Agricultural Water Management 108 (2012) 83–95

Contents lists available at SciVerse ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat

Lost in translation? Water efficiency in Spanish agriculture

E. Lopez-Gunn[a,b,*], P. Zorrilla[c], F. Prieto[d], M.R. Llamas[e]

[a] Water Observatory, Botin Foundation, UCM, Madrid, Spain
[b] IE, Madrid, Spain
[c] Terrativa SL, Madrid, Spain
[d] AEVAL, Madrid, Spain
[e] Water Observatory, Botin Foundation, and Spanish Royal Academy of Sciences, Spain

ARTICLE INFO

Article history:
Received 1 April 2011
Accepted 12 January 2012
Available online 18 February 2012

Keywords:
Water efficiency
Irrigation
Modernisation
Water savings
Water productivity
Waterenergy nexus
Common agricultural policy
Public policy
Infrastructure investment

ABSTRACT

This paper re-visits the concept of water efficiency applied to Spanish agriculture and assesses how this technical concept is sometimes lost in translation when applied at different spatial scales. The paper traces the historical dominance of irrigated agriculture in Spanish water policy. It analyses the water efficiency concept at the macro level, by evaluating recent national policy initiatives and public investment programmes over the last decade to modernise irrigation, which anticipated large water savings. "Water efficiency" is then framed in its socio-political context, by looking at debates and discussions over the past, current and future role of irrigation, key evaluation criteria and objectives for large scale irrigation modernisation plans, what are the links to water rights and allocation, benefits and beneficiaries from water savings and important unanticipated consequences and co-benefits in modernisation, and the reform of agricultural policies. Finally it identifies the central role played at national, European and global levels by agricultural (and energy) policies as key external drivers for the long term viability of modern irrigation on social, environmental and economic-productivity terms.

1. Introduction

Spain is the most semi-arid country in the European Union, and it is increasingly hitting the global media headlines due to regional conflicts over water resources. This paper will argue that the twists and turns of the concept of "water efficiency", analysed through the lens of political ecology, provide a mirror to understand the traditional dominant use of water by agriculture, and new challenges in the form of other competing users – mainly the environment and public water supply including tourism sprawl and development along its coastlines. In Spain there has been an evolution in concepts used in an effort on the part of the dominant water user – irrigated agriculture – to secure water resources using language itself as a discursive tool (Boelens and Vos, this volume). This is partly due to increased pressure to re-allocate water away from agriculture towards competing uses, and also to reduce the amount of water used in irrigated agriculture.

This paper, therefore offers a number of perspectives by analysing the implementation of national modernisation plans for irrigation, and secondly by discussing the twists and turns centred on the "truth" of water savings. This paper is based on a literature review and the analysis of data on the implementation of national and some aspects of regional irrigation modernisation plans. Data on the effectiveness of National Irrigation Plans and "modernisation" processes (Boelens and Vos, this volume) are then framed in a socio-political and economic context (Baghel and Nusser, 2010). Through a series of expert interviews,[1] it analyses the discourse and opinion from people that held senior positions and were strategic decision makers at the time the National Irrigation Plan 2008 (from now NIP 2008) and its continuation the Shock Plan[2] (SP 2006) were being designed and implemented.

The paper is structured in the following way: the first part of the paper focuses on the use of the water efficiency concept at the macro level, by analysing the implementation of one of the most significant irrigation modernisation plans in the European Union, which targeted one million hectares, anticipating water

[1] Interviews were held with irrigation representatives, an ex-deputy minister, ex deputy directors for water planning and irrigation, regional agriculture representatives, environmental NGOs, academics, planning chiefs and commissariats from water authorities, from state and private companies involved in water planning and irrigation modernisation.

[2] *Plan de Choque* 2006.

* Corresponding author at: Dpto Geodinamica, Facultad de Ciencias Geologicas, Universidad Complutense de Madrid, Jose Antonio Novais s/n, Madrid 28040, Spain. Tel.: +34 648192910.
E-mail address: e.lopez_gunn@geo.ucm.es (E. Lopez-Gunn).

0378-3774/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
doi:10.1016/j.agwat.2012.01.005

Table 1
Area irrigated in the European Union.

	Cultivated area (1000 ha)	Total population (1000 inhab.)	Area equipped for irrigation: actually irrigated	
			1000 ha	%
Austria	1.450	8.307	40	0.4%
Belgium	863	10.531	3	0.03%
Bulgaria	3.281	7.641	54	0.5%
Cyprus	145	854	33	0.3%
Czech Republic	3.271	10.268	17	0.2%
Denmark	2.313	5.445	252	2.4%
Estonia	607	1.343	–	0.0%
Finland	2.261	5.283	0	0.0%
France	19.519	61.714	1.696	16.2%
Germany	12.075	82.343	–	0.0%
Greece	3.245	11.112	1.313	12.5%
Hungary	4.790	10.032	75	0.7%
Ireland	1.063	4.355	0	0.0%
Italy	9.702	59.305	2.613	24.9%
Latvia	1.198	2.269	0	0.0%
Lithuania	1.866	3.356	0	0.0%
Luxembourg	63	475	0	0.0%
Malta	9	406	2	0.02%
Netherlands	1.094	16.460	93	0.9%
Poland	12.906	38.132	70	0.7%
Portugal	1.672	10.641	454	4.3%
Romania	9.013	21.450	89	0.9%
Slovakia	1.402	5.394	45	0.4%
Slovenia	203	2.010	2	0.0%
Spain	17.396	44.051	3.365	32.1%
Sweden	2.648	9.159	49	0.5%
United Kingdom	6.131	61.129	208	2.0%
Total	120.187	493.465	10.475	100%

Source: FAO AQUASTAT.
Spain is the EU-27 country with most irrigated area (data from 2003–2007).

savings to be made through water efficiency. The second part of the paper uses a political ecology framework to discuss the twists and turns on the discourse of water efficiency and water savings. Ultimately the goal of the paper is to assess how the concept has been "lost in translation" in three ways; first, it engages with the debates in the literature and this special issue on the meaning (and usefulness) of the concept of water efficiency (Perry, 2007); second, it applies these different interpretations to Spain, particularly assessing the aggregate national level of current initiatives to incentivise water efficiency in agriculture as a "demand management measure"; third, the limited monitoring and evaluation of this programme is then analysed by looking at water efficiency in a wider political economy context, as a cornerstone concept in a semi-arid country facing tough decisions and choices on water allocation, reallocation (Boelens and Vos, this volume; Knox et al., this volume) and misallocation between competing uses.

2. The role of irrigation in Spain

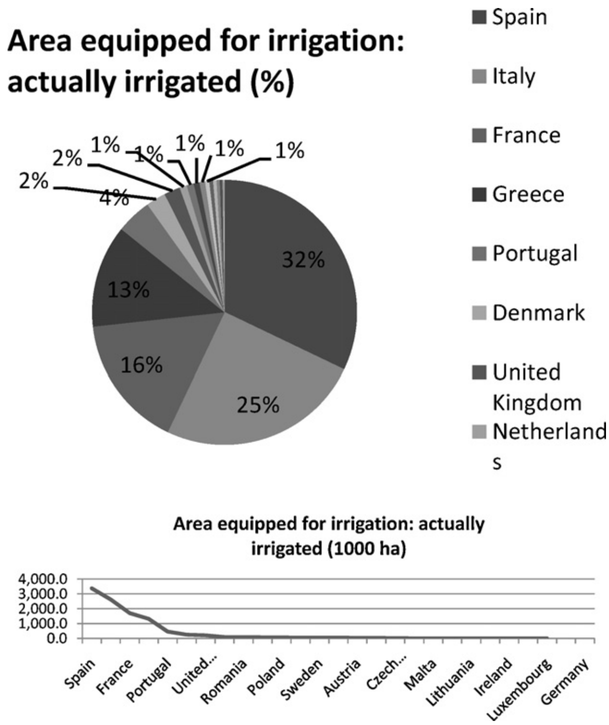
In Spain the hydraulic paradigm permeates water-related decision making and policy frames. Within this paradigm, agriculture (together with hydroelectricity) is positioned as a privileged user (Ex-secretary of State, personal communication; Ex-water Director Regional Water Agency, personal communication) due to history of agrarian change in Spain. A hard economic crisis in the end of the 19th century created tension between a growing bourgeois society amidst a largely rural and illiterate country. Water thus became a symbol of prosperity and modernity, and irrigated agriculture seen as pivotal for change (Lopez-Gunn, 2009). In the Spain of the late 19th century irrigation became the means and the end: 'progress'.

Yet in the Spain of the 21st century it could be argued that irrigation is now centre stage because water has many productive uses, of which modern irrigation is only one. In an increasingly urban society, the production of natural or ecological values increasingly questions the dominant use by irrigated agriculture. As Allan (2010) identifies, the challenge in many semi-arid countries are decisions on the allocation of the "big" water i.e. the 70% of water used in Spain by irrigation rather than small gains to be made on efficiencies in the public supply sector.

Spain by itself accounts for almost a third of all the total irrigated area in the whole of the EU (see Table 1) and this potential irrigated area is almost fully utilised (Figs. 1 and 2). Irrigation thus is considered a strategically crucial sector since it consumes the largest proportion of total water resources (estimated at 23,000 Mm^3), and uses 50% of the water kept in reservoirs and dams in Spanish reservoirs (Pindado, 2005). Irrigation is also a key part of the agricultural sector since it accounts for 60% of the total agricultural produce (i.e. 13,000 M€ out of an estimated 20,500 M€), and 80% of total farmer exports. Yet it only represents 14% of the agricultural area, with 3.5×10^6 ha of the total Agricultural Used Area (Barbero, 2005), where on average 1 ha of irrigated land produces 6 times more than a hectare of rain fed agriculture (Camacho Poyato, 2005; Maestu and Gómez, 2010). This in turn generates an income four times higher than in rainfed agriculture and more employment per hectare (Camacho Poyato, 2005).[3]

These figures of increased production, higher incomes, direct and indirect employment and contribution to agricultural GDP explain the drive and inertia for irrigation in Spain. First because it is already the dominant user (rule of capture); second, because it represents the main portion of the most productive and export led agricultural sector and third, because of its historical and symbolic

[3] For example in the Guadalquivir basin employment is 3.5 higher per irrigated ha than in rain fed agriculture (Berbel and Gutiérrez, 2004).



Figs. 1 and 2. EU area equipped for irrigation actually irrigated.

value for dry, inland regions as a means to prevent depopulation (Saiz Romero and Ajo Villagra, 2003).

Most of Spain is naturally water scarce due to its geographical location. However, water scarcity framed within a hydraulic paradigm was seen as a problem to be solved through state intervention to augment or control water resources, mainly via technological or infrastructural measures. This policy paradigm was dominated by so called supply management measures to increase available water through water transfers and reservoir construction. Yet this paradigm started to be challenged in the 1990s, with the push for so called demand management measures of which "water efficiency" and "water savings", through the modernisation of agricultural irrigation technology, was perceived as the main measure (Rubio de Villanueva, 1997).

In addition the farming sector had also became sensitive to a public image as old fashioned, wasteful and inefficient. This "public image" became particularly poignant in the mid 1990s, when during a prolonged drought, many cities in southern and Mediterranean Spain and a total of 12 million Spaniards experienced cuts to their public water supply, whilst fields continued to be irrigated. It was at this point, in the midst of the discussion on the 1993 National Hydrological Plan that the Spanish Parliament asked for a review of irrigation in Spain and for a National Irrigation Plan (Technical Director Water Authority, personal communication; Geography academic professor, personal communication). In this context it is important to remember the strong social legitimacy of irrigation in many regions as a policy to settle population in rural areas and generate employment. Therefore rather than a discussion on the criteria under which irrigation was suitable or suited, the debate turned to the almost half of irrigated land in Spain which was still watered through traditional gravity fed surface systems, and where "water savings" could be achieved through technology-change. The umbrella objective was to tackle "water scarcity" to conserving water resources through increased water efficiency by all users, and particularly by agriculture.

In line with the argument presented by Lankford, 2011, traditional irrigation systems in Spain were portrayed as having low water efficiency (60% on average) (Barbero, 2006) due of substantial water losses in old conveyance networks in extensive flood irrigation systems. Before 2002, 700,000 ha were irrigated by ditches often through a network of concrete channels more than 60 years old, and there were reported large water losses on 400,000 ha. That is, approximately one-third of the Spanish irrigated infrastructure was more than a century old (Pindado, 2005). In terms of type of irrigation, it was estimated in 2002 that 60% of irrigated areas was irrigated by flood irrigation, while more than a third of irrigated land did not have their water supply guaranteed.[4] Meanwhile sprinkler irrigation was used in only 24% of the irrigated area and only 17% had drip irrigation. The discourse framed this old infrastructure as inadequate, outdated and in need of substantial investment.

3. Public policy on irrigation modernisation: the National Irrigation Plan

In the early to late 1990s conflict between two ways of conceiving water policy clashed and materialised in the failure to reach a consensus on the 1993 National Hydrological Plan (NHP). The main NHP outcome was the request from the Spanish Parliament to present a new irrigation plan for Spain as a pre-requisite for the NHP.

The lead was taken by the State together with the water authorities (responsible for water management), and the regions (responsible for agricultural matters) embodied into the Spanish National Irrigation Plan, and parallel programmes run directly by the regional governments[5] (Varela-Ortega, 2006). Farmer organisations and the main national Irrigators Union became active campaigners for modernisation, a strong lobby able to glue all the different (often) competing organisations into a common objective: a major investment programme for irrigation modernisation. This represented a shift away from big water infrastructure like reservoirs or water transfers, opting instead to look at irrigation modernisation, which was thought to be cheaper per m^3, particularly when taking into account social and environmental aspects. The aim was to ensure "that each m^3 had a name and surname" (i.e. the traceability and control of water systems) (Secretary General National Irrigators Association, personal communication). In terms of discourse, there were clear synonyms established between irrigation efficiency and water conservation. Finally, after more than seven years of data collection, research and analysis, Royal Decree '329/2002' was enacted in 2002 as the starting point for the 'National Irrigation Plan – Horizon 2008' (NIP 2008).[6] The NIP 2008 took a staged approach, targeting half the area by 2008 with a stated policy objective to modernise 1,134,891 ha (i.e. 1/3 of the irrigated area), a larger figure that the 700,000 ha originally identified. The NIP 2008 used the framework of river basins, specifying areas to be modernised in terms of ha per region (Diaz Eimil, 2001). The modernisation of existing irrigation infrastructure was based on the lining of old canals and improving the irrigation system and storage facilities, farmer training on good irrigation practices, and on improving water quality and drainage. It had a three pronged strategy: first, to *consolidate irrigation* guaranteeing water resources in areas that had unreliable irrigation resources; second, to *modernise existing irrigation* with a target of 1,134,000 ha by the end 2008 and third, *new irrigation*, although ringfenced and limited to highly

4 A irrigated plot of land is considered "under-supplied" when water supply is less than 70% of the demand.

5 E.g. in Andalusia (Junta de Andalucía, 2010a,b) and Aragon, where 128.3 M€ invested between 2000 and 2009 (CESA, 2010) With data from the Agenda of Andalusian Irrigation-Horizon, actions have been undertaken in 352,000 ha, with an investment of 1380 M€.

6 *Plan Nacional de Regadios – Horizonte 2008.*

Table 2
Main action programmes of the Spanish National Irrigation Plan.

Programme	Area (ha)	Investment (M€)
Improvement and modernisation	1,134,891	3056.5
Zones into execution	138,365	1136.6
New infrastructures for social purposes	86,426	681.9
New infrastructure Private Irrigation Communities	18,000	123.8
Support Programme		25.7
Total	1,377,682	5024.5

Source: MAPA (2001).

vulnerable areas (i.e. 104,000 ha of the 1.13×10^6 ha). In order to achieve these objectives the Plan was divided into 5 separate action programmes, with a budget of 5024.57 M€ (see Table 2).[7]

The programme was implemented through the coordination of the Ministry of Agriculture and the Ministry of Environment, which after the 2008 national election were merged into a single Ministry.[8] Before the merger, these ministries had different responsibilities; the Ministry of Agriculture was in charge of irrigation water downstream to the plot level, while the Ministry of Environment was responsible upstream at the catchment to supply water resources for irrigation. The most important programme was centred on the "*Improvement and modernisation of traditional irrigation systems*" where State-owned companies[9] acted like an executive arm of the State through direct agreements with farmer irrigation communities, potentially covering the whole area in Spain (President State Irrigation Investment company, personal communication; Saiz Romero and Ajo Villagra, 2003). The logic for creating these state companies was to act as catalysts for state investment, encapsulating the advantages of the private sector by speeding up the investment process. It also indirectly re-established a degree of central control in agriculture which had been devolved to the regional governments during the decentralisation process undergone by Spain from 1975.

In terms of financing, the Plan was based partly on soft loans under preferential conditions[10] (Barbero, 2005) (see Table 3) and partly on subsidies including EU subsidies which established as precondition that no new irrigation could be funded (Environmental NGO, personal communication).[11] The modernisation programme

Table 3
Investment Spanish National Irrigation Plan Horizon 2008.

Investment	Amount invested
Private investment	2007260.227€
Public investment (Ministry of Agriculture – MAPA)	1430396.788€
Public investment (Autonomous Communities)	1586918.370€
EU finance	1009700000.0€
Total investment	5024575.385€

Source: MAPA (2001).

Table 4
Overall targets for irrigation modernisation from public policy plans. Period 2002–2008.

	Funding (M€)	Area (hectares targeted)	Planned water savings
National Irrigation Plan – Horizon 2008	5024 M€	1,377,682	2000
Shock Plan 2006	2344 M€	866,898 ha	1162 Mm^3/yr
Total	7368	2,244,570	3162

relied on three parallel modernisation tracks to succeed: (1) modernisation upstream or so called *en alta*,[12] e.g. water regulation from infrastructure managed by water authorities, (2) downstream or *en baja* by agricultural agencies like the lining of canals, and finally, (3) at plot level (*finca*) by farmers modernizing their farm. All these pieces in the puzzle had to succeed if the overall targets on efficient water use were to materialise.

The NIP 2008 had an ambitious target of 2100 Mm^3 in terms of projected water savings. An analysis undertaken by Barbero (2005) estimated that by 2004, half way through the implementation of the plan, the estimated water savings amounted to 844 Mm^3, indicating that expected water savings were behind schedule[13] because regional governments were not adopting a demand led position (Environmental NGO, personal communication). This concern, together with a severe drought in 2006 triggered a second plan, the "Shock Plan for Irrigation Modernisation" (or SP 2006[14]), passed as an urgent measure, to prioritise projects with a planned investment of 2344.00 M€[15] to modernise an irrigated area of 0.87×10^6 ha, to achieve additional water savings of 1162 Mm^3/yr[16] on top of the planned water savings of the NIP 2008. Therefore the total investment considering both NIP 2008 and SP 2006 was more than 7000 M€ expected to generate water savings in the order of 3100 Mm^3 (Tables 4 and 5).

4. A geographical analysis of National Irrigation Plans 2002–2010

In Spain, like in many other countries, there is a great diversity in terms of data in irrigation, often with large differences between data sources, and with additional problems of a lack of transparency and ease of access to information (OECD, 2010).[17]

[7] First, the improvement and modernisation of traditional irrigation area; second, to complete infrastructure in the big irrigation zones created during the 20th century; third, to build new infrastructure for social purposes (to be implemented in irrigation zones of less than 2000 ha), to maintain the population in rural areas; fourth to build new infrastructure for private irrigation communities (irrigation zones of less than 2000 ha) in order to consolidate local agricultural production, and fifth to develop farmer support programmes, which included monitoring programmes, training and dissemination of modern technologies.

[8] Ministry of Environment, Rural and Marine Affairs Established: Royal Decree 432/2008, April 12th.

[9] These were the Public Companies for agricultural infrastructure or *Sociedades Estatales de Infraestructuras Agrarias. Sociedad Anónima*. Originally, there were four SEISAS (North east, North, Plateau south and Plateau south and East), created in 1999, after a decision by the Council of ministers to facilitate public investment into agriculture. From 1st January 2011 all the Public Companies for agricultural infrastructure were merged into a single agency.

[10] The financing was based on a 24% subsidy and a 76% soft loan to irrigation communities, of which farmers had to pay 30.5% upfront through a preferential loan and the rest was financed by the Public Companies for agricultural infrastructure, to be paid back after 50 years, with a 25 year period without a need to make payments, and no interest or actualisation of the debt. Some of the finance came from EU funding for Objective 1 regions, and therefore investment could not contravene the National Strategic Lines agreed with the European Union on agricultural policy that there would be no irrigation expansion.

[11] A proviso was added after the public consultation process by NGOs where water rights could be revised downwards as a result of the irrigation modernisation process. However this might clash with expectations from farmers on potential water markets (Agric. Economics Professor A, personal communication).

[12] "En alta" – primary canal or wholesale water system and "en baja" – secondary/tertiary distribution or retail water system.

[13] The target set for 2008 was water savings of 1250 Mm^3/year, equivalent to 10% of the water used in irrigation agriculture (Pindado, 2005).

[14] *Plan de Choque de Modernización de Regadíos 2006* (SP 2006) (BOE 11703/2006).

[15] Slightly more than the 2344 M€ originally planned.

[16] I.e. also higher estimates than the original 1162 Mm^3 anticipated.

[17] Internally between Spanish water authorities and regional governments and between different ministries at central government. These turf battles in effect go to the detriment of an *ex post* analysis of the NIP 2008 and SP 2006. This lack of access to data seems to also have spilled downwards and upwards, into civil society and to the European Union. In the case of civil society, WWF launched a series of requests for information backed by the Spanish Ombudsman on the specifics of irrigation

Table 5
National Irrigation Plan – Horizon 2008 – investment per programme and execution by 2006.

Programmes	Total investment (€)		% programmed execution	Area (ha)		% programmed execution
	Programmed	Executed		Programmed	In execution	
Modernisation	3,056,591,302	1,504,487,055	49	1,134,891	1,384,696	122
New Zones	1,136,567,982	341,536,622	30	138,361	136,095	98
Social purposes	681,908,331	96,177,192	14	86,425	35,594	41
Private communities	123,808,492	19,768,218	16	18,000	7296	40
Support programme	25,699,278	28,502,612	111	–	–	–
Total	55,024,575,385	1,990,471,699	40	1,377,682	1,563,681	113

Source: Barbero (2006).

Table 6
Evolution in the use of irrigation technology. Period 2002–2009.

Type of irrigation	2009/2002 (%)	2009/2002 (ha)
Flood Irrigation	−18.9%	−244,731
Sprinkler Irrigation	−17.2%	−99,701
Pivot irrigation	2.6%	6,681
Drip irrigation	43.9%	485,317
Other irrigation systems	−82.6%	−93,747
Total	3.3%	109,285

Source: Hardy and Garrido on data from MARM (2009) Encuesta sobre superficies y rendimientos de cultivo (ESYRCE)).

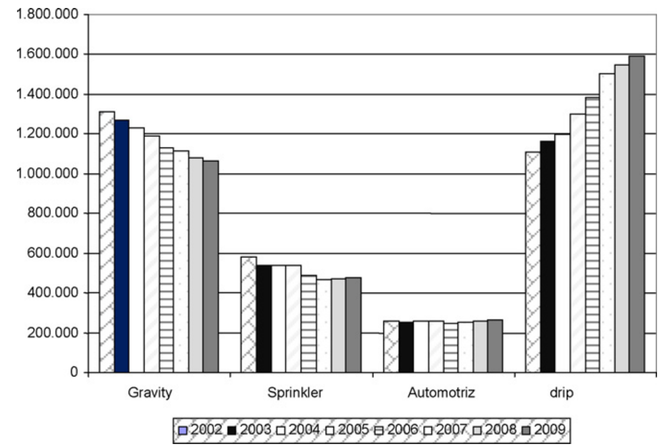


Fig. 3. Evolution of irrigated area by type of irrigation at national level. Period 2002–2009.
Source: MARM (2009).

Taking into account these limitations, available data seems to indicate that the level of investment ranged from e.g. 1600€/ha in the Guadiana basin to 3000€/ha in the Segura basin[18] and an evaluation of the NIP 2008 shows that the area dedicated to more efficient crops (in terms of water consumption as well as productivity) has increased. Equally in terms of irrigation technology there has been an evolution from flood irrigation towards drip irrigation. Whereas in 2002 1.3×10^6 ha were irrigated by gravity, greater than the 1.1×10^6 ha by drip irrigation, by 2009 1.6×10^6 ha of drip irrigation exceeded the 1.05×10^6 ha by flood irrigation (MARM, 2009) (Tables 6 and 7; Fig. 3).

However although the water available per basin has increased, it is difficult to assess whether this was translated into water savings at catchment level – one of the main stated objectives of the NIP 2008 (OECD, 2010). In order to have water savings from a reduction in intensity of use, the irrigated area had to remain constant. However there is some evidence that the volume of water "saved" by the modernisation programmes were used to increase the irrigated area and/or change to crops sometimes with higher water consumption. Thus, according to a study by the Public Policy Evaluation Agency (AEVAL, 2010) on the Segura and the Guadiana basins, the estimated water savings were around 94 Mm^3 in the Guadiana and 65 Mm^3 in the Segura; however this has not necessarily translated into reduced withdrawals which would diminish the pressure on the basin or potentially free up water for other uses (Molle and Turral, 2004). This is due to a number of reasons: first, numbers included in the NIP 2008 and the SP 2006 were estimated savings at plot level (or classical efficiency as described by Lankford, 2011); second, assumptions were made on the type of crop remaining constant; and third, that there would be no increase in the irrigated area.

5. Evaluation of the Plan de Choque or *Shock Plan 2006*

This section analyses official data from MARM on investments made under the SP 2006, to highlight that investment was not necessarily proportional to a corresponding amount in terms of water savings, since the type of actions under irrigation modernisation were varied. In terms of public investment, the regions with the largest investment were Andalusia (corresponding largely to the Guadalquivir basin and internal regional basins), Valencia (Jucar basin), Castille-Leon (Duero basin) and Aragon (Ebro basin) (see Tables 8–10). Water savings in Extremadura were greater per euro invested, whereas 9% of the state investment went to Extremadura, this was expected to generate 19% of the water savings (an amount equivalent to the Tajo-Segura water transfer (i.e. 269 Mm^3), the largest water transfer in Spain. Meanwhile, the 17% of the total money invested in Valencia was planned to generate 10% of the total water savings i.e. 148 Mm^3 (See Figs. 4–6). However what is also relevant in this context is that an analysis of water savings does not shed light or facilitate debate on the "logic of modernisation". This is because it does not demonstrate a clear *ex ante* analysis or decision criteria on where or why money should be invested, like e.g. estimated water savings per euro invested, or other criteria. For example, the type of crop along the Mediterranean coast tends to be fruit trees and vegetables, and therefore the investment will have a high return for farmers. Meanwhile, in the case of Extremadura, modernisation projects are often taking place e.g. areas of traditional rice irrigation, which can be justified and explained in terms of quality of life and settling rural population. The logic for modernisation e.g. along the Mediterranean coast has been very different to

modernisation projects (Rodríguez and Peiteado, 2011; Defensor del Pueblo, 2009). In the case of the European Union some doubts remain on whether EU funding was used to finance directly or indirectly the expansion of irrigated land.

[18] According to a recent study by AEVAL (2010) cost recovery in the Guadiana is on average 79% for the general distribution system, and at plot level, around 43%, although including the distribution costs at plot level this would rise to 70%. In the Segura, cost recovery for the general distribution is 90.12% while there is no data at plot level. A recent analysis by Calatrava and Garrido however places the average for Spain on 45% (Calatrava and Garrido, 2010), and the OECD (2010) in a recent study emphasised the allocative role that prices can play.

Table 7
Evolution in irrigation technology. Period 2002–2009.

Type of Irrigation	Area (ha)								Variation (%)	
	2002	2003	2004	2005	2006	2007	2008	2009	2009/08	2009/average 2008
Gravity	1,308,979	1,265,344	1,230,073	1,192,717	1,132,090	1,115,271	1,082,604	1,064,248	−1.7%	−10.5%
Sprinkler	579,398	537,943	536,654	535,503	490,421	464,619	469,868	479,697	2.1%	−7.1%
Automotriz	259,216	250,228	259,434	256,573	248,753	250,483	257,654	265,897	3.2%	4.4%
Drip irrigation	1,106,299	1,162,614	1,197,465	1,302,810	1,381,835	1,502,327	1,548,043	1,591,616	2.8%	21.1%
Other systems and with no info	113,594	47,987	54,433	38,132	25,808	28,081	16,463	19,847	20.6%	−57.2%
Total	3,367,486	3,264,116	3,278,059	3,325,735	3,278,907	3,360,781	3,374,632	3,421,305	1.4%	3.0%

Source: MARM (2009).

Tables 8 and 9
Shock Plan 2006: water savings per region.

	Regions					
	Budget (million €)	Water savings (Mm^3/year)	Land (ha)	Farmers	No. of projects	No. actions
Andalusia	634	280	187,825	11,828	62	28
Valencia	462	148	157,463	53,627	33	21
Castille and León	451	203	129,081	16,270	25	15
Aragón	363	244	416,349	12,539	30	7
Extremadura	229	269	239,165	9070	101	10
Murcia	222	65	57,193	17,368	18	9
Catalonia	113	147	184,279	17,863	25	16
Castille La Mancha	84	36	13825	2600	4	4
Basque Country	42	4	1500	652	2	2
Balearic Islands	30	2	1305	568	7	7
Madrid	30	8	600	0	1	1
Cantabría	8.6	0	435	189	1	1
Canary Islands	4.5	2	182	383	2	2
Galicia	3.9	1	760	70	1	1
Navarre	3.8	11	2500	0	2	1
Asturias	0.6	0	35	15	1	1
Total	2680	1421	1,392,497	143,042	314	125

	Budget (million €)	Water savings (Mm^3/year)	Land (ha)	Farmers	No. of projects	No. actions
Andalusia	24%	20%	13%	8%	20%	22%
Valencia	17%	10%	11%	37%	11%	17%
Castille and León	17%	14%	9%	11%	8%	12%
Aragón	14%	17%	30%	9%	9%	5%
Extremadura	9%	19%	17%	6%	32%	8%
Murcia	8%	5%	4%	12%	6%	7%
Catalonia	4%	10%	13%	12%	8%	13%
Castille La Mancha	3%	3%	1%	2%	1%	3%
Basque Country	2%	0.3%	0.1%	0.5%	0.6%	2%
Balearic Islands	1%	0.1%	0.1%	0.4%	2.2%	6%
Madrid	1%	0.5%	0.0%	0.0%	0.3%	0.8%
Cantabría	0.3%	0.0%	0.0%	0.1%	0.3%	0.8%
Canary Islands	0.2%	0.1%	0.0%	0.3%	0.6%	1.6%
Galicia	0.1%	0.1%	0.1%	0.0%	0.3%	0.8%
Navarre	0.1%	0.7%	0.2%	0.0%	0.5%	0.4%
Asturias	0.0%	0.0%	0.0%	0.0%	0.3%	0.8%
Total	100%	100%	100%	100%	100%	100%

Source: http://www.plandechoque-ahorrodeagua.es/pag/esp/100.asp).

that of e.g. inland continental areas. Along the Mediterranean coast the emphasis has been more on control, traceability and increased auditing of water use, as well as to guarantee access to water for crops highly vulnerable to drought (e.g. fruit trees) or which are only viable under irrigation (e.g. high value horticulture). Meanwhile investment in inland Spain was focused on settling rural population.

6. Lost in translation: technical concepts travel into the policy arena

The social expectation was that the combined plans would help generate water savings in the order of more than 3000 Mm^3, i.e. three times the size of the most controversial water transfer in Spain, the Ebro water transfer of the year 2001, which planned a transfer of 1000 Mm^3. Beyond technical definitions (as discussed in a number of the papers in this special issue), this paper also draws on perceptions and future directions of what is understood, or indeed expected when irrigation modernisation is used in a sociopolitical context, to justify major public policies like in the case of Spain. Summarising interviewees' responses, all identified that increasingly the concept of efficiency has to draw in as many factors as possible (Senior consultant private firm, personal communication, see also Gleick et al., 2011). Different efficiencies somehow have to be integrated or put in context, for example in terms of production per unit of water, allocation efficiency (Rodriguez-Diaz et al., 2004); as an engineering concept at plot level; as efficiency

Table 10
Regional water savings and investment per ha and farmer.

	Mill. €/Mill m^3	€/ha	€/farmer
Andalucía	2	3377	53,618
Valencia	3	2931	8606
Castilla y León	2	3496	27,739
Aragón	1	871	28,921
Extremadura	1	958	25,265
Murcia	3	3883	12,788
Catalonia	1	613	6328
Castille La Mancha	2	6051	32,177
Basque Country	11	27,775	63,899
Balearic Island	16	23,142	53,169
Madrid	4	49,233	–
Cantabría	18	19,770	45,503
Canary Islands	2	24,725	11,749
Galicia	3	5132	55,714
Navarre	0	1518	–
Asturias	20	17,143	40,000
Average	2	1925	19,000

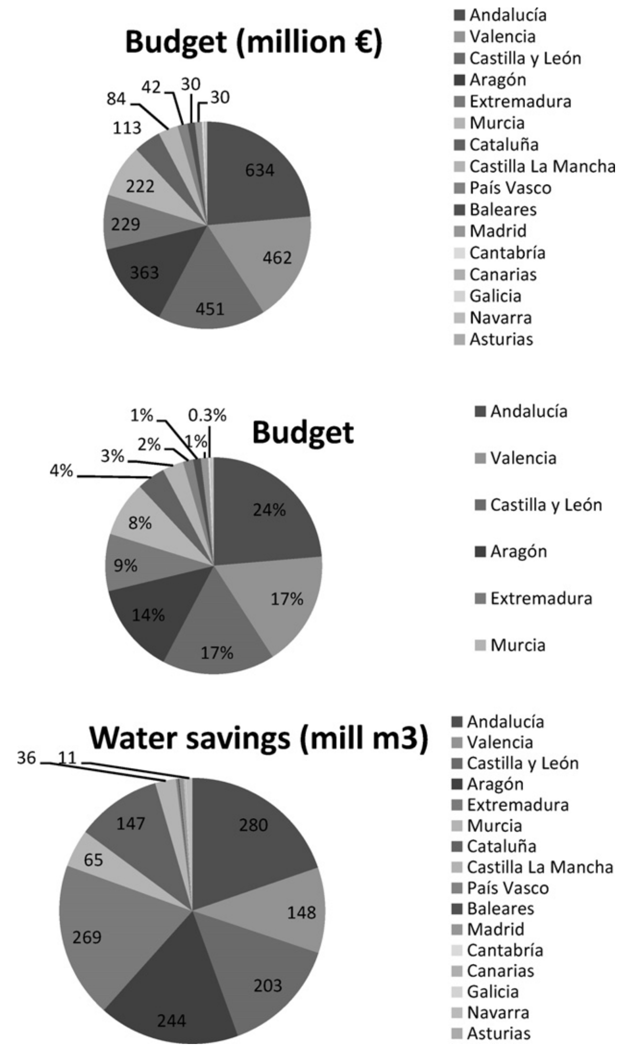
Source: http://www.plandechoque-ahorrodeagua.es/pag/esp/100.asp.

in the farming process (e.g. energy, labour); and as efficiency at a business and economic level for all factors of production (Agric. Economics Professor A, personal communication). In the case of some respondents, the emphasis was on efficient technology while for others the linkage with social welfare to ultimately reach equitable wealth and wellbeing was favoured (i.e. efficiency as a means to an end, not an end in itself).

7. Water efficiency and quality of life

Dominant in Spanish water policy and general rural development discourse, irrigation has been associated with lifting people out of poverty. One of the expert interviewees described how in the early 1970s, when the interviewee was a young irrigation engineer in Southern Spain his job was to drill wells, sometimes one or two per day, when the town where he was living had no drinking water, which was collected and transported by donkeys (Ex-water director for regional water agency, personal communication). This indicated the priority given to irrigation by both the authorities and the local residents and to the productive uses of water over the drinking water needs of the local population. The underlying social expectations was that irrigated agriculture would "modernise" the village by increasing income per hectare, which in turn would incentivise local agro-industry, acting as an engine for rural development. Irrigation in many regions had dramatically increased the productivity per hectare as compared to rain-fed agriculture. For example in 1950 there were 1.5×10^6 ha irrigated; and half a century later this had more than doubled to 3.5×10^6 ha (Corominas, 2009)[19] (see Fig. 1).[20]

Therefore, what the modernisation programme has achieved has been to allow the irrigation of hectarage that previously could not be irrigated due to canal/gravity led infrastructure, the so called difference between potentially irrigated area and actual irrigated area. In official Spanish statistics farmers would be legally entitled to the potentially irrigated area, and yet were irrigating less hectares due to old infrastructure. As discussed by Lankford 2011 one of the main advantages of irrigation modernisation is the increase in adeptness. Whereas in the 1940–1980s the key aim was to irrigate as a major driver to prevent rural depopulation, settle people, and increase farmer income which underpinned the whole widespread legitimacy of irrigation rural areas. The current modernisation programme is a logical evolution towards productive irrigation and quality of life for farmers.



Figs. 4–6. Budget invested and theoretical water savings per region.
Source: http://www.plandechoque-ahorrodeagua.es/pag/esp/100.asp.

All interviewees acknowledged some of the very positive effects from irrigation modernisation, like an increase in farmers' quality of life. Farmers no longer have to rely on irrigation turns (some at night), and are benefitting from the added bonus of an increase in the reliability and guarantee of water and a larger element of flexibility (Ex-irrigation secretary, personal communication; Barbero, 2008a). The flexibility is both spatial and temporal, (i.e. "timely" and inter-annually) and this has reduced farmer exposure to drought risk and climate variability, which allows farmers more decision making space and choice in terms of crop planning. It also opens the door for water markets, both formal (Ex-General Secretary for Irrigation, personal communication; Agric. Economics academic professor, personal communication), like the case between farmers in Estremera and the Tajo-Segura beneficiaries (Gil Meseguer, 2010) and informal markets like in Almeria or the Segura basins.

As a question mark on the issue of prevention of depopulation, interviewees confirmed that, thanks to irrigation, the need for labour is reduced, or there is a change in the labour market towards more highly skilled labour force. There was consensus from all expert interviewees on the improvement in real time decision

[19] This is a natural progression in a modern water economy, which evolves, firstly from the objective to increase the irrigated area – which in Spain occurred steadily from the 1940s, and secondly, a gradual stabilisation in the 1990s.

[20] Spain leads all other European countries in the use of irrigation. In terms of irrigated area, around 3.2×10^6 ha out of these 3.4×10^6 ha are estimated to be irrigated (Ex-water director for regional water agency, 2009).

making, not just focused on water but also on all additional inputs like more control over e.g. fertiliser or energy use. This has been a catalyst towards more profitable and/or productive crops, which in turn increases farmer income and can thus help justify the investment made in irrigation technology. This increase in reliability for farms that were underserved in their water concessions, has meant that farmers have also been able to increase the area irrigated to their full entitlement, which before could not be done due to lack of reliable water flows. In some areas like e.g. the Guadalquivir basin, farmers have opted to reduce irrigation of highly water consumptive crops like cereals, supported by the EU Common Agricultural Policy, whilst taking a calculated risk by increasing irrigation of crops more exposed to market volatility, but which are potentially highly profitable like soft fruit, vegetables and horticulture. This means that, after a large investment to better prepare for drought induced shortages, the overall resilience of the system has possibly decreased, since there is less elasticity in the system where resources are fully committed and also due to the type of crop (e.g. fruit trees). Therefore the plan has had the opposite effect to what was intended, prepare for drought, i.e. where possibly a higher long-term locked in demand means more exposure to drought events (Senior consultant private firm, personal communication).

8. Water efficiency, water savings and water rights

In relation to water savings a number of interviewees pointed out that the water savings mentioned in the NIP 2008 and SP 2006 were only estimates, when actual water savings (i.e. so called basin efficiency as described by Lankford, 2011) could be substantially less (Molle and Turral, 2004). For example, an estimated saving of 1000 Mm^3 might eventually materialise in the order of 300–400 Mm^3 (Technical Director Water Authority, personal communication). In theory in the SP 2006 one of the conditions was that water savings made could not be utilised to irrigate new land, as specified under the Law on Sustainable Development of Rural Environment, and also reflected in the new regional water law in Andalusia (Geography academic professor, personal communication). The principle written into the formal agreement between farmers and the state investment companies in agricultural investments (Deputy Water Comissariat, River basin authority, personal communication) was that modernisation would consolidate existing irrigated land with the underlying expectation that water saved would be released for other uses like ecological flows to help meet the EU WFD requirements on good ecological flows.[21] This is relevant because under the SP 2006,[22] water savings were ringfenced and no new official irrigation was allowed (Lopez, 2006). However, results from interviews stressed that expectations and perceptions from different agents were and remain different: environmental NGOs saw this large public investment programme as a means to free up resources for river flows and aquifer recharge to help comply with the EU Water Framework Directive; meanwhile farmers and farmer organisations saw irrigation modernisation as a way to ensure that exploitation of the potential irrigated area – which until modernisation had not been irrigated and where water savings generated at plot level were used for the intensification of irrigation (making it a hyper-efficient system). There are other cases where water conservation in

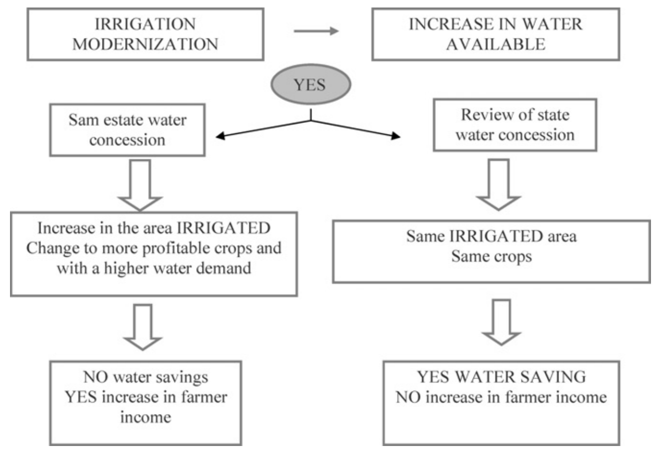


Fig. 7. Modernisation, water concessions and water savings.
Source: Prieto (2010).

irrigation could have increased water use by areal expansion (Ward and Pulido-Vazquez, 2008). This is one example of the rebound effect or Jevons paradox (Polimeni et al., 2008; Geography academic professor, personal communication) i.e. the more efficiently that a resource is used, the more it is used (Fig. 7).

9. Water efficiency and river basin planning

The current system of water rights is an excessively rigid, outdated water right system, which does not take into account the protection of the general interest (public trust doctrine). This was confirmed in an interview with a deputy water commissariat who clarified that since water in Spain is tied to land i.e. it is bundled, the incentive for efficient water use is missing because farmers pay per hectare not per cubic metre used (Deputy Water Comissariat, River basin authority, personal communication). However, there are some changes on the horizon; the first is that one modernised (as will be seen below) farmers no longer rely on gravity fed systems and therefore start to pay per m^3 through energy. This is also due to the liberalisation of the energy sector which means that farmers pay market prices per m^3; second, in the case of the (regional) Andalusian water law, and also in Draft River Basin Plans like the one presented in the Duero, there is a similar intention to gradually force a more efficient use of a scarce resource. In the Duero draft river basin plan (CHD, 2010) increased reductions in water demand will be introduced gradually as a future target. Users will have to introduce water efficiency targets to meet future reduced allocated demand in the river basin plan (Water planning chief B River basin authority, personal communication; Technical Director Water Authority, personal communication). Meanwhile in the case of the Jucar basin, in the *Acequia Real de Jucar*, it is foreseen that under the draft Jucar river basin plan, water rights will be adjusted from 392 Mm^3 to 212 Mm^3 for the whole irrigation system (Water planning chief River basin authority, personal communication; Secretary General National Irrigators Association, personal communication). This is important because it has been a negotiated and agreed change between river basin authorities and farmers without compensation for rights lost. As stated in Spanish water law, a water concession which is not used in the most efficient manner can see the water right automatically reduced (Ex-water director for regional water agency, personal communication). In summary under the EU WFD and river basin plans overall water allocation is going to be reviewed, and demand per unit will be identified and specified in the norms for each river basin plan, which eventually could become legally binding and where water savings could become part of the Programme of

[21] Water rights were granted collectively to the irrigation community who then set up a *Follow up commission* with the state investment company in irrigation modernisation, who acts as mediator with the water authority, introducing an element of both flexibility in water use and also of control (President State Irrigation Investment company, personal communication; Saiz Romero and Ajo Villagra, 2003).

[22] Art. 9 "The water savings generated can be used to consolidate the existing irrigated area or the irrigation guarantee, and meeting environmental needs in the area considered and the improvement to the reliability of public water supply".

Measures in river basin plans (Technical Director Water Authority, personal communication; Deputy Water Comissariat, River basin authority, personal communication).

However, in order to fulfil this planning goal, it is necessary that the difficulties internally on the part of water authorities to obtain disaggregated data on water savings achieved by completed modernisation programmes are addressed. As stated by one interviewee: the agricultural and the water departments remain disconnected systems, and there is room for the water administration to engage in the irrigation modernisation process.

The issue of water rights in Spain has become one the most controversial issues in relation to water savings from national irrigation modernisation programmes. In the general study undertaken by AEVAL on indicators – as identified by Barbero (2008b) which could be linked to performance indicators (Pereira et al., this volume), it is difficult to reach definite conclusions except that more data and analysis is needed on whether actual water savings i.e. a reduction in water withdrawals have been achieved, in order to evaluate the NIP 2008 and SP 2006. This requires in depth case by case studies of projects undertaken, and could be conducted within the framework of river basin planning required under Spanish water law and the EU Water Framework Directive. It could also be linked to evaluating the cost effectiveness of the measures introduced (Deputy Water Comissariat, River basin authority, personal communication). The study presented in this special issue on the Fergana and water accounting could provide an applicable framework (Molden and Sakthivadivel, 1999; Karimov et al., this volume; Ward and Pulido-Vazquez, 2008). In addition, increasing the transparency in the traceability of water use in terms of origin would substantially increase effectiveness, forward planning and joint management of water resources (Gil Meseguer, 2010). There are other voices however, that argue that there are other factors in efficiency that go beyond "new" water and water savings (Gleick et al., 2011).

10. Water, energy and unanticipated consequences

A very positive unintended consequence (and co-benefits) of the modernisation programme identified by a number of interviewees is the reduction in pollution due to the onset of collective fertirrigation, whereby farmers irrigate and apply nutrients at the same time in a much more efficient manner. This has a clear positive externality in the reduced pollution to streams and aquifers since lower doses of agro-chemicals are applied, whilst costs are also reduced by half (e.g. from 300–400€/ha to 200€/ha) (Secretary General National Irrigators Association, personal communication; Ex-water director for regional water agency, personal communication; Technical Director Water Authority, personal communication). However one, if not the most important unintended consequences of the modernisation programme, is related to the water-energy nexus. In the year 2008, after a process of energy liberalisation which started in 2007, and just when the NIP 2008 was coming to an end, the preferential binomial tariffs, the so called tariff "R" were removed. Interviewees commented on an increase in prices of between 50% and 80%. Whereas the cost of water per ha was estimated at 80–100€/ha, the costs of energy was around 200–300€/ha, that is the irrigation communities are now paying three times the cost of water in energy costs (Ex-water director for regional water agency, personal communication). According to Head of the Agricultural Public Investment company (personal communication) on average there has been a drop in 30% water use at plot level due to modernisation, and for farmers this lower water use compensates for the increase in energy prices. This water/energy nexus is being considered for future projects which are hoping to integrate renewable energy into modernisation projects. The result has been that farmers now have a stronger incentive to be more efficient in water use because of the associated energy costs of using additional water resources (Ex-General Secretary for Irrigation, personal communication). For example, in the current draft Plan[23] that would represent the continuation (or third stage) of Irrigation Modernisation, energy efficiency is considered as a key priority. To access public subsidies from both regional government and the State, it will be a prerequisite to undergo beforehand energy audits (IDAE, 2008 quoted in Hardy and Garrido, 2010).

However the main conclusion regarding the modernisation of irrigation in Spain relates to the drivers to irrigate, and in the case of Spain, this is deeply influenced both by the EU Common Agricultural Policy and market prices. Ten years ago due to the price support mechanism there was an incentive to produce where the Common Agricultural Policy was instrumental in the decision on whether to irrigate or not certain crops, which drove water use to around 7500 m^3/ha. Now as a result of the modernisation programme, this has reduced to 5500 m^3/ha. Although there are other important factors in the equation, like the cost of labour and the rise in the costs of energy, changes in the CAP subsidy structure has meant that overall farmers (who now can plan better due to modern infrastructure), will opt to use less water and/or irrigate less land due to reduced CAP subsidies, which are decoupled from production. However and most important the same farmer will also reduce risk (Gil Meseguer, 2010) by diversifying into other crops (sometimes more water demanding per ha) and which are more profitable (e.g. fruit trees). This translates in less interest in irrigated crops supported by the CAP (Ex-irrigation secretary, personal communication) and an increased interest in high value crops and increased water productivity. A telling example on the impact of the modernisation programme is the case of Andalusia (Geography academic professor, personal communication). In Andalusia 350,000 ha have been modernised out of a total irrigated area in the region of 800,000 ha, and where there has been an average drop of 15% water use per ha, i.e. equivalent to 435 Mm^3 at plot level, and around 260 Mm^3 at basin level, i.e. a total efficiency of around 60%, with an investment of 6.3€/m^3 (Ex-water Director Regional Water Agency, personal communication). What is most relevant at an aggregate level is that, despite an increase in irrigated area of around 30% since 2002, and despite a very serious drought in 2005 and 2006, modernisation enabled farmers to irrigate; what is a fallacy is that water savings at basin level freed up water for public water supply or instream river flows (Ex-water director for regional water agency, personal communication) (Plate 1).

11. From hegemonic irrigation to complex irrigation systems

We might also ask whether there are a limits to efficiency and the benefits of modernisation, in line with the cases from Boelens and Vos (this volume). Many traditional irrigated areas in Spain like the Albufera de Valencia (see Plate 2) and the Delta del Ebro partly relied on large irrigation returns which eventually made their way downstream for their re-use. The move towards hyper-efficient systems combined with increased areas under command, means that irrigation returns no longer reach deltas, and according to Hardy and Garrido (2010) "inefficient irrigation upstream in the basin must be considered as rain for the downstream areas" (p. 106). It is estimated for example e.g. that in the case of the *Albufera of Valencia*, a natural park, there has been a drop from 1000 Mm^3 to 300 Mm^3 in the irrigation returns that reach the delta (Secretary General National Irrigators Association, personal communication)

[23] National Strategy for the Sustainable Modernisation of Irrigation-Horizon 2015 (Estrategia Nacional para la Modernización Sostenible de los regadíos-Horizonte 2015).

Plate 1. Hagar project.
Source: WWF/Spain in Fernández Lop et al. (2007).

Plate 2. The Albufera of Valencia.
Source: Miguel Mondria.

(see Plate 2). Equally, some areas around the Alpujarras (Geography academic professor, personal communication) and the Vega of Granada (Agric. Economics Professor A, personal communication), which date back to the Muslim period, are not modernised due to their heritage and environmental added value. This is also the case in the *Vega del Segura* (Geography academic professor, personal communication) considered part of the Spanish hydraulic heritage (Gil Meseguer, 2010). Less conspicuous but also equally relevant is the dramatic shift in social norms in relation to the collective management of irrigation and the more than 7000 irrigation communities registered and dotted all around the Spanish territory (Secretary General National Irrigators Association, personal communication). The emphasis is on the value of collective action and irrigation practices (Boelens and Vos, this volume), where there are some arguments that when one triggers behavioural change (Rodriguez-Diaz et al., 2004), traditional systems can also be efficient, and that flood or sprinkler systems can obtain fairly high levels of efficiency. There is also an awareness towards valuing other environmental services provided e.g. by "inefficient" flood irrigation systems where "wasted water" is perceived as an asset and main source for e.g. aquifer recharge. This is the case for example of irrigation in the Llobregat area, where farmers generate very effective aquifer recharge at no cost for the administration (Academic Professor of Hydrogeology, personal communication), and are considered a strategic and low cost resource during times of drought, to help increase the resilience to climate extremes like floods and droughts.

Table 11
Summary on Irrigation Modernisation Programmes in Spain (2002–2010).

	Quantitative evaluation					Qualitative evaluation		
	Intended budget (million euros)	Actual expenditure (million euros)	Area (ha)	Theoretical water savings (Mm^3)	Real water savings	Original policy intentions	Outcomes	
							Positive	Negative
National Irrigation Plan 2008	5024.57	–	1,134,000	2100	Not measured	To modernise irrigation infrastructure To prevent abandonment of rural areas To prepare for drought	Improved Quality of life for farmers Less diffuse pollution Potential Monitoring of water use Possibility for crop planning and diversifying	Farmer indebtness Less resilience to drought High associated energy costs
Shock Plan 2006	2344.00	2680.00	870,000	1162 or 1420	Not measured			
Results	7368	–	2,004,000	3262	Unknown			
	Unitary investment (euros/ha)		**Unitary water savings (m^3/ha)**		**Investment per m^3 (euros/m^3)**			
National irrigation Plan 2008	4430.83		1851.8		2.39			
Shock Plan 2006	2694.25		1335.6		2.01			
Overall average	3676.64		1627.7		2.25			

Meanwhile on the other end of the spectrum there is dramatic change in highly technical irrigation along the Mediterranean coast, which might mean that in the future like Campo de Dalias, that there is a shift from a *regador*; "a face, a person, an organisation, a President, an *acequiero*, a *relojero*... towards an IT technician. You lose the personal touch yet ...this is the 21st century, everytime you make a choice you also give up something" (Secretary General National Irrigators Association, personal communication). The future might bring a highly technical irrigation, which combines deficit irrigation[24] (Fereres and Soriano, 2007; Hardy and Garrido, 2010), soil or root moisture measuring with sensors (Knox et al., this volume), ferti-irrigation, and demand irrigation with efficient technologies, possibly in the future powered by renewable energy sources. This represents a more industrialised and professional agriculture, representing a new technological frontier in irrigation (Agric. Economics academic professor, personal communication; Agric. Economics Professor A, personal communication; Head Agricultural Public Investment company, personal communication) (Plate 1).

The missing debate is whether some irrigated areas should revert to rainfed agriculture with some farms under supplementary irrigation, thus making more use of the green water available, and seeking joint use between green and blue water, along the green to blue water spectrum (Vidal et al., 2009). Also missing is a discussion on whether to integrate energy use and a full life cycle analysis, combining a joint examination of efficiencies in water and energy use. In institutional terms, changes are likely to occur in collective management institutions, on the one hand, preserving the way of life and traditional irrigation communities whilst at the same time acknowledging an evolution towards larger management units, less atomised, and ideally larger than 500 ha, productive and technified (Secretary General National Irrigators Association, personal communication).[25] This forces a shift away from irrigation as a black box, towards a more nuanced view on irrigation as a complex system which generates positive externalities like e.g. aquifer recharge, or a more sophisticated interplay between green and blue water through better land use planning.

12. Conclusion

In the 1990s wasting water in irrigation was bad for the public image of agriculture and for irrigation as a key dominant water user in Spain, when cities experienced restrictions, while fields continued to be irrigated. Ten years later, despite a more prolonged and severe drought than the one in the mid 1990s, no restrictions were introduced. According to the representative of the irrigation associations of Spain, this is both tribute and evidence on the success of the irrigation modernisation programme, and a water use reduction in irrigation of 12% due to the modernisation of irrigation techniques at basin level for the whole of Spain (OECD, 2010). However other voices are also engaging in the debate on the future and logic of irrigation. Some sectors demand that water flows again in rivers and that water is preserved for other sectors, as required in a modern society, to reduce the pressure on aquatic systems.[26]

As one of the interviewees stated "Spanish water policy is (synonymous) with irrigation policy" (Ex-water Director Regional Water Agency, personal communication). This has been largely the result and consequence of history and a privileged position of agriculture (and irrigation) in Spain in relation to water use. However in a modern country where only 4% of the population is directly employed in agriculture and a great portion of it is aged, there is a new dichotomy (Ex-secretary of State, personal communication) since this co-exists with a highly dynamic, entrepreneurial agribusiness sector thriving despite or because of the current economic crisis. This dichotomy forces a re-think on the logic for irrigation in Spain as a mature water economy, and where the Spain of the 20th century bears little resemblance to the Spain of the 21st century. Yet discourse on irrigation in Spain is still imprinted by its historical past, whereas before the focus and concern was over hunger, in inland and Mediterranean regions, this has now been re-vitalised as the need to irrigate and address global hunger, with Spain having to secure a level of self sufficiency due to the volatility of food prices whilst also playing a role as an actor on global food security through farm trade and virtual water (Ex-irrigation secretary, personal communication; Garrido et al., 2010). Equally the so called "permanent drought" has now been converted to a concern over climate change, and how to solve structural water deficits[27] which could be made worse due to Spain's location in a climate change hotspot. In a new understanding on the concept of structural water deficit there is a new push to define it objectively, i.e. as the difference between the current demand and existing resources, and where in some regions and areas there has been a larger imbalance between available resources and current demand, and where in some cases the negotiated solution might be to gradually reduce demand like in the case of Australia.

One of the upcoming questions in Spain after a public investment programme only considering the state investment of 7 billion € over the last decade on irrigation modernisation,[28] is to establish the logic and parameters for irrigation modernisation. As was analysed in this paper, water savings are not equivalent necessarily to water conservation. This public initiative on efficiency did not assess and/or differentiate between "wet" and "dry" gains made (Seckler et al., 2003). This, as discussed in other papers in this special issue, depends very much on the scale of analysis. This paper argues that a focus on water savings has to be complemented by water accounting methods, within a range of different policy measures. The ideal policy mix has to be designed to fit different circumstances, i.e. technological irrigation efficiency is one option, but there are others incentives and measures that can be applied; water tariffs (OECD, 2010); water quotas; restrictions on water licenses or conditional water licenses (Knox et al., this volume); and crop switching to less water consumptive crops, where there are a variety of indicators and accounting methods that also take into consideration farmer welfare and water productivity (Molden and Sakthivadivel, 1999).

Probably the most important question underpinning this paper is centred on the future and type of agriculture (and irrigated agriculture in particular for a semi-arid country). For example, a number of interviewees made reference to agriculture where there was space for the co-existence of systems of high ecological value, or towards high quality products where irrigation focuses on quality rather than yield (Knox et al., this volume), or as a multifunctional agriculture (Wilson, 2010; Gil Meseguer, 2010). In the case of the NIP 2008 and the SP 2006, there were no pre-defined criteria in the allocation of funding for modernisation projects, although it existed indirectly in the funding allocated (Head Agricultural

[24] I.e. application of water to the plant at the time when it will generate most benefit.

[25] In the current modernisation programme the unit of action is the irrigation community, in the future maybe it should be on the basis of the water management unit, so that the overall efficiency of the system (e.g. in terms of energy and water) can be considered like in the Segre irrigation area.

[26] That is "rivers also need water" (Alagh, 2009 as quoted in Baghel and Nusser, 2010).

[27] Some areas particularly in the highly productive Mediterranean belt are portrayed as having a water deficit, so called "structural water deficit", which justifies and legitimises the drive towards transferring water from other "water rich" regions.

[28] A higher figure with the addition of parallel regional irrigation modernisation programmes.

Public Investment company, personal communication).[29] A debate is pending at the national or even regional level on the productivity and viability in social, hydrological and environmental terms of future irrigation modernisation processes.

A number of experts increasingly refer to the need to talk about irrigation in a more nuanced manner, distinguishing different type of irrigation areas, and where a prognosis for the future would be greatly conditioned by geographical location and characteristics.[30] Framed by political ecology and a deepening economic crisis, there is a parallel debate in Spain over subsidies and over major public investment programmes in irrigation (Calatrava and Garrido, 2010; NGO environmental expert, personal communication). These are linked with discussions on cost recovery in the EU Water Framework Directive and the cost effectiveness of programmes of measures to comply with regulatory requirements under the Directive. Questions are being posed on territorial cohesion within regions (Ex-secretary of State, personal communication) and debates on the reform of the CAP under Pillars 1 and 2 and the weight of funding given to both pillars, which an increased expectation of a more even balance between the two pillars and a "greening" of the CAP (Geography academic professor, personal communication; Ex-irrigation secretary, personal communication; NGO expert, personal communication). Rural development does not have to be a synonymous with irrigated agriculture, but rather seek a more diversified and integrated economic balance between sectors (e.g. renewable energy and solar farms, rural tourism, etc.) (Deputy Water Comissariat, River basin authority, personal communication).

The nation's agriculture is currently at a crossroads of two external policies; the reform of the Common Agricultural Policy and compliance with the EU Water Framework Directive both deeply interconnected in a semi-arid country like Spain. Agriculture (and irrigated agriculture in particular) has a strong role and voice in Spanish water policy. This requires however – as yet missing – a careful analysis *ex post* of a large investment programme. In terms of investment, irrigation modernisation has represented a large public investment programme, 5€/m^3[31] for "saved" water. What is clear however after the analysis of available data and expert interviews, is that – in order to evaluate whether irrigation modernisation has represented a shift in policy towards demand management – there has to be an *ex post* in-depth evaluation and analysis of the social, environmental and economic benefits of the SP 2006 and the NIP 2008 (Table 11).[32]

This should analyse both water efficiency and productivity, while separating the different threads in the debate; technology; incentives; rural development, productive and competitive agriculture, rural population and agro-ecological systems of high natural value. It is important however to stress that at present the lack of hydrological studies at the basin level precludes reaching any firm conclusions about the magnitude of the real basin-level water savings brought about by irrigation modernisation in Spain. Ironically it is the unexpected impact of a parallel policy, energy liberalisation, that has opened a new space for decision making in Spain.

Acknowledgments

Thanks to all the people interviewed in the preparation of this paper for their time, and expertise. Thanks also to Beatriz Mayor (University of Wageningen) for her help in the preparation of some of these tables and for help with fieldwork.

References

AEVAL, 2010. Evaluación de la gestión y funcionamiento de las Confederaciones Hidrograficas. Agencia de Evaluación y Calidad, Ministerio de la Presidencia, Madrid.

Agric. Economics professor A, personal communication. Associate Professor of Agricultural Economics and Policy and Rural Sociology, Technical University of Cartagena, January 2011.

Agric. Economics academic professor, personal communication. Professor of Agricultural Economics, UPM, Madrid, January 2011.

Alagh, Y.K., 2009. Drained of all sense. *Indian Express* (May 2 Editorial).

Allan, T., 2010. Prioritising the processes beyond the water sector that will secure water for society – farmers in political, economic, and social contexts and fair international trade. In: Martinez-Cortina, L., Garrido, A., Lopez-Gunn, E. (Eds.), Re-thinking Water and Food Security. Taylor and Francis, London. Available from: http://www.fundacionbotin.org/fbwater-workshop-40september-200941-8216re45thinking-water-and-food-security8217-seminarios-internacionales_fundacion-botin-areas-de-actividad_observatorio-de-tendencias-8691267687.htm (Chapter 6).

Baghel, R., Nusser, M., 2010. Discussing large dams in Asia after the World Commission on Dams: is a political ecology approach the way forward? Water Alternatives 3 (2), 231–248.

Barbero, A., 2005. La financiación de la modernización y transformación del regadío. Vida Rural (15th October), pp. 34–35.

Barbero, A., 2006. The Spanish National Irrigation Plan. In: OECD Workshop on Agriculture and Water: Sustainability, Markets and Policies Session 5 – Institutions and Policies for Agricultural Water Governance, 14–18 November 2005, Australia.

Barbero, A., 2008a. Las perspectivas del regadío en España en los comienzos del Siglo XXI. Ambiental (July–August), pp. 49–52.

Barbero, A., 2008b. El programa de vigilancia ambiental del PNR: seguimiento de la sostenibilidad del regadío. CONAMA Congreso Nacional de Medio Ambiente, Comunicación técnica, Madrid.

Berbel, J., Gutiérrez, C., 2004. I Informe sobre la Sostenibilidad del Regadío. Edita Feragua.

Boelens, R., Vos, J., this volume. The danger of naturalizing water policy concepts: water productivity and efficiency discourses from field irrigation to virtual water trade. Journal of Agricultural Water Management.

BOJA, 2009. ORDEN de 28 de julio de 2009, por la que se establecen las bases reguladoras para la concesión de subvenciones para la mejora de los regadíos en Andalucía, en el marco del Programa de Desarrollo Rural de Andalucía 2007–2013, y se efectúa su convocatoria para el 2009. BOJA No. 152 Sevilla, 6 August 2009, p. 6.

BOJA, 2010. ORDEN de 21 de julio de 2010, por la que se modifica la de 28 de julio de 2009, por la que se establecen las bases reguladoras para la concesión de subvenciones para la mejora de los regadíos en Andalucía, en el marco del Programa de Desarrollo Rural de Andalucía Sevilla, 27 July 2010 BOJA núm. 146, p. 7.

Calatrava, J., Garrido, A., 2010. Measuring Irrigation Subsidies in Spain: An Application of the GSI Method for Quantifying Subsidies. International Institute for Sustainable Development (IISD), Geneva, Switzerland.

Camacho Poyato, E., 2005. Análisis de la eficiencia y el ahorro del agua en el regadío de la cuenca del Guadalquivir. Agricultura: Revista agropecuaria, No. 880, pp. 880–887.

[29] This contrasts for example with the case of modernisation subsidies in Andalusia, which specified criteria to be able to benefit from subsidies for modernisation programmes (Ex-water director for regional water agency, personal communication) (BOJA, 2009, 2010).

[30] For example, to distinguish between humid Spain, the northern plateau, the olive and vine areas of southern Spain, the whole Guadalquivir basin and Mediterranean Spain (Ramos and Gallardo, 1999; Agric. Economics academic professor, personal communication). This can be seen for example in the analysis undertaken for Andalusia by Rodriguez-Diaz et al. (2004).

[31] Some interviewees pointed out that, in some specific cases (e.g. the rice fields in the Marismas del Guadalquivir), it might have been more efficient to purchase the land (2–3€/m^3). One option that could be considered is to insert more traceability between usersĩ water savings and payment, as is the case in Australia, where Melbourne city paid for farm modernisation in exchange for 1/3 of the water "saved" (Schneider, 2009).

[32] To give a general estimation of the improvement in classical efficiency (beneficial crop transpiration/withdrawal) or effective efficiency (beneficial crop transpiration/consumption or depletion) (Lankford, 2008) brought by the modernisation plan is difficult. This is motivated by the fact that in many cases no measurements of actual crop transpiration in the fields before and after the implementation of the plans were made. Nevertheless, these parameters are not very good indicators of the gainings made in modernisation. Because each one of the different types of modernisation works (change of irrigation system, e.g. from surface to drip irrigation; renewal of the pipeline system "en alta"; building of storage ponds, introduction of telecontrol systems, etc.) had a different effect over "efficiency": reducing water withdrawal, reducing water losses on the way, increasing water storage capacity, or just improving the capacity for controlling the amount and timing of irrigation. There is also a reduction of water evaporation (non beneficial consumption) as a result of the substitution of open irrigation channels for close pipelines which is not reflected by these indicators.

CESA, 2010. Informe sobre la situación económica y social de Aragón. Consejo Económico y Social de Aragón.

CHD, 2010. Propuesta de Proyecto de Plan Hidrológico del Duero: Memoria y Normativa (Borrador para consulta pública), 15th December.

Corominas, J., 2009. Agua y energía en el riego en la época de la sostenibilidad Comunicaciones de los invitados especiales. Jornadas de Ingeniería del Agua, 27th and 28th October, Madrid.

Defensor del Pueblo, 2009. Agua y ordenación del territorio (May).

Deputy Water Comissariat River basin authority, personal communication. Deputy Water Commissariat Duero River Basin Authority, January 2011.

Diaz Eimil, C., 2001. La modernizacion del regadio a traves de las SEIASAS. Agricultura, pp. 244–247.

Environmental NGO, personal communication. WWF Spain, Madrid, January 2011.

Environmental NGO, personal communication. WWF Spain Rural Development Coordinators, January 2011.

Ex-general Secretary for Irrigation, Ministry of Agriculture, Spain, January 2011.

Ex-secretary of State, personal communication. Ex-Deputy Minister for Land Use Planning, Ministry of Environment (2004–2008), currently FUNDICOT, Madrid, January 2011.

Ex-water Director, Regional Water Agency, personal communication. Andalusian Water Agency, currently Agriculture Department, Junta de Andalucia (Andalusian regional government), January 2011.

Fereres, E., Soriano, M.A., 2007. Deficit irrigation for reducing agricultural water use. Journal of Experimental Botany 58 (2), 147–159 (Special Issue Integrated Approaches to Sustain and Improve Plant Production under Drought Stress).

Fernández Lop, F., Peiteado, C., Schmidt, G., Fuentelsaz, F., 2007. Irrigation water saving in overexploited systems. Summary and results on LIFE Project HAGAR (2001–2005). Efficient water use in agriculture in Central Spain. WWF/Adena, Spain.

Garrido, A., Llamas, R., Varela Ortega, C., Novo, P., Rodríguez-Casado, R., Aldaya, M.M., 2010. Water Footprint and Virtual Water Trade in Spain: Policy Implications. Springer, New York.

Geography academic professor, personal communication. Professor of Human Geography, University of Seville, and Founding member New Water Culture Foundation, Spain, January 2011.

Gil Meseguer, E., 2010. La región de Murcia. Un laboratorio de experiencias de ahorro y eficiencia en el uso del agua: la modernización de sus regadíos, entre las políticas agraria y ambiental de la Unión Europea, unpublished.

Gleick, P., Christian-Smith, J., Cooley, H., 2011. Water-use efficiency and productivity: rethinking the basin approach. Water International 36 (7), 784–798 (Special Issue: Keeping the cutting edge sharp: the IWRA 40th anniversary issue).

Hardy, L., Garrido, A., 2010. Análisis y Evaluación de las relaciones entre el agua y la energía. Papeles de Agua Virtual No 6. Available from: www.fundacionmbotin.org/agua.htm.

Head Agricultural Public Investment company M., personal communication. Coordinator Spanish SEIASA, Head of the SEIASA, South and East, Spain, January 2011.

Instituto para la Diversificación y Ahorro de la Energía (IDAE), 2008. Ahorro y eficiencia energética en la agricultura. Secretaria General de Energía del Ministerio de Industria, Tursimo y comercio, Madrid.

Junta de Andalucía, 2010a. Agenda del regadío andaluz H-2015, Seville.

Junta de Andalucía, 2010b. Inventario de regadíos y su evolución en la última década9 Noviembre, Consejeria de Agricultura y Pesca.

Karimov, A., Molden, D., Khamzina, A., Platonov, A., Ivanov, Y., this volume. The water saving potential of the Fergana valley. Journal of Agricultural Water Management.

Knox, J.W., Kay, M.G., Weatherhead, E.K., this volume. Water regulation, crop production, and agricultural 1 water management – understanding farmer perspectives on irrigation efficiency. Agricultural Water Management.

Lankford, B., 2008. 'Towards a political ecology of irrigation efficiency and productivity' presentation made at towards a political ecology of irrigation and water use efficiency and productivity, Thursday 6 November 2008. Institution of Civil Engineering, London.

Lankford, B., 2011. Fictions, fractions, factorials, fractures and fractals: on the framing of irrigation efficiency. Journal of Agricultural Water Management 108c, 27–38.

Lopez, A., 2006. Plan de Cuoque 2006–2007 para agilizar la modernización de los regadíos. Vida Rural (1st of April), p. 10.

Lopez-Gunn, E., 2009. Agua para todos: a new regionalist hydraulic paradigm in Spain. Water Alternatives 2 (3), 370–394.

Maestu, J., Gómez, C.M., 2010. Water uses in transition. In: Garrido, A., Llamas, M. (Eds.), Water Policy in Spain. CRC Press.

MAPA, 2001. Plan Nacional de Regadíos Horizonte 2008, Madrid.

Ministerio de Medio Ambiente, Rural y Marino (MARM), 2009. Encuesta sobre superficies y rendimientos de cultivo (ESYRCE).

Ministerio de Medio Ambiente, Rural y Marino (MARM), 2010. Estrategia nacional para la modernización sostenible de los regadíos Horizonte 2015, July 2010.

Molden, D., Sakthivadivel, R., 1999. Water accounting to assess use and productivity of water. Water Resources Development 15, 55–71.

Molle, F., Turral, H., 2004. Demand management in a basin perspective: is the potential for water saving overestimated? International Water Demand Management Conference, Dead Sea, Jordan.

OECD, 2010. Economic Surveys: Spain, December 2010. OECD, Paris.

Pereira, L., Cordery, I., Iacovides, I., this volume. Performance indicators to support a new paradigm in efficient water use and productivity, particularly for irrigation. Journal of Agricultural Water Management.

Perry, C., 2007. Efficient irrigation; inefficient communication; flawed recommendations. Irrigation and Drainage 56, 367–378.

Pindado, P., 2005. The Spanish Programme of Improvement and Modernization of Traditional Irrigation Systems.

Polimeni, J.M., Mayumi, K., Giampietro, M., Alcott, B., 2008. The Jevons Paradox and the Myth of Resource Efficiency Improvements. Earthscan, London.

Professor of Hydrogeology, personal communication. UPC, Barcelona, January 2011.

Ramos, E., Gallardo, R., 1999. Disparidades de la agricultura española ante la modernización y las nuevas funciones del territorio. Revista de Estudios Regionales 54, 17–45.

Rodriguez-Diaz, J.A., Camacho-Poyato, E., Lopez-Luque, R., 2004. Application of data envelopment analysis to studies of irrigation efficiency in Andalusia. Journal of Irrigation and drainage engineering (May–June), 175–183.

Rodríguez, R., Peiteado, C., 2011. Modernización de regadíos y Directiva Marco de Agua, ¿dónde va el agua ahorrada? WWF España, VII Congreso Ibérico sobre gestión y planificación del agua "Ríos Ibéricos +10. Mirando al futuro tras 10 años de DMA", 16/19 de febrero de 2011, Talavera de la Reina, Spain.

Rubio de Villanueva, T., 1997. Plan Nacional de Regadios: la racionalizacion del usos del agua se convierte en uno de los objetivos que debe lograr. Sup. Vida Rural No. 41, 913 (15th March).

Saiz Romero, M., Ajo Villagra, M., 2003. El programa de consolidación y mejora y las SEIASAs. Agricultura, 605–614.

Schneider, K., 2009. Here's something new in Australia: a plan that takes water from agriculture. http://www.circleofblue.org/waternews/2009/world/agriculture-water-policy-australia/.

Seckler, D., Molden, D., Sakthivadivel, R., 2003. The concept of efficiency in water-resources management and policy. In: Kijne, J., Barker, R., Molden, D. (Eds.), Water Productivity in Agriculture: Limits and Opportunities for Improvement.

Secretary General National Irrigators Association, personal communication. Secretary FENACORE (Spanish irrigation Communities association) and also general Secretary Acequia real del Jucar, Valencia, January 2011.

Technical Director, Jucar Water Authority Technical Director Water Authority, personal communication, ex-Water Planning Deputy Director, Ministry of Environment. Spain, January 2011.

Varela-Ortega, C., 2006. Socio economic institutional and policy considerations for irrigation modernization. In: International Symposium on Irrigation Modernization: Constraints and Solutions. FAO-IPTRID-NOSSTIA. University of Damascus, Damascus, Syria, 28–31st March.

Vidal, A., van Koppen, B., Blake, D., 2009. The green-to-blue water continuum: an approach to improve agricultural systems' resilience to water scarcity. On the Water Front, pp. 66–72.

Ward, F., Pulido-Vazquez, M., 2008. Water conservation in irrigation can increase water use. PNAS 105 (47), 18215–18220.

Water planning chief River basin authority, personal communication. Jucar River Basin Authority, Spain, January 2011.

Water planning chief B River basin authority, personal communication. Duero River Basin Authority, January 2011.

Wilson, G., 2010. Multifunctional 'quality' and rural community resilience. Transactions Institute of British Geographers 35, 364–381.