14 Policy-driven Determinants of Irrigation Development and Environmental Sustainability: A Case Study in Spain

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Introduction: Water Use and Agricultural Policies

Objective and contents of the chapter

This chapter analyses the role that water and agricultural policies play in the evolution of irrigated agriculture and water use and, as a consequence, on the conservation of aquatic ecosystems. Using an illustrative case study from central Spain, the chapter focuses on the joint impacts of the implementation of agricultural policies (the EU Common Agricultural Policy, or CAP) and water conservation policies (both European and national) on the development of irrigated agriculture, groundwater abstraction, and the conservation of depleted aquifers and associated wetlands. The chapter is divided into three sections. The first introductory section provides a general picture of how water policies and agricultural polices have determined to a great extent water consumption trends in the Mediterranean countries of the EU. A subsection illustrates how groundwater use for irrigation has been determined by the evolution of policy programmes in the region of Castilla-La Mancha of Spain's southern central plateau, introducing the case study. The second section examines the specific agricultural polices and water policies that have been successively applied in the area of study. Special attention is given to analysing the capacity of these polices to respond to the societal needs of socio-economic development and ecosystem conservation as well as to the comparative cost-effectiveness of the different public policy programmes. A subsection compares the impact of these policies with the alternative mechanism of water pricing. The third section includes some concluding reflections.

Evolution of water use and irrigated agriculture

The evolution of irrigated agriculture in the Mediterranean countries as in other countries worldwide has been determined by policies that relied to a great extent on technical solutions for water supply enhancement. Publicly funded large water infrastructures resulted in water deliveries at subsidized costs, increasing the burden on the public budget and leading to environmental damage (Rosegrant *et al.*, 2002; Benoit and Comeau, 2005).

In contrast to the one-sided water supply paradigm of the past, public authorities in many countries in the world are now confronted with the challenge of elaborating demand-side, integrated, and cost-effective water management policies. These policies will have to be designed and enforced to address the dual aims of achieving a more efficient use of water among sectors and social groups while ensuring the sustainability of water resources. The increasing incorporation of economic, social and institutional aspects, as well as public participation and the involvement of stakeholders, has proven to be effective for integrated water management and hence for food production, protection of water ecosystems and overall socio-economic development (Bromley, 2000; Rosegrant *et al*., 2002; Margat, 2004; Benoit and Comeau, 2005). The recently enacted EU Water Framework Directive (WFD), which is mandatory for all member states, is an example of new integrated water management policies (EU, 2000).

In the EU, agricultural policies have affected water consumption in irrigated agriculture, most acutely in the arid and semi-arid regions of southern Europe that extend along the Mediterranean littoral and its hinterland. During the 1980s and 1990s, the CAP encouraged expansion of irrigation in response to production-based subsidies with contradictory effects in many irrigated areas. On the one hand, irrigation expansion led to unquestionable socio-economic benefits to the rural areas concerned but, on the other, it generated negative externalities with clear detrimental consequences to aquatic ecosystems (Baldock *et al*., 2000; Varela-Ortega *et al*., 2002).

Over time, the CAP evolved with the aim of promoting a more balanced integration of the agriculture and environmental sectors by incorporating environmental objectives into agricultural policy programmes. The first initiative was the McSharry reform of 1992, which added to the CAP specific environmental programmes governed by explicit regulations. The subsequent reform of Agenda 2000 gave a new impulse to introducing agri-environmental instruments into the CAP regime by making access to production-related direct payments conditional upon compliance with certain environmental standards. This new system of cross-compliance became mandatory for all member states under the Luxembourg reform of 2003, which promotes a multifunctional sustainable agriculture with direct payments for specific programmes substituted by a single farm payment fully decoupled from crop production.

The effect of the new CAP regime on irrigated agriculture (the implementation of which started in 2005) remains uncertain though several studies have underlined the potential of the new instruments for achieving compatibility between agricultural production and water resources conservation (Petersen and Shaw, 2000; Varela-Ortega *et al*., 2002; Brouwer *et al*., 2003). In particular, it can be expected that in many areas in Spain and in other member states, the decoupled single farm payment (SFP) will induce a land use shift away from highly productive and heavily water-consuming crops (such as maize). As the SFP was calculated as the annual average of the total payments received by a given farm during a 3-year reference period (2000, 2001, 2002), these crops are losing their financial comparative advantage, since they no longer benefit from the high production-related subsidies of the previous CAP programmes. Moreover, the new CAP requires the application of cross-compliance schemes that protect the environment and natural resources. These also can be expected to have a substantial impact on irrigated crops and water use.

Agricultural policies are not, however, the only policies that affect irrigated agriculture. In Spain as elsewhere in the EU, the reformed CAP is being implemented in parallel with the WFD, which calls for the adoption of water pricing instruments that incorporate the principle of full cost recovery of water services. If rigorously implemented, the WFD could well call into question the viability of a substantial proportion of irrigated farms in some areas of Spain (certainly in less fertile regions) (Berbel and Gutiérrez, 2004; Gomez-Limón and Riesgo, 2004; Mejías *et al*., 2004; Varela-Ortega *et al*., 2006b; Garrido and Calatrava, 2007). How these two ongoing policies will interact in the varied regions of Spain, how they will affect water use, irrigated agriculture, land use patterns, the conservation of natural resources, and the socio-economic development of rural areas, are still being investigated and constitute a major concern for public authorities.

Irrigation development and groundwater use in Spain: a policy-driven response

Groundwater is a strategic source of water in arid and semi-arid regions that face uneven distribution of rainfall and recurrent drought spells, such as the Mediterranean region. The use of groundwater for irrigated agriculture has expanded in recent decades relative to the use of surface water due to its accessibility to many private irrigators, the low cost of the associated irrigation infrastructure, high farming profitability, and lower vulnerability to climatic vagaries. New technologies for well drilling, pump installation and improved knowledge of hydrology have allowed an increasing number of independent private irrigators to resort to groundwater for farming in a 'silent revolution' (Llamas and Martinez-Santos, 2006). As a result, irrigation expansion has induced important socio-economic developments in rural areas due not only to the increase in direct farming activity but also to the indirect effects of secondary irrigation-related activities. Irrigation development and the resulting increase in groundwater abstractions have, in turn, however, caused overexploitation of aquifers and the progressive degradation of associated wetland ecosystems of high ecological value.

Depletion of aquifers by intensive irrigation has occurred in several regions of great environmental value in Spain. A remarkable example can be found in the western part of the region of La Mancha, on the southern central plateau. In this area, past CAP programmes encouraged irrigation expansion with positive social effects, including an increase in farm incomes, the creation of employment opportunities, the development of irrigation-related firms, population stability and overall socio-economic development (Martinez Vega *et al.*, 1995). On the other hand, the CAP programme has led to the overexploitation of the western La Mancha aquifer and to the subsequent degradation of the associated wetland ecosystem of the nearby national park 'Tablas de Daimiel' (Rosell and Viladomiu, 1997; Varela-Ortega and Sumpsi, 1999). This policy contradiction is depicted in Fig. 14.1 and illustrates how agricultural policies and environmental policies need to have common and coherent objectives. With the aim of remedying this ecological impact, a special agri-environmental programme (AEP) was launched in 1993 under the CAP environmental regulation of 1992.

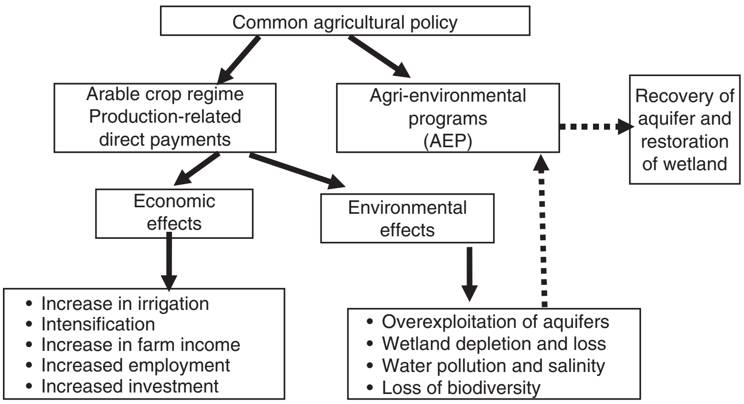

Fig. 14.1. A policy contradiction in the CAP agricultural and environmental programmes.

Irrigation Development and Environmental Sustainability: A Case Study in Spain

The unresolved controversy: groundwater irrigation or wetland conservation?

The wetland known as 'Tablas de Daimiel' in the western La Mancha region is unique and one of the most peculiar geomorphologic formations of the Spanish territory. The last example in Europe of a continental ecosystem known as a 'fluvial table', covering an area of about 2000 ha, this extraordinary wetland was formed by the overflow of the neighbouring rivers (Guadiana and Cigüela), its formation being favoured by the flat surrounding terrain and the high water table of the western La Mancha aquifer. The wetland is a unique habitat for the conservation of European and North African aquatic birds, with large populations of nesting and hibernating waterfowl and numerous species of aquatic flora and fauna. As a result, the wetland has attracted national as well as international recognition and has been registered under a number of national and international agreements, being made a UNESCO Biosphere reserve in 1981, a RAMSAR site in 1982 (Ramsar, 2006), a Special Protection Birds Area under the EU Birds Directive, and a Natura 2000 site under the Habitats Directive (Baldock *et al.*, 2000; MIMAM, 2006).

Over time, this fragile ecosystem has been progressively degraded as a result of excessive groundwater abstraction from the western La Mancha aquifer (Llamas *et al.*, 2001; CHG, 2006). The central aquifer covers an area of about 5000 km^2 and it had a surplus water balance up to the mid-1970s, before irrigation started to expand in the region. The expansion of irrigation has a clear policy-driven component. Figure 14.2 shows the evolution of water abstraction and irrigated area from 1985 to 2005. It also

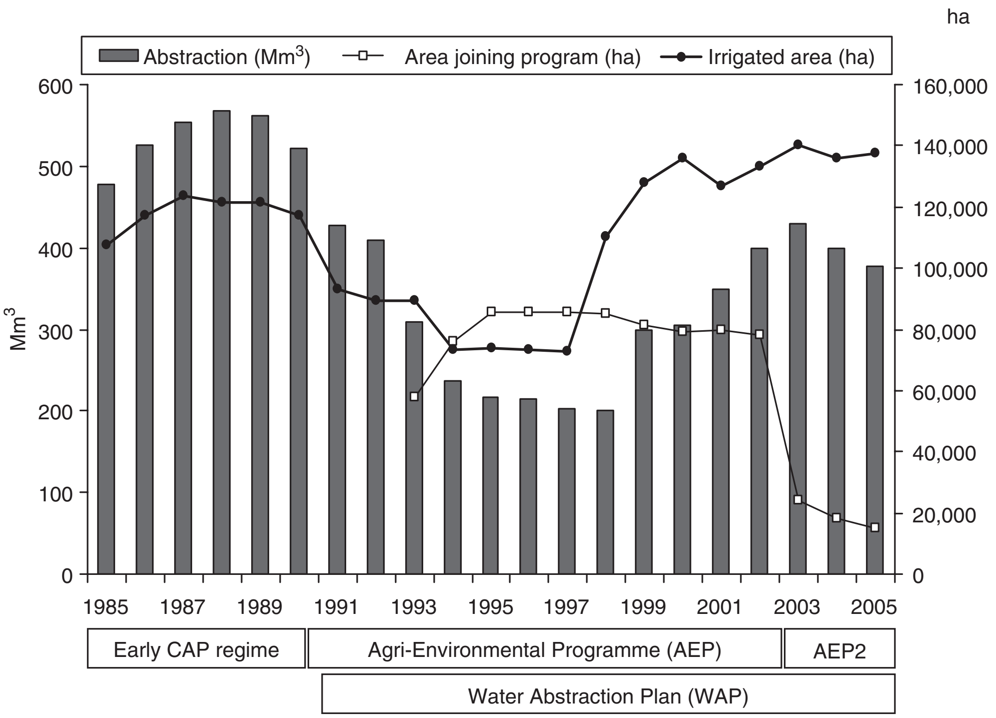

Fig. 14.2. Water abstractions, total irrigated surface and surface joining the AEP in the western La Mancha aquifer: 1985–2005. (From CHD (Confederación Hidrográfica del Guadiana) (2006) – JCC-LM (Junta de Comunidades de Castilla-La Mancha) (2006).)

shows the corresponding policy programmes that were applied during this period.

Following Spain's integration into the EC in 1986, the trend in irrigation expansion was reinforced. From the mid-1980s into the 1990s the intensity of well drilling and water abstraction by private irrigators increased considerably in response to the CAP subsidies. In the early 1990s, annual water abstractions rose to more than 500 Mm^3, greatly exceeding the natural recharge rate of the aquifer estimated at 230 Mm^3/year (CHG, 2006). As a consequence, return flows diminished considerably, the water table lowered and the aquifer was officially declared overexploited in 1991 (MOPTMA-CHG, 1995). The groundwater also suffered from salinization problems and contamination, while eutrophication of surface water produced changes in vegetation, peat fires, and a generalized decline of flooded lands that had devastating impacts on the local flora and fauna. Furthermore, the profitability of irrigated farming simultaneously diminished due to both the decrease in water availability and rising costs of deeper well drilling (Iglesias, 2001; Varela-Ortega *et al.*, 2002).

Two policies in the upper Guadiana basin: one objective and two instruments

The national policy

The official declaration that the western La Mancha aquifer was an 'overexploited aquifer' came about in 1991 and the River Basin Authority adopted a specific regulation that imposed a strict Water Abstraction Plan (WAP) (CHG, 2006) with the aim of restoring the overexploited aquifer. This regulation imposed strict water abstraction quotas on licensed wells and prevented the drilling of new ones. Maximum permitted water volumes were established according to farm size and crop type and, on average, the maximum allowable volume was set at 2000 m^3/ha, well below the preceding average water entitlement of around 4200 m^3/ha. Quotas were modified on an annual basis depending on climatic and demand conditions.[1]

Since the enactment of the 1985 Spanish Water Act, all water resources have been in the public domain, and irrigators have usufructuary water rights through administrative concessions granted by the Water Authority. Reflecting public ownership of the water, the WAP was defined by a water quota instrument and the farmers were not granted any compensation for the income foregone as a result of these compulsory measures. The water quotas were controlled either directly by water meters installed on-farm or – in most cases – indirectly by the crops grown by each individual farmer, making policy enforcement and control a difficult and costly exercise (MOPTMA-CHG, 1995). Moreover, 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. This behaviour is common to other areas in the world where subterranean water is the major source of water for irrigation farming (Provencher and Burt, 1994; Shah *et al.*, 2000; Varela-Ortega and Sagardoy, 2003; Schuyt, 2005; Llamas and Martinez-Santos, 2006). Farmers opposed the cropping restrictions and water use limitations, given the lucrative price and subsidy incentives provided under the CAP. In sum, this water conservation policy faced major implementation difficulties and high transaction costs, as is typical of other similar cases of environmental policies (Whitby *et al.*, 1998; McCann *et al.*, 2005).

The EU policy

Following the CAP reform of 1992, a special 5-year AEP was adopted for the area in 1993 with the objective of recovering the wetlands of the National Park by reducing water abstraction from the aquifer. This programme proceeded in parallel with the national WAP but

[1]For 2006, the established permitted water volumes were 2640 m^3/ha for farms under 30 ha, 2000 m^3/ha for farms between 30 and 80 ha, and 1200 m^3/ha for farms above 80 ha (vineyards were granted a special entitlement of 1000 m^3/ha) (CHG, 2006).

was voluntary and had a social component that granted income compensation payments to irrigators in return for reductions in their water use. The initial 5-year programme was extended for another 5 years (1993–1997 to 1998–2002). Three levels of water use reductions were established, namely a 50%, 70% and 100% reduction in the irrigators' original (fixed) water entitlements (not subject to WAP annual adjustments). These reductions corresponded to three levels of income compensation payments, respectively (see Table 14.1). Thus, the policy instrument used for attaining the policy objective was a combination of voluntary water quotas and an income compensation scheme.

The overwhelming majority of farmers in the area joined the first AEP. By 1997 close to 90% of the total 120,000 ha of irrigated lands came under this programme and annual water abstractions were reduced by 60% or about 300 Mm^3, greatly exceeding the programme's objectives, which had targeted a reduction of 255–270 Mm^3 per annum (JCC-LM, 1999). While it was estimated that the water use restrictions of the compulsory WAP induced an average farm income loss of around €200–250/ha (MAPA-JCC-LM, 1992; Rosell and Viladomiu, 1997), the AEP with its income compensation scheme greatly reduced the social distress created by the WAP and encouraged farmers to shift to less water-demanding crops and to adopt water-efficient technologies (Rosell and Viladomiu, 1997; Iglesias, 2001). This water-saving behaviour was reinforced by the nationwide 5-year drought that lasted from 1991 to 1995. Due to the higher resilience of groundwater, the impact of the drought was much less severe in this area than in the lower part of the Guadiana basin where surface water irrigation is predominant (Llamas and Martinez-Santos, 2006). The programme had a much larger impact than foreseen and was able to achieve its environmental and socio-economic objectives (Rosell and Viladomiu, 1997; Iglesias, 2001). Its main drawback was its high cost in terms of public funds so that the cost-effectiveness of the policy was increasingly questioned (Varela-Ortega and Sumpsi, 1999).

The coupling of national and EU policies

The AEP was modified in 2003, reinforcing the environmental objectives promoted by the new CAP reform (also enacted in 2003). For this second phase, only the 50% and 100% water reduction levels were considered and the level of payments was based on farm size, with larger farms receiving a lower payment. Furthermore, water use volumes under the second phase were to be calculated not based on initial entitlements but on the water volumes established annually under the WAP, which reduced the permitted volumes even further. The second

Table 14.1. Evolution of the EU AEP. (From JCC-LM, 2006.)

EU AEP of western La Mancha aquifer Income Compensation Payments €/ha					
Level of reduction in water consumption (%)	First Phase (1993–2002) AEP1 Payments are independent of farm size			Second Phase (2003–2007) AEP2 Payments are modulated according to farm size	
	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

phase thus coupled, for the first time, the EU and National Policies within a common framework aiming to reduce water consumption in the agriculture sector, restore the aquifer and conserve associated wetlands. Since the new water quotas of the AEP2 were calculated as 50% or 100% of the WAP permitted volumes, they were substantially lower than the water quotas of the first phase of the EU programme, and thus the income compensation payments offered barely covered the income loss: the programme was hence abandoned by the majority of farmers. The total area where farmers participated in the programme was no more than 15,000 ha in 2005, as compared to close to 90,000 ha in 1997, and the total water use reduction was considerably lower than in the previous programme. Table 14.1 shows the evolution of the AEP during its two phases.

Besides seeking to control public expenditures, the merging of the two water policies (the Spanish WAP and the EU AEP) also reflected the EU WFD, enacted in 2000. As the first EU initiative designed to promote a comprehensive basin-based integrated water policy, this directive requires all EU member states to achieve 'good ecological status' of all watercourses by 2015. This meant that the River Basin Authority was required to strengthen the control of water abstractions and illegal drillings, so as inter alia to limit water abstraction by the agriculture sector to the maximum permitted total annual volume (200 Mm^3) compatible with the aquifer's natural recharge. For this reason, a Special Plan for the Upper Guadiana basin was recently presented with strict water consumption limitations for the irrigation sector, along with a socio-economic restructuring plan and the strengthening of public participation procedures (CHG, 2006).

The policy matrix given in Table 14.2 summarizes the agricultural and water policies that affect the study region. In the matrix, policies have been characterized by their objectives, instruments, and environmental and societal effects, including private (e.g. farmers' income) as well as public effects (e.g. enforcement and cost-effectiveness). The agricultural policies include the McSharry reform of the CAP in 1992 and the recent 2003 reform. The water policies are divided into two blocks: the first block includes the policies specific to the area of study, that is, the (national) WAP and the two phases of the subsequent EU AEP. The second block includes the general water policy (i.e. the WFD) that affects all regions of the EU.

The matrix underlines the interactions between agricultural and water policies by showing how the water quota of the first phase of the AEP is linked to the initial water endowments that prevailed prior to the last CAP reform in 2003. The matrix also shows how the quota instrument of the second phase of the AEP is linked to the (national) WAP, emphasizing the recent coupling of the national and EU policies.

Public Policies for Cost-effective and Sustainable Groundwater Management

In this section we present the methodology and results of the recent research EU project (NEWATER) conducted in the study area with the objective of analysing the respective environmental and socio-economic effects of the application of agricultural and water conservation policies.

The basic characteristics of the methodology are, first, the elaboration of a knowledge-base supported by considerable fieldwork and stakeholder consultation and, second, a farm-based non-linear static mathematical programming model of constrained optimization. The model describes the behaviour of representative farmers confronted by different policy scenarios. Following previous work in the area of study (Varela-Ortega *et al.*, 1998, 2002) the model incorporates new risk parameters and maximizes a utility function subject to technical, economic and policy constraints. The utility function is defined by a gross margin and a risk vector that takes into account climate as well as market prices variability. Activities are defined by a given cropping area and associated production

Table 14.2. Policy Matrix for Agricultural and Water Policies.

Policy		Policy objectives	Policy instruments	Environmental effects	Societal effects
Agricultural Policies	CAP McSharry Reform, 1992 Agenda 2000	• Farm income stability • Environmental protection	• Direct payments tied to production $\boxed{\text{Original water Allotments}}$	• High water consumption • Increase in irrigated surface • Overexploitation of aquifer • Loss of wetlands	• Increase in farm income • Increase in employment • Socio-economic development of rural areas
	CAP Luxembourg Reform, 2003 2005…	• Competitive agriculture • Farm income stability • Environmental sustainability • Rural development	• Single farm payment decoupled from production • Cross-compliance schemes: payments subject to compliance with environmental regulations	(expected) • Lower water use • Increase in extensive productions and low-water-demanding crops • Higher environmental sustainability	(expected) • Decrease in farm income • Larger application of rural development programmes
Specific Water Policies	Spanish WAP 1991…	• Reduction of water consumption • Aquifer stability • Wetland recovery	$\boxed{\text{Water Quotas}}$ Established for aquifer recovery are lower than original allotments • Compulsory	• Less effective than expected • Lower water consumption • Use of modern irrigation techniques • Increase in low-water-demanding crops	• Farm income loss • Social unrest • Farmers opposition and litigations • Low implementation rate • High enforcement costs
	EU AEP1 1993–2002	• Independence of EU and National Policy • Independence of programme from the Spanish WAP • Reduction of water	$\boxed{\text{Water Quotas}}$ Fixed as a 50%, 70% and 100% reduction from original water allotments	• Lower water consumption • Use of modern irrigation techniques • Increase in low-water-demanding crops • Recovery of the aquifer	• Large adoption rate by farmers • Compensation payments are sufficient • Farm income gain • Employment increase

Continued

Table 14.2. *Continued*

Policy		Policy objectives	Policy instruments	Environmental effects	Societal effects
		consumption and wetland recovery	+ Income compensation payments • Voluntary	• Partial restoration of wetlands	• Social stability • Low enforcement costs • High public cost • Low cost-effectiveness
	EU AEP2 2003. …	Dependence of EU and National Policies • Modulation of the programme and being tied to the Spanish WAP • Reducing water consumption and promoting wetland recovery	Water Quotas Fixed as a 50% and 100% reduction from quotas of the Spanish WAP + Income compensation payments	• Lower water consumption • Use of modern irrigation techniques • Increase in low-water-demanding crops • No recovery of the aquifer due to low implementation of the programme • Recharge of wetlands by water transfer from the Tajo basin	• Low adoption by farmers as water allotments are already low in the WAP upon which the new quotas are fixed • Compensation payments are not sufficient to attract farmers • Farm income loss • High public cost and low total water
General Water Policies	EU WFD 2000–2015	• Good ecological status of all water courses • Sustainable use of water resource • Integrated water management • Cost recovery of water services	• River Basin Organization as management unit • Planning and integrated management of all water resources • Economic instruments: Water pricing and application of the PPP • Development of programme measures in all basins	• Amelioration of the ecological conditions of watercourses • Lower water use in some areas • Increase in water use efficiency • Protection and recovery of wetlands	• Transparency and public participation • Accountability and cost-effectiveness assessment of policy measures • May reduce the economic viability of certain irrigated farms in southern EU

technique, irrigation method and soil type. The problem-solving instrument used is GAMS (General Algebraic Modelling System). The technical coefficients and parameters of the model were obtained from fieldwork carried out during 2006 in the study area, consisting of surveys and interviews with farmers, irrigation community representatives, technical experts, river basin managers, and regional government officials. The model was duly calibrated and validated, using the risk aversion coefficient as the calibration parameter and comparing results with data on crop distribution, land and labour in the study area.

The study area was represented by a set of four statistically representative farms that characterize the variety of production systems and farms types in the area. These representative farms correspond to the Irrigation Community of Daimiel that covers around 20,000 ha of irrigated lands and have 1450 affiliated members. The typology of representative farms is shown in Table 14.3.

Policy options

For comparative purposes, policy options have been selected for two reference years (2001 and 2006). All policies have been explained in the previous section and are summarized in the policy matrix (Table 14.2).

For year 2001 (based on results of previous research, Varela-Ortega *et al.*, 2002), two policy alternatives have been selected: (i) the CAP Agenda 2000 measures (reference policy), that include direct payments (a yield-based differentiated hectare premium which is higher for irrigated lands than for rain-fed lands); and (ii) the AEP that was in place in 2001 which includes water reduction quotas and an income compensation scheme.

For year 2006 (based on the model explained above) we have the 2003 CAP reform applied in conjunction with a water conservation policy chosen from amongst three options: (i) the WAP; (ii) the AEP2 with 50% water consumption reduction; and (iii) the AEP2 with 100% water consumption reduction. The WAP is mandatory and the two AEP are optional. The 2003 CAP reform is defined by a partial 75% decoupling scheme, the modality chosen by Spain, and the 4% modulation of subsidies.

The aggregate results of the policy analysis of 2001 are summarized in Table 14.4 (AEP1 70% was the modality chosen by the great majority of farmers) and are based on results of previous work (Varela-Ortega *et al.*, 2002), while the weighted average aggregate results of the policy analysis for 2006 (current policy options) are shown in Table 14.5.

Table 14.3. Farm Typology for the Irrigation Community of Daimiel in the Region of Castilla-La Mancha (2006). (From Field work analysis (2006) updated from Sumpsi *et al.*, 1998 (crop distributions are approximate).)

	F-1	F-2	F-3	F-4
Area (ha)	8	24	30	70
Soil quality	Low	High	Medium	Medium and low
Cropping pattern	Vine (100%)	Winter cereals (30%) Maize (5%) Horticulture (30%) Melon (20%) Set-aside (15%)	Winter cereals (25%) Maize (5%) Melon (25%) Vine (30%) Set-aside (15%)	Winter cereals (58%) Maize (2%) Horticulture and melon (30%) Set-aside (10%)
Coverage (% of area)	22	19	28	31

Table 14.4. Results of Policy Analysis (2001). (From Own elaboration based on Varela-Ortega *et al.*, 2002).

Aggregate results		Policy option: Reference agenda 2000	Policy option: AEP1 (70% reduction)
Farm income	Total	655	698
(€/ha)	%	100	107
Water consumption	Total	3776	1500
(m^3/ha)	%	100	40
Public expenditure	Total	212	386
(€/ha)	%	100	182

Table 14.5. Results of Policy Analysis (2006).

Aggregate results (2006)		Policy option: Reference policy CAP ref. with partial decoupling	WAP (mandatory)	AEP2 50% reduction	AEP2 100% reduction
Farm income	Total	944	765	676	584
(€/ha)	%	100	81	72	62
Water consumption	Total	3285	2495	1247	0
(m^3/ha)	%	100	76	38	0
Public expenditure	Total	100	82	339	630
(€/ha)	%	100	82	338	628
Water shadow price	Total	0.033	0.058	0.137	0.678
(€/m^3)	%	100	177	221	2058
Water costs (€/ha)	Total	201	154	79	0
	%	100	76	39	0
Water costs (€/m^3)	Total	0.06	0.062	0.063	0
	%	100	101	103	0
Water productivity (€/m^3)	Total	0.29	0.31	0.54	0
(average)	%	100	104	184	0
Income compensation of AEP (€/m^3)	Total			0.159	0.197
Crop distribution (%)	Rain-fed	12.4	34.3	54.6	100
	Irrigated	78.6	65.7	45.4	0
Labour (man-day/ha)	Hired	26.8	20.9	11.3	0.1
	Total	39.7	27.8	16.1	4.0

Discussion on the results is presented as follows:

On water consumption

The results for 2001 (Table 14.5) show that water use reduction under the first phase of the agro-environmental programme (AEP1 – Table 14.2) more than achieved the original AEP's objectives, reaching about 1500 m^3/ha. This was below the target of 2000 m^3/ha, as most of the farmers joined at the 70% reduction level (with water consumption on average reduced by 60%). However, as discussed above, from 2003 onwards, and with the adoption of AEP2 (Table 14.2), the average water consumption in the reference policy was smaller than in 2001 (3285 m³/ha instead of 3776 m³/ha) and the WAP reduced it even further (to 2495 m³/ha, on average) with the purpose of restoring the aquifer. For the 50% reduction level, the AEP2 resulted in a reduction down to only 1247 m³/ha on average, clearly insufficient for most crop requirements (Table 14.5).

Extrapolating these results to the overall aquifer (see Fig. 14.5), AEP1 was joined by a majority of farmers and affected around 90,000 ha, resulting in an estimated total reduction in water abstractions of 250 Mm³. But under AEP2, fewer farmers joined the programme which extended to only 15,000 ha, while the total volume saved in the aquifer was 35 Mm³ only.

On cropping patterns

Figure 14.3 shows the aggregate results for two CAP scenarios: Agenda 2000 (yield-based payments) and the recently applied CAP reform with decoupled payments (75% partial decoupling scheme). The water quantities that appear on the graph's *x*-axis correspond to the water allotments of the water scenarios selected (see Table 14.5). Extensive irrigation denotes crops that use low water quantities, such as barley and wheat and intensive irrigation denotes crops that use large water volumes, such as maize or sugarbeet. Results show that the newly applied decoupled CAP policy induces a shift away from water-intensive crops, such as maize, which loses its high direct subsidies. In the new CAP, rain-fed agriculture appears even in the reference scenario (3285 m³/ha) while in the former CAP Agenda 2000, rain-fed agriculture appears only under the AEP 50% reduction (1247 m³/ha). On the other hand, the cultivation of horticultural crops increases under the new policy across all water scenarios due to their higher profitability and their technical suitability to water-efficient irrigation technologies such as sprinkler and drip irrigation.

On-farm income

The new AEP2 (2006) results in a clear reduction in farmers' income despite the compensation payments that are granted to the farmers that voluntarily engage in this programme. For the 50% and 100% reduction alternatives, income is reduced by 30% and 40%, respectively. In contrast, the AEP1

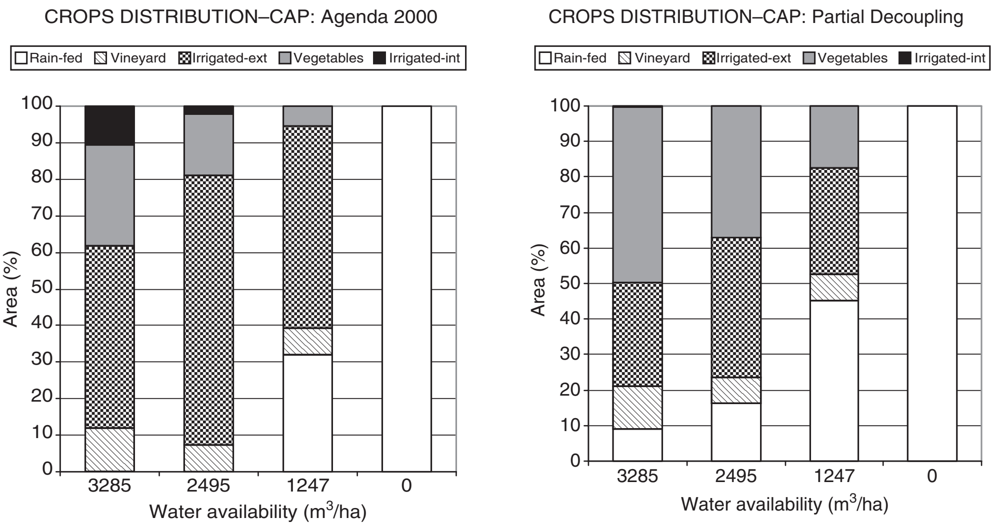

Fig. 14.3. Crop Distribution by Water Scenarios and Agricultural Policy Programmes. (From CAP, 2006.)

produced an increase of 6% in the income received by the farmers (Table 14.4). The reason is that, on the one hand, water allotments under AEP2 are calculated based on the WAP and thus amount to an average maximum permitted level of 1247 m^3/ha, lower than in the AEP1. On the other hand, income compensation payments in the previous programme were attractive enough for farmers to engage in the programme's 70% reduction level. Under the AEP2, income compensation is neither sufficient for the 50% reduction scheme nor for the 100% reduction level to make the programme attractive to the farmers.

On public expenditure

Both AEP1 and AEP2 are costly policies. In 2001, under AEP1, an average reduction of 60% relative to the original water allotment resulted in public expenditure almost doubling, rising by €386/ha. In 2006, under AEP2, public expenditure (including CAP payments) rose threefold to sixfold for the 50% and the 100% water reduction levels, respectively, corresponding to €339/ha and €630/ha, thus exceeding the impact on total farm income of this last option. The cost-effectiveness of these policies must therefore be questioned. Moreover, the direct costs (without the CAP payments) needed to reduce water use by one cubic meter are high under both options, amounting to €0.16 and €0.20 for the 50% and 100% reduction levels, respectively.

On water productivity

The average water values in all water scenarios are higher than the compensation payments, in unit terms, offered by the programme. Under the AEP2, for a 50% reduction level, average water productivity is €0.54/m^3, and the compensation offered to reduce consumption by half is €0.16/m^3. The same conclusion applies to the compensation offered under the alternative of abandoning irrigation altogether (€0.20/m^3). These results help explain the real situation in the area where the majority of the farmers are no longer willing to join the programme under this new stricter and less compensating scheme, as evidenced in the fieldwork survey and stakeholder interviews conducted in the zone (Varela-Ortega *et al.*, 2006a) and official data of the regional department of agriculture (JCC-LM, 2006).

Using average water values rather than marginal values for policy evaluation can, however, be ambiguous or even misleading as discussed extensively in the literature (Agudelo, 2001; Johansson *et al.*, 2002; Rogers *et al.*, 2002; Hanemann, 2006, among others). The reduction of water volumes under the AEP has been expressed in bulk volume terms as the compensation payment is equivalent for all units of water in the reduced allotment (€0.16/m^3 in the 1247/m^3 reduced allotment). However, the average value of water is not constant and increases as less water is supplied because farmers are likely to change their crops and technologies in response to water availability, as shown in the model results where cropping pattern changes according to the available water volumes and to the policy programmes. This can be shown in the results (Table 14.5) where average water value declines (from €0.54/m^3 to €0.29/m^3) as more water is delivered (from 1247/m^3/ha to 3285 /m^3/ha, respectively); thus the marginal value of water (shadow price of water in Table 14.5) is less than the average value.

The shadow prices of water thus increase as less water is supplied from €0.033/m^3, to €0.058/m^3, to €0.137/m^3 to a maximum of €0.678/m^3 as water allotments vary from 3285 m^3/ha, to 2495 m^3/ha, to 1247 m^3/ha and to 0, respectively. Similar results can be found for the region of Andalucia in Spain (Iglesias *et al.*, 2003). In our example, the results show that shadow price of water is greater (€0.678/m^3) than the compensation payment in unit terms (€0.197/m^3) for the first marginal unit of water. This result helps explain why the majority of farmers have proven unwilling to join the second phase of the AEP2.

The role of water pricing

Following the discussion of the previous sections, it is clear that water policies applied in the upper Guadiana basin have been ineffective in reducing water abstractions to a level compatible with the replenishment of the aquifer and hence the recovery of the wetlands. As the WAP is not fully enforced and the new AEP2 has been joined only by a small proportion of the irrigators, the quota instruments used in both programmes are not effective. In this situation it is interesting – for the purpose of policy analysis – to explore the potential effect of the application of an alternative instrument such as a water tariff structure.

The use of water tariffs has been discussed extensively in the literature as a major instrument for demand management policies and water conservation (Varela-Ortega *et al.*, 1998; Johansson *et al.*, 2002; Rogers *et al.*, 2002; Rosegrant *et al.*, 2002; Gomez-Limón and Riesgo, 2004; Garrido and Calatrava, 2007, among others). Water pricing policies can provide the farmers with the proper incentive to save water but, as water demand tends to be inelastic at low price ranges and institutional factors are determinant, volumetric pricing remains a controversial issue in many real-world examples and its wide application is still limited (see de Fraiture and Perry, Chapter 3, this volume; Molle and Berkoff, Chapter 2, this volume).

Subsequent research has been carried out by the author's research team in the area of study (Blanco, 2006), based on the same type of methodology and they have analyzed the effects of the application of simulated volumetric tariffs on irrigated farms. The results of this research can be used as a baseline for assessing the cost-effectiveness of the current policies applied in the area.

Two selected farms have been used for this analysis (E1 and E2) that correspond basically to the extensive large farm (F4) and the more intensive medium-size farm (F3) of Table 14.3. Table 14.6 shows the aggregate results of the application of increasing volumetric water tariffs on water demand, farm income, revenue collected by the water authority and public expenditure. Figures 14.4 and 14.5 show the water demand curves of the individual farms and the farm income variation when water tariffs are applied.

Water tariffs are applied once the current policy is in place (that is the WAP quota of 2049 m³/ha) and we can see from the simulation results that water demand is reduced progressively and reaches an average level

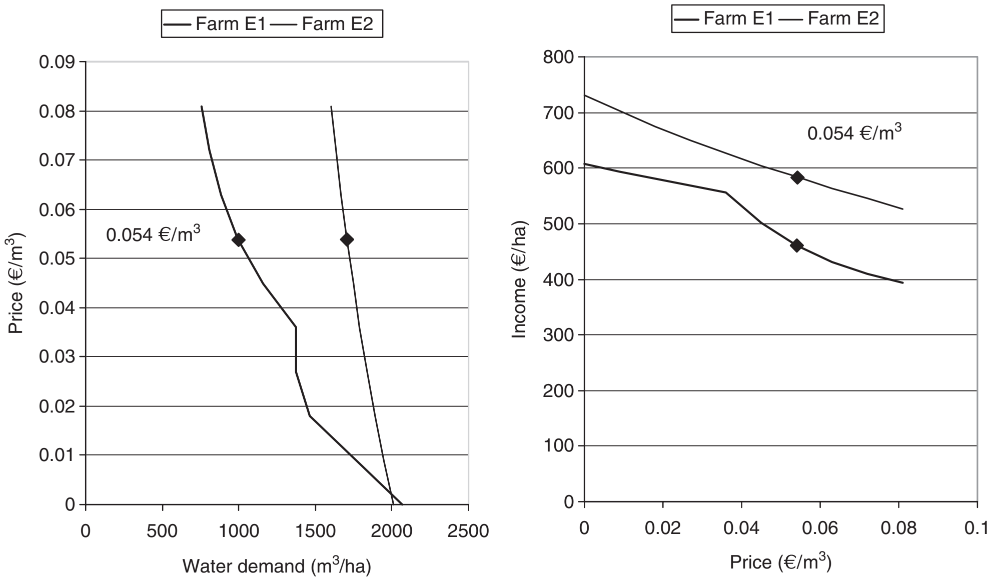

Fig. 14.4. Water demand in two representative farms in the western La Mancha aquifer. (From Blanco, 2006.)

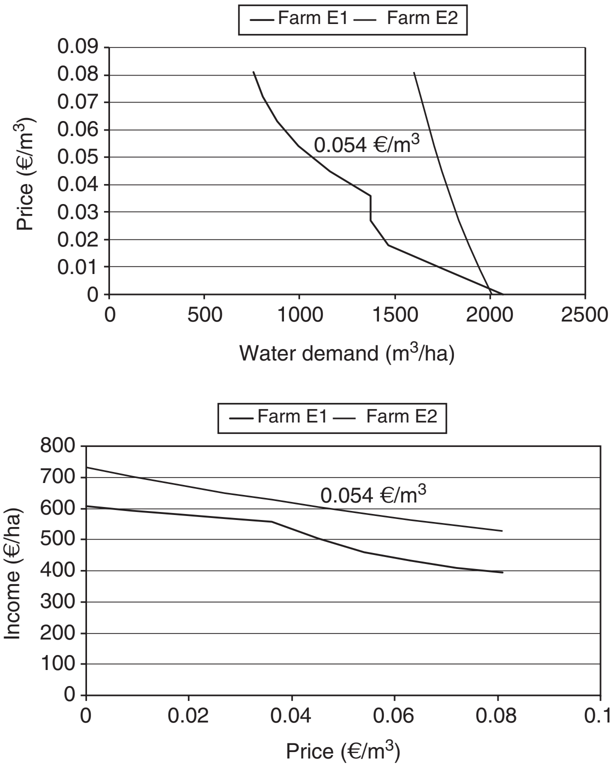

Fig. 14.5. Farm income variation in two representative farms in the western La Mancha aquifer. (From Blanco, 2006.)

Table 14.6. Effects of the Application of Volumetric Water Tariffs on Irrigated Farms in the Western La Mancha Aquifer. (From Own elaboration from Blanco, 2006.)

Water tariff (€/m³)	Water demand (m³/ha)	Farm income (€/ha)	Collected revenue (€/ha)	Government expenditure (€/ha)	Net public expenditure (€/ha)
0	2.049	646	0.0	115.4	115.4
0.009	1.822	627	16.4	97.5	81.1
0.018	1.596	610	28.7	79.4	50.7
0.027	1.518	594	41.0	74.3	33.3
0.036	1.503	578	54.1	74.6	20.5
0.045	1.342	534	60.4	78.2	17.8
0.054	1.215	499	65.6	80.9	15.3
0.063	1.127	472	71.0	82.9	11.9
0.072	1.064	452	76.6	84.2	7.6
0.081	1.018	435	82.4	64.7	–17.7

Note: Farm income figures for a zero water tariff are not exactly the same as for the WAP option in Table 14.5 due to slight differences in the farms considered but they are largely equivalent.

compatible with the natural recharge rate of the aquifer (1215 m^3/ha) at a water tariff of €0.054/m^3. This water consumption level is equivalent to the level attained by the AEP2 (of 50% reduction in water use) in Table 14.6. Figure 14.4 shows that water demand is more inelastic in the more intensive farm (E2) as higher productivity permits to absorb increased water use costs without drastically changing the cropping pattern towards less water-demanding crops or to rain-fed farming.

For this level of water tariff (€0.05/m^3), farm income is reduced by 23% (€147.6/ha) in the aggregate. However, aggregate results can be misleading. As shown in Fig. 14.5, in the more intensive farm E2, inelastic demand responses result in water use reductions of 15% that face higher income losses (about 21%), a result widely found in the literature. But the more extensive E1 farm responded to increasing water prices by shifting away from water-intensive horticulture (such as potato) to specialized low-water-demanding vegetables such as melon, a lucrative adapted crop in the area that is grown with drip irrigation. This explains why, in the aggregate, water use reductions are accompanied by a rather small income loss. In the case of the quota-based AEP2 income loss is barely 12% (€90/ha). However, public expenditure in the case of the application of water tariffs (that include only CAP subsidies) is, in fact, reduced by a small amount of €34/ha (from €115/ha to €81/ha) when prices rise to the desired target of €0.05/m^3 that recovers the aquifer. As water prices are administered prices, the revenue collected from the water fees by the water agency is public revenue and thus the overall net public expenditure is almost nil (apart that is from collection costs that have not been considered here). Conversely, AEP2 is an expensive policy, as pointed out in the previous section, and public costs rise more than fourfold to support this policy, reaching €339/ha, a substantially larger budget. This evidences the fact that agri-environmental polices that entail income compensation are not sustainable financially and their cost-effectiveness is indeed questionable.

Concluding reflections

- In general, water conservation polices that apply a strict quota system can achieve water use reductions and wetland recovery at low public costs. However, these policies are likely to be opposed strongly by the farmers, motivating costly litigation processes, a low uptake of the programmes and high enforcement costs to public authorities. Increasing the direct participation of stakeholders and stronger involvement in the decisions as well as social learning activities are strongly needed for the acceptance of this type of policies.
- Water conservation polices that include a quota system and an income compensation scheme (such as the AEPs applied in the area of study), can achieve the programmed water conservation target, provided that the compensation payment is attractive to the farmers. These policy programmes generally have a higher social acceptance and farmers' unrest can be avoided when compensation payments are sufficiently high to balance the income foregone by the farmers. However, these policies can be very costly, thus questioning the sound application of the policy. Moreover, such programmes conflict with the recently adopted EU WFD that, to ensure the good ecological status of all water bodies, requires the application of the polluter pays principle and a cost-effective evaluation of all programme measures (EU, 2000).
- It may occur that water quotas which entail compensation payments are too low (such as 50% from the permitted volumes) so that farm income can decrease if, for budgetary reasons, compensation payments are not sufficient to compensate for income loss. This will result in a limited adoption of the income compensation policy by the farmers and, in the aggregate, the policy may not meet the overall programmed water conservation targets.
- Water pricing policies can be effective instruments to induce water conservation strategies and are inexpensive

policies when compared with AEPs with an income compensation scheme. It seems likely that this kind of economic instrument could be effective for achieving the desired goals of reducing water extraction from the aquifer. For 50% water reduction levels, we may conclude that water pricing policies are more cost-effective than AEPs. However, even though volumetric pricing induces water use efficiency, it may produce distinctive effects across farm types. Due to the inelastic response of water demand to price changes in some farm types, a uniform water tariff may not achieve water conservation purposes in all areas. In addition, enforcing such water pricing schemes in private groundwater use has proved to be extremely difficult (see Venot *et al.*, Chapter 10, this volume).

- From an environmental perspective the application of a water pricing policy in this zone will be beneficial if reduction of irrigation in the area would achieve environmental objectives, but this policy would also entail economic and social costs to the area.
- Evaluating water productivity and water values needs careful attention. There is a tendency in the evaluation of water policies and projects to use average value estimates rather than marginal values, as marginal values require modelling estimates. A disparity between average and marginal values might be a crucial factor in misrepresenting the real value of water as, in most cases, average values are taken to be constant and hence overvalued (as argued by Hanemann (2006) in the case of the water transfer from the Ebro basin).
- Integrating agricultural polices and water polices is a key element for water conservation purposes. In fact, the new EU agricultural polices that incorporate, to a larger extent, environmental requirements, can play a major role in influencing water use trends and hence in meeting water conservation objectives. Water policies and agricultural policies should be designed and implemented in an integrated stakeholder-participatory manner, avoiding contradictions, finding synergies and integrating common objectives. However, the social context in which these policies will have to be implemented requires the selection of socially accepted instruments to balance the dual objective of protecting natural resources and maintaining farm-based livelihoods at tolerable social costs. This dual objective is best attained when strict water polices are combined with accompanying measures of rural development programmes and the establishment of water banks that permit a more flexible distribution of water allotments among farmers. This is the challenge facing the Spanish regional administration in charge of the application of both national and EU water policies in the area that we have studied. The requirements of the WFD to reach 'a good ecological status of all water bodies' in the EU with 'public transparency and participation' are providing incentives to the regional and national administrations to better enforce the water conservation policy. The new rural and social development program (*Plan Especial del Alto Guadiana*) being launched in this area is designed to diminish economic and social burdens. The design and enforcement of well-balanced polices are major tasks of policy makers in achieving successful water policies.

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