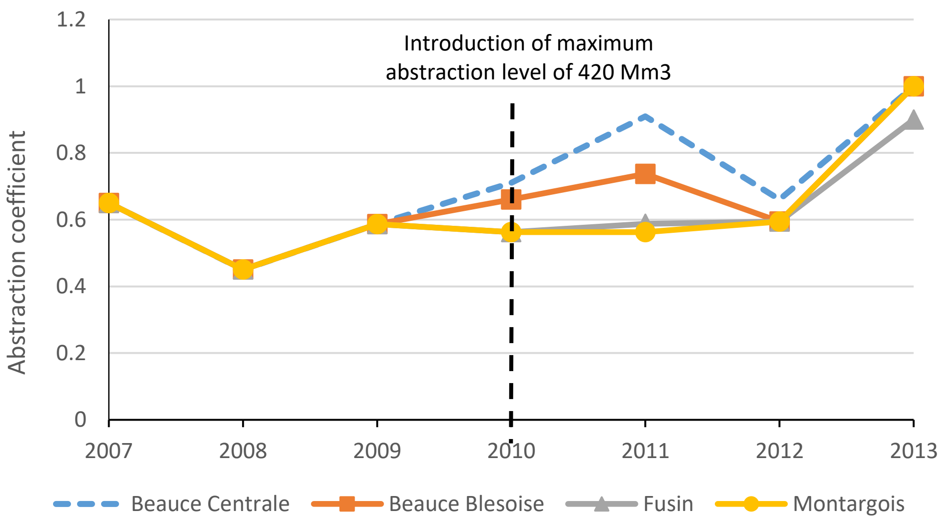
Note: S1 denotes the piezometric management threshold of alert.
Source: SAGE 2013.

Figure 16. Evolution of abstraction coefficients and aquifer levels in the Beauce Aquifer (1999-2010)



Source: Golaz and Girard 2011.

Figure 17. Evolution of abstraction coefficients in Beauce



Source: Based on data provided by Deruyver 2014, pers. com.

Monitoring of groundwater abstractions is done via meters, installed in every borehole since 1999 (Deruyver 2014, pers. com.). Each irrigator holds a monthly register of withdrawals, and the registry may be inspected by the 'Water Police', and the registry must be reported annually to the Administration. Additionally, irrigators are told "early enough about their annual quota to adjust their rotations accordingly" (ibid.). According to France's legislation, the Ministry of the environment uses the administrative structure of the Prefectures to implement and sanction water and groundwater management as well as to approve the different measures related to the allocation of abstraction volumes for groundwater and area water (‘*Prefet coordonateur de Bassin’*) (Departement d’Eure-et-Loir et al. 2012).

Permit requests for wells are reviewed by the state services and the Local Water Commission monitoring the compliance with the integrated water resources plan for the basin. Usually, the substitution of an old well for a new one is authorised to the extent that the new well is in the same aquifer and the abstracted volume is equivalent to the old one. New wells are authorised on a case by case basis, depending on the location, as some aquifers are reserved for drinking water supply only, or on the level of pressure on groundwater resources in the area. Volumes abstracted through newly authorized wells will have to comply with the total groundwater abstraction volumes for the aquifer which will have to remain unchanged, thus implying to adjust the system of groundwater allocation amongst the users (ibid.). Since 1993 a total of 2,138 wells have been registered. Between 2007 and 2013, authorisations were only given to replace wells (unusable wells or located in the lands expropriated for the highway Artenay-Courtenay) (Chauvet 2014, pers. com.). With the water resource plan for the Beauce in June 2013, drilling new wells is possible but subject to an environmental impact assessment (ibid.).

Permit applications for new wells in Beauce are generally accepted, in so far as the petitioner has made a request previous to the application process in order to know about the possibility and conditions to drill and operate a well in the area considered (ibid.). The control of groundwater abstracted is done every year and farmers have to submit a printed statement reflecting the abstracted volumes as well as the monthly readings from their water meters. Due to the large number of groundwater users, control by the authorities is done randomly through a lottery and around 15 wells are checked every year. Additionally, during the irrigation campaign, unannounced visits to farmers are also carried out, in order to detect meter misuse. If the authorities detect that a groundwater user is exceeding the annual volume, a letter is sent requesting an explanation for the excess, within the following 15 days. Failure to provide an explanation entails a sanction in the form of a reduction in allocated volume for the following year based on the difference between authorized volume and excess volume (ibid.). Additional controls are also carried out during the year focusing primarily on the compliance with specific restriction measures adopted during alert or crisis situations (prohibition to irrigate during certain days or hours). In order to effectuate such controls and monitoring, the Department of the Loiret has the equivalent of one full-time employee dedicated to these tasks allocated between three different staff members (ibid.).

3.5 Collective management of groundwater in Beauce

The 2006 Water and Aquatic Ecosystems Law (LEMA) initiated however a process of ‘disengagement’ of the state in groundwater resource management (Montginoul and Rinaudo 2013) whilst introducing the possibility of common resource management for irrigation. According to this Law, although the state remained responsible for setting up the maximum volume of groundwater to be abstracted in each basin declared as overdrawn through the designation of areas of water allocation (Zone de Repartition des Eaux), it delegated the responsibility to allocate this overall quota to a ‘Unitary Body for Collective Management’ (*Organisme Unique de Gestion Collective,* or OUGC in its French acronym) (BRGM 2012; Montginoul and Rinaudo 2013; Moreau et al. 2014). Even though there should only be one OUGC in Beauce, the administrative and political structure overlying the aquifer, with 2 regions and 6

Departments, would have made the management of the OUGC complicated.[16] Thus, the choice was to create one OUGC per Department.[17] An existing structure or organisation (e.g. Agricultural Chamber) can submit an application in order to become one OUGC. Its application is considered then by the Prefecture, judged on criteria such as the hydrological boundaries represented by the organisation, its ability to represent irrigators, as well as its relationships with the state (BRGM 2012).

Mostly, OUGCs help implement the abstraction coefficients and withdrawal limits established since 1999 for the Beauce Aquifer in the SAGE (integrated basin management plan). Once it has been designated, such as in the Beauce aquifer, the OUGC will take into account each irrigator's water needs and will submit a plan for the allocation of groundwater abstracted, issued as a multi-annual authorization for a maximum of 15 years and replacing all individual applications submitted before the creation of the OUGC (Figureau et al. 2013).[18] The OUGC will gather the requests for groundwater abstraction from the users and will make sure that the quotas and thresholds are maintained each year. After its creation, the maximum authorized groundwater volume to be managed by each OUGC will be revised. This situation caused, in the Loiret, an 'insurgency' as 600 irrigators filled a complaint with the Prefect in February 2014 claiming that the granted 15-year period was actually a de facto recognition of expiring irrigation rights as opposed to historical irrigation rights (the Department has around 1,000 irrigators).[19] The OUGC will annually review the proposed allocation plan submitted to the Prefecture, which will then be approved annually by the Prefect. Additionally, since 2012, OUGCs are allowed to request fees from its members (ibid.).

In the Beauce Aquifer region, the Agricultural Chambers have been the bodies designated by Prefectural Decree as OUGCs. Since the 2006 Water and Aquatic Ecosystems Law was passed, and after several consultations between October and December 2011, the Prefect signed the order designating the Agricultural Chamber of Eure-et-Loir as the body in charge of groundwater withdrawals from the Fusin sub-basin part of the Beauce Aquifer and located in the Department of Eure-et-Loir, representing around 80 percent of irrigators in the Department. The Agricultural Chamber of the Loiret was also designated as OUGC in December 2011 for the sub-basins of Central Beauce, Fusin, and Montargois. The Agricultural Chamber of Loir-et-Cher also applied in

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[16] « L'Irrigation en France: les disponibilités en eau et la gestion par l'organisme unique (OU) », 19th March 2013, http://www.coordinationrurale.fr/lirrigation-en-france-les-disponibilites-en-eau-et-la-gestion-par-lorganisme-unique-ou.html (Accessed 26th August 2014).

[17] Ibid.

[18] Code de l'Environnement, Article R211-112, http://legifrance.gouv.fr/affichCode.do?idSectionTA=LEGISCTA000006176815&cidTexte=LEGITEXT000006074220&dateTexte (Accessed 25th August 2014).

[19] According to the Prefect in an interview, "Of course I have understood that the concept of perennial right is very important in the minds of the irrigators, who see it as some kind of historical right. However, in the meantime the nation has recognized the fragility and scarcity of water resources. So now, we must make a collective and efficient management of this resource. The authorization for 15 years does not mean that things will be radically changed every 15 years, to the point of undermining an investment that would take longer to pay off. With this horizon of 15 years that I would qualify as reasonable, we review the situation of the resource, the nature of infiltration in the land plots, etc. The general tendency is not to undermine individual rights. However, as we are all in this together, we have to admit that we need a new perspective on water resources, which is becoming a scarce resource". Loiret Agricole Rural, 27th February 2014, http://www.loiret-agricole.fr/actualites/interview-600-irrigants-du-s-insurgent-contre-l-organisme-unique-le-prefet-du-loiret-repond:VH8EO80Q.html (Accessed 25th August 2014).

October 2011 as OUGC for the sub-basin of Beauce Blesoise. The Agricultural chamber of the Loir-et-Cher represents around 60 percent of all irrigators in the Department of Loir-et-Cher.

The management of groundwater is ensured via the normal administrative and governing bodies of the Agricultural Chambers. For the case of the Agricultural Chamber of the Eure-et-Loir, decisions according to their importance will be taken during regular assembly sessions or by delegation by the Office of the Agricultural Chamber. The Chamber decided during one of its general assemblies on the creation of a steering committee involving the irrigators and concerning all decisions taken by the OUGC. The steering committee consists of 9 members, 4 from the Agricultural Chamber, 4 from different associations of irrigators, one representing each of the main crop producers (cereal, beetroot, vegetables, seeds) with one of them being an irrigator from the area or using groundwater as conjunctive use. The OUGC would have internal rules, voted by the assembly of the Agricultural Chamber. The budget for the management activities of the OUGC, when not covered by state grants, would be covered by the users themselves.

The degree of collective management of OUGCs is however considered limited by some analysts (Figureau et al. 2013; Lafitte et al. 2008). Even though the allocation of volumes abstracted is delegated to the OUGC, it has no real "strong power entrusted and is sometimes considered a simple delegate" (Bourgeois 2011 in Figureau et al. 2013: 4). Moreover as Lafitte et al. (2008) has studied, the OUGCs are defined as 'hybrids' between organisms delegated to fulfil a public service and representative bodies for irrigators. The state via the Prefect remains in control of the main decisions such as the approval of the OUGC or the annual approval of the groundwater abstraction plan. Although OUGCs can impose sanctions onto their members, police duties remain in the hands of the state (BRGM 2012). In case the multi-annual plan is not approved, the Prefect will notify individually each irrigator about the individual volumes to be abstracted (ibid.).

It is too early to assess whether the OUGC will be able to carry out tasks as expected (BRLi and AFD 2015b) while, at the same time, the overall yearly management plan has not yet been tested by a pluri-annual drought. It is noteworthy, in particular, that the Montargois sector has repelled the establishment of quotas on its territory (being located on the margin of the aquifer, the yield of the aquifer is lower and farmers have not accepted the restrictive measures envisaged (BRLi and AFD 2015b). The process of establishing the strategic water management plan (SAGE) for the Beauce has created the opportunity for all stakeholders to meet, exchange, debate and somehow reconcile their views. The process has also benefited from the leadership and neutrality of the president of the CLE (Commission Locale de l’Eau) in charge of the SAGE process. Since the imbalance between demand and the available resource is not too large there are hopes that management rules can be designed and enforced to keep the system in balance while meeting farmers' needs (BRLi and AFD 2015b).

4 Managing groundwater over-abstraction in La Mancha, Spain[20]

4.1 Introduction

Spain is a largely semiarid country notable for the importance of surface and groundwater resources in its economy, for its high built water storage capacity, and for a number of wells estimated between one and two-million. It offers a rich history of policies that have been implemented in order to control and curb groundwater use. Of its 699 aquifers covering approximately 70 percent of the country's surface area, 232 are at risk of not fulfilling the environmental indicator standards established for 2015 by the European Water Framework Directive (WFD) (IGME 2012; De Stefano 2013). Among those, the Western Mancha aquifer,[21] located in the Upper Guadiana River basin, stands out as an iconic example of the problem of sustaining both irrigated agriculture and environmental services. This section looks at the history of groundwater use and policies in the past 30 years and attempts to draw generic lessons from the diversity of regulations that have been implemented, the interplay between stick and carrot instruments and how legal loopholes are possibly negotiated and exploited by groundwater users. The section concludes with reflections on the power of the state to reorder the water regime. The different steps of this rich history are summarized in tables and charts in the appendix.

4.2 The groundwater fever in La Mancha

In 2013, groundwater represented 22 percent of the total water demand in Spain with agriculture being its main user (73 percent of the total groundwater demand) (De Stefano et al. 2013). In La Mancha, a region located around 200 kilometres south of Madrid, the rapid development of groundwater abstraction occurred in a matter of years between the 1960s and 1970s, when farmers tapped into the Western Mancha Aquifer with increasingly powerful pumps in order to reach deeper layers, resulting in aquifer drawdown (Closas 2014).

This 'silent revolution' (Fornes 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 policies in areas such as La Mancha,[22] coupled with irrigation subsidies which helped sustain the groundwater-fed irrigation boom (Closas 2014). Along with a 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 neighbouring Campo de Montiel aquifers. It also caused the environmental degradation of the groundwater-dependant Mancha Húmeda Biosphere Reserve, a 400,000 hectare wetland-rich region that includes the Tablas de Daimiel, an international RAMSAR protected wetland and a National Park since 1980, which was fed by waters from the Western Mancha aquifer and the Guadiana and Cigüela rivers (Closas 2013). As a result of groundwater level drawdowns, the Tablas de Daimiel saw a reduction in its naturally flooded area from 1,800 hectares in the 1960s to as little as 15 hectares in 2009. This

[20] Some of the contents of this section are to be published separately as an IWMI Research Report.

[21] Under the European Water Framework Directive, the Western Mancha Aquifer has been subdivided into 3 bodies of groundwater: 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). The Water Framework Directive defines aquifers as bodies serving as a drinking water source for more than 50 people or supplying over 10 m3 per day and groundwater bodies as distinct bodies of groundwater within aquifers.

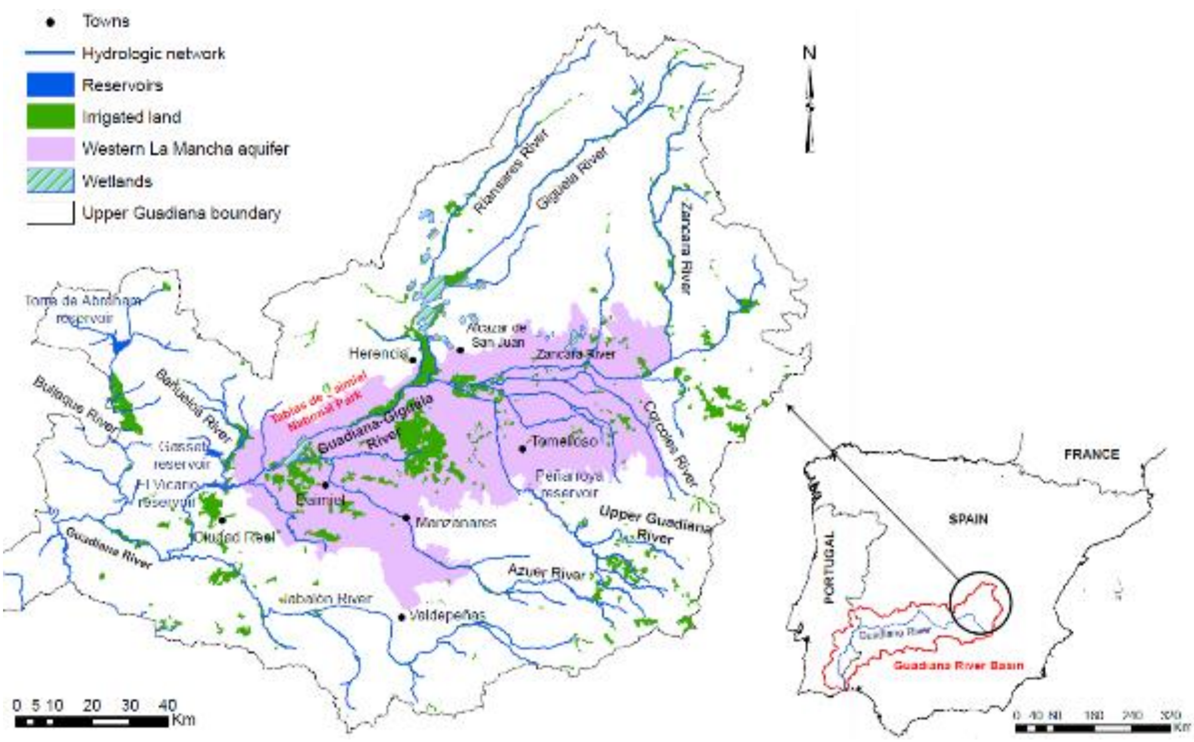
[22] The state built in the 1950s three colonization areas in La Mancha with new irrigation works and two towns: Llanos del Caudillo and Cinco Casas. The newly irrigated Peñarroya area used surface water from a neighbouring 47.5 Mm3 (million cubic meters) storage capacity dam to irrigate 8,176 hectares. The irrigated areas of Llanos del Caudillo and Cinco Casas used groundwater wells to irrigate around 2,000 hectares (Closas 2013; Closas 2014).

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, which had stopped surfacing altogether in 1983 and only reappeared in 2010 after a period of extraordinarily high rainfall (CH Guadiana 2010; Closas 2013).[23]

Intensive groundwater use for irrigation in the Western Mancha, aggravated by drought periods in the mid-1970s, mid-1990s and again in 2005-2009, resulted in an accumulated loss of stored volume of an estimated 3,000 Mm3 and average water table drawdowns of 23 m between 1980 and 2006 (MMA 2008a). In the 1990s, abstraction rates in excess of recharge resulted in a water level drawdown of 1 meter per year (Closas 2013). Abstraction reached its peak in 1995, with over 650 Mm3 being pumped annually against an estimated average annual natural recharge of 230 Mm3 per year (Bromley et al. 2001; Varela-Ortega 2007).

The geographical area of La Mancha is administratively located in the autonomous community of Castilla-La Mancha. The climatic conditions of La Mancha are typically semiarid, with hot and dry summers and short winters and an annual rainfall average of 415 mm (Martinez-Santos et al. 2008). The Western Mancha Aquifer, with an extension of 5,500 km2, 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 Km2 transboundary basin shared between Spain and Portugal (Figure 18).

Figure 18. The Western Mancha Aquifer



Source: Varela-Ortega et al. 2011.

[23] Located around 12 kilometres northeast of Daimiel, the '*Ojos del Guadiana*' (Eyes of the Guadiana) are a natural water surfacing phenomenon caused by the combination of a depression of the terrain in the centre of the Western Mancha Aquifer and a naturally high water table discharging into the surface.

4.3 Regulating groundwater abstraction rights

4.3.1 Historical groundwater abstraction regulation and reform attempts in 1985

During most of the twentieth century, groundwater abstraction rights in Spain were linked to land ownership. The 1879 water law granted private groundwater rights to land owners 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[24] as a way to secure investments in property (Closas 2013). As a result, groundwater was defined as private property.

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 these non-registered wells, reverting in its judgement 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 forged starting in 1975. Seventeen Autonomous regions gradually assumed powers in all matters ranging from health, education, agricultural, environmental and land use policy. In terms of water management the 1985 Water Law established that when a river crosses more than one autonomous region, a central government-dependant River Basin Authority (*Confederación Hidrográfica)* has management and planning responsibilities. When the river basin remains within an autonomous region, it is that region's government that is responsible (Hernández-Mora et al. 2014). The new law also changed the regime of abstraction rights from a private regime to a public one. Water (including aquifers) was declared 'public domain' and the state would regulate and control groundwater abstractions via concessions for all users (except wells under 7,000 m3/year) issued by River Basin Authorities (Closas 2012). The original aim of the law was also to put all groundwater rights under the same status, by transforming historically acquired private groundwater rights into concessions after a transitional period (Moreu Ballonga 1996).

This new law gave owners of pre-existing wells two options. The first option was to register their historical rights in the Registry of Public Waters within three years of approval of the Law. This option granted users a temporary state of private ownership for another 50 years. After this period these users would be given priority by the state to receive an administrative concession. The second option was to remain in the private property regime indefinitely by registering the rights in the Catalogue of Private Waters. In either case, a modification of the originally declared characteristics of the well or groundwater volumes abstracted (location, depth, or abstraction capacity), required a new concession granted by the River Basin Authority. The incentive to register groundwater historical rights in the Registry of Public Waters was the 'administrative protection' granted by the state, which lasted for as long as the concession lasted (renewable

[24] 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 the monarchic restoration in 1875.

after 75 years). All groundwater users had to prove that they were abstracting water prior to the enactment of the Law, by presenting proof of groundwater use prior to 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.[25]

The law gave groundwater users 3 years to register their rights through either of these two procedures (Figure 19). If after this period groundwater users had not declared their rights, they would automatically be considered as part of the Catalogue. The decision by the state to maintain private groundwater abstraction rights was designed to avoid the need to financially compensate users for the loss of their private right (Cabezas Guijarro and Sanchez 2012), as dictated by article 33 of Spain's Constitution, in case the state would privatize or limit of access to a good or property (ibid.). Although the legislator did not expect that the registration in the Registry of Public Water would be appealing, 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 alternatives (Requena and Garcia 2010). The socialist party (PSOE), in government at the time, was the main party backing this change in ownership of groundwater abstraction rights (from private to public). The main opposition party (the conservative Popular Party, PP), however, considered this measure to be unconstitutional as it would infringe on private property, individual rights and liberties (BOE 1985).[26] Even though the PP filed an appeal to revoke the application of the Water Law, the Constitutional Tribunal[27] 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).

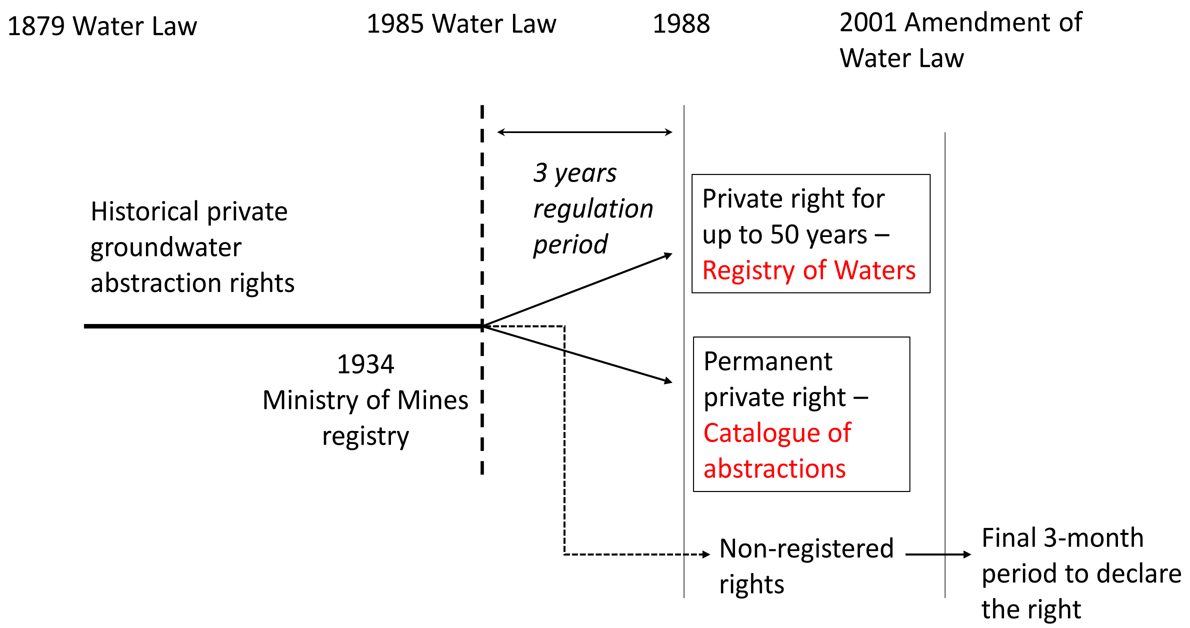
A combination of lack of information given by the state, the lack of trust of groundwater users vis-a-vis the water authority, and the many wells previously not registered at the Ministry of Mines, resulted in an estimated 10 to 20 percent only of all private groundwater abstraction rights registered in the Registry, and only 8 percent of rights registered in the Catalogue (Fornes Azcoiti et al. 2005). The rest remained unregistered and liable to penalties from the River Basin Authorities. The reluctance of 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).

[25] 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).

[26] At the parliamentary level there was a lot of resistance and discussions about the alleged 'nationalisation' of natural resources, which would have meant large compensations to private right holders. What was then instituted was a 'hybrid system' where in theory all groundwater abstraction rights would eventually migrate to the public Registry (López-Gunn 2014, pers. com.).

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

Figure 19. Evolution of private groundwater abstraction rights in Spain



Consequent delays in the registration procedures due to a last minute rush in application submissions, together with unclear regulatory guidelines and insufficient resources in River Basin Authorities meant that, in most cases, well registration did not start until 1991. Alongside disagreements between users and the River Basin Authority about abstractions without rights, River Basin Authorities had its resources partially paralyzed by the administrative deadlock generated by the sudden influx of permit requests, which helped sustain a generalized sense of distrust and impunity among farmer groups (Martinez-Santos et al. 2008). The situation of the Guadiana River Basin Authority 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 River Basin Authority (Fornes et al. 2005).

4.3.2 Subsequent regulatory attempts of groundwater abstraction

Subsequent programs by the government to regularise groundwater abstractions included the ARYCA (Actualization of Registries and Catalogues of Abstractions) and the ALBERCA (Actualization of Registry Books and Catalogue) national programs. The ARYCA program was envisioned as a census of groundwater abstractions in the Groundwater White Book released in 1994 by the Ministry of Public works and Environment (MOPTMA-MINER 1994). The initial outlay earmarked for this program mentioned in the White Book was 25 million euros although by the time of its official launch in 1995 it had been raised to 42 million (reaching 66 million euros in 2000) (ibid).[28] The ARYCA program intended to clarify the legal status of groundwater uses in Spain by: 1) completing the registration process of the thousands of wells previously declared for inscription in either the Registry or the Catalogue; and 2) inventorying and registering non-

[28] Its estimated cost was much higher however. The initial cost for this type of project had been evaluated in a technical report to the 1985 Water Law by Llamas and Custodio (1985 in Fornes et al. 2005) between 150 and 300 million euros (with around 500,000 wells to be registered in Spain at a unit cost per well of 300 to 600 euros).

declared abstractions thus identifying potential illegal wells (that is, those drilled after 1985 without an administrative concession) (ibid.).[29]

The White Book on Water issued in 2000 (MMA 2000) described the implementation of the ARYCA program across the country as ‘discouraging’, due to the slow process of registration as well as its limited budget. The results of the ARYCA program by 2002 showed an estimated number of 433,576 wells in Spain, 43.2 percent of which had been registered (187,301); 13.4 percent in process (58,136); and 43.4 percent pending registration (188,139). However, these numbers grossly underestimated the real number of wells, estimated by the same Water White book at one million (ibid.) and by Llamas et al. (2001) at around 2 million wells. As a result of the limited success of the ARYCA program as well as the deficit of registration of private waters in the Catalogue of Private Waters (only 8 percent of estimated private groundwater rights had been registered by 2000), the 2001 National Hydrological Plan (Law 10/2001) introduced a final 3-month deadline for groundwater users to register their private rights, which essentially represented a closure of the Catalogue after that period (ibid.).[30]

The ALBERCA Program that followed in 2002 aimed to finalize the procedure of groundwater permit registration in the Registry of Public Waters by unifying the registration process in every River Basin Authority, characterizing existing wells (including georeference and type of use), and modernizing the Registry via computerization and digitalization so that information is available online in the near future. According to the Ministry of Agriculture, Food and the Environment, 566,316 inscription requests had been submitted between 2002 and 2012 of which 466,272 had been resolved (MAGRAMA 2012a).

According to Martinez-Santos et al. (2008), nearly 40,000 wells exist in the Western Mancha aquifer of which only 17,000 had been registered at the Guadiana River Basin Authority in 2008. Data provided by the Spanish Agency of Evaluation and Quality in its assessment of River Basin Agencies mentioned in 2010 that around 46 percent of all well regularization files had been processed and resolved (AEVAL 2010). Furthermore, the Guadiana River Basin Authority calculated in 2008, based on data from the ALBERCA program, that there were 52,408 hectares of illegally irrigated land (i.e. without registered permits) (MMA 2008b). In 2012, the Ministry of Agriculture indicated that in the Guadiana River Basin Authority, a total of 128,835 requests for groundwater authorizations had been filed through the ALBERCA programme by December 2012 (MAGRAMA 2012a).

4.3.3 River basin authorities, groundwater regulation and political conflicts

The increasing conflicts around the distribution of political and management powers between River Basin Authorities, as representatives of the central government in Madrid, and new regional governments – Autonomous Communities – created after 40 year of centralizing dictatorship, also helped fuel the conflict between users and the state. The state’s centralizing hydraulic mission (more supply-driven water policies and infrastructure) and the so-called ‘hydrological solidarity’ between regions in Spain enshrined in a National Hydrological Plan drafted in 2001 clashed with diverging political identities and local water and environmental needs. This caused political

[29] The Registry is not closed, as concession requests are still being submitted. However, the section in the Registry which includes the ‘temporary private rights’ is officially closed, as no requests made after 1988 can be included.

[30] For groundwater uses existing period to 1985 and for aquifers declared ‘overexploited’, after that deadline the only way to recognize groundwater abstraction rights 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 (Fornes et al. 2005).

conflicts between Autonomous Communities, with water-scarce south-eastern Spain expecting to receive water through large-scale water transfers from the north (Hernández-Mora et al. 2014) (Box 2).

Box 2. River basin authorities in Spain

River Basin Authorities that manage interregional river basins are functionally dependant of the National Ministry of Agriculture, Food and the Environment. However, their complex organizational and institutional structure integrates the state, the different Autonomous Communities within the River Basin, and a representation of different permitted users (irrigators, urban water supply and hydroelectric users). Environmental interests or recreational users are only nominally represented (Varela and Hernández-Mora 2010). Even though the public character of water typified by the 1985 Water Law requires a centralized management body, when river basins extend over more than one Autonomous Community the different Autonomous Communities are present in the Governing body of River Basin Agencies, their Consultative Council, and Authorities Committee (aimed at articulating the sectoral activities of the River Basin Agencies with the different interests of the members and users in the basin) (Fanlo Loras 2007). This is due to the fact that when Autonomous Communities were created, they incorporated specific responsibilities (e.g. environment, agriculture, health, urbanism), all requiring representation within the organizational structure of River Basin Agencies (ibid.).

Box 3. Interbasin water transfers in Spain and La Mancha

The largest interbasin water transfer operating in Spain today transfers up to 600 Mm3 per year from the central Tagus River to the Southeast, and an additional 50 Mm3 to the Tablas de Daimiel National Park in times of drought (Hernández-Mora et al. 2014). An additional water transfer project to the southeast was to be one of the cruxes of the government’s National Hydrological Plan of 2001: to transfer 1,043 Mm^3 per year of ‘excess water’ from the Ebro River Basin in the North of Spain to the water-scarce south-eastern Autonomous Communities (Swyngedouw 2014). This project was fought politically by the Autonomous Communities in north-eastern Spain (e.g. Aragon and Catalonia) as well as socially on the streets by a large number of citizens claiming a new type of ‘water culture’, and demonstrating against more water transfers and infrastructure whilst demanding new water management principles, respecting the environment, achieving public participation, and implementing demand-management principles (Font and Subirats 2010; López-Gunn 2009). When the Conservative party was voted out in the following elections in 2004, the newly appointed government (with the socialist party PSOE) suspended the Ebro water transfer and initiated an ambitious desalination plan instead (Swyngwedouw 2014).

River Basin Authorities and their functions evolved during these years from the mere implementation of government infrastructure projects, without a real river basin approach, after the 1985 Water Law, towards a more central role in water resources management and planning which conceptualised the river basin as a space with water to be shared and allocated between conflicting uses (AEVAL 2010). With the European Water Framework Directive (WFI), this vision was enhanced to incorporate the river basin’s varied ecosystems and the necessity to preserve its ecosystem functions (ibid.). However, critical evaluations of the WFD implementation process in Spain indicate that the necessary transformation from a hydraulic-centered to ecosystem-based water management is not yet complete (FNCA, 2014; Hernández-Mora et al. 2014). Amidst this increasing institutional and political complexity with the decentralisation of political power to the

Autonomous Communities, River Basin Agencies have evolved as instances of increased state influence (Font and Subirats 2010). This increase of state influence is partly due to the fact that the new 1985 Water Law placed an emphasis on state intervention “by extending the idea of the public domain and focusing on planning” (Font and Subirats 2010: 3). For instance, the Guadiana River Basin Authority suffers from high centralisation of its administrative and regulatory functions, and has been characterised more as a peripheral organ of the Ministry rather than the autonomous organisation considered by the 1985 Water Law (AEVAL 2010). In addition, River Basin Authorities, who are funded through user fees, transfers from the central government and European Union cohesion funds, are largely underfunded, 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 (ibid.).

4.4 Sticks and carrots to control groundwater abstraction

The 1985 water law also allowed the state to declare aquifers as overexploited and, in such a case, entrusted River Basin Authorities with the power to enforce emergency regulatory regimes limiting groundwater abstraction. In the case of the Western La Mancha Aquifer, a provisional declaration of overexploitation was approved in 1987. In 1991 the Guadiana RBA approved the first annual management plan *(Régimen de Explotación)* for the aquifer which included: volumetric restrictions at individual wells, the prohibition to drill new wells; freezing new groundwater abstraction concessions; and the 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). Groundwater abstraction limitations were only imposed however on the users having registered their wells in the Registry of Waters or in the Catalogue, as illegal wells were not known or identified. These restrictions would remain in use as long as the declaration of overexploitation would last.

The 1991 groundwater abstraction regime (quota system 1), put in place by the Guadiana River Basin Authority, established maximum irrigation volumes calculated on the basis of what is called *normal consumption (consumo normal)*, set at 4,278 m3/ha/year. Maximum volumes are modulated in relation to the amount of land being irrigated, so that as the irrigated area increases, the amount of water allocated per hectare decreases: a 5-hectare farm would be able to use its total groundwater allocation (i.e. 4,278 m3/ha) whereas a 20-hectare farm would only be allowed to use 2,352 m3/ha and a farm of 100 hectares would be limited to use only 1,375 m3/ hectare (Closas 2013). Farmers growing vines had a limited allocation of 2,000 m3/ha/year. It was also calculated that groundwater abstraction limitations would entail a 25-percent reduction in the workforce directly involved in agriculture and as a result, farmers and their representative bodies demanded compensatory measures from the state (Rosell and Viladomiu 1997). Furthermore, farmers also demanded compensations due to the fact that, in spite of having invested in new harvesting machinery to cultivate and harvest maize (a water-intensive crop), the River Basin Authority was preventing them from cultivating it because of the new abstraction regime (Viladomiu 2014, pers. com.). According to Varela-Ortega (2007: 332), "the drastic reductions in the allowable quotas led to considerable social unrest and to free-riding behaviour in the form of illegal drilling of wells and excessive abstraction."

In 1992 an Agro-Environmental Plan, known locally as the Wetlands Plan or *Plan de Humedales,* was set up by the European Commission aimed at reducing the total volume of groundwater abstracted from the Western Aquifer to 240 Mm3 per year by compensating farmers willing to stop or reduce groundwater abstraction for irrigation (Rosell Foxà 2001). This program 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 was also put forward by Spain to take advantage of the 1992 reform of the Common Agricultural Policy, which approved funds for member states to support agro-environmental projects inducing farmers to reduce water use and preserve natural ecosystems (Regulation CEE 2078/1992) (Rosell and Viladomiu 2000; Viladomiu 2014, pers. com.). Given the poor state of the Las Tablas de Daimiel National Park, Spain coupled its (urgent) need for funds to compensate farmers with the necessity to protect the endangered ecosystem (Viladomiu 2014, pers. com.).

According to the European Agro-Environmental plan (AEP1), the reduction of abstracted volumes by farmers was established according to three different levels in relation to an average consumption that the Program estimated at around 4,200 m3/ha/year (Hernández-Mora 2002): 50 percent, 70 percent, and 100 percent, and payments were established per hectare of irrigated land (Varela-Ortega 2007). The European institution provided 75 percent of the funds and Spain's ministry of Environment contributed 12.5 percent. The regional government of Castilla-La Mancha added the remaining 12.5 percent and was in charge of the implementation of this plan. The first phase of the Program was approved for a five-year period (1993-1997), with a total budget of 96 million euros (Hernández-Mora 2002).

Farmers could join the plan on a voluntary basis but since the monetary compensations per hectare were by and large offsetting the income losses of the quota program – estimated at around 200–250 euros per hectare (Rosell and Viladomiu 1997; Varela-Ortega 2007), farmers responded positively to this incentive (Table 4, Table 5). Rosell and Viladomiu (1997) estimated that in the Western Mancha and Campo de Montiel aquifers, 2,652 farmers had joined to the program by 1995, representing 85,410 hectares of irrigated land and 298 Mm3 of water saved in 1995 (51 percent of total volumes recognized by the Guadiana Basin Authority at the time according to AEVAL, 2008) (Table 4).

Table 4 Total surface area participating in the rent compensation programme for the reduction of irrigation in the Western Mancha and Campo de Montiel aquifers

Year	Participating hectares	Total theoretical savings (hm3)
1993	57,973	182.39
1994	74,853	235.97
1995	85,410	298.19
1996	85,834	302.16
1997	85,838	310.**
1998	85,020	not available
1999	61,127	not available

Source: Hernández-Mora (2002) with data from Viladomiu y Rosell (1998) for 1993-1996; Department of Agriculture, Fisheries and Nutrition, Castilla-La Mancha regional government for the 1997-1999 period (unpublished data).

It must be noted that the levels of reduction in total volumes abstracted indicated in the AEP1 were calculated as reductions over the normal consumption established by the program (4,200 m3/ha/year), and therefore accepting a reduction of 50 percent was almost equivalent to the quota of 2,000 m3/ha imposed for vine, or the 2,352 m3/ha for a 20-hectare farm. Funds from the EU program were not enough to pay for farmers to comply with the law as the quota per hectare was stricter for large farms but these same farmers also received much larger payments in case they adopted the 70 percent reduction, which corresponded more or less to what they were already subjected to by the 1987 regulation.

Table 5 Evolution of compensatory payments from the Agro-Environmental Programme in the Western Mancha Aquifer

EU AEP of western La Mancha aquifer Income Compensation Payments €/ha					
	First Phase (1993–2002) AEP1 Payments are independent of farm size			Second Phase (2003–2007) AEP2 Payments are modulated according to farm size	
Level of reduction in water consumption (%)	1993	1997	2001	2006	
50	156	164	179	1–40 ha	209
				40–80 ha	125
				>80 ha	63
70	258	271	296		
100	360	379	414	1–40 ha	518
				40–80 ha	311
				>80 ha	155

Source: Varela-Ortega 2007.

In spite of these measures and their relative success, and in view of the continuing depletion of the Western Mancha Aquifer, the Spanish government was preparing itself to tighten its quota regulation. With the overexploitation of the Western Aquifer finally officially declared in 1994, it established a new maximum allowable volume of 2,000 m3/ha for all users and crops, except for vine which was given a new maximum allowance of 1,500 m3/ha (Varela-Ortega 2007). These quotas were not fully fixed and were intended to be modified according to climatic and demand conditions. Sanctions ranging from 3,000 to 30,000 euros were put in place under the emergency groundwater abstraction regime banning the deepening of existing wells, the change in location of a well, and the drilling of a new well (López-Gunn 2003). Although meters started to be installed from 1996 onwards, the lack of public funds to subsidize meters meant that farmers had to cover the installation cost themselves (ibid.). Since not all wells had installed meters, groundwater abstraction was also monitored via so-called ‘consumption tables’ based on groundwater consumption estimates established by the Regional Agricultural Center (López-Gunn 2014, pers. com.). However, the monitoring of crop areas via remote sensing was the main tool used by the River Basin Authority to assess groundwater use. A guard service overseeing extractions was also set up but had only four guards to cover an area of 5,500 km2 (López-Gunn 2003).

With these very strict quotas, the number of farmers in the area joining the AEP1 program increased further. By 1997 almost 86,000 ha had come under this programme and water abstraction was reduced by 60 percent (about 300 Mm^3), exceeding the programme’s objective of 255–270 Mm3 per year (Varela-Ortega 2007). The 5-year Agro-Environmental Program was extended until 2003. The implementation of this first phase was chaotic however, since after 1994 farmers were paid to ‘break the law’. This was due to the fact that the financial incentives to reduce groundwater abstractions had been calculated based on the estimated "normal volumes" of 4,200 m3/ha/year as established in the initial 1991 groundwater abstraction regime (quota system 1) and not on the revised and much lower emergency abstraction limits (quota system 2) approved in 1994. Applying the reduction rates indicated in the AEP1 program was not enough to be in conformity with the 1994 new quotas as the different reduction levels were still higher than the revised quotas after 1994.

Moreover, the AEP1 program did not include irrigated areas with groundwater abstraction rights not recognised by the Guadiana River Basin Authority (Rosell and Viladomiu 1997). This compensation plan was further modified in 2003 (AEP2) and only included 50 and 100 percent reductions in groundwater abstraction based on much smaller groundwater allocation (4,278 m3 down to 2,000 m3) resulting from the revised 1994 Groundwater abstraction regime, while making payment dependent on farm size with the intent to reduce the positive bias toward large farms that was incorporated in AEP1. The incentives for farmers to join the program were reduced, as compensations now barely covered the income loss resulting from the reduction of groundwater abstraction. In view of the lack of interest from farmers, the program was abandoned in 2005 (Varela-Ortega 2007; Martinez-Santos et al. 2008).

Infrastructure projects to prevent a further degradation of the Las Tablas de Daimiel National Park were also implemented during this decade. In 1988 a regeneration plan was put forward in order 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). Also, a 150-kilometer deviation from the Tajo-Segura water transfer to the Ciguela River, a tributary of the Guadiana, was completed in 1994 which allowed for a transfer of a maximum of 50 Mm3/year into the National Park. This infrastructure proved essential in 2009 when an emergency transfer of 20 Mm3 was approved by the Council of Ministers in order to bring water back to the wetland after an especially dry summer which caused the combustion of underground peat in some areas of the wetland (Closas 2013). However it also had the unintended consequence of destroying the Cigüela riparian wetlands since the bed of the Cigüela River was dredged in order to enhance the efficiency of water transfers to the Tablas de Daimiel wetland (Cruces et al. 1998).

The contradictions between European environmental programs and goals and the Common Agricultural Policy (CAP) meant that while environmental programs were trying to reduce groundwater stress, agricultural funds were incentivizing groundwater abstraction with subsidies to 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 funnelled to the production of grapes for wine arose from the reform of the European Common Market for Wine in 1999 (Sanjuan 2013). In La Mancha, the increase of irrigated vineyards during the 1990s and 2000s and the conversion of dry-farm vines into irrigation was linked to specific funds allocated to the modernization of agriculture and the receipt of EU subsidies linked to production (ibid.). Specific subsidies and restructuring programmes and crop conversion for vines included start-up costs for cultivation (removal of rocks, soil preparation, land levelling, plant disinfection and treatment) (Ruiz Pulpon 2013; Sanjuan 2013). In the Autonomous Community of Castilla-La Mancha, although a mixture of coupled and decoupled subsidies still existed in 2009, coupled subsidies for vine production represented the majority of European funds (over 90 percent of CAP funds went for the production of grapes alone) (Ruiz Pulpon 2013).

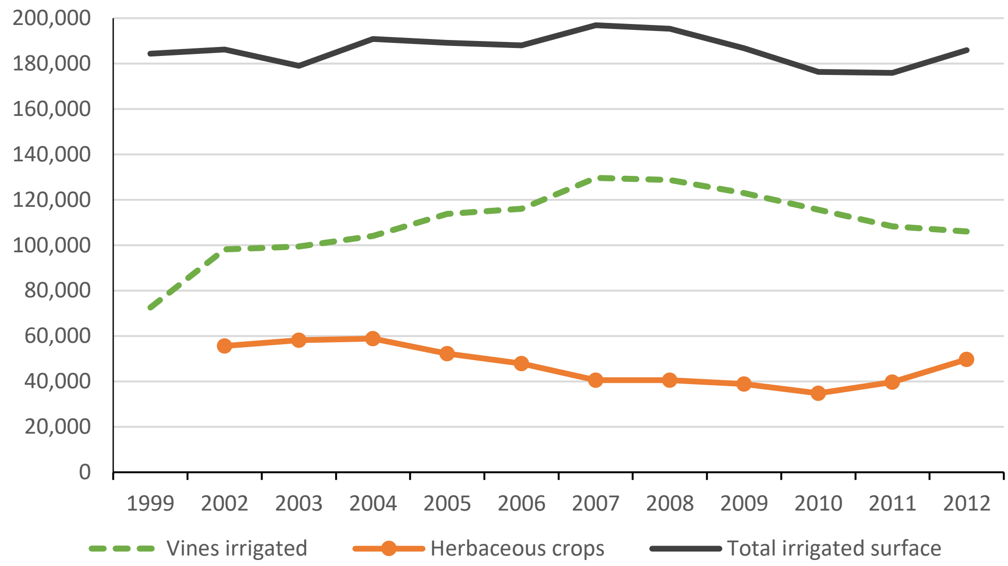
These subsidies and restructuring programmes for vineyards also had a perverse effect as they represented an incentive to increase the total area cultivated with vines, offsetting potential water savings due to this substitution of crops. In addition most of the new grapes is grown on 'espaliers', a type of cultivation technique requiring more water than conventional vines on the ground (between 2,000 and 3,000 m3/ha) (Ruiz Pulpon 2013; Sanjuan 2013). In total, irrigated vines increased from 72,000 hectares in 1999 to almost 130,000 hectares in 2007, representing 66 percent of the total irrigated area in the province of Ciudad Real, where the largest part of the aquifer is located. Subsidies for planting vines could not be higher than 75 percent of the total costs for investments made by a group of users and 63.75 percent for individual farmers. Between 2003 and 2009 the Regional Government of Castilla-La Mancha invested around 65 million euros per year for the transformation of vineyards; with the Western Mancha Aquifer representing the highest concentration of espalier grapes at 41 percent of the total cultivated area in 2013 (ibid).

At the River Basin level, the 'stick' function of the Guadiana River Basin Agency and its enforcement and regulatory capacities have also been curtailed by a lack of staff for control and monitoring (AEVAL 2010). Each member of the river guard patrol (*guardería fluvial*) in charge of controlling water uses and abstractions on the ground has to cover an area of 1,000 km2 with an estimated average population of 33,067 inhabitants (ibid.). Control and sanctions for illegal wells by the Guadiana River Basin Authority were all the more critical during drought episodes in the Guadiana as Figure 20 shows, with peak periods for registration of sanctioning files coinciding with important decreases in the average precipitation levels (in 1993-1994 and 2004-2005).

Box 4. Would water pricing policies work in La Mancha?

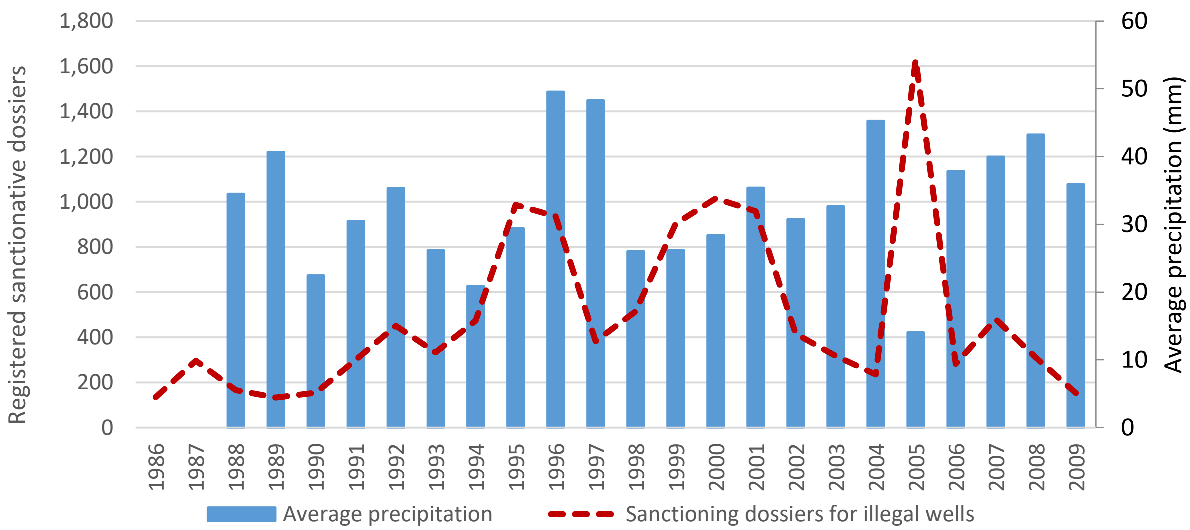
The use of water pricing is considered a major instrument for demand management, internalization of externalities via cost recovery, and water conservation (Molle and Berkoff 2007). Although water pricing policies have not been adopted in La Mancha, Varela-Ortega (2007) has tried to assess what would be the impact of such a policy 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-size farm. Results show that water demand is reduced progressively, but differs between two types of farms. Water demand proves to be more inelastic for the more intensive farm "as higher productivity permits to absorb increase water use costs without drastically changing cropping patterns towards less water-demanding crops or rainfed farming" (Varela-Ortega 2007: 343). The model also shows that a water tariff of 0.054 euros per m^3 would produce the necessary incentives to reach the 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 percent in the aggregate. Additionally, for water pricing to work, wells would have to be monitored volumetrically, something which, given the previous experience of well regulation, would be difficult to achieve in La Mancha.

Figure 20. Irrigated areas in Ciudad Real province (1999-2012)



Note 1: herbaceous crops include cereals, legumes, forage crops, industrial crops, and vegetables.
Note 2: The decrease in irrigated vines after 2007 could be due, according to some authors, to the globalized financial crisis after 2008 which 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 also been quoted as drivers affecting the decrease in wine production (Barco Royo and Navarro Pérez 2012; Fernández Portela 2013).
Source: Authors with data from Encuesta sobre superficies y rendimientos de cultivos (ESYRCE), various years, Ministerio de Agricultura, Alimentacion y Medio Ambiente, http://www.magrama.gob.es/es/estadistica/temas/estadisticas-agrarias/agricultura/esyrce/resultados-de-anos-anteriores/default.aspx (Accessed 7th April 2014).

Figure 21. Registered sanctions at the Guadiana River Basin Authority and average precipitation in La Mancha (1986-2009)



Source: Authors with data from AEVAL (2010) (for registered sanction dossiers) and AEMET for average precipitation (measured at the Ciudad Real weather station) for series 1988-2010 and 2013, and INE for 2011-2012.

4.5 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 European Water Framework Directive prompted the development of a Special Plan for the Upper Guadiana basin (PEAG) as part of the 2001 National Hydrologic Plan approved by the conservative Popular Party government. A first draft of the Plan emphasizing the regularization of unregistered wells was presented in December 2003, but was rejected by the Castilla-La Mancha autonomous region's socialist government who developed an alternative proposal more in line with the European Water Framework Directive goals. However, after a surprise win by the socialist party in the March 2004 national elections, the incoming government negotiated a new PEAG proposal together with the agricultural lobby organisations, national environmental groups and the regional government. [31] The new proposal was presented in 2006 and finally approved in January 2008, after 22 different drafts. The final version presented a series of activities aiming at socio-economically restructuring the area 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 become news and on the 14th of June 2008 the 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 in 2015 (Closas 2013).

In 2008, the socialist government was re-elected. However, while the 2004-2008 legislature had been characterized by a significant push to transform water policy in Spain in line with the European Water Framework Directive requirements, the re-elected government changed its focus toward more agricultural-friendly environmental policies.[32] At the same time, the Castilla La Mancha regional government, still under socialist rule, emphasized its defence of agricultural interests in detriment of the achievement of environmental objectives. The evolution in the implementation of the PEAG has to be understood in this political context.

The PEAG, which included the Western Mancha Aquifer, was managed by a consortium composed of the state, via the Ministry of Environment, Rural and Marine Affairs, and the regional government of Castilla-La Mancha and was to be implemented between 2008 and 2027. It had

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[31] This included primarily ASAJA (a more conservative farmer union whose position toward the PEAG during this period changed from outright opposition to finally approving and defending it) but also other farmer unions representing smaller farmer (COAG, UPA) as well as the 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 main stakeholders in the negotiations process are all national-level environmental NGOs (e.g. WWF, SEO-Birdlife). The government appointed a PSOE (Socialist Party) political appointee 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. "Asaja Castilla La Mancha dice no al plan especial del Alto Guadiana", 6th of November 2006 (http://www.agroterra.com/blog/actualidad/asaja-castilla-la-mancha-dice-no-al-plan-especial-del-alto-guadiana/14518/, Accessed 10th of February 2015); "Asaja insta al gobierno a que desarrolle el PEAG y pide que se cuente con Enrique Calleja", 22nd of May 2008, (http://www.abc.es/hemeroteca/historico-22-05-2008/abc/Toledo/asaja-insta-al-gobierno-a-que-desarrolle-el-peag-y-pide-que-se-cuente-con-enrique-calleja_1641884485491.html, Accessed 10th of February 2015).

[32] 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 agro-industrial and farming union sectors, "Josep Puxeu ha sido nombrado Secretario de Estado de Medio Rural y Agua", 18th of April 2008 (http://www.soitu.es/soitu/2008/04/18/info/1208543580_909450.html, Accessed 10th of February 2015). Environmental groups opposed this merger and denounced the shift away from a commitment to environmental conservation and a re-alignment with farmers' interests, "Greenpeace denuncia el desguace del Ministerio de Medio Ambiente", 12th of April 2008, http://www.greenpeace.org/espana/es/news/2010/November/greenpeace-denuncia-el-desguac/ (Accessed 10th February 2015).

been conceptualised as an umbrella plan integrating the various measures and programs developed in the past, as well as new initiatives (Calleja and Velasco 2011).[33] The PEAG aimed at achieving the sustainable management of the aquifer through a combination of measures, most significantly by continuing the conversion of private groundwater abstraction rights into concessions, 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),* and purchase of land around the Las Tablas de Daimiel National Park (López-Gunn et al. 2013). The state would buy voluntarily offered user rights through public acquisition offers and, via this public water bank, reassign up to one third of the rights 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, since the provisional declaration of overexploitation in 1987, no new concessions could be granted. The rest was designated to improve aquifer levels, with an environmental target that a minimum of 35 Mm^3 per year would reach the Tablas de Daimiel National Park before 2027 (WWF 2012). The PEAG also included an outreach and education program targeted at the farming community as well as the general public in the Upper Guadiana. It included training courses, funding for research programs at the regional university, educational programs in schools, seminars and conferences, among other activities. With an original budget of 55 million euros, it was severely underfunded and only partially implemented.[34]

Groundwater abstraction rights were purchased by the state though six public offers of acquisition, three before the approval of the PEAG and three more once the PEAG had been approved (Table 6), Purchase prices ranged between 3,000-10,000 €/ha for herbaceous crops and 3,000-6,000 euros per hectare for vineyards per declared hectare (recognised by the RBA) (Cabezas-Guijarro and Sánchez 2012).[35]

[33] The PEAG included additional programs such as the support to the different communities of irrigators, an environmental plan for habitat recovery (including reforestation programs), awareness, communication and research projects, and waste water treatment projects (Calleja and Velasco 2011).

[34] This measure could be described as a 'sermon', 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).

[35] 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 allocation of groundwater for each land plot of 1,500 m^3/ha and also differentiated between vine crops and non-vine crops. According to farmers, the market price to be paid for irrigable land in La Mancha was around 18,000 €/ha (Ferrer Matvieychuc and Martin de la Cal 2009). It is difficult however to directly compare this price with the one offered through the PEAG as it corresponds to the difference between irrigated and dry land farming.

Table 6. Public offers of acquisition of groundwater abstraction rights in the Upper Guadiana

Date	Total Budget (€)	Applied Budget (€)	# offers acquired	Total affected hectares	Total volume purchased (m3)
November 2006	600,000	487,275	4	59	210,000
April 2007	10,000,000	9,445,300	35	1,061	4,434,000
September 2007	30,000,000	12,344,196	79	1,282	5,322,000
September 2008	11,950,000	11,945,342	85	1,256	5,292,000
March 2009	20,000,000	19,919,000	140	2,011	8,405,000
November 2009	11,950,000	11,648,574	83	1,200	5,400,000
TOTAL	**84,500,000**	**65,789,687**	**426**	**6,896**	**29,063,000**

Source: Cabezas-Guijarro and Sánchez 2012.

Interested farmers could apply to the Guadiana RBA for a groundwater abstraction concession. Concessions were granted after a thorough process of analysis and farmers were selected according to plot size (average of 10 hectares), age (between 18 and 40 years old), professional status, and with agriculture as the main source of income (Aragon Cavaller 2014, pers. com.).

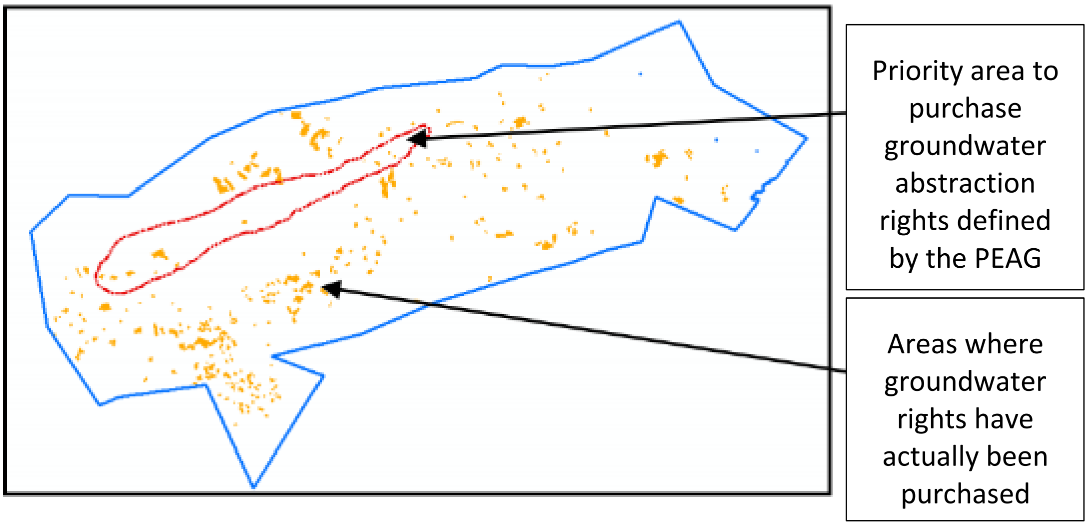
Farmers having sold water rights would have to keep the land under dryland farming (López-Gunn 2014, pers. com.). Within a month after the sale, well owners would have to remove pumping equipment and other machinery as well as closing and sealing the wells (Requena and Garcia 2010). Once this had been verified, the River Basin Authority 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 only part of the abstraction rights from their wells, in which case the River Basin Agency would control the meter installed in the well in order to know the real groundwater consumption and limit the remaining abstraction right to what was allowed (Calleja 2014, pers. com.). The River Basin Authority would not allow the expansion of irrigated surface by users with remaining rights even if the farmer said that it would be done with less groundwater per hectare (established at 1,500 m3/ha for vine and 2,000 m3/ha for other crops in the groundwater abstraction regime) (Calleja 2014, pers. com.). What was allowed however was the 'concentration of groundwater abstraction rights' on smaller irrigated areas, depending on the crops,[36] monitored in theory by the River Basin Agency and the various Communities of Groundwater Users (providing information to the River Basin Agency) via water meters and field visits (ibid.). The River Basin Agency signed a memorandum of understanding vis-à-vis the control of groundwater abstractions and monitoring of meters with the General Community of Groundwater Users of Aquifer 23 (ibid.). Visits by officials have been however infrequent, and there was no increase in visits by guards from the River Basin Authority to land plots having purchased or sold rights since the beginning of the PEAG (Fernandez Lop 2014, pers. com.).

[36] As an example, a farmer having sold half of his groundwater rights and cultivating 20 hectares of melon, would only be allowed to plant 10 hectares, even if his remaining rights was enough to cultivate the 20 hectares (Calleja 2014, pers. com.).

The purchase of water rights, meant to be the principal activity of the PEAG, helped regularize the use of water for vine and incorporate most of the informal irrigators into the water rights system (with 15,700 hectares regularized out of a target of 17,500 hectares) (Aragon Cavaller 2014, pers. com.). This was done by purchasing water rights and land from farmers irrigating mainly cereals and redistributing them to irrigate more economically productive crops such as vine (López-Gunn et al. 2013). In terms of funds, the PEAG disbursed almost 66 million euros for the purchase of groundwater rights (only 10 percent of the initial budget component allocated just for the purchase of rights) (Fernandez Lop 2013). In other words, the state extended a big 'carrot' to illegal well owners, whereby a water right – bought 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' and shifts to higher value vine varieties. Of course, for this to happen, illegal wells needed to be declared.

However, irregularities were found in the implementation of the measure to reduce the volume of groundwater abstraction from the Western Mancha Aquifer via the public purchase of groundwater rights. Although the PEAG established rules aimed at controlling the sale of groundwater rights with proven groundwater abstraction for at least 3 years before the sale (checked and tested by members of the River Basin Authority) (Ferrer Matvieychuc and Martin de la Cal 2009), research by WWF (2012) found that 83 percent of the rights purchased by the government had not been used for 5 years prior to the sale. Despite the critical needs for monitoring, the River Basin Agency did not put more human resources to control 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 would not denounce them to the River Basin Agency (Fernandez Lop 2014, pers. com.).

Figure 22. Groundwater abstraction rights purchased outside the designated areas



Source: Fernandez Lop 2013.

In addition, the WWF study established that 95 percent of the rights sold to the Ministry were located outside the priority area designated for purchase (the area around the National Park of the Las Tablas de Daimiel Wetland). This was due to the fact that, despite the PEAG's plans to incentivize the transfer groundwater rights between users, not everyone in the designated priority area adhered and not many users overall wanted to sell (Fernandez Lop 2014, pers. com.). This situation meant that after the second public purchase, the Ministry allowed itself to buy rights from wells whose owners had not been abstracting water for a long time and with the only requirement that they should have water in them (ibid.).[37]

Likewise, although the initial agreement with the Regional government of Castilla-La Mancha included in the PEAG established that only one third of the rights acquired (around 70 Mm3) would be transferred to the Junta de Castilla-La Mancha in order to reallocate them for social uses (i.e. allocated to users without abstraction rights), in 2010 this situation changed and the majority of acquired rights were used to regularize illegal abstractions (Requena 2013).[38] Asked by the Junta de Castilla-La Mancha, the PEAG consortium put forward to the Guadiana River Basin 4,000 application files to irrigate vines with the objective, according to WWF (2012), to allocate 100 percent of effective purchased rights (around 13.5 Mm3)[39] to users with wells without permit. As López-Gunn et al. (2013 citing Requena 2011) wrote, the purchase of water rights by the PEAG resulted in 81 percent of purchased rights reallocated to non-authorized users, thus becoming a de facto regularization of illegal groundwater abstraction. This created a further imbalance in the originally allocated percentage of purchased rights designated for aquifer recovery. The actual volume of rights purchased left to the environment (that is, not transferred to another farmer) in 2011 amounted to 9 percent of the total volume expected to be allocated for the environment (ibid.).[40] Additionally, some of the rights purchased continued to be used after the sale (around 8 percent), and in an even more striking case, rights were purchased from 212 hectares of land in farms within the legally defined 'public water domain' and thus pertaining to the state (WWF 2012).[41]

In addition, lack of funds due to Spain's economic crisis after 2008 and a lack of 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 which, as a 'siren song', had planned to invest around 5 billion euros from the state budget for its various activities until 2027 (Calleja and Velaso 2011; López-Gunn et al. 2013).[42] Political changes after the general elections in Spain in 2011 and the arrival of a conservative government with a different approach to water management than the previous socialist government (Swyngedouw 2014) resulted in a change of

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[37] This was due to the fact that these wells were often located in the periphery of the aquifer and without water, as 2007, 2008, and 2009 were very dry years and aquifers were very low. Additionally, the wells offered also happened in some instances to be owned by retired farmers whose children did not continue farming. The right remained therefore but the land was not being farmed.

[38] In 2008 the political situation in Spain changed. The Ministry of Environment was merged with the Ministry of Agriculture and a new Secretary for Water in charge of the water dossier in the ministry was appointed, himself being a former farmer.

[39] While 29 Mm3 were purchased on paper, the decision had been made to only consider the "effective rights" that is, the water that could be effectively used according to the Groundwater Management Plan. Thus only 13.5 Mm3 could be reallocated.

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

[41] This anomaly was due to the fact that the state purchased groundwater rights from farms in the vicinity of the 'Ojos del Guadiana' which, being dry for almost twenty years, had been privately farmed. The fact is that some of these farmed lands were actually located in the old Guadiana river bed 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 was defined as the river course and a stretch of land of 100 meters on each side – Article 6, Royal Decree 1/2001 of 20th July 2001 approving the revised 1985 Water Law). The reclamation of these abstraction rights by the state should have been done without any money transaction as the state is the ultimate owner of these rights (WWF 2012).

[42] The PEAG budget was planned to be 3 billion euros for the period 2008-2027, complemented with another 2 billion euros for complementary programs (other agricultural measures such as crop substitution, wastewater treatment plants) (Calleja and Velasco 2011).

direction in national water management policy. This meant, according to an interview in 2013 to the new Minister of Agriculture, a push for the approval as well as a re-evaluation of the pending river basin management plans (in November 2013 only 1 out of 17 had been approved), [43] as well as reaching a 'national water pact' with the widest consensus possible which would then allow the Ministry to draw a new National Hydrological Plan "that will ensure the water supply, in quantity as well as quality, with the support and solidarity of all Autonomous Communities."[44,45]

A "Liquidating Director" was appointed in July 2013 to close the PEAG management consortium.[46] 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.[47] The plan also sought to establish environmental flows for all 313 surface water bodies and 20 groundwater bodies found in the river basin, and invest over 40 percent of its 800 million euros budget, up to 2015, on new infrastructure for drinking water treatment, and new wastewater treatment infrastructure and reuse.[48]

Some critical voices such as some communities of irrigators in La Mancha and environmental groups consider this new River Basin Management plan as the 'death' of the PEAG, a plan that took many years to agree upon and approve, and without putting forward any new measure to attain its environmental goals (a priority for environmentalists) or further regularize illegal wells (a priority for farmer groups).[49] However, other interest groups such as the president of ASAJA, one of the main farmers' unions in La Mancha, mentioned during a speech in front of the secretary general of the Popular Party that "organizations that do not work, such as the Special Plan for the

[43] The Water Framework Directive of the European Union (Directive 2000/60/EC) required river basin management plans to be approved by December 2009, and revised plans in December 2015.

[44] iAgua.es, "Entrevista exclusiva a Arias Canete (I): 'El gobierno no ha criticado la tecnica de la desalacion ni a las empresas especializadas'", 25th of November 2013, www.iagua.es/noticias/espana/13/11/25/entrevista-exclusiva-arias-canete-i-el-gobierno-no-ha-criticado-la-tecnica-de-la-desalacion-ni-las-e-4-, (Accessed 12th March 2014).

[45] Needless to say, these were polemical declarations in Spain as the Minister did not exclude the Ebro River when he hinted during that interview at the possibility of new water transfers, subject however to technical and economic feasibility studies. These declarations were mentioned by newspapers in Aragon and Catalonia as opening once more the possibility for a new Ebro Water Transfer (El Heraldo de Aragon, "Arias Canete abre la puerta a realizar 'mejoras' en el Plan Hidrologico del Ebro", 5th November 2013, www.heraldo.es/noticias/aragon/2013/11/05/canete_abre_puerta_realizar_mejoras_plan_hidrologico_del_ebro_255758_300.html, Accessed 12th March 2014) (El Pais, "El Ebro lucha por su caudal", 4th August 2013, http://ccaa.elpais.com/ccaa/2013/08/04/catalunya/1375628130_520820.html, Accessed 13th March 2014).

[46] BOE (Boletin Oficial del Estado), 'Resolucion de 19 de Julio de 2013, de la secretaria de Estado de Medio Ambiente, por la que se publica el Convenio de colaboracion con la Junta de Comunidades de Castilla-La Mancha, para la disolucion y liquidacion del Consorcio para la gestion del Plan Especial del Alto Guadiana', http://www.boe.es/diario_boe/txt.php?id=BOE-A-2013-8530, (Accessed 3rd March 2014).

[47] In its Environmental proposal, the revised 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 continues" (MAGRAMA 2012b: 31).

[48] MAGRAMA 2013 'El gobierno aprueba el Real Decreto del Plan Hidrologico de la parte española de la demarcación hidrográfica del Guadiana', http://www.magrama.gob.es/es/prensa/noticias/el-gobierno-aprueba-el-real-decreto-del-plan-hidrol%C3%B3gico-de-la-parte-espa%C3%B1ola-de-la-demarcaci%C3%B3n-hidrogr%C3%A1fica-del-guadiana/tcm7-278666-16 (Accessed 19th October 2014).

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

Upper Guadiana, the sooner they are removed, the better."[50],[51] Some communities of irrigators also maintained that the Guadiana River Basin Authority was leaving them behind as they had asked for a modification of the regime of groundwater abstraction (an increase of 16 Mm3) due to the good status of the aquifer after a recent series of wet years and the existing conservation measures in place. They also demand more flexibility from the River Basin Authority as the allocation of groundwater abstraction rights under the PEAG for 2,000 'irregular' users without rights, but already consuming 26 Mm3, was paralyzed and had not been approved yet.[52]

4.6 Solar power and the groundwater/energy nexus in La Mancha

The prospect of companies investing in renewable solar energy in La Mancha and buying water rights transferred to them by the state also acted as an incentive for users to consider selling groundwater abstraction rights (Closas and Hope 2012; López-Gunn 2014, pers. com.). Castilla-La Mancha is at the forefront of solar energy production in Spain linked to high solar irradiation (5 kWh/m^2). This has led to solar energy contributing 50 percent of the region's total energy production in 2009 (Closas and Hope 2012).[53] The 2008 PEAG plan had acknowledged this scenario and stated that potential socio-economic gains could arise from the installation of renewable energies in the area (ibid.).

Within the Western Mancha aquifer, four 200-hectare solar-thermal power plants are being built. Two of them (Manchasol 1 and 2) in the municipality of Alcazar de San Juan, in the central part of the aquifer, are already operational. Despite the fact that photo-voltaic installations require essentially no water (apart from cleaning the panels), thermo-solar energy needs water for its cooling system. Based on data from the Environmental Impact Assessment for Manchasol 1 and 2, each of these plants will abstract between 0.9 and 1 Mm3/year of water for electricity production, which represents between 4,500 to 5,000 m3/ha per year (ibid.). The land surface where the plant has been built extends over 648 hectares, which, according to the abstraction regime set up by the River Basin Authority for the Western Aquifer, would be allocated a groundwater quota of 860,800 m3/year (below the estimated water demand for the solar plant of 0.9-1 Mm3 per year). The Environmental impact assessment published by the Regional Government demanded that, due to this deficit, the solar plant should obtain, either through concessions or direct purchase of additional land with attached water rights, the additional rights needed to satisfy its water needs.[54]

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[50] The farmers' union ASAJA was founded in 1989 by merging three conservative farming unions as a result of the re-arrangement of the traditional 'vertical agricultural syndicates' existing during Franco's regime. This was carried out after Spain joined the European Economic Community in 1985 (Moyano Estrada 1994).

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

[52] Lanza Digital "Araceli Olmedo: 'La Confederacion del Guadiana le da la espalda a los agricultores', 12th of December 2013, www.lanzadigital.com/actualidad/araceli_olmedo__la_confederacion_del_guadiana_le_da_la_espalda_a_los_agricultores_-57703.html (Accessed 4th March 2014).

[53] At the national level, solar energy production in Spain is planned to increase by up to six percent annually between 2010 and 2020 to contribute to a higher share of renewable energies in the production of electric energy. This was however a heavily subsidized sector receiving €2.8 billion in aid allocated by the government in 2009 (Closas and Hope 2012).

[54] Resolución de 03- 04- 2008, de la Dirección General de Evaluación Ambiental, sobre la declaración de impacto ambiental del proyecto: Planta Termosolar Manchasol I (Exp. CR5415/07), situado en el término municipal de Alcázar de San Juan, (Ciudad Real), cuyo promotor es Central Termosolar Uno, S. L, http://legislacion.derecho.com/resolucion-02-mayo-2008-consejeria-de-medio-ambiente-y-desarrollo-rural-999241 (Accessed 2nd June 2014).

With the 2008 global credit crunch squeezing Spain's national budget, subsidies to renewable energy production were reduced in 2010. In spite of that, the thermo-solar plant of La Mancha was spared from the cut in subsidies and fiscal exemptions for this type of projects, due to an alleged intervention from the embassy of the United States of America asking the Spanish government to consider two projects led by two American solar energy companies in Spain as 'very favourable' (one of them being the thermo-solar plant in La Mancha) (EL PAIS 2013).

4.7 User participation in groundwater management in La Mancha

In Spain, collective action for groundwater management has been developed through user initiatives along a spectrum of different available organizational and institutional formats both public and private, reflecting the diversity of types of groundwater rights (López-Gunn et al. 2013).[55] 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. The changes, brought by the new 1985 Water Law expanded this concept and allowed water users with permits (irrigators, hydroelectric users and domestic water supply) to have an active presence as voting members within the formal structure of River Basin Authority's decision-making councils and boards) (López-Gunn 2003; Varela 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. In addition, the influence of the agricultural sector on management decisions exceeds their role in the River Basin Authority's management boards. Beyond their statutory role as part of the Water Council in the Authority, they are also able to influence the development of 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 La Mancha, the 'General Community of Irrigators of Aquifer 23' ('*Communidad de Regantes del Aquifero 23'*)[56] was created in 1996 after the final declaration of over-exploitation of the Western Mancha Aquifer was issued in 1994. The creation of this General Community was a compulsory measure found in the 1985 Water Law which stated that, in case of a legal declaration of aquifer over-exploitation, users would have to organise themselves into a Community of Users. The main objective of this Community was to implement the new emergency regime of groundwater abstractions resulting from the declaration of over-exploitation.

The General Community operates as a federal organism, integrating 20 Irrigation Communities from 20 different municipalities and representing around 17,000 farmers using groundwater within the Western Mancha Aquifer (López-Gunn 2003).[57] During the creation of the community of users, rivalries between farmers' leaders for the presidency of this over-arching organisation led to the split of the farming community into two different groups, one in the Western part of the aquifer and another one for the Eastern part (López-Gunn 2012). This resulted in the

[55] 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 collective institutions were created with only 3 being created following the state's newly approved water law in 1985 (ibid.). The rest 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 overexploitation for an aquifer by the state (Rica et al. 2012).

[56] 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'.

[57] The origin of these 20 individual irrigation communities (also called Water User Associations by López-Gunn 2003) dates back to 1989 and their size varies according to the number of hectares for irrigation declared by its members. The community of irrigators of Alcázar de San Juan is the largest, with more than 35,000 hectares and 1,431 members, although the Community with the largest number of members is Daimiel with 2,288 members (López-Gunn and Hernández-Mora 2001).

spontaneous creation of a separate user association that encompassed seven municipal communities. However, they continued to be a (reluctant) part of the umbrella General Community.

Individual irrigation communities appeared as a self-driven movement 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 and a generalized feeling of mistrust towards the state (Cabezas Guijarro and Sanchez 2012; López-Gunn 2012). Users in these municipalities also created these local level associations 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 of General Community due to internal fights between farming elites for its control (López-Gunn 2012). In order to facilitate its creation these communities organised themselves according to municipalities, relying on existing agricultural organisations such as agricultural chambers and farmer unions to establish themselves (Cabezas Guijarro and Sanchez 2012).[58]

However, these local groundwater user associations in La Mancha were captured in the 1990s by already established and influential farming unions and effectively became lobbying organizations "seeking subsidies rather than the water management bodies that were foreseen by the Water Act as formally part of the river basin administration", and unable to develop themselves from the bottom-up, nor to gather internal legitimacy amongst its constituents (López-Gunn 2012: 1143). The co-opting of these associations by local elites and union representatives was reinforced by frequent meetings (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 village relationships can be based on historical animosities and rivalries leading to mistrust between users from different villages (López-Gunn 2012; López-Gunn and Martinez-Cortina 2006).

Rent-seeking behaviour and political clientelism from farmers in the Western Mancha Aquifer also appeared as an unintended result of the original 5-year European Agro-Environmental plan in 1993 that helped the consolidation of municipal-level groundwater user associations as they would operate as intermediaries managing the relationships between the regional government and the users (Rosell and Viladomiu 1997). For years the fees paid by farmers to the user associations for the management of the Agro-Environmental plan were their only source of income (Hernández-Mora 1998). The purpose for these associations became therefore to manage and allocate European funds, preventing further social learning amongst users "by buffering farmers from the consequences of their lack of collective action, when water levels continued to go down" (López-Gunn 2012: 1147). Regional governments were thus expected to support

[58] The existence of these local irrigation communities or 'Comunidades de Regantes' was already regulated in the original 1879 Water Law. The 1985 Water Law codified their existence once again, establishing 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 Association for its final approval (Del Campo Garcia 1996). These irrigation communities are considered 'public corporations' under Spanish Civil Law, and attached to the different River Basin Agencies. They are granted internal management autonomy, and have to regulate the representation and participation of water users in its governing bodies (ibid.). For the individual Irrigation communities in La Mancha, their role is to safeguard the interests of their members vis-à-vis the River Basin Agency, ensure the implementation and control of the groundwater abstraction regime under the declaration of over-exploitation of the aquifer (Diaz Mora 2014). The communities can also establish agreements and partnerships with the River Basin Agency in order to receive technical and financial support for the effective control of the groundwater abstraction regime and respect of groundwater rights (ibid.).

farmers via subsidies whilst establishing a reciprocal relationship of political support and votes from the farmer associations and unions (López-Gunn 2012).

The situation of these individual irrigation communities is at the moment precarious as they rely solely on their member fees in order to finance their operations. Additionally, following the latest River Basin Plan for the Guadiana approved in 2013, the Guadiana River Basin Authority has split the Western Mancha Aquifer into three new aquifer units. This jeopardises the existence of the General Community of Users of Aquifer 23 (according to the declaration of aquifer over-exploitation, there has to be one user community per designated aquifer unit) as well as the future of the individual irrigation communities, as some of them overlap two of the newly created aquifer sub-units (López-Gunn 2014, pers. com.).

4.8 Discussion and conclusions

Different types of sticks and carrots have been used by the state in Spain to attempt to regulate, control, and limit groundwater abstraction for irrigation (Table 2 and Figure 23). The example of La Mancha and the Western Aquifer is paradigmatic due to the variety of policy tools applied and implemented at various political and administrative levels coupled with the serious environmental degradation of the aquifer underlying the plains of La Mancha (Figure 24 and Figure 25). All these tools have been or are planned to be implemented in most countries in the MENA region, which makes the assessment of their effectiveness real event to the Mediterranean region.

Well registration is in most cases 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 logistic nightmare which exposes the substantial time needed and the high costs involved in such an undertaking (which in particular includes 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 is unlikely to be successful, as it generates free riding and deviant behaviours that are close to impossible to check; 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, constantly monitoring what is happening on the ground has proved to be beyond the capacity of the state.

The establishment of the first Agro-Environmental program from the EU clearly illustrates that earlier stick-only policies, whereby users were forced to reduce abstraction with a veiled threat on the future status of their historical rights, does not work. The European agro-environmental programs were elaborated at a moment when the stick policy of the imposed quotas translated into high political costs. Environmental objectives and policies – and EU financial support - were used to reduce these costs by granting financial compensations. Large farms, which had been struck by a bigger stick, were given bigger carrots.

The transfer of historical abstraction rights (private) to concessions can also open the door to future conflicts (Closas 2012). As this case study shows, the inherited fuzzy 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 finalise an inventory of wells and rights in Spain, results have been partial and inconsistent due to the impossibility to apply the rules on the ground, lack of funding, and difficulties in obtaining farmers' cooperation, as well as a lack of political will due to the high social and political sensitivity of increasing enforcement and control measure by the state (De Stefano and López-Gunn 2012). Additionally, as De Stefano and López-Gunn (2012) also wrote, net benefits from agriculture based on unauthorized use of groundwater outweigh its negative consequences to the user (e.g. water table drawdown, higher energy costs, potential sanctions).

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 and supported financially by government agencies. 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 Special Plan for the Upper Guadiana basin ended without any more carrots when the funds from the government dried out. Further political struggles and a change of government killed the plan altogether.

This case also highlights the potential perverse effects of technology improvements such as drip irrigation, promoted at great state expense as a water saving solution, which in some conditions lead to an increase in water consumption, through intensification or expansion. This example should serve as a lesson for all other countries of the MENA region that have embarked on similar massively subsidized projects to 'modernize' irrigation. Another commonplace conclusion is that demand side policies alone are seldom sufficient to reverse over-exploitation; supply augmentation measures via the use of water transfer technology are invariably extended in parallel. Simulations suggested that demand management tools such as pricing, which could help to achieve the required environmental objectives, may be impractical because of the reduction in farm income that they would incur, especially in more extensive farms. Such policies, based on volumetric management of water, are also very hard to implement because of the near impossibility to monitor volumetrically a large number of independently operated wells.

The present case also shows the policy contradictions between European and national programs incentivizing (irrigated) agriculture or solar energy on the one hand, and seeking to protect the environment on the other. It also shows how, in the name of higher productivity, 'modernization' policies result in the expansion of vine and higher evapotranspiration, reducing the return flow to the aquifer, and therefore compromising the very environmental objectives pursued; and how the environmental objectives were gradually forgotten during the program that transferred the water rights bought by the state, because of lobbying and a weak environmental constituency in the region. The contradictions between the WFD and the CAP continue to date, even if they have been attenuated, as their goals are not fully synchronized.

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 the water banking system as part of the PEAG, shouldering the full cost of buying back rights from some farmers to transfer them to others abstracting water illegally, but ended up paying for granting legal use to those who had breached the law. The program even included the possibility to buy and transfer partial rights, whereby the legal farmer would retain part of his abstraction rights. This flexibility resulted in high monitoring and enforcement costs, opening the door to opportunistic strategies. The program was bedevilled by several irregularities, such as farmer selling the rights of wells which were not used any longer, the state buying rights from farmers located 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 because of a lack of means or a combination of political power struggles between local communities, governments and corrupt practices.

Despite community organization for groundwater management in La Mancha (Rica et al. 2012), the lack of devolution of management powers to user communities, and their financial difficulties and small budgets, paralyses their activities. The fact that the River Basin Authority has neither facilitated the work of the water users associations nor devolved or decentralised any power, adds to this lack of common purpose between users (López-Gunn 2003). Additionally, while the 1985 Water Law has provisions for the establishment of a General Community of water users in aquifers declared overexploited, the expectation that such water user group would help enforce state regulation on the ground is naïve. As may have been expected, they are not prepared to inflict stick-like regulation onto themselves but they also morph into lobbying groups which try to influence policymaking in their favour. Some powerful members of local associations have also skilfully exploited windows of opportunity to co-opt 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, which are particularly relevant for all other Mediterranean countries. 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 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 by most other countries in the MENA region.

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 River Basin by the hijack of the PEAG's objectives by the Regional government of Castilla-La Mancha over the goals of the River Basin Agency. Additionally, the proximity 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 in terms of recovering water table levels since the declaration of over-exploitation of the Western Mancha Aquifer in 1994, hydrological data from 2012 and after seems to confirm that groundwater levels have been recovering in La Mancha. However, even though the Guadiana river started flowing again into the Las Tablas de Daimiel Wetland in November 2012 (EL PAIS 2012), some critical voices (e.g. WWF 2012; Martínez-Santos et al. 2008) have warned that such recovery might not be the result of state-sponsored recuperation plans but due to exceptionally good rainfall periods, masking yet once more the reality of groundwater over-abstraction in the area (Figure 24). It would seem therefore that, in the end, praying for the rain may be the most reliable management option in La Mancha.

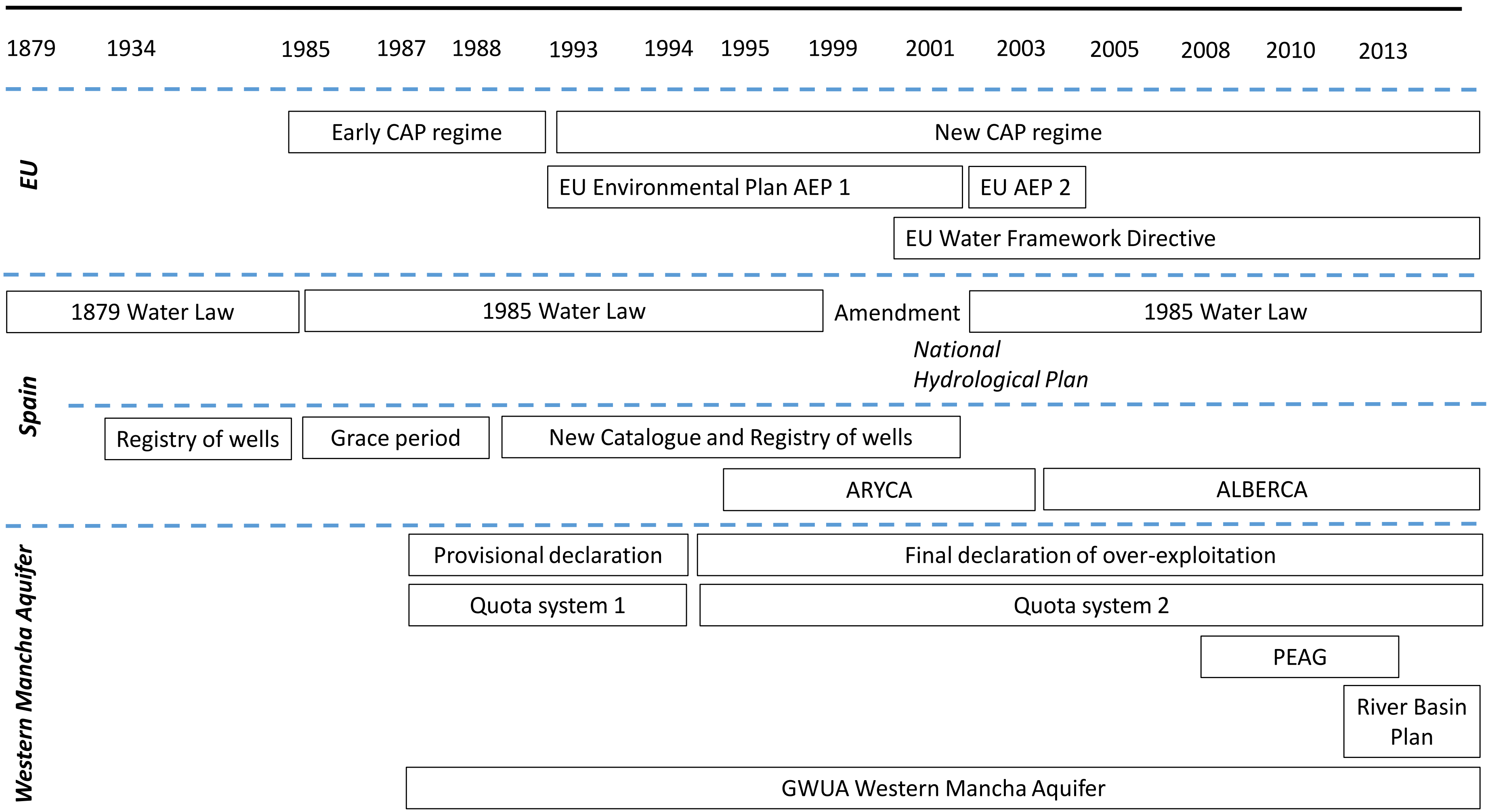
Table 7. Groundwater management policies adopted in the Western Mancha Aquifer

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 a recognition of private right (Catalogue of Private Waters)		*Veiled threat that nonregistered wells rights could be affected*	Almost 30 years have been necessary to complete the well registration process. Some illegal wells remain today
Declaration of overexploitation 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* *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 hectares of irrigated land and 310 Mm^3 of water saved in the first 5-year phase (1992-1997) with farmers adopting the scheme and 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 programme due to reductions based on already low water allocations. Compensation payments not sufficiently attractive for farmers

Policy implemented	*Carrots*	*Sticks*	*Outcomes*
PEAG (2007-2013) Purchase by the River Basin Authority of water rights and allocation of water rights to new users and the environment	***Public purchase of groundwater rights from users by the state*** ***Allocation by the state of purchased rights 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.)
	*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 of irrigated area due to substitution of dry 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.

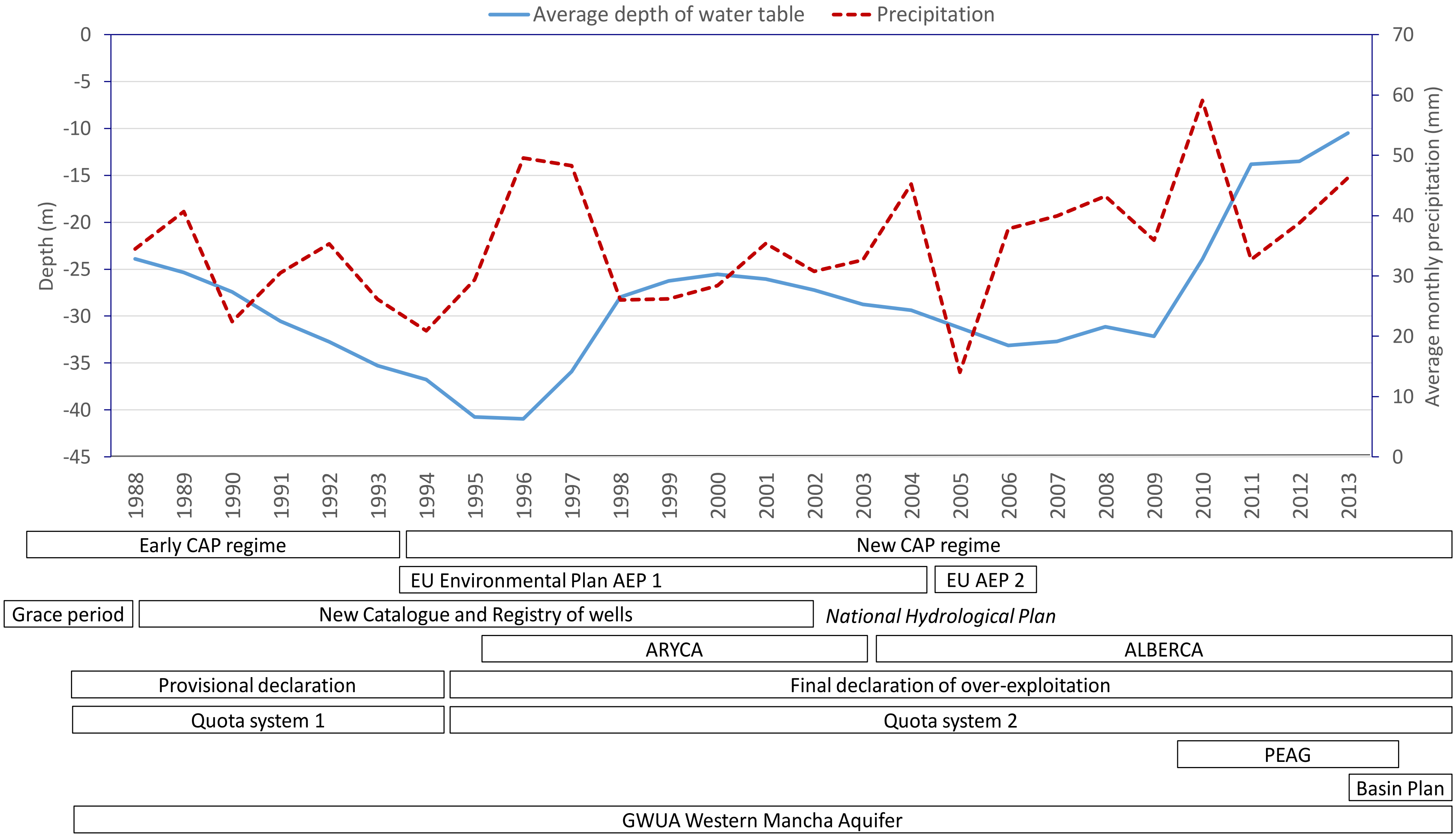
Note (*): Sermons are a type of policy tool defined as "attempts at influencing people through the transfer of knowledge, the communication of reasoned argument and persuasion" (Bemelmans-Videc 1998: 11).

Figure 23. Policy and regulation chronology – groundwater abstraction in Spain and La Mancha



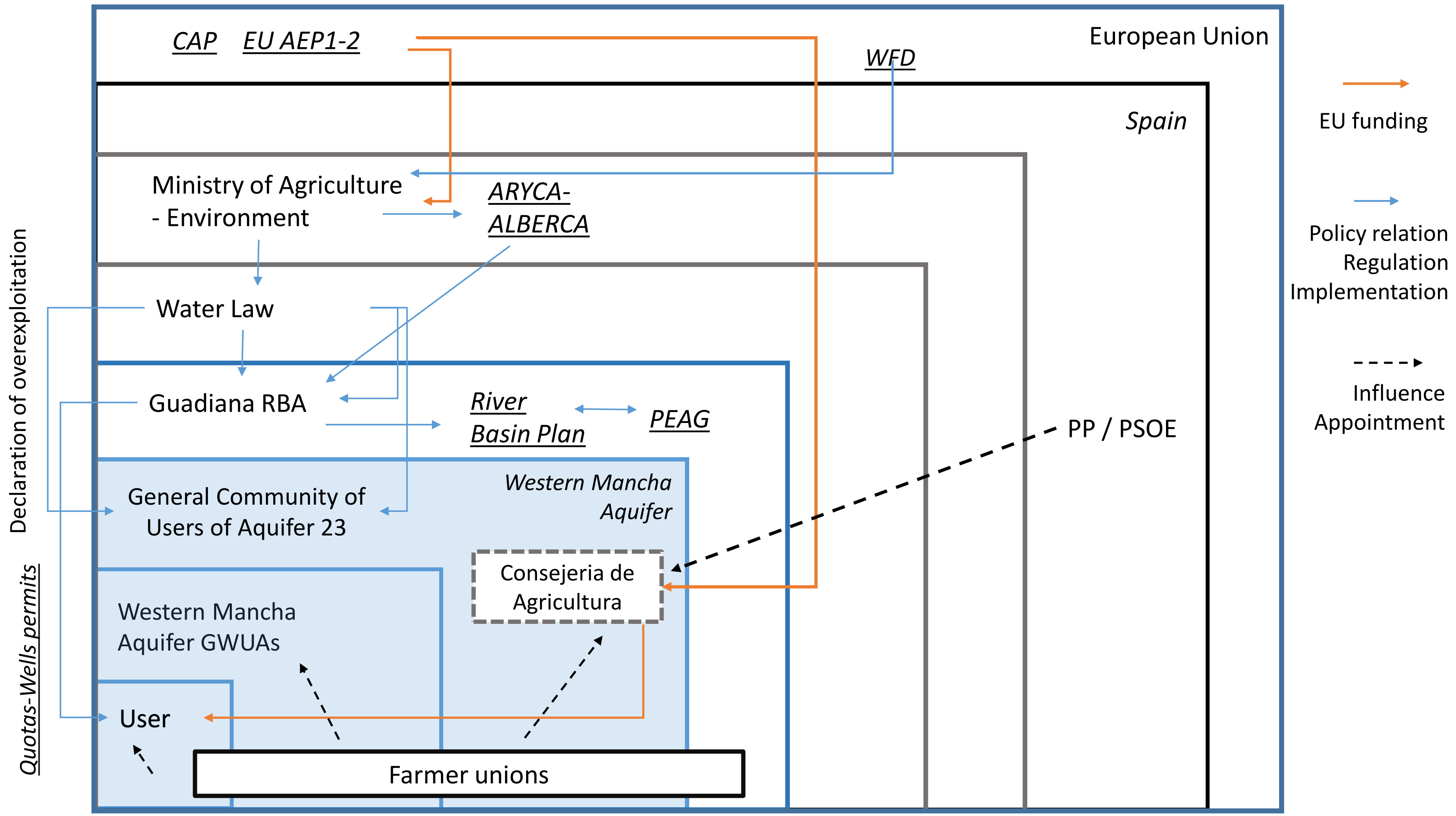
Source: Authors.

Figure 24. Depth of water table at the Ojos del Guadiana springs, Daimiel and average precipitation in Ciudad Real



Note: Average annual depth of water table measured at the groundwater abstraction well for Daimiel's public water supply, located near the 'Ojos del Guadiana'. Source: Authors with data from Centro de Interpretacion del Agua, Daimiel (groundwater levels) and for average monthly precipitation measured at the Ciudad Real weather station, source is AEMET for series 1988-2010 and 2013, and INE for 2011-2012.

Figure 25. Actor interactions and policy relations regarding agriculture, irrigation, and the implementation of groundwater regulation policy in La Mancha



Source: Authors.

5 Groundwater user communities in Spain

5.1 The tradition of groundwater user communities in Spain and their establishment under the law

Irrigation user communities with surface water have a long tradition in Spain with around 60 percent of all irrigated land with surface water being managed by some kind of user organization (López-Gunn 2003; López-Gunn et al. 2012). Groundwater user communities, on the contrary, are much more limited in space and time, despite the fact that there were already informal associations of users managing private wells in the 1940s in the areas of Castellon-Valencia or in the north-east of Spain.

Guillet (2000) found informal *noria* (Persian water wheel) partnerships in the north-east of Spain (Duero region) dating from the 1940s and earlier, formed through common property arrangements in order to acquire groundwater for irrigation. This author also found that farmers would enter into these partnerships to meet labor and investment start-up costs as well as to share operational costs. Groundwater could also be sold to neighboring users. According to Guillet (2000: 718), "[w]ater was allocated to shareholders in a variety of ways. In the case of an unusually well-endowed well and a few shareholders, one could obtain water on a first-come, first-served basis. Other partnerships occasionally calculated shares on the basis of the area irrigated. And partnerships with a poorly endowed well, incapable of supplying 24 hours of continuous water, allocated water by *pozao*, the nighttime accumulation of water." The existence of other social institutions used to share common property (graze lands and woods) provided enough social and cultural capital as well as structure to enable and maintain these *noria* societies (Guillet 2000). The concentration and consolidation of landholdings, population growth, increasing water needs, agricultural expansion and the introduction of powerful electric and diesel pumps after 1950s disrupted these societies.

However, the general lack of groundwater user associations throughout most of Spain is due to the fact that until 1985 only surface waters were declared public domain (López-Gunn and Martinez Cortina 2006). Until 1985, groundwater remained a private resource belonging to the user who would pump it. With the new Water Law in 1985, user communities were formalized within the law and were given a role in water management. These user communities can be of three different types of orders: first order, formed exclusively of private users; second order, with a federated structure, composed of different individual irrigation communities under a General Community; third order, including both user communities and individual users abstraction groundwater from the same aquifer (López-Gunn and Martinez Cortina 2006; Rica et al. 2012).

In terms of legal establishment there are two main types of groundwater user communities in Spain co-existing together, those established under public law and those established as private associations of individual users with private rights (these can include Agrarian Societies of Transformation, well societies, or irrigation cooperatives) (Rica et al. 2012). Reasons for choosing to create an association following either of these two forms (public or private) often refer to cultural, social and historical backgrounds, with a predominance of private associations in the Levant of Spain (Valencia) (López-Gunn and Martinez Cortina 2006). Additionally, there is a certain degree of path-dependency regarding the type of rights owned by users and the choice of user community. In areas with a majority of private groundwater rights (established as historical rights before the 1985 Water Law), users would tend to establish associations under private law. For those areas with a higher number of users abstracting water with a public concession (with permits issued after the 1985 Water Law), the communities would tend to be established under public law (Rica et al. 2012). Communities under public law are entitled by the Water Law to be involved in water regulation and to access state subsidies, whereas communities under private law are regulated by the law of civil partnerships (ibid.). Both types are however allowed to carry out aquifer monitoring and control of abstractions, fully or partially, together with the River Basin Authority (ibid.).

However, since the new Water Law was passed in 1985, the state has preferred public law institutions, and in cases refused to acknowledge the legitimacy of private user associations, resulting in long delays in the authorization process (López-Gunn and Martinez Cortina 2006). Such resistance originates from the fact that these private associations are usually created to defend the rights of private users against the control and regulation of groundwater by the state. Communities under public law are preferred by the water authorities as they can act as 'proxy agents' of the water administration and issue public acts such as sanctions (even though they actually have a dual nature, respecting both the vested interests of users and abiding by public mandate to enforce the Water Law) (Moreu-Ballonga 2003 in López-Gunn and Martinez Cortina 2006).

5.2 The creation of groundwater user communities

Given the historical nature of groundwater abstraction in Spain, it would seem that there are not too many incentives for users to be organized as communities. The majority of groundwater user communities in Spain have no shared infrastructure that requires joint management decisions or financial obligations from all users (Huertas Gonzalez 2010). Moreover, all users retain their private abstraction right or individual concession. However, incentives to associate change, if there is a risk of over-exploitation (declared by the state according to the Water Law), or if users fear a change in the status-quo. Following the declaration of over-abstraction of the aquifers in La Mancha (Western Mancha and Campo de Montiel) in 1989 and 1994 respectively, the state imposed a strict regime of abstraction volumes to the users in the Western Mancha Aquifer (also known as Aquifer 23). This, according to López-Gunn (2003), represented a main incentive for the users in the Campo de Montiel to regulate themselves and create a user community.

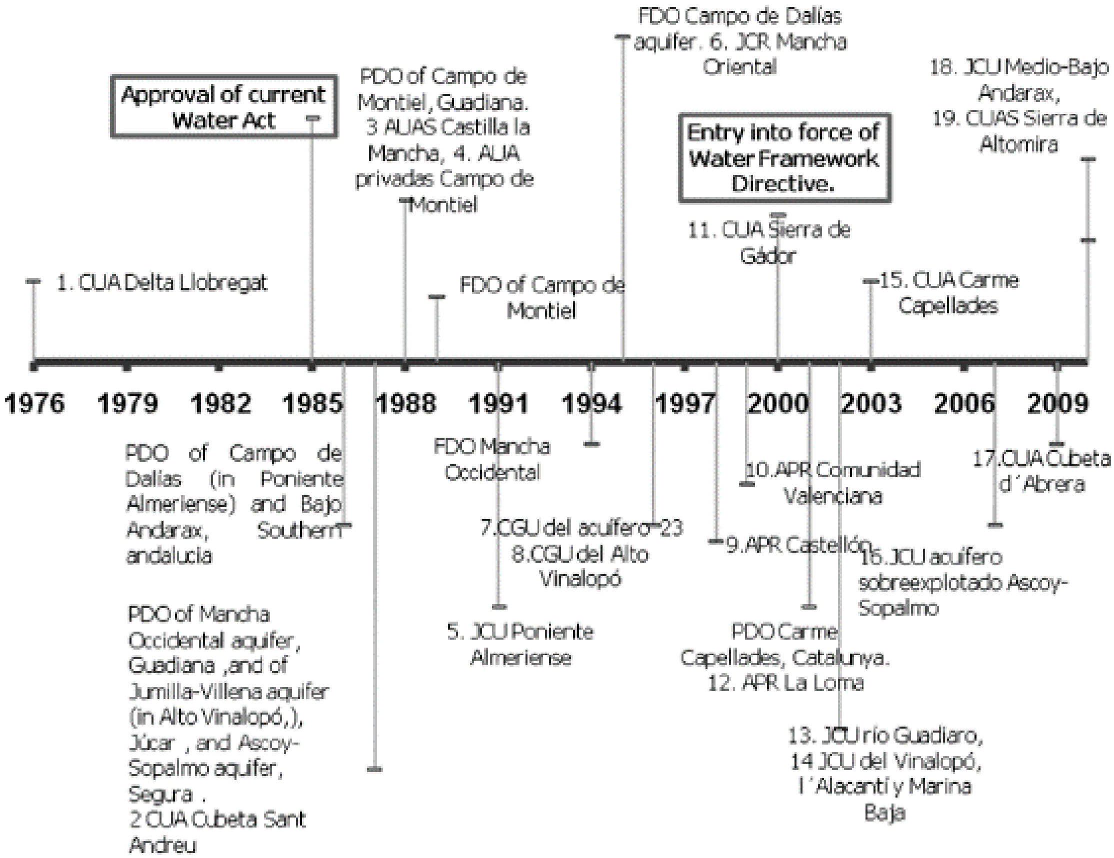
In Spain there are 20 communities of groundwater users organized to manage groundwater (López-Gunn et al. 2012) (Figure 26). Only 3 user communities have been created by the state in accordance with the 1985 Water Law,[59] the rest emerging out of self-interest, following drought periods, or in order to defend the private interests of users and farmers and secure resource entitlements in front of the state (López-Gunn et al. 2012; Rica et al. 2012). The use and joint ownership of infrastructure or the collaborative development of joint plans are also reasons reviewed by López-Gunn et al. (2012) as reasons for users to form a community. These are however a more recent wave of user communities, that has been emerging in Spain, with the aim of reducing risk through the development of a portfolio of water supply options enlarging water availability (e.g. conjunctive use surface/groundwater, desalination, aquifer recharge) (López-Gunn et al. 2012).

The main reason for the creation of these communities is however not the joint and efficient management of the resource but, as mentioned before, as a joint initiative pre-empting a potential intrusion of the state in the affairs of groundwater users (López-Gunn and Rica 2010).

[59] According to Spain's Water Law from 1985, the state can force a community of users to be organised if the aquifer is officially declared overexploited.

There is though, according to these authors, no single template or blueprint followed by these user communities. They are varied in scope, powers, organization and structure. This is due to the fact that private user initiative is heterogeneous in nature and responds to local contexts and needs. However, even though private users have the advantage to be the owners of the infrastructure, the majority of user communities formed has not enough operational capacity, powers, or legitimacy to make decisions about the resource itself.

Figure 26. Chronology of creation of groundwater user organizations in Spain

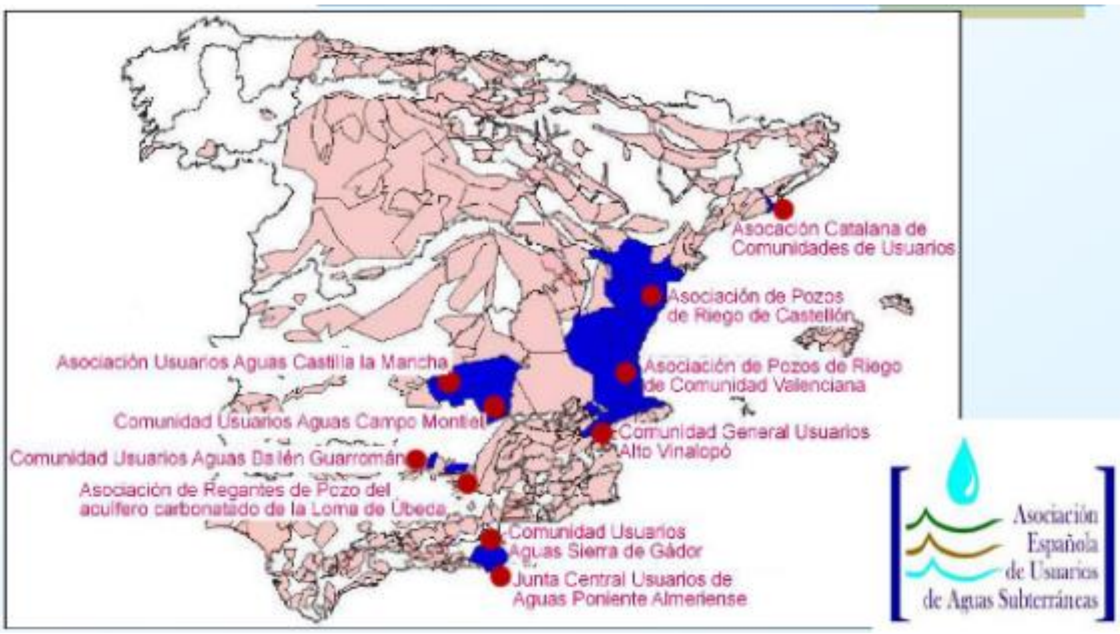


Source: Rica et al. 2012.

The Eastern Mancha User Community was created bottom-up and with the support from different social groups (NGOs, banks, citizen groups) (López-Gunn 2003). It also emerged as a spontaneous initiative from farmers following a severe drought episode in the early 1990s and three years after the community had been established, 85 percent of farmers in the Eastern Mancha Aquifer had joined (Figure 28) (López-Gunn 2012). Initially users could associate themselves voluntarily but in 1998 the River Basin Management Plan established that all water users (surface and groundwater) had to be organized under one single community of users in order to better manage water resources (JCRMO 2014). A further endorsement from the Jucar River Basin Authority[60] in 2002 declaring the community as the only officially recognized user association saw the number of members rise to 95 percent (López-Gunn 2012).

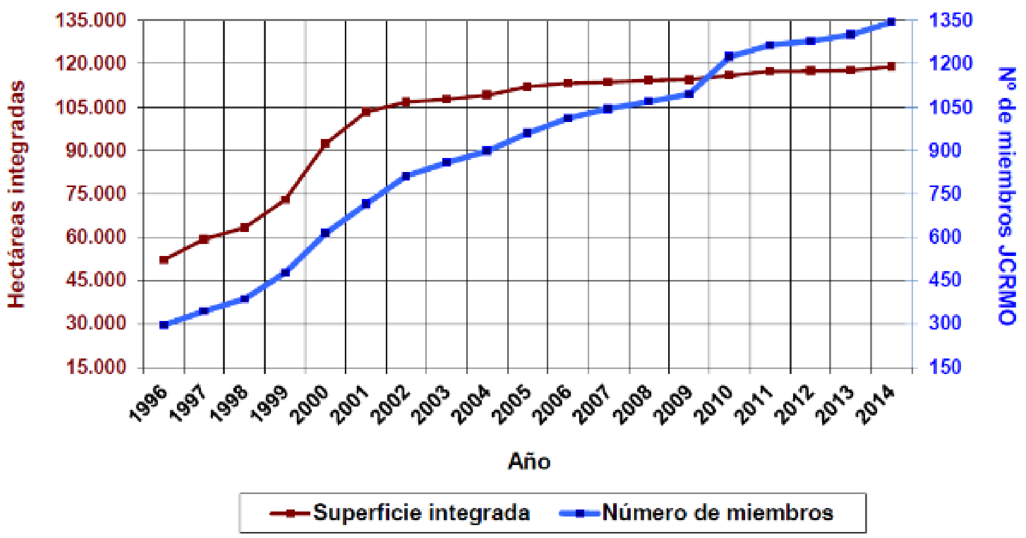
[60] The Eastern Mancha User Community is located within the Jucar River Basin, not the Guadiana River Basin like the user communities found in Western La Mancha.

Figure 27. Geographical location of some of the groundwater user organizations in Spain



Source: Planas Olivella 2010.

Figure 28. Evolution of the number of members and hectares under the Eastern Mancha Groundwater User Community



Source: JCRMO 2014.

In La Loma in Jaen, Andalucía, farmers started pumping groundwater from the aquifer in the 1990s following a decade-long drought which threatened the survival of olive trees and agriculture in the area (Garcia del Valle 2010). Small and informal user groups were established in the area amongst farmers needing to pump groundwater and facilitated by the fact that private companies would offer a bulk price for drilling a shared well, building the infrastructure, irrigation pipes, and storage reservoir (ibid.). The Association of Groundwater Users of La Loma (a private association) was finally established in 2001 when farmers became worried about the expansion of irrigation in the area, the lowering levels of the aquifer, and the delays and hurdles users were experiencing from the administration in the application of groundwater abstraction permits (90 percent of wells had no administrative concession and most requests to regularize groundwater abstraction rights were pending since 1988).

In La Loma, the Association of Users started in order to represent and defend users' interests and to legalize and regulate groundwater use. The association therefore consists of 426 members, of which 247 are private users (with 6,829 hectares) and 179 are user communities (with 16,930 hectares). However, the delay in the approval of the statutes and official recognition of the Association of Users (in 2010) meant that groundwater resources continued to be un-regulated, with a failure to use of the regulatory mechanisms at hand to control abstraction (sealing of wells without permits, etc.). The users associated themselves in order to guarantee access to groundwater and regularize their situation vis-à-vis the state, "seeking legitimacy to become a valid stakeholder as a public corporation (and therefore be able to access public funding)" (Rica et al. 2012: 121). The Eastern Mancha Groundwater User Community, despite its good relations with the River Basin Authority, has 750 requests to regulate wells pending at the River Basin Authority, representing 72,214 hectares and 87 Mm3 of groundwater volume to be registered (JCRMO 2014).

5.3 Providing services and representing user interests

Successful groundwater user communities in Spain have three common characteristics (López-Gunn et al. 2013): 1) they managed to secure access to groundwater through a stable agreement with the regulator, formalized in an agreement subject to constant renegotiation or through water rights; 2) they have mutually accepted rules on resource access backed by a strong sanctioning regime, and users are actively involved through the establishment of social norms and penalties; 3) these organizations have received support from the state through the regulator (i.e. River Basin Authority), providing legitimacy and endorsement of their actions. The establishment of User communities in Spain also arose from the possibility to access European funds and subsidies provided by the state. As will be developed in the next section, these communities therefore developed a rent-seeking behavior when, in the mid-1990s the European Community channeled funds to compensate for a decrease in irrigation and groundwater abstraction in La Mancha (López-Gunn 2003).

Responding to user needs and a changing environment, groundwater user communities in Spain have shown imagination and creativity when it comes to providing services and solutions for their members. Following a rise in energy prices after the liberalization of the energy market in Spain in 2008, which eliminated regulated energy prices, groundwater users faced increasing production costs (Poveda Valiente 2010). Facing this scenario, and with the potential risk of collapse due to financial difficulties, the Community of Users of the Aquifer of Western Almeria realized the potential clout that these communities have as large consumers of electricity (ibid.). To this effect, they developed a scheme by which they aggregated all the energy uses of its members and purchased electricity in the market with more leverage when signing the contract (ibid.). They were also able to negotiate better fees by choosing amongst more than 60 electricity suppliers (Poveda Valiente 2010).

The Community of Users of the Alto Vinalopo created in 1988 also established some rules regarding the management and use of energy in its wells due to the dramatic increase in fees (an increase of around 600 percent between 2008 and 2010 for the flat rate fee all users pay, and additional increases in the different blocks of the tariff) (Menor Hernandez 2010). This community decided to pay only peak-consumption tariffs for wells supplying drinking water. Wells with contracts for off-peak consumption are penalized when they pump groundwater during peak hours. The Community also purchases electricity directly to the bulk supplier via the market. This required an investment in order to control all uses and electricity consumption of the users (with a system of remotely monitored electricity meters measuring consumption).

The Eastern Mancha Groundwater User Community carried out a survey in 1994, of irrigated lands, checking all land plots following the census and including information on wells, crops, etc. This was then used in 1998 by the River Basin Authority to establish the different units of water management and fed into a new information-based management tool shared between the Community and the River Basin Authority (JCRMO 2014). Moreover, the River Basin Management Plan allocated a maximum of 80 Mm3 per year to the User Community in order to substitute groundwater by surface water for irrigation, maintain agricultural activities in the area and achieve a sustainable management of the aquifer (JCRMO 2014). So far, between 2001 and 2014 the River Basin Authority has transferred 258 Mm3 to irrigation from surface water resources.

Other user communities have been more active in ensuring that the rights of their members are upheld. In the Campo de Montiel (in La Mancha), the Groundwater User Community established there in 1988 by the state further to the declaration of over-exploitation, has been claiming that state-led studies demonstrating the existing groundwater deficit are inconclusive and that the declaration of over-exploitation should be lifted (Garcia Vizcaino 2010). This is also found in the Western Mancha Aquifer User Community where users do not trust data and reports published by the state. Equally, the Water Authority does not trust the data provided by the users (López-Gunn 2012). In the Campo de Montiel, users also claim that they were not asked when the state decided to establish the community and that the allocations granted by the state are unfair compared to the allowed abstraction volumes of other users further downstream, in the neighboring aquifer (to which most of the groundwater saved in the Campo de Montiel contributes) (Garcia Vizcaino 2010; López-Gunn 2003). This is the opposite of what happened in the Eastern Mancha User Community, where technical studies were jointly conducted by farmers and the water authority through formal agreements (López-Gunn 2012).

5.4 The regulation of groundwater abstraction by user communities, social capital, and vested interests

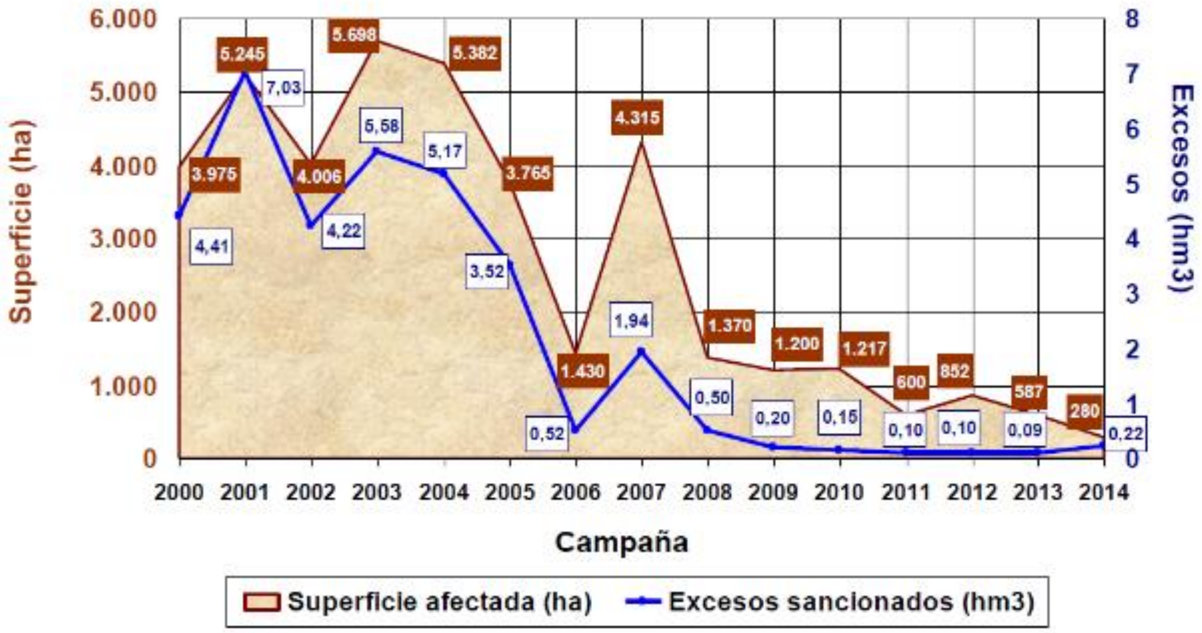
López-Gunn and Martinez Cortina (2006) found that there is a high level of trust and reciprocity amongst users and members of groundwater user communities in Spain. Bonding social capital is strong in the Eastern Mancha Groundwater User Community (López-Gunn 2012), with a structure that facilitates diversity but also centrality through a federal structure with all uses represented. This leads for instance to a progressively low degree of sanctions and an increasingly higher level of respect for the rules (Figure 29). During the 2013 irrigation campaign, the Irrigation Court of the Eastern Mancha Groundwater User Community opened 5 disciplinary proceedings against its members, with 4 ruling against the users ending up in the restitution of 90 m3 of groundwater pumped in excess (a small amount taking into consideration that the total volume reclaimed by the user community from users between 2006 and 2014 was 6.83 Mm3) (JCRMO 2014). The situation has improved since the early 2000s, when the Irrigation Court of the User Community had to issue sanctions to non-associated members (12 in 2000 and 2001, with a total of 50 sanctions in those two years) (JCRMO 2002).

The Eastern Mancha Groundwater User Community will charge between 100 and 600 Euros for groundwater volumes abstracted over the authorized cap (between 0 and 30,000 m3 per year), requesting the return of those volumes in the following irrigation campaign plus an additional 10 percent (JCRMO 2014). The amount paid will be added to a sanction by the River Basin Authority (of up to 10,000 Euros). If the amount abstracted in excess is over 30,000 m3 per year, then the River Basin Authority intervenes and will enforce more drastic sanctions (Table 8).

Some regulatory measures developed by user communities are however agreed with the state. In the case of the Eastern Mancha User Community, a joint decision between the River Basin Authority and the Community established that no water meters would be installed and that groundwater monitoring would be carried out via satellite imagery and remote sensing together (JCRMO 2014; López-Gunn 2003). Water management units were defined in the area (around 1,400), defined as a set of plots using water in common from one or more wells (Sanz et al. 2016). Crop classifications are also established for these water management units. The Annual Operating Plan for groundwater abstractions sets the volume authorized per hectare and each user will plan its own crop pattern according to the volume allocated to each water management unit in order not to exceed the total allocated volume (ibid.). Monitoring and system operation is carried out in real time and done with a GIS spatial analysis tool used to estimate the average volume consumed in each water management unit (ibid.).

The respect for these measures has meant that the annual operating plan for groundwater abstraction defined by the User Community is followed and respected at 98 percent and the requested volumes over-abstracted by users are 100 percent returned (JCRMO 2014). Water use verifications are carried out jointly between the User Community and the River Basin Authority and sanctions are imposed by both organizations (Sanz et al. 2016). The User Community also promotes collaboration agreements with water authorities and research groups in universities to improve management and information access and technical meetings are held throughout the year by the User Community and farmers are informed about the progress of studies (ibid.). Also, The User Community carried out 158 visits to the field to monitor and complement the satellite observations. On the contrary, the lack of agreement on control measures in the Western Mancha Aquifer between the state and users means that official estimates of irrigated areas and groundwater use are not recognized as legitimate by the users (López-Gunn 2003). Additionally, the enforcement capacity of measures such as remote sensing was improved as the Spanish Supreme Court ruled in 2012 that remote sensing cropland maps are admissible in court proceedings as proof (Sanz et al. 2016).

Figure 29. Land surface and groundwater overdraft sanctioned by the Irrigation Court of the Eastern Mancha Groundwater User Community



Note: in brown, area (in hectares) in the user community where groundwater over-abstraction has been found and sanctions have been enforced; in blue, groundwater abstraction volumes sanctioned.
Source: JCRMO 2014.

Table 8. Sanctions enforced by the Jucar River Basin Authority to users in the Eastern Mancha

Volume abstracted over the authorized amount	*Sanctions*
Between 0 and 30,000 m3/year	Up to 10,000 Euros
Between 30,000 and 150,000 m3/year	Between 10,001 and 50,000 Euros
Between 150,000 and 1.5 Mm3/year	Between 50,001 and 500,000 Euros
Over 1.5 Mm3	Between 500,001 and 1 million Euros
All sanctions will include damages to the Public Water Domain, valued at 0,12 Euros per m3 pumped in excess	

Source: JCRMO 2014.

The comparison of 8 groundwater user associations in Spain by López-Gunn and Martinez Cortina (2006) showed that one of the main reasons for the success of self-regulation of uses and users in Spain is leadership. Even though it is not a homogenous phenomenon across the different user organizations, leadership ensures internal legitimacy and also competence. Leadership can also be based on charisma, encompassing intangible attributes binding the community of users together (López-Gunn 2012; López-Gunn and Martinez Cortina 2006).

Despite the positive effects of leadership and social capital, the dependence on local leaders also makes these organizations subject to local politics. Social bonds and intra-community associations have reinforced local village-level user communities but have also created and sometimes cemented rivalries and conflicts between neighboring villages (López-Gunn 2012). This created mistrust between communities of users and skepticism as to which villages would adhere and follow the rules designed to restrict abstraction (ibid.).

The General Community of Users of the Western Mancha Aquifer, which was set up as a federal structure and coordinating all the village-level communities in the Western Mancha Aquifer arose from a state mandate after the declaration of over-exploitation in 1994. It was also mired with rivalries as to who would become president (López-Gunn 2012). This eventually led to a split into two separate communities, the Western Mancha Aquifer Community and the Groundwater User Community of Castilla La Mancha (in the eastern part of the La Mancha aquifer) (ibid.).

Large landowners and the concentration of power in farming elites and farming union representatives helped maintain the existing groundwater abstraction status quo within the community. The village-based user communities amalgamated under the General User Community of the Western Mancha Aquifer (created in 1994) were therefore subject to political capture by these elites or farming unions, becoming lobbying organizations seeking additional agriculture subsidies. These same subsidies and compensations put in place by the state with European funds in the mid-1990s were also one of the main arguments that compelled many farmers to join their village-level user community in the Western Mancha Aquifer (López-Gunn 2012). An unintentional result of these European funds was therefore to forestall farmers' capacity to self-regulate and turned user associations in the Western Mancha Aquifer into rent-seeking bodies, developing a culture of subsidy dependence (ibid.). Given their role and political power, the regional government's policy initiatives continued this trend, aiming to secure further subsidies for a non-negligible voting base of farmers (ibid.).

5.5 Conjunctive use and groundwater user associations in Valencia

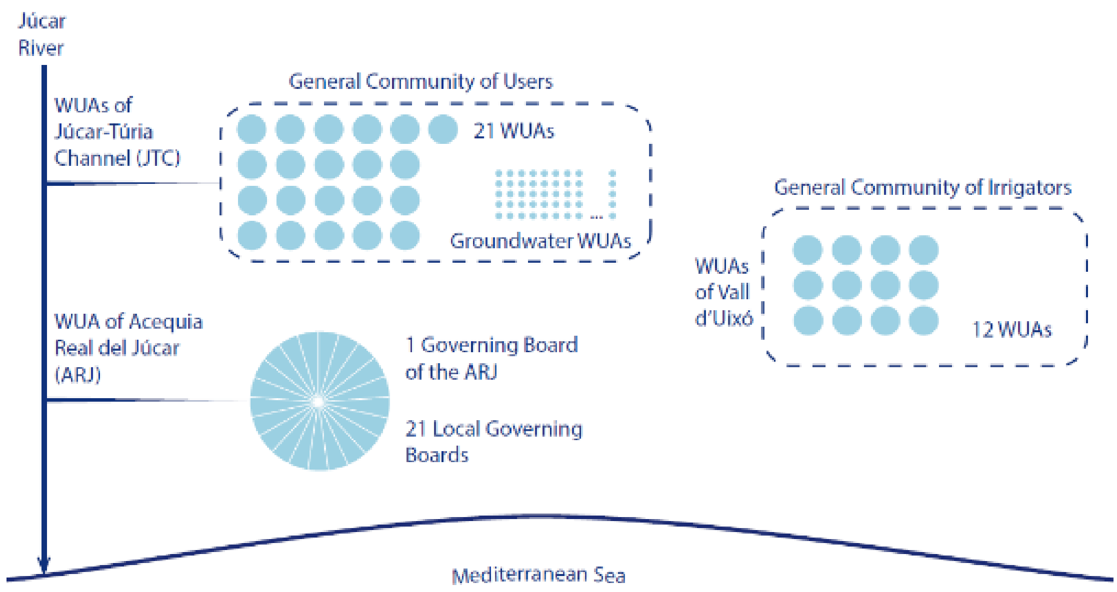
The long-lasting and extensively studied traditional irrigation system of Valencia (e.g. Glick 1970; Maass and Anderson 1978; Ostrom 1990; Trawick et al. 2014) has been adapting its rules to decreasing surface water and incorporating more and more conjunctive use of surface and groundwater (Ortega-Reig et al. 2014). Following the drilling in 2006 of a large emergency well for communal use in each of the canal communities in Valencia's huerta by the River Basin Authority (Trawick et al. 2014), users have drilled additional emergency drought wells located upstream of the distribution channels and serving nearly the entire irrigated surface studied by Ortega-Reig et al. (2014) (41,000 hectares) to be used as supplement to surface water. Groundwater has been used to compensate for loss of surface water due to drought episodes (most wells were drilled during droughts) but also to meet new water requirements for crops (with expanding horticultural areas), and also spread in specific areas of the irrigation system with shallow water tables allowing for a less costly groundwater abstraction (ibid.). For those surface water irrigation communities near wastewater treatment plants, wastewater has also been used for irrigation during drought episodes.

In these systems, farmers have formed societies in order to drill the collective wells, selling water to other users by the hour. The overall monitoring is done by the River Basin Authority and each Groundwater User Association has an allocated volume to be abstracted per year. In most cases however, no reliable control mechanisms are enforced (Ortega-Reig et al. 2014). These groups according to these authors are from the same huerta in Valencia and are "mostly comprised of the same users as the ICs [irrigation communities]" using the same distribution canals and interact with the irrigation communities managing surface water (Ortega-Reig et al. 2014: 60). The authors found 75 groundwater user associations, irrigating a smaller area than the surface water irrigation communities (ranging between 15 and 100 hectares each and with 30 to 150 users). Users pay their respective association for the use of groundwater by the hour.

The groundwater user associations "are not part of the huerta's long tradition of communal water management, but they have been strongly shaped by its institutions" (Trawick et al. 2014: 89). These new groundwater user associations have their own governing body with a president, a secretary, a treasurer, and elected members. Users follow written rules or statutes and are part of a general assembly (as the supreme authority which decides if a new investment is made, or if irrigation can be expanded in a new area). The associations can also establish sanctions and according to fieldwork by Ortega-Reig et al. (2014), 83 percent of interviewed users mentioned that sanctions are enough to deter users from violating the rules. These groundwater user associations do not own any distribution network as groundwater is conveyed through the surface water irrigation canals. Following Ortega-Reig et al. (2014: 61), "[g]roundwater from GUAs can only be used to irrigate when river water is not flowing in the canal because, as ensured by the rules of ICs, if groundwater from GUAs gets mixed with river water, the right to irrigate will always remain with the one irrigating with river water." So, despite the overlap of associations, there is nevertheless a hierarchy of uses traditionally established.

Groundwater allocation in these communities can be done through land ownership (shares of water will be proportional to land owned) or to time (users will own a certain amount of time shares independently of the land they own). The small amount of land irrigated with groundwater (only when surface water is lacking) is circumscribed and allows neighboring farmers and association members to identify free-riders using the well when it is not their turn. A system of tokens specially marked by characteristic grooves (each user has its own special mark for each token used) is used to activate the pump by each one of the users. These are bought from the well-society officers. The use of fake tokens is extremely rare and in such case, other farmers can trace back the use of water by simply following the water flow and identifying the field and the user.

Figure 30. Surface water user communities and groundwater user communities in Valencia's *huerta*



Source: Ortega-Reig 2015.

5.6 An example of associative groundwater management: the Community of Users of the Low Llobregat Valley and Delta, Barcelona, Spain

The Community of Users of the Low Llobregat Valley and Delta (CUADLL) was created in 1975 in order to manage groundwater abstraction in the Low Llobregat aquifers (south of Barcelona) (Figure 31). At the time of its creation in 1975, the community of groundwater users in the Low Llobregat Valley and Delta requested a 'Special Legal Regime' (‘*Regimen Juridico Especial*’) in order to protect the groundwater resources of the area, stop groundwater quality degradation due to significant sea water intrusion, and represent the users vis-a-vis the Authorities. The CUADLL was created as an association of individual users (independent of the use) aiming at implementing a sustainable regime of abstraction for the Llobregat Aquifer, solve allocation conflicts, and manage common interests as well as functions delegated by the Administration (such as enforcement, monitoring and control). After a long legal procedure,[61] the final statutes of the CUADLL were approved in 1981, the first Community of Groundwater Users created in Spain.

At the time of its creation in 1975, groundwater levels were already decreasing rapidly (reaching a historical minimum level of 22 metres below the sea level in 1975) (Figure 32). In conjunction with a severe drought at the same time, the users of the Llobregat Aquifer decided to organise themselves as a Community of Users (Queralt 2015, pers. com.). Thus, the community was organized by the users with the main objective to jointly protect the interests related to the abstraction rights granted by state water concessions. The Community of Users is organised around: a General Assembly of users (each one paying a fee based on the volume abstracted); a Governing Board (8 members); a Court (to resolve any conflicts);[62] a technical Commission (an advisory body in charge of technical follow up, and formulation of technical projects); a consultative council; and a technical department (carrying out and implementing the technical projects and management of the aquifer). Voting rights in the community of users are allocated depending on groundwater volumes abstracted.

The creation of the CUADLL was requested in 1975 under the auspices of a ‘special legal status’ put forward by the users in order to protect the Llobregat water resources and its Delta, which in turn sustained several important economic activities part of Barcelona’s industrial belt. With the new Spanish Water Law of 1985, this type of associations were considered as 'private corporations'[63] ascribed to the River Basin Authority and since then relationships with the Catalan regional water management authorities have evolved.[64] In 2001, the CUADLL signed an agreement with the Catalan Water Management Agency (*Agencia Catalana de l’Aigua*) that allowed the collaboration between the two entities in matters regarding aquifer recharge, well inventory, backfilling of wells, and the creation of a follow-up commission. The agreement also allowed for technical cooperation and sharing of data between the two. Even though the CUADLL

[61] This is possibly due to the fact that the CUADLL was the first ever community of groundwater users to be created in Spain (Queralt 2015, pers. com.). As such, the Ministry did not know how to deal with it which could have potentially lengthened the process of approval. Additionally, the timing of its creation (the end of the Dictatorship and transition to Democracy) possibly played its role in delaying the process.

[62] The Court has never been convened, all conflicts have been solved through negotiation within the Community of Users and without necessity to initiate a formal procedure (Queralt 2015, pers. com.).

[63] These are called in Spanish ‘*corporaciones de derecho publico*’ (corporations of public law). They are legal entities adopting an associative form and created by a law that determines their objectives, structure and functioning. They are subject however to private law, and the membership to these corporations is compulsory for those members who want to exercise the rights enabled by the corporation.

[64] The Llobregat River Basin is managed at the regional level by the government of Catalonia. The 1985 Water Law of Spain legislates that river basins contained within the administrative boundaries of regions will be managed internally by the regional government.

is able to control newcomers and issue permits (usually only for small farms in the Delta abstracting less than 7,000 m3 per year), in 2002, the Catalan Water Agency established a ban on well registrations in the Low Llobregat Basin (lifted two years later). In this context, the community had stressed "that even if many powers were devolved, final responsibility should lie with the authorities and that groundwater users should always, as a last resort be accountable to the authorities" (López-Gunn and Martinez Cortina 2006: 376).

During that period it also developed recharge ponds for the aquifer, a control and stricter monitoring of wells, development of hydraulic barriers against saline intrusion and re-channelling of the Low Llobregat River. The Catalan Water Agency had also been subcontracting different technical services to the CUADLL (especially due to new infrastructures being built in the Llobregat area – e.g. a new railway and metro line) until the financial crisis in 2008, when most projects stopped due to budget cuts and a heavy debt of the Catalan Water Agency. Since then the CUADLL has continued to perform its duties singlehandedly. The CUADLL continues to collect information on abstraction and recharge, for instance and reports it to the Regulator, it performs control and 'police' duties on abstraction of its members, and charges fees to its users for management costs according to groundwater use.

The community of users covers an area of 120 km2 where groundwater abstraction represents around 60 Mm3 per year (in 1990 the surface area of the CUADLL was extended by the Catalan Regional Government in response to a change in environmental law and demarcation of aquifer and water bodies). There are 150 users registered with 800 wells. The Delta and Llobregat River Aquifer groundwater is used for drinking water supply for Barcelona (70 percent), industry (24 percent), and agriculture (6 percent). Agriculture with surface water irrigation mainly covers an area of 1,755 hectares in the lowlands near the coast.

Industrial groundwater abstraction was driving the depletion of groundwater levels up to the 1970s (Figure 33) (due to the large demand of water from some of the users in the Llobregat area, mainly factories and industrial activities in the industrial belt surrounding Barcelona – e.g. two paper mills, and some textile factories). Industrial use began to decrease however in the late 1970s due to water efficiency improvements facilitated by the Community of Users. Later on in the early 2000s groundwater abstraction levels continued to decrease due to the delocalization of several industrial activities (Queralt 2015, pers. com.). This delocalization of industries did not represent a major transfer of groundwater rights (as most of them elapsed after 3 years not being in use – as per Spain's Water Law).[65] The decrease of groundwater volumes for industrial use during this time was reallocated in order to improve the water balance of the aquifer and decrease seawater intrusion (Queralt 2015, pers. com.).

The main problem facing the CUADLL is seawater intrusion affecting groundwater abstraction and drinking water supply. Seawater intrusion is controlled through groundwater recharge creating a 'hydraulic barrier' in the Low Llobregat Aquifer (Figure 34). This procedure started in 1950 (with surface water infiltrations from the river) and in 1969 with 20 boreholes injecting treated water into the aquifer. The installed recharge capacity is 75,000 m3 per day and in the 1990s aquifer recharge volumes varied between 5 and 15 Mm3 per year (recharge is however dependent on surface water availability for injection – hence the variability shown in Figure 34 and the state of recharge infrastructure) (Queralt 2015, pers. com.). Additional recharge technology developed by the CUADLL includes recharge ponds.

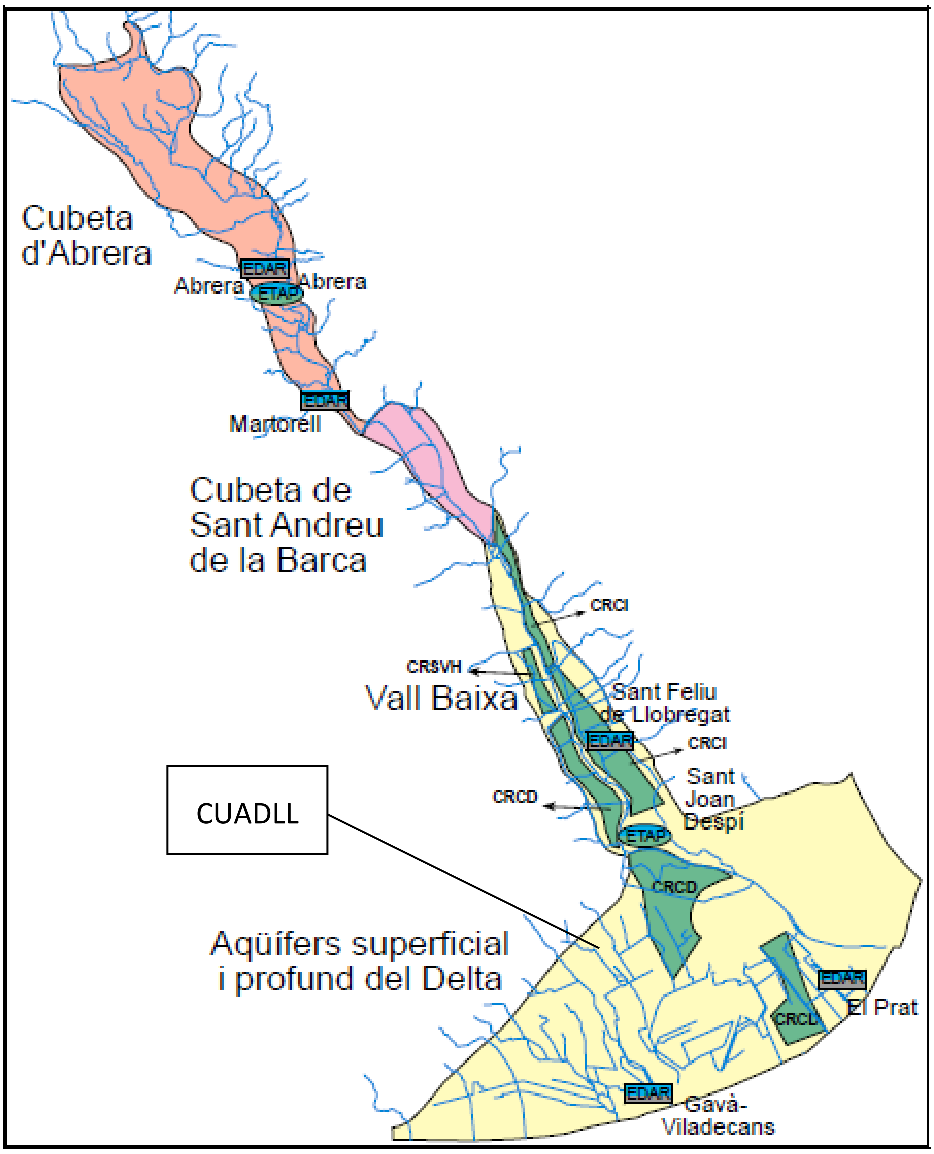
[65] Only one user sold its groundwater abstraction right to another user during this period (Queralt 2015, pers. com.).

All CUADLL members have access to information at the aquifer level as the technical department shares its reports on the status of the aquifer (piezometric levels, uses, groundwater quality, etc.). Users value this service and understand the necessity to have an 'integrated management' of the system and the value of understanding groundwater management at the local level and more regionally (the CUADLL had to dedicate resources to this matter in the late 2000s so that users were on board regarding this 'integrated management' approach) (Queralt 2015, pers. com.).

North of the CUADLL, two smaller user communities were constituted with similar goals and administrative structure: the User Community of the Cubeta de Abrera created in 2009 with 50 users abstracting 22 Mm3 per year over 30 km2 (mostly municipalities for their water supply under private management by water utilities, small farming activities, and industries), and the User Community of the Cubeta de Sant Andreu created in 1985 following a meeting by the municipalities of Castellbisbal, Sant Andreu de la Barca, and the private water utility of Castellbisbal, all in the industrial belt around Barcelona (8 km2 and 40 users abstracting 9 Mm3 per year) (Figure 31).[66] Groundwater use from the Cubeta de Abrera Aquifer is mainly for drinking water supply for the metropolitan area of Barcelona (79 percent), followed by industrial use (16 percent), and agriculture (5 percent). Groundwater use from the Cubeta de Sant Andreu Aquifer is for drinking water supply (26 percent), industry (70 percent) and agriculture (4 percent). Since 2009, the CUADLL advises these other user communities regarding technical issues as they are too small to have their own technical services.

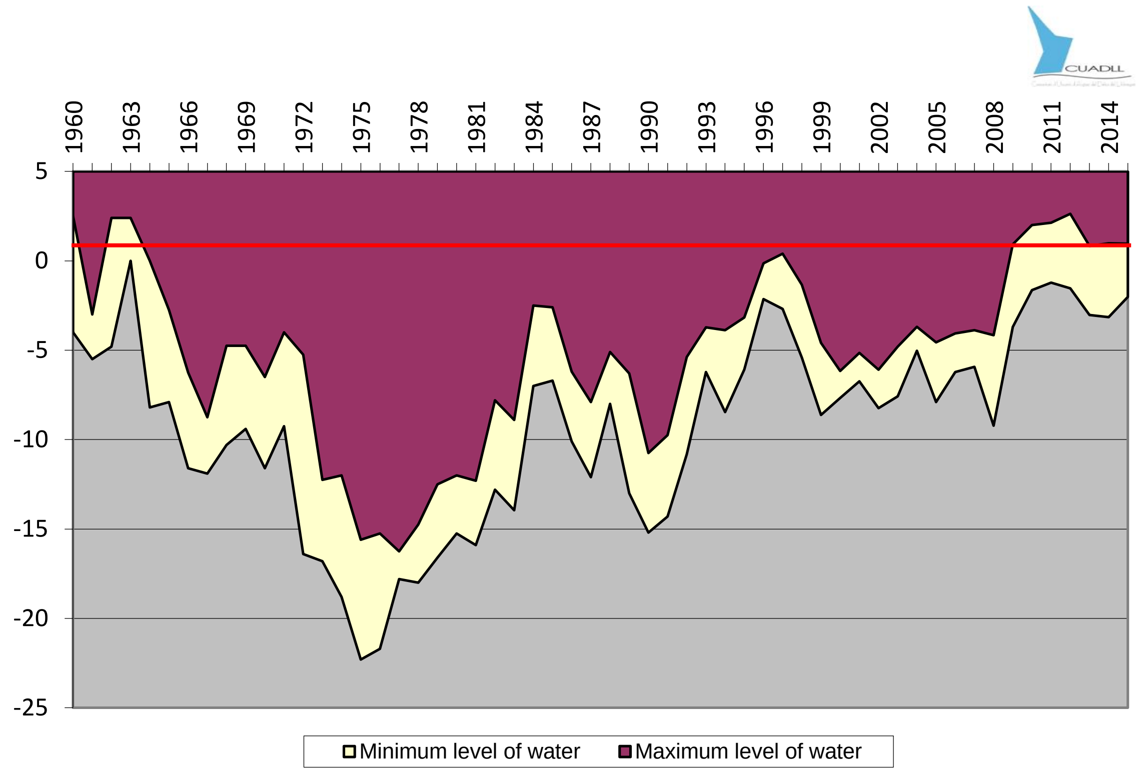
[66] Comunitat d'Usuaris d'Aigues de la Cubeta de Sant Andreu de la Barca, http://www.cuacsa.org/modules.php?name=historia (Accessed 19th November 2015).

Figure 31. Aquifers in the Low Llobregat Valley and Delta and User Communities



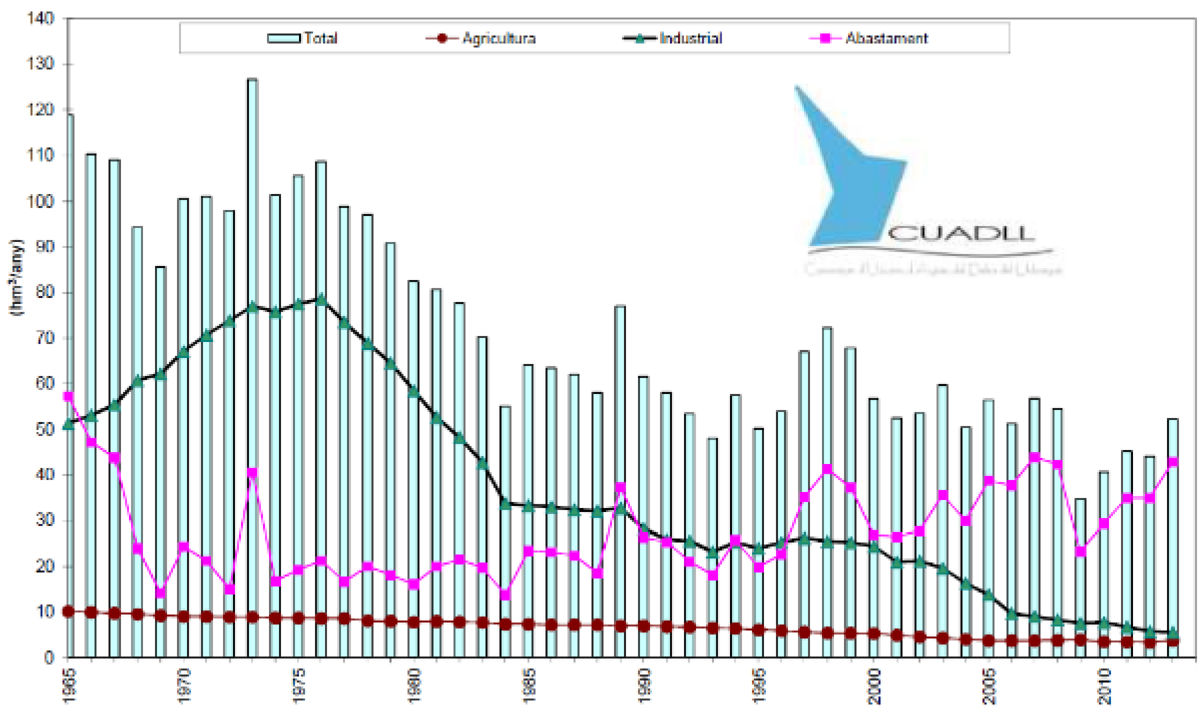
Source: CUADLL.

Figure 32. Minimum and maximum piezometric levels for the Llobregat Aquifer



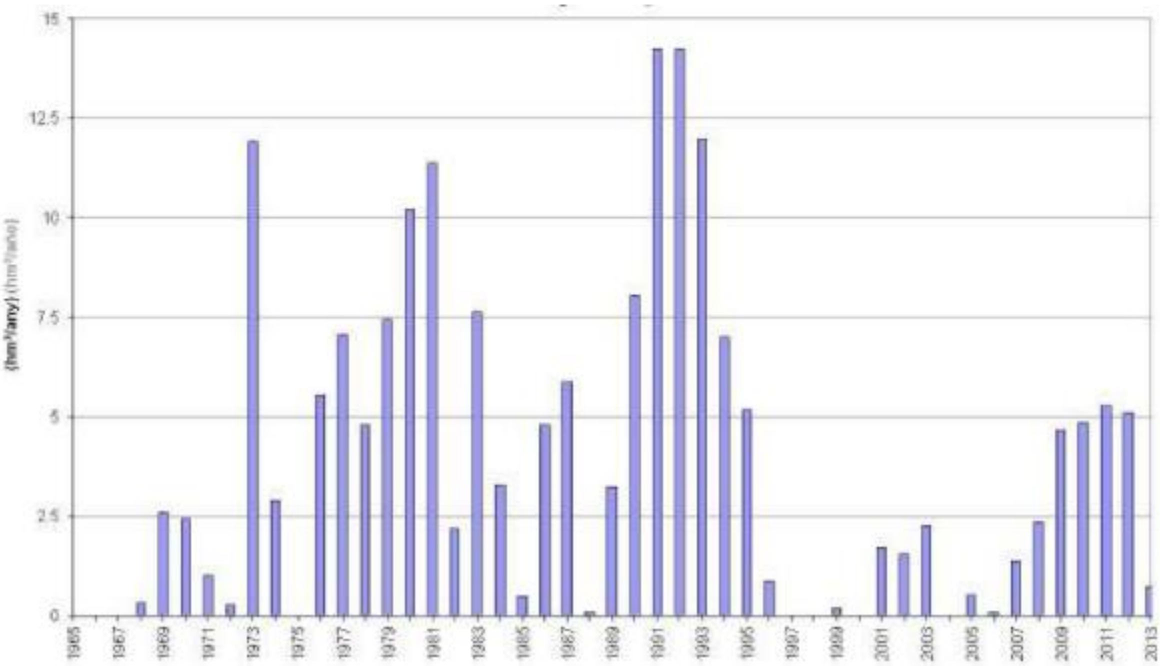
Source: CUADLL 2014.

Figure 33. Groundwater use in the Low Llobregat River and Delta



Source: CUADLL 2014.

Figure 34. Artificially recharged volumes into the Llobregat Aquifer



Source: CUADLL 2014.

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