Integrating strategies for an efficient water management under uncertainty: empirical evidence in Spain

Blanco Gutiérrez I., Varela Ortega C.

in

Lamaddalena N. (ed.), Bogliotti C. (ed.), Todorovic M. (ed.), Scardigno A. (ed.).
Water saving in Mediterranean agriculture and future research needs [Vol. 3]

Bari : CIHEAM
Options Méditerranéennes : Série B. Etudes et Recherches; n. 56 Vol.III

2007
pages 45-63

INTEGRATING STRATEGIES FOR AN EFFICIENT WATER MANAGEMENT UNDER UNCERTAINITY: EMPIRICAL EVIDENCE IN SPAIN

I. Blanco Gutiérrez * and C. Varela Ortega
*Corresponding autor
Research assistant in the Department of Agricultural Economics. Polytechnic University. Madrid. Spain
E-mail: irene.blanco@upm.es. Telephone: (+34) 91 336 57 98. Fax: (+34) 91 336 57 97

SUMMARY- Water is a scarce resource unequally distributed in the Mediterranean region where agricultural sector is the main user. In Spain, agriculture uses nearly 80 % of the total available resources and the necessity of increasing irrigation water efficiency becomes the main subject of many debates in national water policies. In this context, the integration between agricultural and water policies becomes essential to achieve an efficient water management. At present, the New Common Agricultural Policy (new CAP Reform, 2003) and the Water Framework Directive (WFD, 2000), which constitutes the new policy framework in irrigation water management, are seeking to converge progressively towards mutually compatible objectives. The aim of this paper is to analyse the irrigator's response to water pricing policies application following different agricultural policies scenarios and to assess the implementation of the full cost recovery approach (Art.9 of the WFD). To undertake this analysis a mathematical programming model has been built to simulate farmers' behaviour following distinct risk aversion to climate as well as market prices variations. Empirical application of the model has been carried out in two different Irrigation Communities, which represent the agriculture in Castilla-Leon region in the northern central plateau of Spain. Results show that the application of the EU Water Framework Directive in conjunction with the new CAP reform will be crucial to avoid distortion effects but it would have to be examined carefully. Integrating both agricultural policies and water policies in the EU has to be achieved following the research for a flexible formula adapted to the necessities of each region and each water district. A similar water pricing policy could have distinct effects on water use, land use, cropping patterns, farmer's income and collected revenue by the water authority in different agricultural policy options linked to the agro-climatic and institutional structure characteristics of each affected region. Furthermore, achieving the goal of cost recovery (financial and environmental) could have negative effects on farmers' income and might question the viability of a number of irrigated farms in Spain.

Key words: CAP, water policies, cost recovery, water pricing, and mathematical programming model, risk analysis.

INTRODUCTION: THE POLICY CONTEXT

Spain, as the rest of the Mediterranean countries, is characterised by a heterogeneous distribution (both spatial and temporal) of the water resources and by great rainfall variability, showing acute seasonal water deficits (Varela-Ortega *et al.* 2002, Margat 2004, PNUE 2004).

Because of this weather variation, irrigation is shown to be the best solution to Spanish agriculture. Agriculture sector in Spain, although is not anymore an important sector in economic terms (its contribution to the Gross National Product is barely a 3%), constitutes the most important sector in terms of impact upon natural resources and land use, taking up to 80% of available water resources (Varela-Ortega *et al.* 2002, Gomez Limón *et al.* 2004, MIMAM 1998). Nowadays, irrigation systems in Spain cover a 15% of the cultivated agricultural area (equivalent to 3.7 millions of hectares) and represent 60% of agricultural production, as well as 80% of agricultural exploitations specialised in exports (MAPA, 2005).

Nevertheless, in spite of these beneficial effects, it is necessary to take into account the strong competence generated by the rest of water users (home, industrial and environmental uses) and the growing relative shortage of this resource, as well as the production of by-products and harmful wastes that could potentially harm the environment.

In order to face this problem, new reorientations in water management have been introduced. For the last decades, water has been considered an unlimited resource whose need was mainly covered introducing civil engineering solutions. Nowadays and following the rulings of the major international organizations, a Integrated Water Resources Management (IWRM) is being introduced world-wide and also in Spain, going from a supply management strategy to a demand management strategy according to which water is considered a scarce resource and therefore bearing of a social and economic value (Agudelo J. 2001, Rosegrant *et al.*, 2002, Turner *et al.* 2004, Saleth *et al.* 2004, Varela-Ortega 2006).

One of the example of this new paradigm of water management is the recent approval 2000/60/EC Directive, known as the Water Framework Directive, (UE, WFD 2000). The WFD represents a newly designed integrated Community action in the water domain. It was born with the objective of researching a good status for all water resources by 2015 and proclaims an integrated water management by establishing river basins as the basic unit for all water planning and management actions. Besides, the WFD stipulates that all the member countries will have to carry out an economic analysis of water use (Article 5) and take into account the recovery of costs for water services, including environmental and resources costs (Article 9). For this purpose, the WFD imposes the introduction of the necessary water-pricing measures before 2010 in order to provide adequate incentives for users to use water resources efficiently in accordance with the polluter pays principle.

The application of water pricing instruments to respond to the principle of full cost-recovery of water services, although justified from the economic point of view, might question the viability of a substantial proportion of irrigated farms and this impact will probably be more acutely in arid and semi-arid regions of Southern Europe that extend along the Mediterranean littoral and in-land areas. (Mejías *et al.* 2004, Benoit and Comeau, 2005, Varela-Ortega 2006, Bazzani 2005). For this reason, the WFD considers that Member States "*have regard to the social, environmental and economic effects of the recovery as well as the geographic and climatic conditions of the region or regions affected"* (Article 9) and analyse the cost-effectiveness of the policy in all cases (Article 4).

However, water policies are not the sole policies that affect irrigated agricultural. In Spain as elsewhere in the EU, irrigated systems have been strongly conditioned by the changes in the Common Agricultural Policy carried out during the last years (1992 reform, Agenda 2000) with the objective of stimulating European competitiveness, integrate environmental aspects in a more solid way, guarantee fair incomes for farmers, simplify the law and decentralise its application. During decades of the 80's and 90's, the Common Agricultural Policy (CAP) encouraged the expansion of irrigation as a response to production-based subsidies. In Spain, irrigated surface increased from 2.75 millions ha in 1980 to 3.75 millions ha in 2003 (MAPA 2005, Varela-Ortega 2006).

The 2002 mid-term review of Agenda 2000 determined the beginning of the last CAP reform, already known as Luxembourg Reform of 2003. The reform has constituted a new support model for farms, in the form of three new instruments:

- Farm payment decoupled. The direct payments have been substituted by a single farm payment decoupled from crop production. It constitutes a first step towards liberalisation of agriculture according to the WTO agreements in Petit, 2003)
- Consolidation of the concept of 'cross-compliance', by which all farmers will have to comply with established environmental regulations (and other type of existing regulations) to receive direct payments.
- Compulsory 'modulation' of support.

The effects on irrigated agriculture of the new CAP regime (stating in 2005) is still uncertain, but several studies consider that this new set of policies constitute a good opportunity for incorporating environmental requirements and nature conservation standards into agricultural production activities in the EU (Brouwer et al 2003, Varela-Ortega et al, 2002,Varela-Ortega, 2006, Bartolini *et al.* 2006).

Future trends in water policies (WFD), on the one hand, and the agricultural policies (CAP Reform), on the other hand, will heavily affect the European irrigated systems in general and Spanish farmers in particular (Mejías *et al.* 2004, Riesgo *et al.* 2006).

RESEARCH OBJECTIVE

The objective of this paper is to predict in different regions of Spain the irrigators' response confronted to the joint application of these two on-going policies under the uncertainty of climate and market variations.

We have compared the effects of the water pricing establishment required to comply with the costs-recovery principle proposed by the WFD, defined by the use of volumetric water charges under different agricultural policy scenarios (Agenda 2000 and CAP Reform 2003).

In particular, the analysis is focused on the evaluation of the impacts produced upon the environment, that is, the conservation of natural resources or used water volumes; the farmers' strategy on cropping pattern, land allocation between irrigated and rain fed farming, cropping intensification and management of water in the farm; the private sector, in relation to the farmers' income and the farmers' risk aversion; and the public sector, that is, the revenue collected by the water management agencies.

This research tries to contribute to explain the increasingly important role that the integration of water policies and agricultural policies will play in the agricultural sector of the EU and the essential implications for policy implementation and policy design.

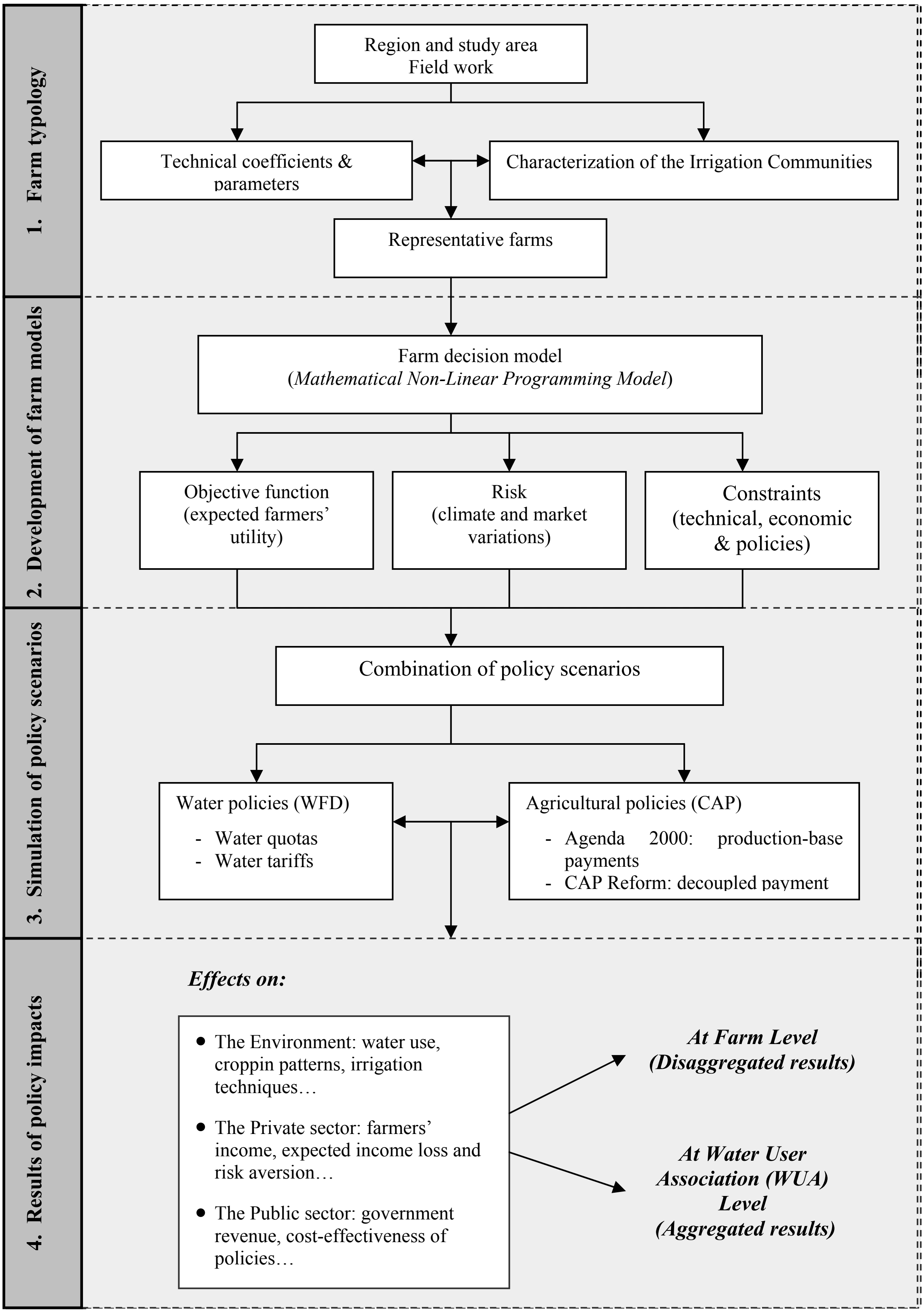
ANALYTICAL FRAMEWORK

The methodology developed for this research is based on the simulation, with mathematical programming techniques, of the rational farmers' behaviour under different policy scenarios. The designed model includes two risk sources that farmers have to face during the decision-making process in a determined growing season: the agronomic risk, represented by the variability of yields in relation to the climatic fortuity; and the economic risk, represented by the market price variations.

Taking into account that the developed model simulates the individual behaviour of a farmer, the simulations that have been carried out in this research have been done at farmer-level, upon selection of the different Water Users Associations and the determination of the study zone's most representative types of exploitation. Despite this, our results have also been analysed at group-level (at Irrigation Community level) using as a grouping parameter the percentage of the WUA's land area that every typified exploitation takes up, under the hypothesis that all of them behave in the same way (following Sumpsi *et al.*, 1998).

The model's technical and economic coefficients, as well as the WUA's institutional, structural, economic and technologic characteristics have been obtained through an intense field work that included numerous experts, technicians and irrigators' surveys from the selected WUAs (2005), as well as the 2001, 2002 and 2003 "Water Satellite Accounting" surveys carried out by the National Statistics Institute. Besides, we counted on expertise and collaboration from a farm management company (INAGRO) in the data analysis.

The methodology can be summarized in the following scheme.



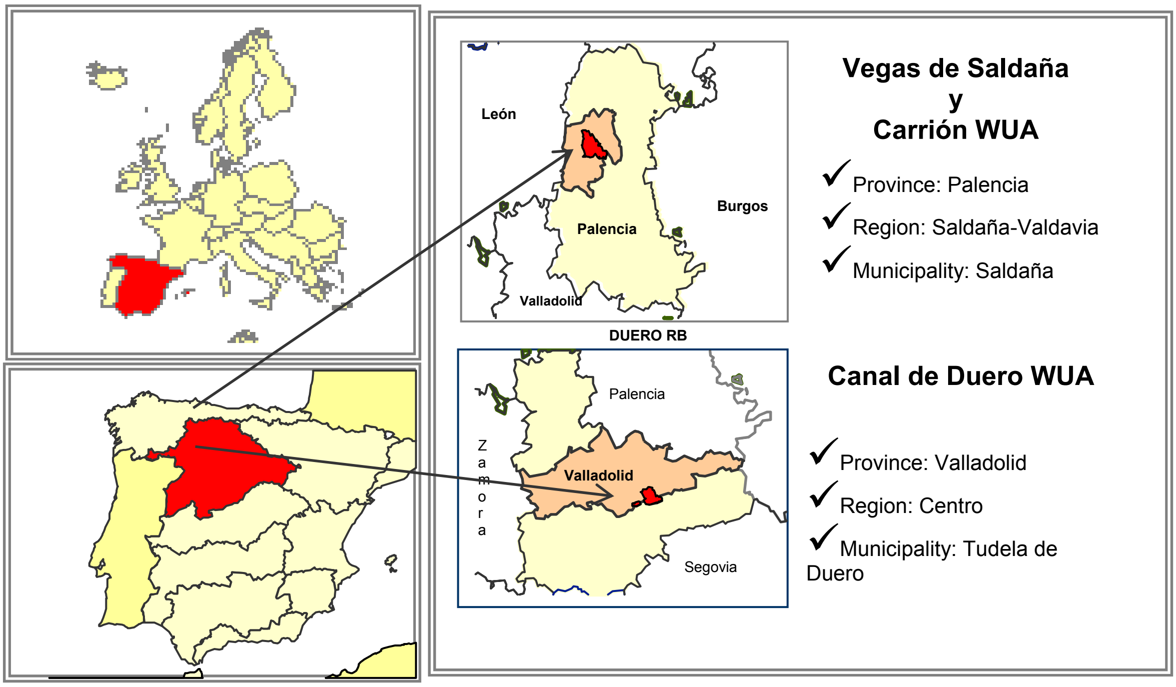
Source: Own elaboration

Fig. 1. Methodology framework

Study area

The empiric application of the model has been carried out in two WUAs (basic analysis units) selected taking into account different criteria (following Bolea, 1998; Sumpsi *et al.*, 1998; Varela et al., 2002, Mejías *et al.* 2004, Varela *et al.* 2006): geographic location, years of service, surface area, water distribution system, irrigation techniques, farm structure, water availability and source, pricing systems, investments and improvements, cost recovery and data available.

The selected water user association are located in the Hydrographical Confederation of the Duero, an area with surplus resources situated in the Autonomous Region of Castilla y León (in the northern central plateau of Spain), which suffers from water shortages only occasionally in periods of drought.



Source: Geographic Information System of Agronomics dates (SIGA) (2005)

Fig. 2. Geographic situation of the study region

The most important characteristics of each one of them have been put together into the *Table 1*.

Table 1. Description of selected WUAs

WUA	*Vegas de Saldaña y Carrión*	*Canal del Duero*
Year of establishment	1942	1972
Infrastructure ownership	Public	Private
Area (ha)	11,966	5,000
Number of irrigators	3,300	2,000
Water source	Carrión River	Duero River
Water allotment (m^3/ha)	4,600	5,100
Irrigation technology	Gravity	Sprinkler
Pricing system	77 (€/ha)	118 (€/ha)
Water distribution system	On demand	On demand/ By turn
WUA revenue (€)	921,382	590,000
On-going modernization programmes	Yes	No
Investment cost (€)	9,003,698.00	26,178.78

Source: Own elaboration from surveys' Statistic National Institute (INE, 2002).

As is observed in *Table 1*, the selected WUAs differ significantly in an ample parameter range. The Canal del Duero is a more modern water user association (WUA) with innovative irrigation systems (like sprinklers) and whose private infrastructures are in fairly good condition and whose investment has already been amortised. The Vegas de Saldaña y Carrión WUA, on the other hand, covers an area that is twice as big as the other irrigation association. It is older and uses less advanced irrigation techniques and systems. Its infrastructures are inadequate, but are being improved thanks to a subsidy granted by the Castilla y Leon Regional Government and plot concentration that has been going on in the area.

Farm typology

.

To represent the irrigation agriculture in the area the irrigation district has been characterized by a typology of four representative farms (F1, F2, F3, F4), two for each selected WUA. The representative farms are statistically representatives in the area, by surface, farm number, production technique and crop distribution. Seven crops were grown – wheat, barley, sunflower, maize, sugar beet, potato and set-aside- and two typical irrigation regimes or techniques in the study area were considered: rain fed and irrigated. Additional data have been obtained from a survey conducted in the zone of study.

In *Table 2* the main characteristics of each farm type are summarized. Also, is specified the surface percentage of the WUA, which includes each farm type, in function of that percentage, the simulation results have been added.

Table 2. Farm typology characteristics in WUAs

WUAs	***Vegas de Saldaña y Carrión***		***Canal del Duero***	
Farm type	**F1**	**F2**	**F3**	**F4**
Area (ha)	20	80	70	250
Irrigated area (%)	100	60	60	30
Crop Distribution (%)				
Wheat (intensive)	0	19.37	0	0
Wheat (extensive)	0	20	32	42
Barley (intensive)	20	4.36	10	5.01
Barley (extensive)	0	10	0	19.6
Sunflower (intensive)	10	2.24	0	0
Sunflower (extensive)	0	0	0	1.4
Maize	50	28.8	15.74	5.82
Sugar beet	11	3.73	21.42	10.07
Potato	1.5	1.5	9.72	9.1
Set-aside	7.5	10	11.12	7
Total area (%)	100	100	100	100
Representative (%)				
UAA	36.87	63.13	38.23	61.77
Farms	55.29	44.71	72.93	27.07

Source: Own elaboration from INE 1999 and farmers' surveys.

The diversity on technical factors, institutional and the water resources supply between both WUAs have permitted us to characterize the study area and analyze the regional and structural differences, which are important to take into account in the policy performances development.

The model

For each farm type, it has been created a mathematical optimisation-programming model, static and no linear, that incorporates a risk vector where climatic and market variations have been taken into account.

The problem-solving instrument used is GAMS (General Algebraic Modelling System) (Brooke *et al.* 1998).

The use of this kind of models is aptly adapted in the farmers' behaviour analysis, in different economic surroundings and in different risk perceptions, allowing to analyze correctly the induced effects because of the changes in the agricultural policies and in the water policies over the decisions taken by the farmers in the selected WUAs (Flichman *et al.* 1995, Varela-Ortega 2000, Semaan *et al.*, 2006, Varela *et al.*, 2006).

Model specification

The model maximizes the expected farmer's income under different constraints (technical constraints, economic constraints and policy constraints).

The objective function is defined by a utility function that corresponds to the gross margin (revenue) minus a variation of that gross margin, as a risk situation consequence. Its formulation is showed in the following equation:

$$\text{Max U} = f(x),\ f(x) = Z - R \tag{1}$$

Where:

U: The expected farmer's utility
Z: The average net revenue of the farmer and R is the risk vector
Z: The average net revenue is calculated through the equation:

$$\begin{aligned} Z = \sum_c \sum_t gm_{c,t} \cdot X_{c,t} + \left(\sum_c \sum_t subs_{c,t} \cdot X_{c,t} \cdot cp + sfp \right) \cdot md - uwc \cdot wc - (wut + rbf) \cdot sirr \\ - foc \cdot \sum_p fla_p - hlp \times \sum_p hl_p \end{aligned} \tag{2}$$

Where:

$gm_{c,t}$: the gross margin (€/ha) obtained by crop type (*c*) and technique (*t*)

$X_{c,t}$: are the decision-making variables that represent the growing area (in hectares) by crop type (*c*) and technique *(t*);

$subs_{c,t}$: the CAP support (€/ha) received by crop type (*c*) and selected technique (*t*) that is coupled to production

cp*:* the support coupling level (it will take value of 0 in the case of full decoupling and a value of 0.25 in the case of partial decoupling, current situation in Spain)

md: the *p*ercentage of support modulation (4% during 2006)

sfp*:* the single farm payment, calculated as the mean support received during the 2000/2001/2002 and is received irrespective of production and growing area

uwc: the unitary water cost (charge per volume applied in €/m^3)

wc: the water quantity consumed (m^3/ha); *wut* is the water use tariff (€/ha)

rbf*:* the river basin fee (€/ha), regulating fee for state-financed infrastructure works

sirr : the irrigated surface (in hectares)

foc*:* is the family labor opportunity cost (€/h)

fla_p: the family labor availability (in hours) depending on the period of the year in question (*p*)

hlp:the hired labor price (€/h); hl_p is hired labor measured in hours labor is hired for.

Following the mean-standard deviation analysis (Hazell and Norton, 1986), R (the risk vector) is defined by:

$$R = \phi \cdot \sigma \qquad (3) \qquad \sigma = \left[\left(\sum_{sn} \sum_{sm} Z_{sn,sm} - \overline{Z} \right)^2 / N \right]^{1/2} \qquad (4)$$

Where:

φ: the coefficient for the risk aversion parameter

σ: the standard deviation of the revenue distribution generated by the variability of yields under different weather conditions (status of nature, *sn*) and the variability of prices (status of market, *sm*)

$Z_{sn,sm}$: the random income assuming that Z is normally distributed

Z: the average farm income expected

N: represents the combination of the different states of nature and market.

The objective function is subjected to the following constraints:

Land constraints. Several land constraints have been considered, so that the model keeps the cultivated surface ($X_{c,t}$) under the limits of the available surface (*surf*) and that the irrigated surface does not exceed the number of hectares declared for irrigation (*sirrg*).

$$\sum_c \sum_t X_{c,t} \leq surf \qquad (5) \qquad \sum_c X_{c,\text{int}} \leq sirr \qquad (6)$$

Labour constraints. The crop labor requirements ($lr_{c,t}$) by cultivated surface ($X_{c,t}$) have to be covered by the family labor availability (fla_p) and hired (fh_p) labor on the market in each period.

$$\sum_c \sum_t lr_{c,t} \cdot X_{c,t} \leq fla_p + hl_p \qquad (7)$$

Water availability constraints. The crop water needs ($wn_{c,t}$) by cultivated surface ($X_{c,t}$) have to be met by the water that really reached the plot, which will be equal to the gross allotment (*allot*: allotment granted by the River Basin Authority to the Water User Associations) multiplied by the irrigated surface taking into account a technical efficiency coefficient (*h*).

$$\sum_c \sum_t wn_{c,t} \cdot X_{ct} \leq allot \cdot sirr \cdot h \qquad (8)$$

Policy constraints. (i) Set aside rate. Equations number 9 and 10 represents a compulsory minimum and maximum land set aside rate for the COP (cereals, oilseed and protein crops) growing area. This set aside area ($X_{set,t}$) must be between 10 (*setmn)* and 30% (*setmx)* of total cop cultures surface ($X_{cop,t}$).

$$\sum_t X_{set,t} \geq setmn \cdot \sum_{cop} \sum_t X_{cop,t} \qquad (9) \qquad \sum_t X_{set,t} \leq setmx \cdot \sum_{cop} \sum_t X_{cop,t} \qquad (10)$$

(ii) Sugar beet limitation. This constraint allows us to come closer to reality by confining the area that can be allotted to sugar beet as observed on real farms in the region. This surface ($X_{sug,t}$) must be maximum a percentage (*quota*) of the whole irrigated surface.

$$\sum_t X_{sug,t} \leq quota \cdot sirr \quad (11)$$

Calibration and validation of the model

The construction of a mathematical programming model for the analysis of agricultural policies requires verifying that the model reproduces the initial choices of production in the farm (Sumpsi *et al.* 1998, Mejías *et al.* 2004, Varela-Ortega *et al.* 2006, Semaan *et al.* 2006). For this raison, the model has been duly calibrated and validated.

The calibration process consists on the determination the parameters or coefficients, which make the model, reproduce the real situation of the system studied. It was carried out by using the risk aversion coefficient, which is parameter exogenous to the model that has been used as a parameter for calibration. This term is a residual parameter, which concentrates all unexplainable aspects in the difference between the model and the reality, e.g. decider's psychological characteristics.

Risk aversion coefficient was kept constant in all simulation in each WUA selected. Its value was fixed at 1.2 in the WUA from Palencia (VSC) and 1.3 in the WUA from Valladolid (CD), to calibrate the results for the model to the initial situation.

The validation process consists on the comparison of the results of the model with those really obtained in other reference years. It was carried out comparing the crop distribution of the typified exploitations against the simulations and verifying the degree of coincidence between both of them. Other used criteria have been the marginal values of land and work equations, in relation to the land's rent and the zone's salary real prices.

Definition of agricultural and water policy scenarios

Description of each scenario

We have defined two policy options within the framework of the CAP:

- Agenda 2000 (production-base payments). This scenario refers to the reference state or starting point.
- New CAP Reform (decoupled payments). In this study, the partial decoupling formula adopted by Spanish law has been chosen. It is represented by a coupled value of 25% (Varela *et al.* 2004). The CAP's second pillar reform has also been taken into account, simulating a subsidies modulation of 4%, whose funds are available since 2006 and will finance rural development projects (UE, Regulations 1782/03 and 796/04).

Policy instruments

For all agricultural policy options considered we have simulated jointly the application of a water instruments in order to reach the WFD's objectives. Two economic instruments have been combined:

- Water rights or quotas, individually assigned to each farmer through a public system of non-interchangeable concessions.
- The establishment of water prices using different tariff systems: fixed pricing system, volumetric tariffs and binomial pricing system (two-part tariff), one of the most used economic instruments for water regulation (Ward et al, 2002; Johansson *et al.*, 2002; Agudelo, 2001, Sumpsi *et al.*, 1998; Varela *et al.*, 1998; Rosegrant *et al.*, 2002; Chohin-Kuper *et al.*, 2003).

Strategies simulated

Taking as a starting point the current situation in which the Agenda 2000 is the agricultural policy in force and the water policy is represented by a fixed pricing system, three simulations were carried out:

1. First simulation transform the current fixed pricing system into a binomial pricing system (two-part tariff), in which a progressive volumetric tariff of 0.015€/ m3 for 20 price levels is added to the area-based system now in place.
2. Second simulation scenario takes into account the change in agricultural policy but maintains the current tariff structure.
3. Finally, both the new agricultural policy and the new binomial tariff structure are integrated.

Briefly, *Table 3* summarises the existent relation between the simulated scenarios, the implicated policies, their objectives and selected instruments to carry them out.

Table 3. The relationship between the scenarios, European directive, policy objectives, and policy instruments.

SCENARIO	UE DIRECTIVE	POLICY OBJECTIVE	POLICY INSTRUMENT	POLICY INSTRUMENTS COMBINATIONS	
Agenda 2000	Water Framework Directive	- Water resources conservation	- Water quota	Current situation (Water quota + Fixed pricing system)	**Water quota + Two-part tariff**
CAP Reform 2003		- Full cost recovery	- Water Prices	**Water quota + Fixed pricing system**	**Water quota + Two-part tariff**

Source: Own elaboration

The broad range of the situations that have been taken into account in the empiric application of the model allowed us to obtain a complete set of results that will allow us to discuss the implications of the integration of the water and agricultural policies on central Spain's irrigation agriculture.

RESULTS AND DISCUSSION

Water policies have been simulated to cover a broad range of water prices comprised between a minimum of 0 €/m^3 and a maximum of 0.285 0 €/m^3 (with 20 simulation levels). With the intention of clarifying the investigation's understanding, we have selected three water level prices in order to summarise the results. The selected values are:

- The first price level (P1), is that of the current tariff structure (in € per hectarea) and the absence of volumetric pricing. Current tariffs are 77 €/ha in the Vegas de Saldaña y Carrión (VSC WUA) and 118 €/ha in the Canal del Duero (CD WUA).

- The second price level (P2), is the volumetric price that attempts to apply the water cost recovery principle advocated by WFD (Article 9) in the irrigated area under study. For the selected WUAs, P2 is 0.06 €/m^3.

- The third price level (P3), is that in which the revenue collected by the government agency is maximised. In this case, it differs between WUAs: Vegas de Saldaña y Carrión Irrigation Community collects 529 €/ha with a tariff of 0.105 €/m^3, whereas Canal del Duero Irrigation Community gets lower takings (476.2 /€/ha) at a higher price level (0.135 €/m^3).

For these three price levels, we have evaluated the effects of this combination of policy scenarios on water consumption, farmers' strategies, farmers' income, farmers' expected income, risk tolerance, and government revenue. In *Tables 4* and *5* the aggregated results for each of the selected WUAs are shown.

Table 4. Results of policy options for different levels of water prices on water consumption, farm income and irrigation district revenue

WUA	POLICY SCENARIO	TARIFFS	EFFECTS					
			Water consumption		Farm Income		Irrigation district revenue	
			m^3/ha	%	€/ha	%	Total collection (€/ha)	%
VSC	Agenda 2000	P1	4650	100	480.43	100	77	100
		P2	4650	100	268.40	55.87	356	462.34
		P3[a]	4304.85	92.57	111.30	23.16	529.01	687.03
	CAP Reform 2003	P1	4650	100	461.94	96.15	77	100
		P2	4650	100	249.90	52.02	356	462.34
		P3[a]	4319.12	92.88	93.24	19.4	530.51	688.97
CD	Agenda 2000	P1	5100	100	442.81	100	118	100
		P2	5100	100	314.29	70.98	424	359.32
		P3[b]	2653.25	52	199.54	45	476.18	403.54
	CAP Reform 2003	P1	5100	100	433.35	97.8	118	100
		P2	5100	100	304.83	68.84	424	359.32
		P3[b]	2833.33	55.5	187.1	42.25	500.05	423.77

VSC=Vegas de Saldaña y Carrión; CD=Canal del Duero; P1 (tariff with no charge per volume applied) =0 €/m^3; P2 (cost recovery price) = 0.06 €/m^3; P3[a] (highest collection in VSC WUA) = 0.105 €/m^3; P3[b] (highest collection in CD WUA) = 0.135 €/m^3

Table 5. Cropping pattern selection by policy option (%).

WUA	POLICY SCENARIO	TARIFFS	WHEAT	BARLEY	MAIZE	SUGAR BEET	SUN-FLOWER	POTATO	IRRIGATED SURFACE
VSC	Agenda 2000	P1	11.4	9.5	37.2	7.6	5.6	1	76
		P2	11.4	9.5	37.2	7.6	5.6	1	76
		P3[a]	0	24.5	35.2	7.6	4.8	0.36	75
	CAP Reform 2003	P1	8.2	13.8	34	7.6	4.4	4.6	74
		P2	8.2	13.8	34	7.6	4.4	4.6	74
		P3[a]	0	26.5	33	7.6	2.4	3.1	73
CD	Agenda 2000	P1	-	6.5	12	12.6	-	10.9	42
		P2	-	6.5	12	12.6	-	10.9	42
		P3[b]	-	24.5	0	12.6	-	0	41
	CAP Reform 2003	P1	-	6.8	9.4	12.6	-	12.8	41
		P2	-	6.8	9.4	12.6	-	12.8	41
		P3[b]	-	29.4	0	12.6	-	0	40

VSC=Vegas de Saldaña y Carrión; CD=Canal del Duero; P1 (tariff with no charge per volume applied) =0 €/m^3; P2 (cost recovery price) = 0.06 €/m^3; P3[a] (highest collection in VSC WUA) = 0.105 €/m^3; P3[b] (highest collection in CD WUA) = 0.135 €/m^3

The effects on water consumption

The simulations show that water demand is inelastic for price rates ranging from 0 to 0.07 €/m^3 (Canal del Duero WUA) and 0 to 0.09 €/m^3 (Vegas de Saldaña y Carrión WUA), implying that only with considerable increases in the tariffs (5 to 6 times) the farmer would develop a thrifty behaviour in relation to water consumption (De Fraiture 2002, Iglesias *et al.*, 1998).

The older water district of Palencia (VSC WUA), shows an initially more stressed inelastic trend, so for mid price rates where the revenue collected by the government agency is maximised (P3[a] = 0.105

€/m^3), consumed water volumes are only reduced an 8%. However, if the same water pricing is applied to the other studied irrigation community (the modern water district of Valladolid), it turns out to be more effective. So at maximum collection price rates (P3^b in this case), used water volumes decrease in a 48%. At high price rates (ranging from 0.105/0.135 €/m^3 to 0.17/0.21 €/m^3) this trend is reversed. Larger savings of water can thus be achieved in the older water district of Palencia (see Fig. 3). This situation follows because the modern water district of Valladolid (CD WUA) had already been endowed with more efficient irrigation systems and for this reason their response to price signals in water savings strategies is smaller. (Varela-Ortega *et al.* 1998).

On the other hand, we can appreciate that the used water volumes does not vary greatly in view of a policy change scenario. De-coupling payment system does not provide incentives to save water when the prices are in the mid-low range and even increases slightly water consumption at high price rates due to the proliferation of non-COP crops more water demanding such as potatoes.

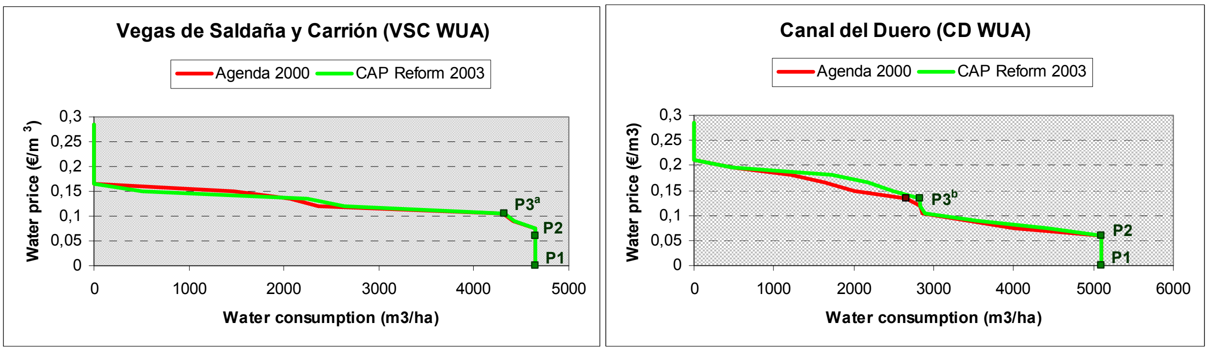


Fig. 3. Water response curves in the WUAs selected

Farmers' strategies

Confirming the developed theoretic models, the obtained empiric data from our simulations point out that the change in agricultural policy will lead to a slight intensification of the growing study area (Varela-Ortega 2005a, Oñate *et al.* 2006, Bartolini et al, 2006).

The new CAP penalises crops, such as maize, that benefited from a bigger comparative advantage under Agenda 2000. In some cases, the maize-growing area will fall by 3.3% in relative terms and 8.9% in absolute terms on average[1]. The area destined to sugar beet does not change due to the quota that has been implemented in the model although wheat and sunflower area does decrease in benefit of crops that are more adapted to the production area and have lower production costs, such as barley.

It is important to point out the noticeable increase the potato-growing area, potato now being more profitable than the traditional irrigated crops. In view of this increase in the potato-growing area, the EU CAP reform Cross Compliance Regulation ha considers the possibility of prohibiting producers benefiting from the single payment from redirecting their production towards fruit and potato production under Regulations 1782/03 and 796/04 so as not to cause distortions in the markets owing to surplus supply. This general spread of more water-demanding crops will counteract the water saving that is promoted by the change in agricultural scenario through the intensification of the growing area.

The introduction of a progressive volumetric tariff has a decisive influence in the strategies that farmers will adopt (even more than the change in agricultural policy), inducing farmers to switch strategies to less water-intensive crops, changes in production techniques and abandonment of irrigation. As shown in the Fig. 4, when water is priced at 8 cents of an € in the old water district of

[1] Values from Palencia's WUA compared to the results obtained by EU's CAPRI model (EU's model used to analyse the regional impact of the CAP in the EU), which indicates an absolute reduction of corn in this region of a 8%.

Palencia (VSC WUA), intensively-irrigated crops (such as maize or sugar beet) tend to diminish as less water-demanding crops increase (such as wheat or barley). Water-demanding crops disappear when water tariffs reach 14 cents and irrigation is abandoned and solely rain-fed crops are grown when water tariffs mount to 18 cents. These effects can be observed in both WUAs. Nevertheless, the variations are less noticeable in the Canal del Duero WUA, since the greater size of its exploitations reflects the effectiveness of scale economies and therefore a more flexible adaptation to change.

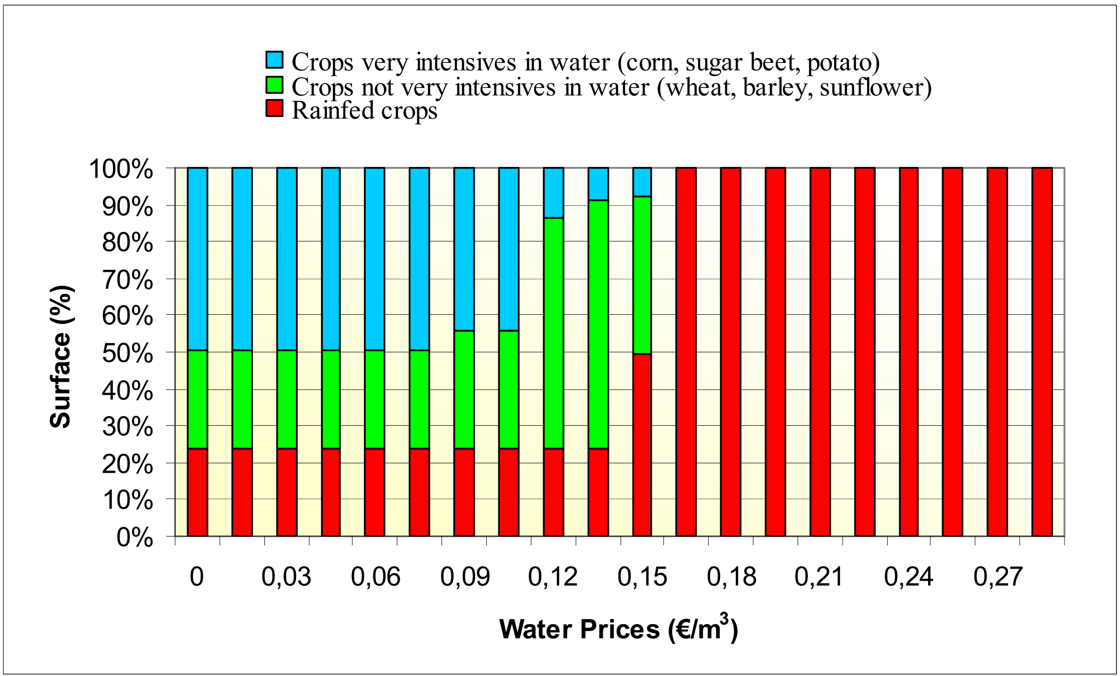


Fig. 4. Crop distribution by water price in Vegas de Saldaña y Carrión WUA in Agenda 2000.

Farmer's income

The simulations indicate that the change to a new agricultural policy scenario (CAP Reform 2003) entails a 3% farmers' income decrease at average in the studied area[2].

This income loss increases in an unequal way between the two studied WUAs when water and agricultural policies are integrated (Fig. 5). In the initial inelastic segment of the demand water graph, farmer's income only depends on the volume of water used (Mejías *et al.* 2004, Sumpsi *et al.* 1998). Because of this, the small farms of Palencia (with a high percentage of irrigated and high rentability crops)[3] provide initially very high income to their farmers but turn out to be more penalised by a rise in water prices. In the fairly elastic segments of the demand graph, income losses are related to the volumes of water used and the farmers' strategies to save water. The results show that the large and modern farms of Valladolid's province suffer less acute income losses than the small and old farms of Palencia's province. This is due to the fact that the greater water allotment and irrigation efficiency cover the irrigation crops water needs for longer time, keeping in this way high incomes at higher tariffs. So to reduce water volumes in a 10-20%, Valladolid WUA's farmers would have to sacrifice a 30-37% of their income, whereas Palencia WUA's farmers would lose a 30-50% of their income.

[2] CAPRI model predictions in this region indicate that the new de-coupling system will generate an income loss for farmers growing COP crops of a 5%.
[3] Irrigation crops are six times more profitable than non-irrigation crops.

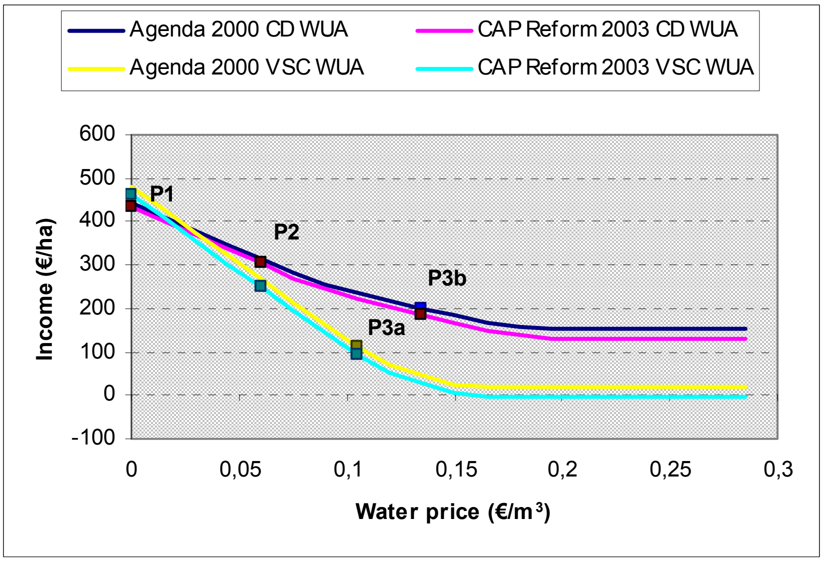


Fig. 5. Farmers' income in the WUAs selected.

Farmers' risk aversion

Fig. 6 shows the different levels of farm income attained by farm type in the two selected water user associations at various risk aversion levels in the two policy scenarios.

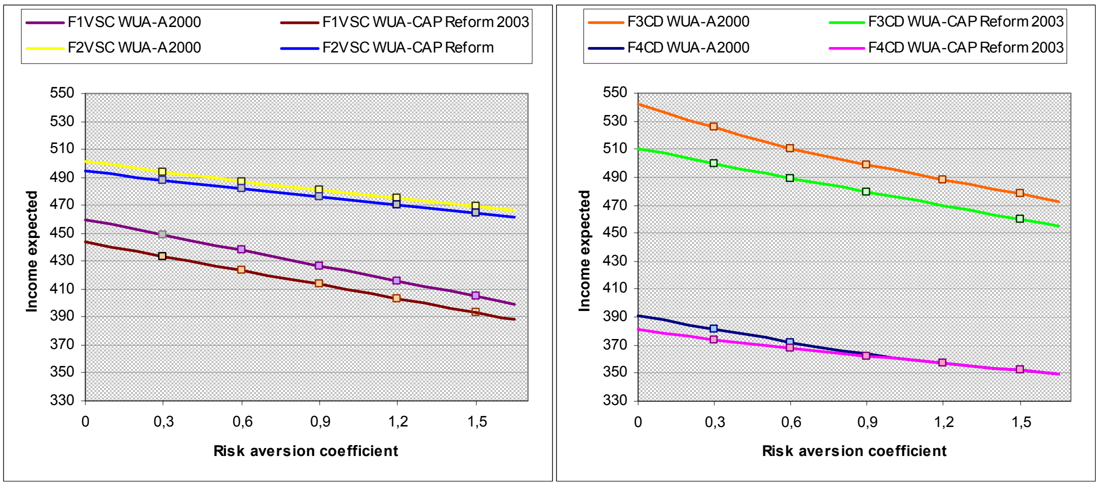


Fig. 6. Expected income and risk aversion by farm type and policy scenario

F1&F2=Representative farms of VSC WUA; F3&F4=Representative farms of CD WUA

In a static analysis, we can observe that, for all simulated risk aversion coefficients; income is higher in medium-size farms (types F2 and F3) than in small farms (type F1), due to scale economies existing in the area. Nevertheless, the unique characteristics of the agricultural activity make this tendency true only up to one point (or farm size), from which this situation reverts. In this way, an inverse relationship between productivity and farm size can be observed in very big farms, due to transaction costs generated when hiring labor force and to the increase of marginal utility of spare time (Varela-Ortega 2000). This is consistent with results obtained for the biggest farm F4 from Valladolid, whose income gain is lower than in the other farms[4].

In a dynamic analysis (when income perception is analyzed face to risk), we can also observe that the farm type largely determines risk premiums. In this case, we can note that, for all selected WUAs, big farms have more flexibility to adapt to risky environments than small ones. In fact, a "neutral to risk" farmer from Palencia or Valladolid who wishes to buy security (corresponding to a risk aversion coefficient of 1.4) will have to sacrifice 11% or 9% of his income when he is operating a small farm (F1 or F3) and 6% in the case of a big farm (F2 and F4). This trend is income loss is reinforced when risk aversion increases.

Globally, farmers belonging to C.R. Vegas de Saldaña y Carrión must scarify an average of 25.54€/ha in order to buy security, while in C.R. Canal del Duero, with more risky and less profitable cropping patterns, this average is 33.62€/ha. These risk bonus correspond to the insurance premiums that the farmers are really buying in Spain, where the medium insurance premium for winter cereals is about 25 €/ha (Garrido *et al.* 2003, Bielza *et al.*, 2004). It points out that our model predicts correctly what the farmer is willing to pay in order to buy security.

In the new CAP scenario (which is already a more secure scenario itself) differences decrease, diminishing scale economies. This result is maintained for all levels of risk aversion. Income loss is lower in the CAP Reform scenario as this policy context acts also as a risk shelter (sure crop subsidies and lower product price variability) (Varela-Ortega 2000, Flichman *et al.* 1995).

Effects on government revenue

In this case, the change in the agricultural policy scenario does not affect substantially to revenue collected by the government. On the contrary, the introduction of a progressive volumetric tariff produces an increase on the Irrigation Communities' and the Water Basin Authority's revenues in the inelastic stretch until the price of highest collection is attained, located at the start of the elastic demand curve segment (0.015-0.12 €/m^3).

Results show that the existing economic and financial regime for irrigation water is not cost-effective. Prices actually paid by users are very low and the total estimated cost of providing water services is financed to a large extent by the national budget (Varela-Ortega 2002).

With the current water pricing, the old water district of Palencia (VSC WUA) would be recovering all operation and maintenance costs (O&M), but not investment costs. However, the addition of a 0.06 €/m^3 volumetric pricing would permit the recovery, as well, of investment costs derived from the improvement of irrigation systems carried out and financed partly by the State (Seiasa Agency in the North). In the water district of Valladolid (CD WUA), the current water pricing scheme allows to recover only 72% of operation and maintenance costs. In contrast, the addition of a 0.06 €/m^3 volumetric pricing would allow to recover not only all financial costs (there are low investment costs due to the lack of innovation works), but also, according to some studies developed in the area, environmental costs would be also recovered within this level of prices (Gómez-Limón *et al.*, 2002, Riesgo *et al.* 2006).

CONCLUSIONS

.We can conclude, from the results of the simulation model, that farmers' attitude towards risk determines crop selection and hence farm income levels across all farm types and policy scenarios. As farmers choose to buy security and operate in a surer environment, expected income losses are lower in the CAP-reform scenario than in the Agenda 2000 scenario for all farm types and irrigation communities. This trend is due to the fact that the new policy acts as a risk shelter as payments decoupled from actual crop yields result in less uncertain farm revenue in comparison to the production-based payments of the former Agenda 2000 policy. In both policy scenarios, risk premia are not neutral to farm structure. In the larger farms, risk-averse farmers tend to sacrifice a smaller

[4] Influenced, as well, by a high percentage of rain-fed crops (60% of low profitable crops).

amount of their income gains (in comparison to their risk-neutral counterparts), than in the smaller farms. In fact, larger farms face lower expected income losses for all risk aversion levels, evidencing the presence of economies of scale in favor of bigger holdings (following similar conclusions of de Janvry et al 1989, Daininger *et al.* 1995, Flichman et al 1995, Varela-Ortega, 2000). However, size is not the determinant factor to explain cropping decisions when farmers are facing the joint application of agricultural and water policies.

The combination of the WFD and the new CAP's objectives should be solidly promoted, although it should be cautiously examined to avoid distortion effects.

This integration must be carried out through the search of formulae both flexible and adapted to the necessities of each country and regions within the countries, taking into account that the establishment of a water pricing policy can play a fundamental stimulating role for a sustainable use of water resources in agriculture, but it will have different effects under different agricultural policy scenarios, as well as in the different studied regions. The application of water policies should therefore take into account the agro-climatic, structural and institutional characteristics of the affected regions, as indicated in Article 9 of the WFD.

Likewise, reaching the cost recovery target (economic and environmental) stated in the same article could have negative effects on the farmer's income and endanger the viability of some irrigated farming system is Spain (Berbel and Gutierrez 2004, Gomez- Limón and Riesgo 2004, Garrido and Calatrava, 2006, Mejias et al 2004, Varela et al 2006). In particular, in this investigation it is possible to see that the prices that achieve cost-recovery (0.06 €/m^3) not only would not generate any water saving but the farmers would be losing income (from a 25% in the modern water district of Valladolid (Canal del Duero WUA) to a 50% in the older water district of Palencia (Vegas de Saldaña y Carrión WUA).

Therefore it becomes an essential matter to analyse the policies' cost-effectiveness (Art. 4, WFD). From this study we can infer that the application of water pricing policies will be more cost-effective in the regions with large exploitations that can benefit from economies of scale (i.e., the CD WUA reduces in a 50% the water volumes against an income lost of 40-50%).

On the other hand, a different agricultural policy scenario will also have repercussions on the farmers' income level. The implementation of the CAP Reform could lead to the farms' abandonment in marginal low-production rainfed lands, although it will not cause any dramatic changes in the current situation in respect of the demanded water volumes, land use or crop distribution.

The most important variations can be observed in a penalisation of those crops that benefited from a bigger comparative advantage under Agenda 2000 (such as corn) and an area increase of non-COP water-demanding crops, such as potatoes. This would justify the introduction of restrictions (by the EU institutions) to the implementation of these crops in order to avoid market distortions (Varela-Ortega *et al.* 2006).

Certainly, the results show that one of the main objectives of the CAP Reform 2003, that of favouring environmental protection by spreading low input agriculture, has not been satisfactorily achieved.

This implies that the New CAP Reform (Luxembourg Reform 2003) only slightly contributes to the achieving of the WFD objectives.

The absence of coherence between these two policies limits the use of water pricing as the only economic instrument for the rationalization of water use and rises the necessity of developing other complementary programs that help to reduce the water consumption in irrigated farming systems, protect water resources and promote agriculture's multifunctional role (MIMAM 1998, Sumpsi *et al.* 1998, Varela-Ortega 2005b)

Therefore, the introduction of additional measures to protect the environment (specific programs through rural development, cross-compliance and the Good Agricultural and Environmental Practices, GAEC) can substantially contribute to improve and protect the environment if the intention is to promote the development of a sustainable agriculture in agreement with the water policy principles (Baldock *et al.* ,2000, Baldock 2004).

REFERENCES

Agudelo, J. (2001), The economic valuation of water: Principles and methods, Value of water research report series No. 5, IHE, Delft.

Baldock, D. (2004), Assessing Implementation Costs of Cross-Compliance, paper presented at the seminar Evaluation of Cross-Compliance of the EU project Developing Cross Compliance in the EU: Background, Lessons and Opportunities (Qlk5-Ct-2002-02640), Granada, Spain, (19-20 April).

Baldock, D., J. Dwyer, J. Sumpsi, C. Varela-Ortega, H. Caraveli, S. Einschütz and J.E. Petersen (2000), *The Environmental Impacts of Irrigation in the European Union*, Commission of the European Communities, Brussels.

Bartolini F. G.M. Bazzani, V. Gallerani, M. Raggi and D. Viaggi (2006). The impact of water and agriculture policy scenarios on irrigated farming systems in Italy: An analysis based on farm level multi-attribute linear porgramming models. Agricultural systems 93 (2007) 90-114.

Bazzani, G.M. (2005), A decision support for an integrated multi-scale analysis of irrigation: DSIRR, *Journal of environmental Management*, 77 (2005) 301-314.

Benoit, G. and A. Comeau (eds). (2005) A Sustainable Future for the Mediterranean. The Blue Plan's Environment and Development Outlook. Plan Bleu. Earthscan / James & James publishers, London, UK

Berbel, J. and C. Gutiérrez (2004). (eds). *Sustainability of European Irrigated Agriculture under Water Framework Directive and Agenda 2000.* Sixth Framework Programme, European Commission, Córdoba.

Bielza, M., A. Garrido and J.M. Sumpsi (2004). Revenue insurance as an income stabilization policy: an application to the Spanish olive oil sector. *Cahiers d'économie et sociologie rurales*, nº70. 27 p.

Bolea, J.A. (1998), *Las Comunidades de Regantes*, Comunidad General de Usuarios del Canal Imperial de Aragón, Zaragoza.

Brooke, A., D. Kendrick, A. Meeraus and R. Raman (1998). *GAMS – A Users Guide*, Gams Development Corporation, Washington, DC. (www.gams.com)

Brouwer, F., I. Heinz and T. Zabel (eds) (2003). *Governance of Water-related Conflicts in Agriculture; New Directions in Agri-environmental and Water Policies in the EU*. Environmental and Policy Series, volume 37. Dordrecht: Kluwer Academic Press

CAPRI, Common Agricultural Policy Regional Impact Analysis, CAPRI Modelling System in: www.agp.uni_bonn.de/agpo/rsrch/capri/capri_e.htm.

Chohin-Kuper, A., T. Rieu and M. Montginoul (2003), Water policy reforms: Pricing water, cost recovery, water demand and impact on agriculture. Lessons from the Mediterranean experience, paper presented at Water Pricing Seminar, Agencia Catalana del Agua and World Bank Institute, Barcelona, 30 June-2 July.

De Fraiture, C. and C. Perry (2002), Why is irrigation water demand inelastic at low price ranges?, paper presented at the conference Irrigation water policies: Micro and macro considerations, Association Marrocaine de l'agro-economie-FAO-CIHEAM-IWMI, 15-17 June, Agadir, pp. 465-482.

De Janvry, A., E. Sadoulet and M. Fafchamps (1989): Agrarian Structure, Technological Innovations and the State. In: Bardhan, P. (ed.) The Economic Theory of Agrarian Institutions. Oxford University Press, Oxford.

Deininger, K. and Binswanger, H.P.(1995). Rent Seeking and Development of Large-scale Agriculture in Kenya, South Africa and Zimbabwe. *Economic Development and Cultural Change.* 43: 493-522

Emlinger, C., F. Jacquet and M. Petit (2004), Les enjeux de la libéralisation agricole dans la zone méditerranéenne, Communication Séminaire ACRALENOS Analyse comparée des relations agricoles en libre échange nord sud, 19-20 November, Montpellier.

Flichman, G., A. Garrido and C. Varela-Ortega (1995). Agricultural Policy and Technological Choice: A Regional Analysis of Income Variation, Soil Use and Environmental Effects under Uncertainty and Market Imperfections. In: Albisu, L. M. and Romero, C.(eds.) Environmental and Land Use Issues. An Economic Perspective. Wissenschaftsverlag Vauk, Kiel, pp. 227-237.

Garrido, A. and J. Calatrava (in press): Recent and future trends in water charging and water markets. In: Garrido, A. and M.R. Llamas (eds): *Water policy in Spain. Issues in Water Resource Policy.* Washington DC: Resources for the Future Press,

Garrido, A., M. Bielza, and J.M. Sumpsi (2003). The impact of crop insurance subsidies on land allocation and production in Spain. Working Party on Agricultural Policies and Markets. OCDE, Directorate for Food, Agriculture and Fischeries, Committee for Agriculture. 34 p.

Gomez-Limón, J.A. and L. Riesgo (2004). Irrigation water pricing: differential impacts on irrigated farms. *Agricultural Economics*, 31: 47-66.

Gómez-Limón, J.A., and L. Riesgo (2002). Irrigation water pricing: Differential impacts on irrigated farms, paper presented at the conference on irrigation water policies: Micro an macro considerations. IWMI. 15-17 June 2002, Agadir, Marocco. Article 7, pp. 118-132.

Hazell, P. and D. Norton (1986): *Mathematical Programming for Economic Analysis in Agriculture.* MacMillan, New York.

Iglesias E., A. Garrido, J.M. Sumpsi and C. Varela-Ortega (1998), Water demand elasticity: implications for water management and water pricing policies, contributed paper presented at the V World Congress of the International Association of Environmental and Resource Economics, Venice.

INE (Instituto Nacional de Estadística) (1999), *Censo Agrario*.

INE (Instituto Nacional de Estadística) (2001, 2002, 2003), *Encuestas sobre el uso del agua en el sector agrario*.

Johansson, R.C., Y. Tsur, T. Roe, R. Doukkali and A. Dinar. (2002), Pricing Irrigation Water: A Review of Theory and Practice, *Water Policy* 4, pp. 173-199.

MAPA (Ministerio de Agricultura Pesca y Alimentación) (2005), Cifras y hechos. MAPA, Madrid.

Margat, J. (2004). Atlas de l'eau dans le bassin méditerranéen. CCGM/Plan Bleu/Unesco. Paris: UNESCO.

Mejías, P., C. Varela-Ortega and G. Flichman (2004), Integrating Agricultural Policies and Water Policies under water supply and climate Uncertainty, paper presented at the XXV Conference of the IAAE (International Association of Agricultural Economists), Durban, South Africa, 16-22 August, and published in W*ater Resources Research*, Vol. 40, No. 7 (2004) (W07S03, doi:10.1029/2003WR002877).

MIMAM (Ministerio de Medio Ambiente)(2000). Libro blanco del agua en España. MIMAM, Madrid.

Oñate J.J., I. Atance, I. Bardají and D. Llusia (in press), Modelling the effects of alternative CAP policies for the Spanish high-nature value cereal-steppe farming systems, Agricultural Systems.

Petit M. (2003), European Policies and World Market Liberalization, in G. van Huylenbroeck *et al.* (ed.), *Importance of Policies and Institutions for agriculture* (Liber Amicorum Prof. Laurent Martens) Ghent: Academia Press, pp. 79-100.

PNUE/PAM/PLAN BLEU (2004). L'eau des Méditerranéens : situtation et perspectives. Nº 158 de la série de rapports techniques du PAM, PNUE/PAM, Athènes, 2004.

Riesgo L. and J.A. Gómez-Limón (2006), Multi-criteria policy scenario análisis for public regulation of irrigated agriculture, *Agricultural systems,* 91 (2006) 1-28.

Rosegrant, M., X. Cai and S. Cline (2002), *World Water and Food to 2025: Dealing with Scarcity*, International Food Policy Research Institute (IFPRI), Washington, D.C.

Saleth, R.M. and A. Dinar (2004). *The Institutional Economics of Water. A Cross-country Analsis of Institutional Performance.* Washington: The World Bank and Cheltenham, UK: Edward Elgar.

Semaan J., G. Flichman, A. Scardigno and P. Steduto (in press), Analysis of nitrate pollution control policies in the irrigated agriculture of Apulia Region (Southern Italy): A bio-economic modelling approach, *Agricultural Systems*.

SIGA (Geographic Information System of Agronomics dates) (2005). MAPA (Ministerio de Agricultura Pesca y Alimentación) (www.mapa.es/es/sig/pags/siga/intro.htm)

Sumpsi, J.M., A. Garrido, M. Blanco, C. Varela-Ortega and E. Iglesias (1998), *Economía y política de gestión del agua en la agricultura*, Ed. Mundi-Prensa-MAPA, Madrid.

Turner K., S. Georgiou, R. Clark, R. Brower and J. Burke (2004). Economic valuation of water resources in agriculture. From the sectoral to a functional perspective of natural resource management. FAO Water Reports N 27. FAO, Rome.

UE (European Union) (2000). Council Regulation (EC) Nº 327/2000 of 22 December 2000, *European Union Water Framework Directive*.

UE (European Union) (2003). Council Regulation (EC) No. 1782/2003 of 29 September 2003, *Establishing common rules for direct support schemes and establishing certain support schemes for farmers.*

UE (European Union) (2004). Council Regulation (EC) No. 796/2004 of 21 April 2004, *Laying down rules for the implementation of cross compliance, modulation and integrated administration and control provided for in Council Regulation (EC) No. 1782/2003.*

Varela Ortega, C. (2000), The role of transaction costs in production decisions and land use patters: evidence from large-scale agriculture in Spain. XXIV International Congress of the IAAE (International Association of Agricultural Economists).Berlin.

Varela Ortega. C. (2005b). Aspectos socio-económicos de la tarificación del agua de riego: implicaciones para la política de gestión del agua. Taller regional de riego y desarrollo rural en el Cono Sur: desafíos y oportunidades. Banco Interamericano de Desarrollo (BID). Ministerio de Asuntos Campesinos y Agropecuarios de Bolivia. Santa Cruz, Bolivia.

Varela-Ortega C (in press), Policy-driven determinants of irrigation water use and environmental protection: a case study in Spain" In: Molle, F. y Berkoff, J. (eds). Irrigation Water Pricing Policy in Context: Exploring The Gap Between Theory and Practice. Comprehensive Assessment of Water Management. IWMI and CABI press

Varela-Ortega, C. (2002), Study on water in the Mediterranean rural areas, country case study: Spain, Institut Méditerranéen de l'Eau, Marseille, France.

Varela-Ortega, C. (2005a), Implementation and Assessment of Multifunctionality, invited paper in the international seminar Multifunctionality of agriculture and rural areas: Essential component for sustainable development?, EU project MULTAGRI (6RFP Global Change and Ecosystems (Proposal/Contract no. 505297), Brussels, 1 September.

Varela-Ortega, C. and J. Calatrava (2004), Evaluation of Cross Compliance: Perspectives and Implementation, Report. EU project Developing Cross Compliance in the EU: Background, Lessons and Opportunities (Qlk5-Ct-2002-02640), Seminar 4, Granada, Spain (19-20 April), IEEP, London.

Varela-Ortega, C., Simó A. and Blanco, I (2006). The effects of alternative policy scenarios on Multifunctionality: A Case Study of Spain. Working paper nº 15. ENARPRI (European Network of Agricultural Policy Research Institutes). CEPS (Center for Eurpean Policy Studies). Brussels

Varela-Ortega, C., J. Sumpsi, A. Garrido, M. Blanco and E. Iglesias (1998), Water pricing policies, public decision making and farmers response: implications for water policy, *Agricultural Economics*, Vol. 19-2, pp. 193-202, special issue containing papers from the XXIII Conference of the IAAE, Sacramento, CA, 10-16 August 1997.

Varela-Ortega, C., J.M. Sumpsi and M. Blanco (2002), Water availability in the Mediterranean region, in F. Brouwer and J. Van der Straaten (eds), *Nature and Agriculture Policy in the European Union*, International Library of Ecological Economics, Cheltenham: Edward Elgar Publishing Ltd., pp. 117-140.

Ward, F.A. and A. Michelsen (2002), The Economic Value of Water in Agriculture: Concepts and Policy Applications, *Water Policy* 4, pp. 423-446.