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THE EFFECTS OF ALTERNATIVE POLICY SCENARIOS ON MULTIFUNCTIONALITY: A CASE STUDY OF SPAIN

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Abstract

This paper focuses on the comparative analysis and evaluation of the impact of multifunctionality on the agricultural sector for different scenarios that take into account the protection of the environment and natural resources as well as the international trade agreements in the context of the EU agricultural sector. The research focuses on two different regions in Spain that represent the continental agriculture of the region of Castilla-Leon in the northern central plateau and the Mediterranean fertile agriculture of Andalusia in the south. The analysis has been carried out based on mathematical programming models that simulate farmers' behaviour and their response to the different policy scenarios that correspond to the EU agricultural policies (CAP programmes) and water policies (Water Framework Directive) currently in place. Specifically, these scenarios are: full and partial decoupling, subsidy modulation, crop prices reduction, cross-compliance measures and water pricing policies. Results indicate that the new decoupled CAP will not lead to drastic changes in land use in the two regions studied but will have negative repercussions on farmers' income. Moreover, the introduction of additional measures, such as cross-compliance, will contribute substantially to improving and protecting the environment even though they amount to an additional cost for farmers. Reduction in crop prices will have significant effects on international trade and is likely to produce a reduction in farm intensification and hence a beneficial effect on the environment but will involve negative socio-economic impacts in marginal rain-fed farms. As regards the integration of agricultural and water conservation policies, the application of the EU Water Framework Directive in conjunction with the new CAP reform would produce different region-specific effects and might question the viability of a number of irrigated farms in Spain.

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1. Introduction

1.1 Objective of the study and general overview

The objective of Work Package 5.3 is to conduct a comparative analysis and evaluation of the impact of multifunctionality (WP4.3) for each of the different multifunctionality scenarios defined in WP.3.3. This report includes the specific case study of Spain in which the analysis focuses on the predicted regionally-based farmers' reactions to various distinct policy scenarios that are relevant to the current policy framework and multifunctionality in the agricultural sector.

This region-specific analysis has been conducted based on the fact that the application and definition of the term multifunctionality differs from one country to another and even from one region to another, taking into account the particularity of each situation. Therefore, any study analysing multifunctionality has to be tailored to the problems and demands of a particular area or region. In this respect the regions chosen for the Spanish case study are representative of Spain's varied agriculture and correspond to different agro-climatic conditions, types of agricultural systems, modes of farm production, labour use and institutional organisation.

The report is organised in six sections:

The first section includes an introduction with a general overview of the policy context as well as a summary of the concepts of multifunctionality in the agricultural sector with specific reference to the Spanish case study.

Section 2 is dedicated to the policy framework in which a first sub-section (heading 2.1) analyses the most relevant measures adopted in Spain regarding the main on-going policies, such as the CAP reform. The second part of this section (heading 2.2) describes the different policy scenarios selected in accordance with the current and future policy contexts as well as the instruments chosen to achieve particular policy objectives within a multifunctionality approach.

Section 3 focuses on the methodology of the analysis. It describes the different study regions selected in Spain, namely Andalucia in the south and Castilla y León in the northern central plateau (heading 3.1), followed by the farm typology and the structure of the representative farms on which the analysis will be based (heading 3.2). The last part of this section (heading 3.3) describes the modelling approach which is further specified in the respective annex.

Section 4 presents the results of the model simulations in the two study regions for the different policy scenarios defined in section 2. It focuses on the analysis of the impacts for each proposed scenario and their implications for land distribution, cropping pattern selection, farm income level, the environment and the use of natural resources.

Section 5 includes the most significant conclusions of this research and ***Section 6*** the bibliographical references. The final part of the report includes four annexes that show in detail the contents of the different sections: Annex 1 the farm typology, Annex 2 and Annex 3 the results tables for the two regions respectively and Annex 4 the detailed specification of the models developed for the simulation analysis.

The policy overview

Agriculture in most EU countries as well as in Spain is still the sector with the biggest impact on land use and utilization of natural resources, having a very significant influence on population settlement in the rural areas, landscape shape and overall environmental impacts and degradation of the natural resource base (Baldock et al., 2000; Varela & Supmsi, 2002; Brouwer, 2004b)

The latest CAP reforms have set Spanish and European agriculture the challenge of building multifunctional, sustainable and competitive farming systems compatible with an increased protection of the environment and conservation of natural resources. However, the anticipated fall in farm prices could jeopardise not only agricultural production itself but also the generation of other closely-related public assets, such as natural ecosystems, biodiversity, landscape, soil, water and water-related ecosystems. In this respect, the application and integration of different EU regulations, such as, for example, the WFD in the water domain, are more necessary and indispensable than ever before for protecting these assets (Mejías et al., 2004)

Most of the agricultural reforms in the past decades have come about as a result of international pressure and especially from multilateral trade negotiations, (Antle et al., 1998; Benjamin & Houee, 2003; Petit, 2003a and 2003b; Emlinger et al., 2004). One of the clearest examples is the 1992 reform, when the EU reduced intervention prices in return for which it introduced compensatory payments (direct payments coupled to production). Later, and with a view to the subsequent rounds of trade negotiations, the next CAP reform, Agenda 2000, was passed and aimed to continue the "liberalisation of agriculture" begun in 1992 by gradually decoupling support as part of a process commonly known as '*greening agriculture*' (moving blue box support to the green box). Based on the establishment of production-related direct aid payments, the Agenda 2000 CAP reform gave a prominent role to agri-environmental instruments to support a sustainable development of rural areas and to respond to society's increasing demand for environmental services.

At the same time, rural development measures sought to stabilise and support rural communities by further integrating environmental and socio-economic aspects as member states were given the option to make access to the CAP aid payments conditional on their meeting certain environmental requisites (cross-compliance option). For this purpose, intervention prices continued to fall, whereas direct payments (now no longer for compensatory purposes) continued to rise and environmental considerations were clearly reinforced, as the concepts of 'cross-compliance' and 'modulation' were introduced and further reinforced in the strongly debated mid-term review of the CAP.

Following this trend, with the aim of adapting to the changes in agriculture and the new international economic context, the EU developed the New Common Agricultural Policy in the so-called 'Luxembourg reform' in 2003, taking advantage of the CAP mid-term review. The new CAP proposes the 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. At the same time, the new CAP establishes the compulsory 'modulation' of support and a modification of the type of direct payments through 'decoupling', in which all direct payments become a single farm payment based on a reference amount independent from production. In this way, the EU aims to transform the blue box subsidies (direct payments) into green box subsidies (single farm payments) to conform to environmental requirements and trade negotiations agreements.

In sum, despite a country-specific, regionally-based and heterogeneous implementation perspective of the new CAP and cross-compliance measures (Varela & Calatrava, 2004; Brouwer et al., 2002; Baldock, 2004,Spash et al. 1997), this new set of policies constitute a major challenge for incorporating environmental requirements and nature conservation standards into agricultural production activities in the EU (Brouwer, 2004a).

1.2 Multifunctionality in agriculture

Multifunctionality is not solely specific to agriculture and characterises many economic activities that entail the production of multiple outputs providing a wide range of societal needs. Complementary to its primary activity of producing food and fibre, the agricultural sector can also provide non-commodity outputs, such as environmental goods and services by shaping landscape and natural sites, preserving biodiversity, conserving land and renewable water resources and contributing to the socio-economic development of rural settings (OECD, 2001a; Brouwer, 2004b). However, this joint production of commodity outputs (COs) and non-commodity outputs (NCOs) that characterises agricultural activity involves the presence of positive and negative externalities due to the public good character of the latter and the absence of market-based mechanisms for the provision of such NCOs.

The concept of multifunctionality is still not systematically defined or fully agreed across different regions, countries and international organisations and therefore it is subject to different interpretations, including its usefulness for agricultural policy analysis, debate and reform (Multagri, 2005; Varela, 2005; Reig, 2005; Brouwer, 2004b). Ample research has been conducted based largely on the positive view of multifunctionality in agriculture regarded as an economic activity of multiple interlinked outputs that are jointly produced, deriving positive and negative externalities (OECD, 2001a). This supply-oriented multifunctionality conceptual research has permitted the elaboration of a conceptual framework and a basis for discussion of policy intervention and debate (OECD, 2001a and 2001b).

EU recent research on multifunctionality in agriculture (Multagri, 2005, Brouwer, 2004b) has somehow enlarged the positive vision by integrating the supply side (production of COs and NCOs) and demand side (societal and consumer preferences) of multifunctionality and incorporating a more normative approach where MF plays a role for achieving a balanced integration of agronomic, economic, environmental, social and institutional aspects (Potter, C, 2004) . Therefore, in this view, MF is goal-oriented as it fulfils varied societal functions in different private and public institutional settings and plays a crucial role as analytical framework for the analysis of integrated resource management of complex systems and a valuable tool for policy decision-making (Cairol et al., 2005).

1.3 Multifunctionality in Spain

The concept of multifunctionality has not had very much impact on the Spanish administration's decision making and policy positioning. Not until recently, in the "White Paper on Agriculture and Rural Development" (MAPA, 2003b), was farming classed as a multifunctional activity (Reig, 2005) that helps to preserve natural resources taking into account that the goods produced by Spanish agriculture are classed as public assets. (MINAM,2000)

Following the OECD conceptual framework analysis of Multifunctionality (OECD, 2001a), the joint-production processes encountered in the Spanish agricultural sector evidence the existence of an ample variety of farming systems (Tió & Atance, 2001). These range from extensive rain-fed herbaceous crops, such as traditional cereal, oilseeds and fallow lands to intensive irrigated farming systems, such as horticulture and fruit trees in the Mediterranean littoral and inland irrigated crops such as maize, sugar beet, cotton and tobacco. From extensive inland livestock systems (cattle, sheep and goat) to intensive animal-production farms (pigs, poultry and calves) to the extensive traditional farming systems of integrated arable crops, forest and livestock productions (mixed productions of cereal, Holm oak, cork oak and Iberian pig, sheep or cattle, called 'dehesas') characteristic of the southwester agriculture in the Iberian peninsula (Díaz et al., 1997).

The production of NCO, positive and negative externalities, jointly produced linked to these varied farming systems, have been reviewed and analyzed in a general integrated Multifunctionality perspective (Tió and Atance, 2001; Reig, 2001, Reig 2005) and also based on one-sided research works focused on specific issues[1] (Arnalte & Ortiz, 2004; Viladomiu & Rosell, 2002; Varela & Sumpsi, 1998; Fundación Marcelino Botín, 1999; Baldock et al., 2000; Coleto et al., 2003, among others). Negative externalities are commonly associated with intensive agricultural systems such as intensive livestock and irrigated agriculture and also with olive groves in erosion-prone areas (Calatrava, 2004). Ground water irrigation, a common source of water in the Mediterranean coastline fertile farming, is particularly prone to environmental impacts. Over-exploitation of aquifers and the subsequent degradation of the associated wetlands have been reported as one of the major negative externalities linked to agricultural production and irrigation development (Fundación Marcelino Botín, 1999; Varela et al., 2002; Coleto et al., 2003). Positive externalities are commonly associated to the Spanish extensive inland farming systems of mixed productions, such as the dehesas (Diaz et al., 1997) or to the cereal growing steppes for birds' conservation (Donázar et al., 1997)

The Spanish view on agricultural multifunctionality has been largely based on the idea that "*agricultural multifunctionality policies are designed to maintain the traditional and extensive farming system to keep up marginal areas*" (Viladomiu et al., 2002). However, it has also been argued that the EU rural development funds in Spain are not aimed at favouring and promoting agricultural multifunctionality. In fact, the process of agricultural development itself does not primarily encourage rural development (Arnalte & Ortiz, 2004). In sum, multifunctionality in Spain is still not well structured as a research agenda and needs a further impulse to play a major role in agricultural policy analysis and enter the forefront of Spain's agricultural policy debate.

2. Policy framework

2.1 The CAP reform implementation in Spain

The main provisions of the CAP reform have been defined in line with the European regulation. Spain has opted to:

- Implement the single farm payment for all products covered by the reform, i.e. to start up as of 1 January 2006.
- Seeds will be excluded from the single payment.
- The annual percentage modulation will be applied to both the direct subsidies and to the part that remains coupled to production (5% in 2006 and 6% in 2007-13).
- The Canary Islands will be excluded from the application of the single farm payment and the annual percentage modulation will not be applied in either the Canary or the Balearic Islands.

[1] For a literature review following the OECD multifunctionality framework, see Tió & Atance, 2001. For an integrated supply-demand goal-oriented multifunctionality approach, see the Spanish report on multifunctionality (Reig, 2005) of the EU project MULTAGRI (2005).

- COP (cereal, oilseed and protein) crops will be partially untied or decoupled (25% of subsidies will remain coupled to production). The primary goals of this choice are to prevent land abandonment, to stop the distortion of competition between different activities and farms and to make voluntary set aside in low-yield districts more flexible.
- As regards the beef sector, Spain has opted to maintain 100% of the slaughter premium, 100% of the suckler cow premium and 40% of the beef special premium.
- In the sheep and goat sectors, 50% of the premium per head is retained, as this sector maintains fragile and valuable ecosystems in less-favoured and mountainous areas.

2.2 Specification of policy scenarios

In this part, the proposed scenarios are described, as are the objectives of the different policies and the instruments selected to achieve these objectives.

Description of each scenario

Agenda 2000: This scenario will be the baseline situation or starting point.

The new CAP scenarios: ‘full or partial decoupling’, which are represented, respectively, by a coupled value of 0% and 25% (for which Spain will opt). Additionally, within these two scenarios, a 4% modulation of subsidies has been included, representing the reform of the second pillar of the CAP, the funds for which will be available as of 2006 and will serve to fund rural development projects.

Cross Compliance measures as part of the new CAP policy (CEE, Nº.796/2004 & CEE, Nº. 1782/2003) to start in January 2006 (Varela & Calatrava, 2004).

Product prices reduction (10%) with full decoupling as a consequence of a liberalisation of agricultural trade.

Policy instruments and objectives

The different goals can be achieved by different means. However, we have opted in our research for the following instruments:

First we have introduced several instruments that will permit us to achieve the environmental requirements defined in the cross-compliance measures of the new CAP reform:

- The first is the obligation to keep a percentage of the COP-growing area as a buffer strip. This measure will contribute to reducing nitrogen pollution of soil and rivers from fertilizers. These buffer strips will absorb the surplus nitrogen, thereby preventing nitrogen from leaching to deeper strata.
- Nevertheless, the fact that this measure brings with it additional costs for farmers and that, consequently, a reduction in their income level is to be expected cannot be overlooked.
- The second measure is a prohibition of mono-cropping. This measure first encourages crop biodiversity and second reduces the application of plant protection products and pesticides, as the practice of rotation can reduce the risk of infections and pests.
- Introduction of a tax on the purchase of nitrate fertilizers to encourage a better fertilizer management in nitrate vulnerable zones. This will be a progressive tax levied in euros/kg.

  This measure is designed to reduce the amount of nitrogen fertilizers used or at least encourage more rational use and better management of such fertilizers. Consequently, this measure should lead to an improvement in soil conservation and a reduction in nitrate pollution.

- Joint application of new Common Agricultural Policy and the EU Water Framework Directive (CEE Nº 327/2000). The WFD represents a newly designed integrated Community action in the water domain. Accordingly, Art. 4 states:

> *Member States shall protect, enhance and restore all bodies of surface water, with the aim of achieving good surface water status at the latest 15 years after the date of entry into force of this Directive.*

To achieve this aim, we have chosen the economic instrument of introducing a volumetric charge to the pricing of water to encourage efficiency in the use of water. Volumetric water pricing raises objections among farmers as farm income is penalized but it is one the most commonly used economic instrument for increasing water use efficiency (Ward & Michelsen, 2002; Johansson et al., 2002; Agudelo, 2001, Sumpsi et al., 1998; Varela et al., 1998; Rosegrant et al., 2002; Chohin-Kuper et al., 2003).

The application of a water pricing policy (in the different CAP contexts) can permit the recovery of water supply costs by the water charges collected, which is another of the key goals of the WFD (Art. 9):

> *Member States shall take account of the principle of recovery of the costs of water services, including environmental and resource costs, having regard to the economic analysis and in accordance in particular with the polluter pays principle. Member States shall ensure by 2010:*
>
> - *That water-pricing policies provide adequate incentives for users to use water resources efficiently, and thereby contribute to the environmental objectives of this Directive,…*

Accordingly, we have transformed the current fixed pricing system into a binomial pricing system (two-part tariff), in which a progressive volumetric tariff of 0.015€ for 15 price levels is added to the area-based system now in place (following Sumpsi et al., 1998; Varela et al., 1998; Varela et al., 2002).

Briefly, all the scenarios, goals, instruments and potential effects can be grouped to form the following Table 1. Table 2 gives an example of the application of a policy scenario defined by partial decoupling (75%) (the current Spanish option), with a 4% modulation and cross-compliance measures, the objectives to be attained, the related EU directive and the instrument selected to achieve the defined objectives.

Table 1. Scenarios, policy instruments, policy objectives and effects

SCENARIO	*POLICY OBJECTIVES*	*POLICY INSTRUMENTS*	*EFFECTS*
AGENDA 2000			*-LAND USE* *-CROPPING PATTERN* *-FARM INCOME(social effects, private sector)* *-ENVIRONMENT* *-COST-EFFECTIVENESS (public sector)*
Partial decoupling	*-Soil conservation* *-Reduction of nitrate pollution* *-Biodiversity*	*-Buffer Strips* *-Crop diversity*	
	-Reduction of nitrate pollution	*-Tax on nitrate fertilizers*	
	-Conservation of water resources	*-Water quota* *-Water prices*	
Full decoupling	*-Soil conservation* *-Reduction of nitrate pollution* *-Biodiversity*	*-Buffer strips* *-Crop diversity*	
	-Reduction of nitrate pollution	*-Tax on nitrate fertilizers*	
Support price reduction and full decoupling	*-Soil conservation* *-Reduction of nitrate pollution* *-Biodiversity*	*-Buffer strips* *-Crop diversity*	
	- Water resources conservation	*-Water quota* *-Water prices*	

Table 2. Scenarios, policy objectives, European directives and instruments

SCENARIO	OBJECTIVE	EU DIRECTIVE	INSTRUMENT
Partial decoupling + **Modulation** + **Cross-compliance**	• Reduction of Nitrate pollution • Protection of biodiversity • Soil conservation	• Nitrates Dir • Habitats Dir • Annex IV GAEC	**BUFFER STRIP**
	• Reduction of pesticide and insecticide contamination • Protection of biodiversity • Soil conservation	• Ground Water Dir • Habitats Dir • Birds Dir • Annex IV GAEC	**SINGLE CROPPING PROHIBITION**
	• Reduction of Nitrate pollution	• Nitrates Directive	**TAX TO NITRATE FERTILIZERS**

Two regions of Spain have been chosen for this study representing different agro-climatic conditions, varied farming systems, cropping potential, land use and structural and institutional settings. The region of Andalucia in southern Spain is characterised by a fertile varied agriculture of an ample cropping diversity. The region of Castilla y León in the central northern plateau is representative of in-land continental agriculture of a more limited cropping and land use patterns. The policy scenarios are similar in both regions (except for full decoupling scenario that has only been analysed in Andalucia), but the policy objectives have been defined in a different manner in both regions, as shown in Table 3.

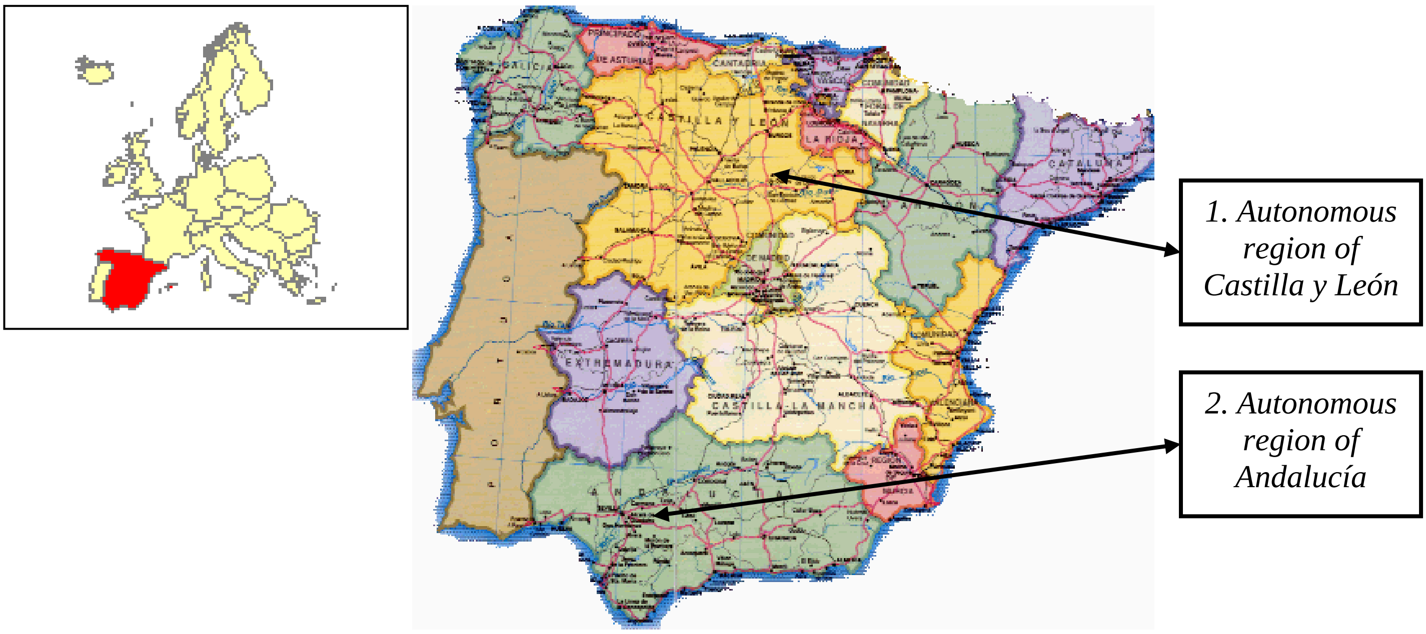
Table 3. The relationship between the scenarios and the different selected regions

	SCENARIOS	*POLICY OBJECTIVES*
Andalucía	-Agenda 2000 -Full decoupling -Partial decoupling -Prices reduction	-Soil conservation -Reduction of nitrate pollution -Biodiversity
Castilla y León	-Agenda 2000 -Partial decoupling -Prices reduction	- Water resources conservation

3. Methodological framework

3.1 Characterisation of study regions

The two autonomous regions selected for this research are shown in the map below.



1. Autonomous region of Castilla y León

The selected drainage basin was the Duero basin, an area with surplus resources located in the Autonomous Region of Castilla y León, which suffers from water shortages only occasionally in periods of drought.

The water user associations within the Hydrographical Confederation of the Duero were selected taking into account the following criteria (following Bolea, 1998; Sumpsi et al., 1998; Varela-Ortega. 2002; Varela et al., 2002):

- Years of service

- Geographic location
- Surface area
- Water availability and source
- Water distribution system
- Irrigation techniques
- Most commonly grown crops
- Farm structure
- Organisational systems and internal operation
- Pricing systems
- Investments and improvements
- Costs recovery
- Data availability

Two water user associations (WUA) were finally selected.

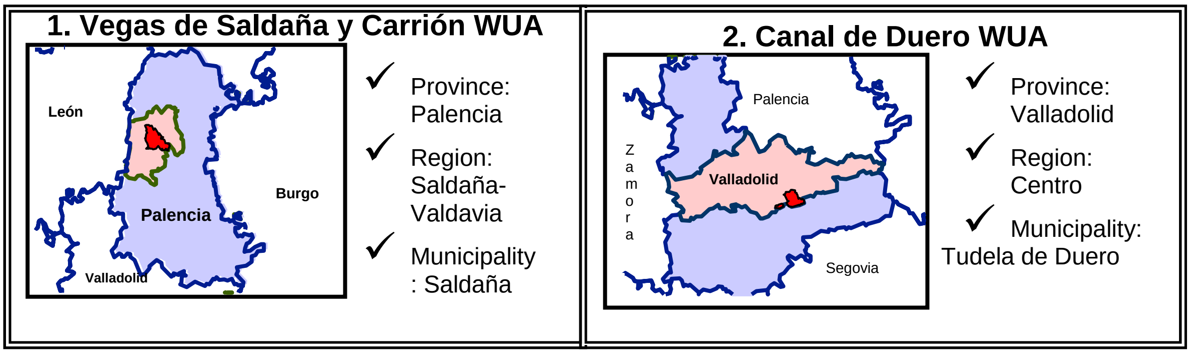


Table 4. Description of selected WUAs

WUA	*Vegas de Saldaña y Carrión*	*Canal del Duero*
Province	Palencia	Valladolid
Region	Saldaña	Centro
Municipality	Saldaña	Tudela de Duero
Year of establishment	1942	1972
Infrastructure ownership	Public	Private
Area (ha)	11966	5000
Number of irrigators	3300	2000
Water source	Carrión River	Duero River
Water allotment (m^3/ha)	4600	5100
Irrigation technology	Gravity	Sprinkler
Pricing system	77 (€/ha)	118 (€/ha)
Water distribution system	On demand	On demand/ By turn
WUA revenue (€)	921382	590000
On-going modernization programmes	Yes	No
Investment cost (€)	9003698.00	26178.78

Source: Own elaboration from INE (2002) surveys.

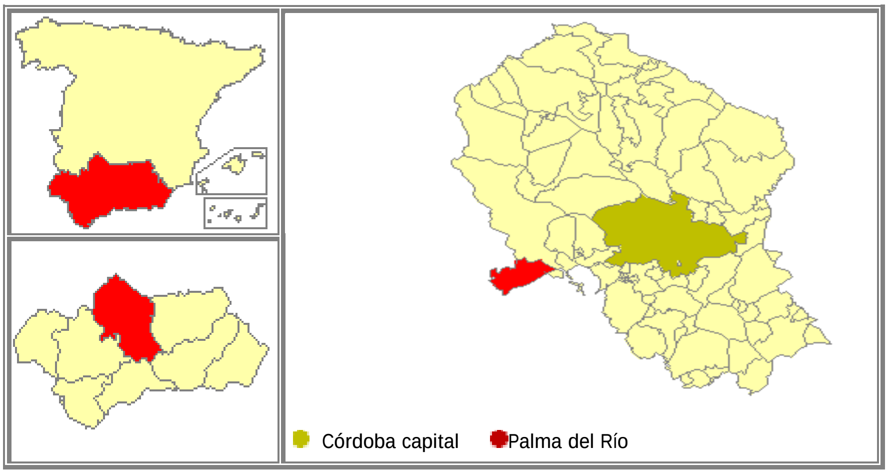
As we can see, there is not much difference between the number of irrigators and water allotment in the two water districts.

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.

2. Autonomous region of Andalucía

Two municipalities have been selected in the second region. These are two municipalities located in the province of Córdoba (Autonomous Region of Andalucía), called Palma del Río and Córdoba, as shown in the map below.



Source: Multi-territorial Information System of Andalucía. IEA.

This is a region located in southern Spain covering part of the Guadalquivir River Valley (Varela et al., 1998). The characteristic of this region is that it is an area with an agriculture of high commercial and business capitalisation thanks to a remarkable production potential, a wide variety of crops, as well as being highly representative of different farm size strata in the Autonomous Region of Andalucía. Both municipalities making up the study area have been characterised geographically, edaphologically and climatologically (Simó, 2005; Carpy-Goulard, 2001). Indeed, the whole area derives a considerable competitive advantage from its agroclimatic conditions in terms of the production of a wide variety of traditional crops (such as durum and soft wheat, sunflower, maize, cotton and chickpea), as well as the production of fruit and vegetables. The main selected productions make up over 60% of the whole UAA regulated by the CAP programmes that will be the object of our study.

This area is classed as a nitrate-vulnerable zone designated in the first phase of implementation of the transposition of the Nitrates Directive (BOE, 1996 Real Decreto261/1996 of 16 February) establishing the compulsoriness of determining what bodies of water are polluted or at risk of being polluted by nitrates draining from agricultural land (Boja 5 of 12 January 1999). Consequently, the adoption and simulation of measures for reducing nitrates pollution from agricultural land are thereby justified.

3.2 Farm typology

Two model farms for each water user association and three farms in Andalucía have been built from the statistical data itemised by size strata (INE and INEA) (see Annex 1 for farm typology by districts).

These farms are statistically representative of the area in terms of crop distribution, area, number of farms and percentage of irrigated land and are the ones simulated in the mathematical programming model.

Crop distribution by farm size conveys the importance of particular strata. In Andalucía and Castilla-León, the selected model farms account for 83.8% and 50% of the growing area and 37% and over 35% of the total number of farms, respectively. (See Annex 1 for farm typology by districts and municipalities).

The system of production defined using the model farms will reproduce the current crop distribution in the different study areas as can be seen from Tables 5 and 6 which show the characteristics of the farms.

Table 5. Farm typology characteristics in Castilla y León

WUAs	***Vegas de Saldaña y Carrión***		***Canal del Duero***	
Farm type	**F1**	**F2**	**F3**	**F4**
UAA (%)	53		40	
Farms (%)	25		56	
Area	20 ha	80 ha	70 ha	250 ha
Irrigated area (%)	100	60	60	30
Fallow	7.5	10	11.12	7
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
Total area (%)	100	100	100	100

Source: Own elaboration from INE 1999 and farmer surveys.

Table 6. Farm typology characteristics in Andalucía

		F 1	F 2	F 3
UAA (ha)		15	80	200
Irrigation %		100	70	25
Soils (%)	**S1**	100	60	30
	S2	0	40	70
Land distribution	**Durum wheat**	40	30	35
	Soft wheat		10	13
	Sunflower		20	25
	Cotton	15	15	
	Maize	20	15	10
	Beans			
	Chickpeas		5	7
	Special crop	20		
	Fallow	5	5	10
s1: Good quality soil		*100*	*100*	*100*
s2: Medium quality soil				

Source: Own elaboration from IEA (2004) farmer surveys.

3.3 The modelling approach

Within the variety of methods and instruments for investigating the impact of agricultural and environmental policies, we have chosen a mathematical programming modelling approach. As any model is an instrument that imitates a simplified reality (Hazell & Norton, 1986), MPM can be used to analyse the foreseeable effects and consequences of different policies depending on the instruments used as well as to reproduce the behaviour of representative farmers in a given regional context (Flichman & Jacquet, 2004). In this view, as both general and individual equilibrium modelling are amply used for analysing policy impacts, we have developed individual equilibrium farm models that describe the behaviour of farmers confronted with different policy scenarios and policy instruments.

Additionally, the measures of multifunctionality must be tailored to a particular area or region, as each area will have different kinds of problems, and consequently we have defined particular instruments for each region-specific case study.

Individual mathematical programming of farm household models was built to characterize farmer's behaviour in the two selected regions. The models are non-linear single-year static models with a risk component that can be summarised as follows:

This model basically consists of maximizing the utility function (U) subject to given technical, economic and policy constraints (g) . This utility function is composed by a profit function (Z) and a risk vector (R) that takes into account climate as well as market prices variations (see Appendix 2. Model specification).

Maximise U = $f(x)$, $f(x)$ = Z - R

Subject to the following constraints $g(x) \in S_1$

$$x \in S_2$$

where "*x*" is

- in the case of Castilla y León, the vector of the decision-making variables or vector of the activities defined by a given crop-growing area and by an associated given production technique.
- in the case of Andalucía, the variable of the area defined as the combination of activities as part of four-year crop rotations (A), soil quality and type (S) and the technical itinerary followed (T) (see Appendix 2: Model specification).

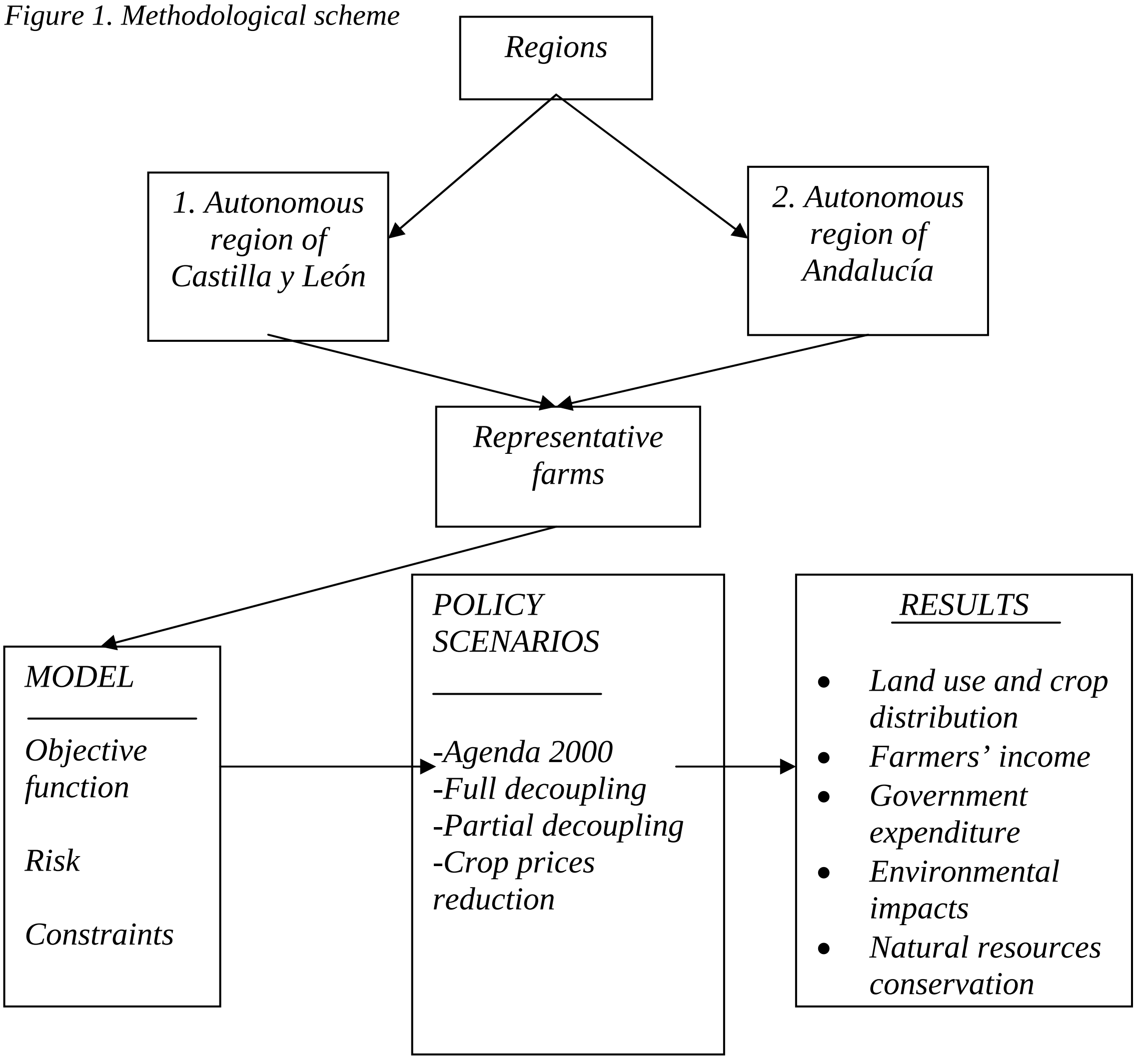
The problem-solving instrument used is GAMS (General Algebraic Modelling System) (Brooke et al. 1998).

Finally, the model has been duly calibrated and validated. Calibration was carried out using the risk aversion coefficient (calibration parameter) and validation was effected in two ways:

- Comparing the data on crop distribution output in the simulation results with the data of the representative farms in each area and
- Checking that the marginal value of land and labour matched the real land lease and wage prices in the respective study areas.

The methodology can be summarised in the diagram in Figure 1 below.

Figure 1. Methodological scheme



4. Scenario Impact Analysis

We have built several tables showing the estimated effects of the different scenarios in the study regions in more detail. The results will be presented by region.

1. Autonomous region of Castilla y León (Northern central plateau of Spain)

In this region, the analysis focuses on the use of water in the irrigated farms in two selected Irrigation Communities (Water User Associations or WUAs, which is the term commonly used in the specialised literature).

The results show the effects of the different agricultural policy scenarios, namely Agenda 2000, partial decoupling and full decoupling on water consumption, farm income and revenue collected by the Irrigation Community (WUA) from the water fees paid by the farmers. In each of the policy scenarios, a water policy instrument has been applied defined by volumetric water tariffs that will encourage a more efficient water use by the irrigators in the selected Irrigation Communities. As water tariffs have been simulated for progressively increasing rates up to 15 simulation levels (see Annex 3), the table below summarises the results that correspond to the water tariff that maximises the revenue collected by the Irrigation Community.

Table 7. Simulation results: Region of Castilla y Leon

WUA: Vegas de Saldaña y Carrión (VSC)

POLICY SCENARIO	POLICY INSTRUMENT	EFFECTS							
		Water volume		Total collection (€/ha)	Cost recovery O&M + Inv. (%)	Income		Cropping pattern	
		Total (m3/ha)	%			Total (€/ha)	%	Rain-fed (%)	Irrigated (%)
Agenda 2000	-	4650	100	77	69.53	480.43	100	24	76
	Water pricing[a]	4304.85	92.57	529.01	100	111.30	23.16	24	76
Partial Decoupling + Modulation	-	4650	100	77	69.53	461.94	96.15	26	74
	Water pricing	4319.12	92.88	530.51	100	93.24	19.4	26	74
Full Decoupling + Modulation	Crop prices reduction (10%)	4650	100	77	69.53	452.58	94.2	25.44	74.56

WUA: Canal del Duero (CD)

POLICY SCENARIO	POLICY INSTRUMENT	EFFECTS							
		Water volume		Total collection (€/ha)	Cost recovery O&M + Inv. (%)	Income		Cropping pattern	
		Total (m3/ha)	%			Total (€/ha)	%	Rain-fed (%)	Irrigated (%)
Agenda 2000	-	5100	100	118	69.83	442.81	100	58	42
	Water pricing[b]	2653.25	52	476.18	100	199.54	45	58	42
Partial Decoupling + Modulation	-	5100	100	118	69.83	433.35	97.8	58	42
	Water pricing	2833.33	55.5	500.05	100	187.1	42.25	58	42

[a] Price = 0.105 €/m3 (highest collection in VSC WUA).
[b] Price = 0.135 €/m3 (highest collection in CD WUA).

Scenario 1 (S1): Partial decoupling

The change of agricultural policy scenario implies:

- Moving from Agenda 2000 to the partial decoupling scenario does not vary substantially the demand for water. Subsidy decoupling does not provide incentives to save water.
- In the move from Agenda 2000 to the partial decoupling scenario, the water charges collected by the WUAs are unchanged.
- Farmers' income falls by 3% on average. The results output perfectly match the outcome forecast by the CAPRI model for this region. CAPRI is the model used by the EU to analyse the regional impact of the European Union's common agricultural policy. Specifically, it will lead to a 5% loss of income for farmers growing COP crops in our region.
- The change of agricultural policy scenario will lead to a slight extensification of the growing area in the Vegas de Saldaña y Carrión WUA (VSC). The new CAP penalises crops, such as maize, that benefited from a bigger comparative advantage under Agenda 2000. The maize-growing area will fall by 3.3% in relative terms and 8.9% in absolute terms. This forecast matches the results yielded by the EU's CAPRI model, which specifies an 8% reduction in absolute terms for maize in this region. On the other hand, the potato-growing area will increase notably, potato now being more profitable than the traditional irrigated crops. In view of this increase in the potato-growing area, the EU has provided a prohibition in regulation 1782 of this CAP reform for farmers benefiting from the single payment to redirect production towards fruit and potatoes so as not to cause distortions in the markets owing to surplus supply.

These effects are observed generally in both water user associations. However, the variations are less marked in the Canal del Duero WUA (CD) because the larger size of its farms means that economies of scale are at work, making them adapt much more flexibly to change.

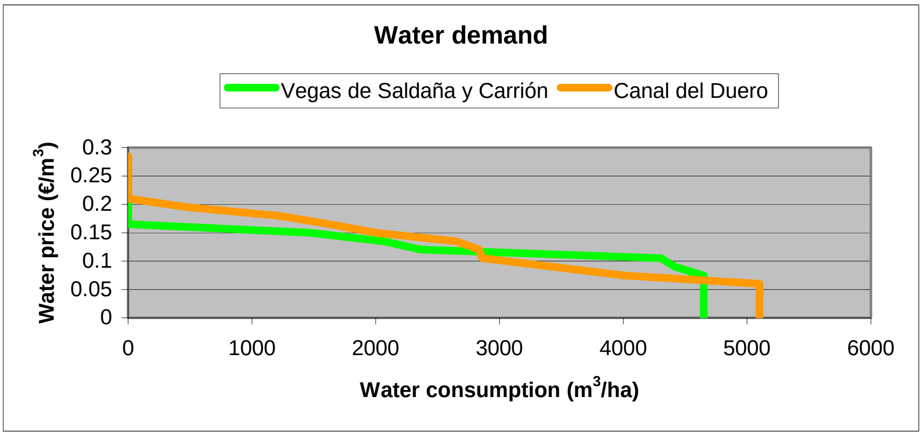
Water Resources Conservation

The goal of water resources conservation (Art. 4 of the WFD) achieved by means of an irrigation water pricing policy implies:

- **Agenda 2000**

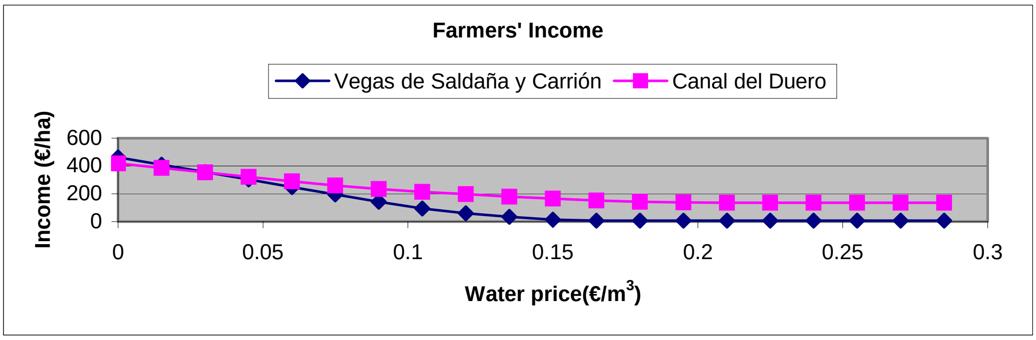
- A ***reduction in the amount of water used*** in the elastic demand curve segment at relatively high prices (0.08-0.19 €/m^3) only (following De Fraiture et al., 2002; Iglesias et al. 1998).

Figure 2. Water demand in the selected WUAs



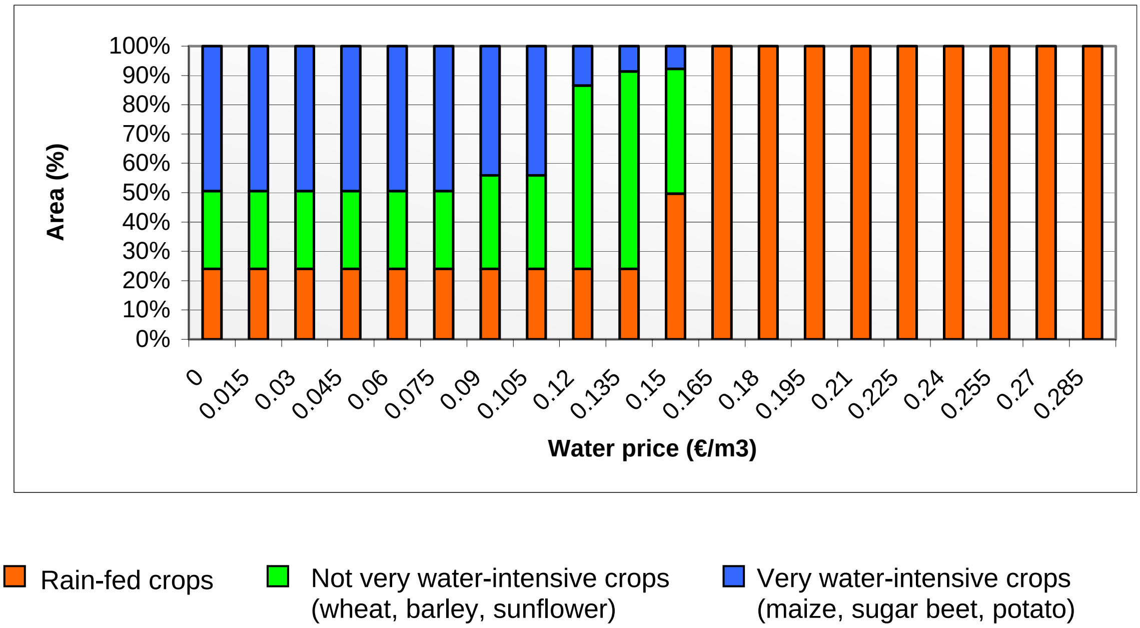
- A ***disproportionate fall in farmers' income***. Accordingly, in the case of the Vegas de Saldaña y Carrión WUA, farmers would have to sacrifice 30-50% of their income to reduce the amount of water by 10-20%.

Figure 3. Farmers' income in the selected WUAs



- An ***increase in water charges collected by the WUA and Hydrographical Confederation*** in the inelastic segment up to the maximum water charge price located at the start of the elastic demand curve segment (0.015-0.12 €/m3).
- An ***incentive for farmers to switch strategies*** to less water-intensive crops, changes in production techniques and abandonment of irrigation. As shown in the figure below, when water is priced at 8 cents of an €, 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.

Figure 4. Crop distribution by water price (Vegas de Saldaña y Carrión WUA)(VSC)



- **New CAP**

The application of the new CAP, in comparison to the water pricing policy applied under Agenda 2000, implies:

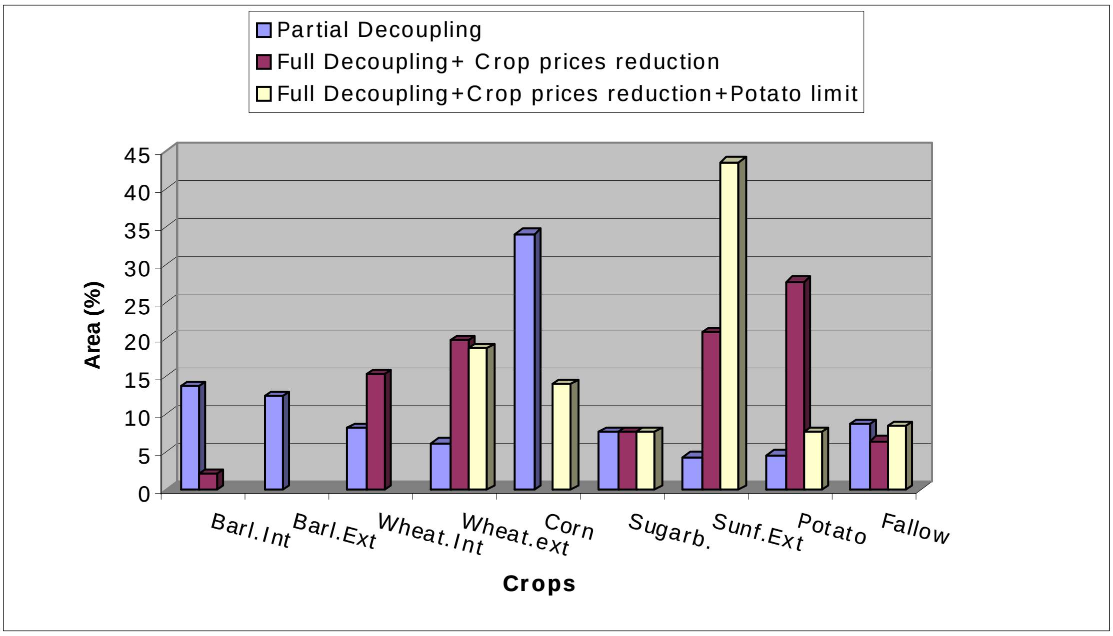
- ***Less water conservation*** in the elastic demand curve segment.
- ***Smaller reduction of farmers' income***.
- ***More water charges collected*** by the public administration and WUA.
- A ***bigger penalty*** for the growing area of water-intensive crops that had a greater comparative advantage within the Agenda 2000 scenario, the biggest loser being ***maize***.

<u>Scenario 2 (S2): Product prices reduction</u>

The liberalisation of agricultural trade by means of a 10% reduction in product prices and full decoupling of payments implies (see also the following Table 6 above and Annex III, Table 26):

- The ***demand for water does not vary substantially***. The 10% reduction is not sensitive enough to promote a reduction and conservation of surface water resources (see Table 6 above).
- The ***water charges collected*** by the Water User Associations ***are unchanged,*** because water prices are not modified.
- ***Farmers' income falls by 2%*** with respect to income earned in the partial decoupling scenario, that is, a 10% cut in product prices and full decoupling of subsidies will only reduce farmers' income by 2% (see Table 6 above).
- ***A widespread reduction of COP cereals and especially irrigated COP cereals*** (such as wheat and barley), with ***maize-growing disappearing completely*** as full decoupling will penalise maize enormously in this region. This crop will lose all its comparative advantage, and there will be a slight increase in the sunflower-growing area, encouraged by its low production costs. The potato-growing area will increase from 4.6% to 27.69%. As was the case with the switch from Agenda 2000 to the partial decoupling scenario, potato is the biggest beneficiary of support decoupling (see Figure 5 and Annex III).
- Due to the disproportionate increase in potato farming, we have simulated a limit on the potato-growing area. The EU CAP reform Cross Compliance Regulation has arrived at identical forecasts and 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**.
- In this case, maize would again be produced, accounting for approximately 15% of the area, set aside would increase slightly and the intensive sunflower-growing area would double, increasing from 21% to 44% (Figure 5, Table 6 and Table 26 in Annex III).

Figure 5. Farmers' strategy for partial decoupling, full decoupling with crop prices reduction and full decoupling with crop prices reduction and limit on potato growing (Vegas de Saldaña y Carrión WUA)



2. Autonomous region of Andalucía

The results for each of the simulated scenarios for the region of Andalucía are presented below.

Scenarios 1 and 2: Partial and full decoupling

We have not made a special distinction between the two scenarios, as the results do not vary significantly.

Both the full and partial decoupling scenarios are found to have effects on:

- ✓ Crop distribution and therefore land use,
- ✓ Farmers' income level and
- ✓ Production techniques that will consequently have a specific impact on the environment.

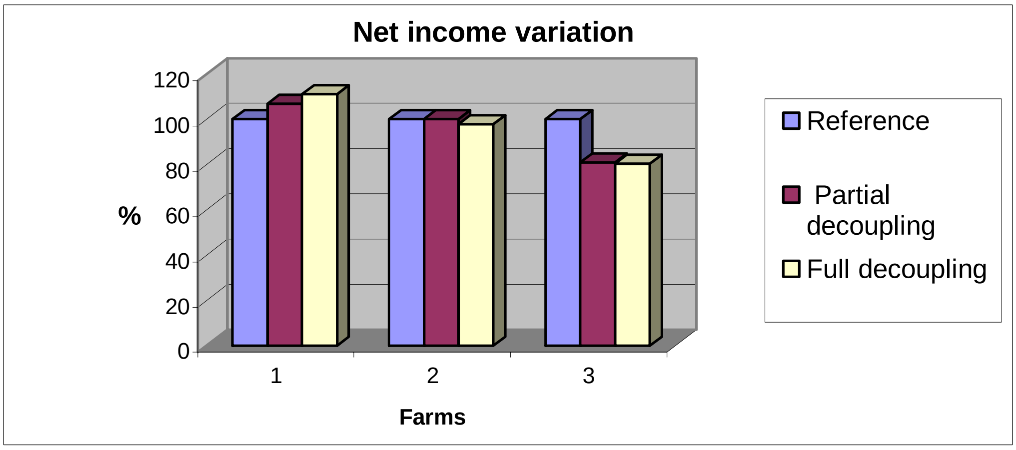
The first observable consequence is the reduction of durum wheat- and cotton-growing areas, as, with the introduction of the single payment, these crops will lose the comparative advantage that they had under Agenda 2000.

Soft wheat is the only cereal that benefits from the reform (which matches the 2003 INRA study entitled *Impacts du compromis de Luxembourg sur les grandes cultures* and CAPRI results & Junta de Andalucía, 2003). The chief reason is that it is a crop that provides farmers with a high gross margin, that is, at equal support levels, soft wheat production costs are lower than for other crops (see Annex 2, Tables 9, 10 and 11).

The effects of one of the main provisions of this scenario, namely the different production coupled percentages, do not have very significant impacts in terms of crop distribution. However, the effects in terms of farmers' income level will be quite sizeable, and the reduction will be directly proportional to the percentage applied (see Annex 2, Table 12).

Some differences have been observed between the partial and full decoupling scenarios as regards farmers' income. It is noteworthy that neither full nor partial decoupling affects rain-fed and irrigated farms equally. For example, for a small irrigated farm with 5% support modulation, the income level will increase by +11.07% in the case of full decoupling and by +6.79% in the case of partial decoupling. However, for a large rain-fed farm, the farmer's income will fall by -19.24% in the case of full decoupling and -19.71% in the case of partial decoupling.

Figure 6. The net income variation: Total and partial decoupling



✓ *Policy instrument: cross-compliance measures (buffer strips and prohibition of single crop cultivation)*

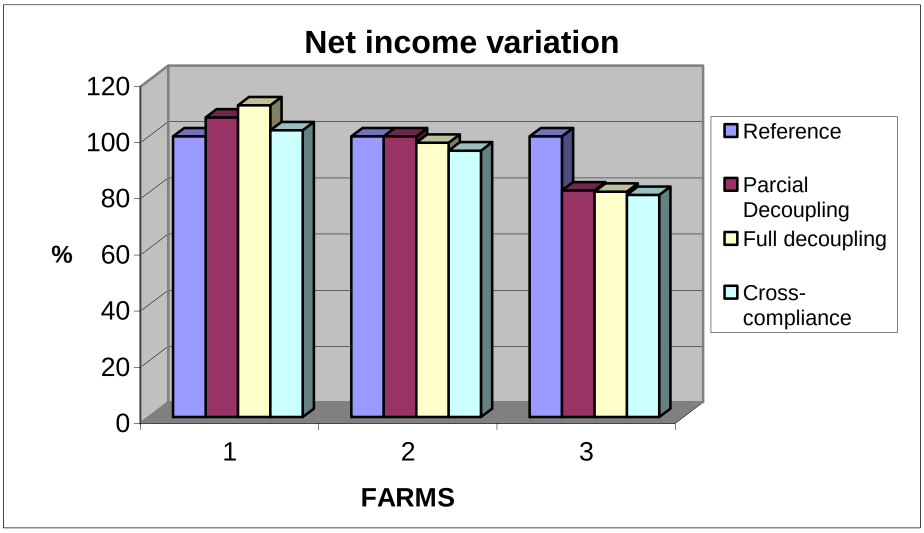
Examining the results for both policy instruments grouped under cross-compliance (BOE 2002; BOE, 2004), the distribution and therefore output of the different crops remains almost unchanged with respect to the first scenario (see Annex 2, Tables 13, 14 and 15).

However, farmers' income level is found to change (see Annex 2, Tables 16 and 17). In this case, the fall in income is higher on irrigated farms than rain-fed farms. This is explained by the fact that the land that irrigated farms are obliged to set aside for buffer strips has a greater opportunity cost in terms of production capacity. Secondly, the obligation to diversify crops on very productive land has a short-term repercussion on farmers, cutting their income level as shown in Figure 7 below.

Both cross-compliance instruments (prohibition of mono-cropping and obligation to keep up buffer strips) lead to a reduction in the emission of polluting substances. The switch in production techniques from more intensive to more extensive practices suggests a notable improvement in the state of the environment.

Therefore, the policy goal for these instruments, which we recall was soil conservation, nitrates reduction and increased biodiversity, appears to be achieved at least to some extent.

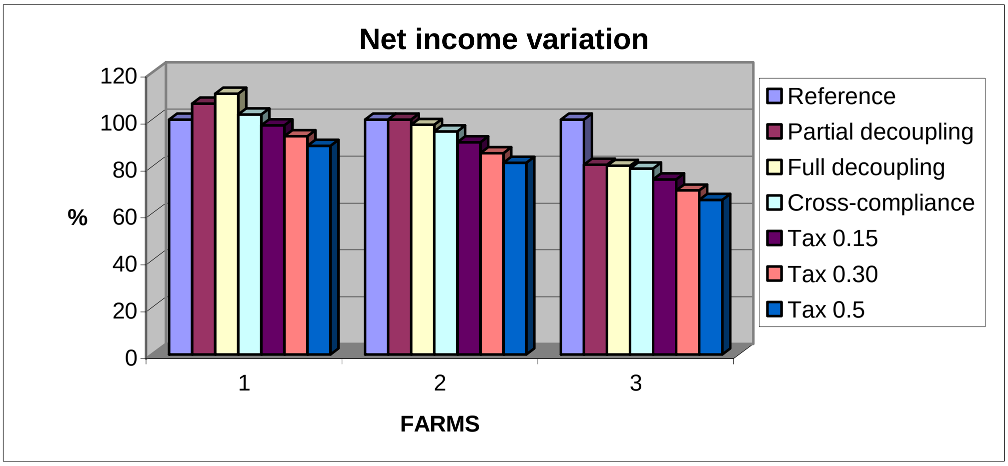
Figure 7. The net income variation: Cross-compliance



✓ *"Partial decoupling with annual modulation, cross-compliance measures and the tax on nitrogen fertilizers"*

This instrument shows how the state of the environment should theoretically improve depending on different levels of tax applied on nitrogen fertilizer buying (see Annex 2, Tables 18, 19 and 20). After simulating a number of levels (euros/kg), it is found that the fall in farmers' income depends on the level of tax applied, as shown in the figure below.

Figure 8. The net income variation: Tax (euros/kg)



Analysing the results, we find that farmers make practically no modification in their crop mix or technical itineraries. Consequently, the extra cost inflicted to the farmers by paying the nitrates tax will not result in any real improvement in environmental conditions. Therefore, the nitrate tax proves to be a non-effective instrument for reducing farming-induced soil pollution by nitrates as no major environmental improvement is expected and farm income loss will be substantial.

Scenario 3. Support price reduction and full decoupling

For this last scenario, we have simulated the results for just one of the model farms built. The selected farm was farm number 2, which has an area of 80 ha and has both rain-fed and irrigated land (see Annex 2, Table 22).

We have found that there is a high percentage fall (63%) in the maize-growing area, as there is in the durum wheat- and cotton-growing area (46%). On the other hand, the special crops and chickpea-growing areas (+19.75% and +124%, respectively) increase due to the high gross margin of these two crops.

As regards income level, there is found to be a sizeable fall (12.31%) with respect to the same scenarios but at current prices. This fall could, therefore, compromise the future of arable and especially rain-ed farms even more.

As regards the impact on the environment, we can say that practices actually do become slightly more extensive. The possible cause is the use of non-ploughing or minimum ploughing techniques with the sole objective of cost cutting.

5. Conclusions

We can summarise some of the main conclusions as follows:

1. The deployment of the new CAP will not lead to drastic changes in the current situation with respect to land use and cropping patterns in the two regions studied. In general, crops with a substantial comparative advantage in the production-based coupled payments (such as maize) will be reduced. Comparing the two regions, these reductions will be more prominent in the inland region of continental agriculture (Castilla) than in the Mediterranean region (Andalucia) with a more varied cropping mix and productive potential.

2. The reduction of the area dedicated to crops with a greater comparative advantage under Agenda 2000 (e.g. maize, cotton, durum wheat) and the increase in the non-COP water-intensive vegetable crops, like potato, would justify the implementation of restrictive measures on the growing of such products by the EU with the aim of preventing market distortions. The only cereal benefiting from the reform is soft wheat (these results match CAPRI *Common Agricultural Policy Regional Impact Analysis*).

3. Partial and full decoupling will have repercussions on farmers' income level. The results differ depending on whether the farms are irrigated, where the income level increases, or rain-fed, where income falls considerably. Therefore, the reform could lead to land abandonment in less-productive rain-fed marginal areas.

4. One of the main goals of the 2003 CAP reform was to promote more extensive farming in Europe and therefore encourage environmental protection. The results obtained show no such improvement in the new CAP decoupled scenarios unless additional measures to protect the environment are introduced. We can deduce from the results that cross-compliance and good agricultural and environmental conditions (GAEC) will contribute substantially to improving and protecting the environment even though they amount to an additional cost for farmers.

5. The measure introducing a tax on the purchase of nitrogen fertilizers does not appear to be very efficient in terms of improving nitrogen fertilizer management. This measure will lead to a very slight improvement in environmental protection but will inflict considerable reductions in the farmers' income.

6. As regards the integration of agricultural and water conservation policies (region of Castilla), a water conservation policy will be spatial-specific and would not yield the same results in all water districts for all policy scenarios considered. An equivalent water tariffs policy aimed at recovering the full cost of water services (as required by the Water Framework Directive) will be more cost-effective in the areas of larger farms that can benefit from the economies of scales (where a 50% reduction in water use will entail an equivalent amount of income loss).

7. We can then conclude that the application of the EU Water Framework Directive in conjunction with the new CAP reform would have to be examined carefully. Achieving the goals of costs recovery (financial and environmental) could have negative effects on farmers' income. And would question the viability of many irrigated farms in Spain. In particular in this study, we found that for prices at which costs can be recovered (0.06€/m3), not only would there be no water savings, but also farmers would be losing from 25% to 50% of their income. It is therefore essential to analyse the cost-effectiveness of the policy, that is, its capacity to achieve the environmental goals of conserving water resources without over penalising farmers' income as stipulated in Art. 4 of WFD:

   Member States may aim to achieve less stringent environmental objectives than those required for specific bodies…when their natural condition is such that the achievement of these objectives would be infeasible or disproportionately expensive, and all the following conditions are met.

8. Therefore integrating both agricultural policies and water polices in the EU will be crucial and a sound combination of both types of policies will have to be encouraged. Specifically, as the new decoupled CAP will influence crop mix changes and hence water consumption in a different manner across water districts, their specific agro-climatic, structural and institutional features would need to be taken into account, as stipulated in Art. 9 of the EU WFD:

   Member States may in so doing 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.

9. Reduction in crop prices and full decoupling will have significant effects on international trade. These effects are denoted by a sharp reduction of certain crops such as maize, cotton and durum wheat growing as a result of the reduction of production-based direct payments and market price decrease. On the other hand, in the EU domestic markets, an increase in water-intensive crops, e.g. potato and fruits, could be expected to substitute for maize for example, which will result in negative impacts to the environment. Consequently, measures that limit the production of these crops as stipulated in the CAP reform cross-compliance regulation (Regulations 1782/03 and 796/04) might be applied. These measures prevent farmers benefiting from the single farm payment from redirecting their activities to the production of fruit and potatoes.

10. Reduction in crop prices as a response to trade negotiations is likely to produce a reduction in farm intensification and hence a beneficial effect on the environment. However, this positive environmental impact, which is one of the objectives of the reform, may not reach the expected levels in a balanced and cost-effective manner. In fact, it will involve negative socio-economic impacts as it will lead to considerable farm income losses that might question the feasibility of certain farms, especially in rain-fed agricultural systems in marginal areas of Spain.

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Annexes

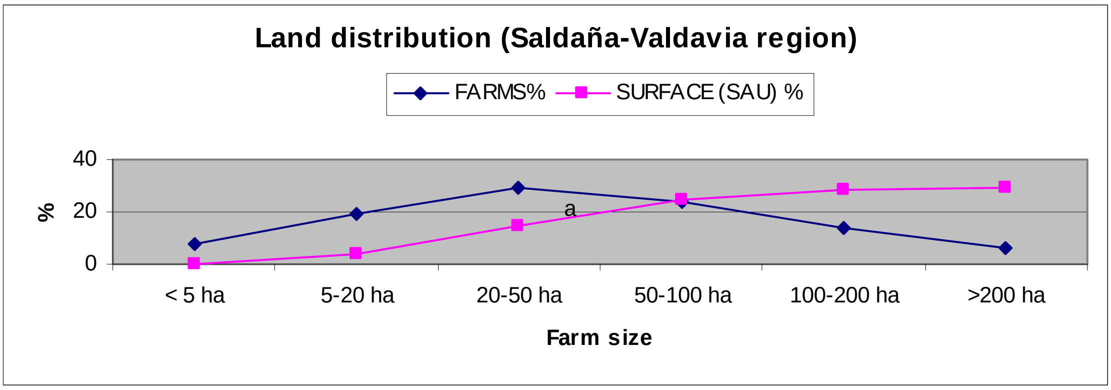
ANNEX 1. FARM TYPOLOGY

Table 1. Farm typology in the Saldaña-Valdavia region (Palencia)

LAND DISTRIBUTION (SALDAÑA-VALDAVIA REGION)			
FARM SIZE	*% FARMS*	*% AREA (UAA)*	*AVERAGE AREA (ha)*
< 5 ha	7.71	0.18	1.56
5-20 ha	19.17	3.51	12.05
20-50 ha	29.19	14.81	33.36
50-100 ha	23.6	24.28	67.63
100-200 ha	13.97	28.29	133.2
>200 ha	6.36	28.93	299.34

Source: Own elaboration from INE (1999).

Figure 1. Farm typology in the Saldaña-Valdavia region (Palencia)



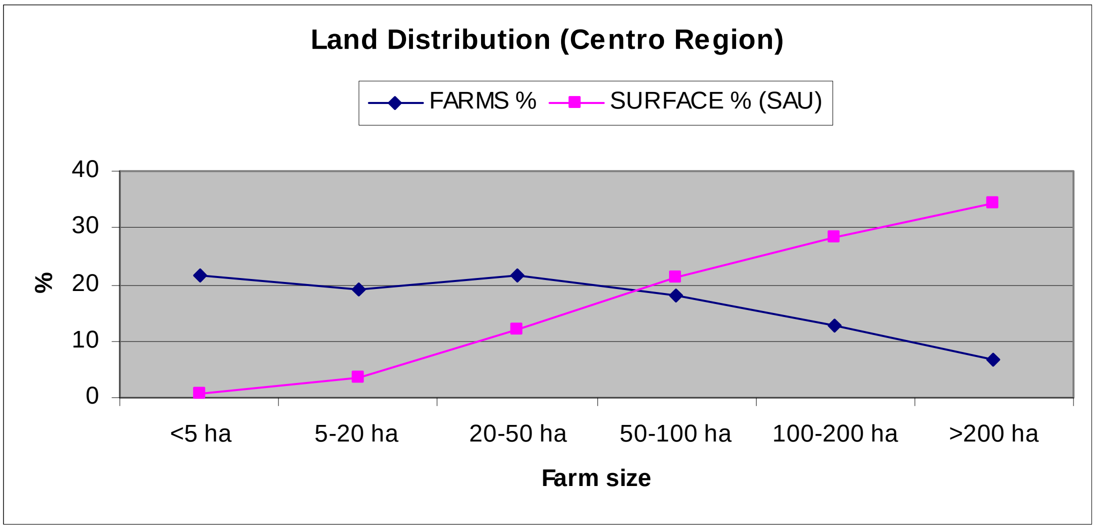
Source: Own elaboration from INE (1999).

Table 2. Farm typology in the Centro region (Valladolid)

LAND DISTRIBUTION (CENTRO REGION)			
FARM SIZE	*% FARMS*	*% AREA (UAA)*	*AVERAGE AREA (ha)*
<5 ha	19.59	0.55	1.51
5-20 ha	19.14	3.42	10.54
20-50 ha	21.59	12.14	33.2
50-100 ha	18.21	21.25	68.89
100-200 ha	12.71	28.31	131.42
>200 ha	6.76	34.33	299.68

Source: Own elaboration from INE (1999).

Figure 2. Farm typology in the Centro region (Valladolid)

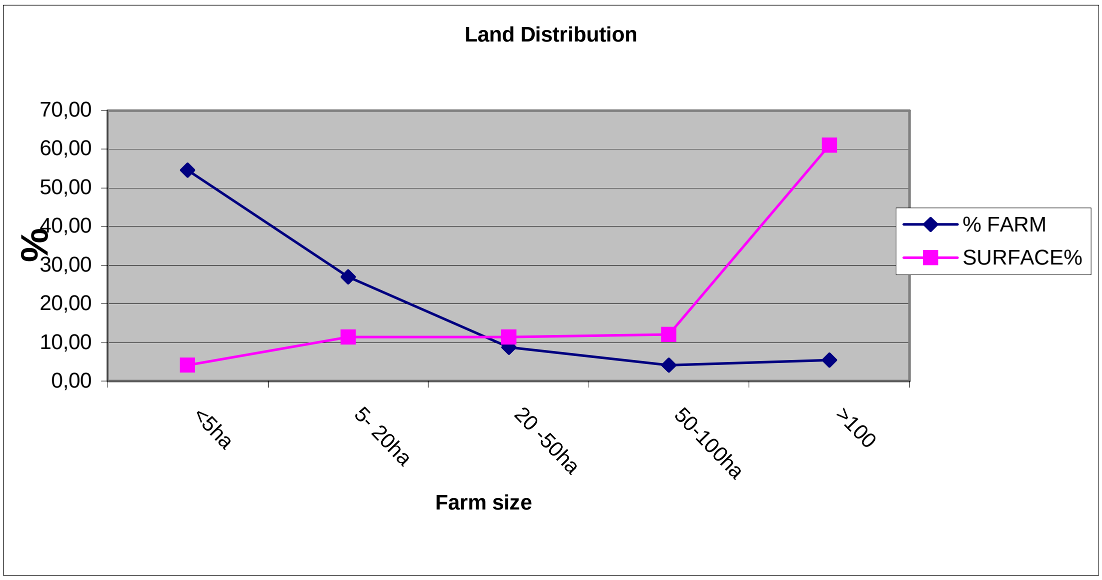


Source: Own elaboration from INE (1999).

Table 3. Farm typology in the Cordoba region (Andalucía)

	%FARMS	*AREA%*
<5ha	54.11	4.40
5- 20ha	27.29	11.87
20 -50ha	8.90	11.75
50-100ha	4.16	12.32
>100	5.54	59.66

Figure 3. Farm typology in Córdoba (Andalucía)



Source: Own elaboration from INE (1999).

ANNEX 2. RESULT TABLES FOR ANDALUCÍA

Table 4. Crop prices (2003)

Crop	*Price (euros/t)*
Durum wheat	163.29
Soft wheat	157.30
Maize	141.70
Sunflower	269.61
Chickpeas	486

Source: IEA (2004).

Table 5. Single farm payment

Farms	*SFP (euros / farm)*
Representative farm No. 1	8.949
Representative farm No. 2	30.454
Representative farm No. 3	55.869

Table 6. Water availability

Crops	*Cropwat[2] (mm)*
Wheat	289.38
Maize	588.9
Chickpeas and Beans	171.82
Sunflower	278.7
Cotton	788

Source: Cropwat (FAO).

Table 7. Fixed costs/faro

Farms	*Fixed costs (euros / ha)*
Representative farm No. 1	660
Representative farm No. 2	340
Representative farm No. 3	181

Source: INAGRO SA.

Table 8. Nitrogen Units

Crop	*Irrigated (nitrogen units/ha)*		*Rain-fed (nitrogen units/ha)*	
	Intensive	*Extensive*	*Intensive*	*Extensive*
Wheat	160	120	120	100
Corn	500	400		
Cotton	250	160		
Chickpeas and Beans	50	30		

Source: INAGRO SA.

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[2] Cropwat: is a decision support system developed by the Land and Water Development Division of FAO. See http://www.fao.org/ag/AGL/aglw/cropwat.stm

Table 9. Scenario simulation - Farm type no. 1

	Full decoupling (% ha)	***Partial decoupling (% ha)***	***Baseline situation (% ha)***
Durum Wheat (TD)	35.4	34.65	37.8
Soft Wheat (TB)	4.52	2.75	0
Cotton (AG)	11.7	13.8	14.2
Maize (MI)	19.02	20.5	19.21
Special crop (CS)	24.3	23.3	23.3
Fallow	5	5	5

Table 10. Scenario simulation - Farm type no. 2

	Full decoupling (% ha)	***Partial decoupling (% ha)***	***Baseline situation (% ha)***
Durum Wheat (TD)	25.7	25.3	28.3
Soft Wheat (TB)	17.19	12.8	14.2
Cotton (AG)	11	10.75	14
Maize (MI)	15.9	15.5	13
Sunflower (GI)	11.2	11.2	11.2
Chickpeas (GB)	6	6	6.3
Special crop (CS)	8.1	8.1	8.1
Fallow	5	5	5

Table 11. Scenario simulation - Farm type no. 3

	Full decoupling (% ha)	***Partial decoupling (% ha)***	***Baseline situation (% ha)***
Durum Wheat (TD)	29.8	29.8	30.75
Soft Wheat (TB)	18.6	18.6	16.75
Cotton (AG)	-	-	-
Maize (MI)	6.75	6.75	6.25
Sunflower (GI)	17.50	17.50	17.50
Chickpeas (GB)	23.75	23.75	23.75
Fallow	5	5	5

Table 12. Income effects of policy scenarios

	Representative farm No. 1	***Representative farm No. 2***	***Representative farm No. 3***
Full decoupling			
Without modulation	12.84%	5.04%	-15.42%
4%	11.07%	2.27%	-19.24%
5%	10.61%	1.55%	-20.20%
Partial decoupling			
Without modulation	8.48%	2.80%	-15.91%
4%	6.79%	0.01%	-19.71%
5%	6.33%	-0.73%	-20.66%

Table 13. Cross-compliance simulation - Farm type no. 1

	Full decoupling (% ha)	***Partial decoupling (% ha)***	***Baseline situation (% ha)***	***Cross-compliance (% ha)***
Durum Wheat (TD)	35.4	34.65	37.8	32.38
Soft Wheat (TB)	3.52	2.75	0	13.31
Cotton (AG)	11.7	13.8	14.2	-
Maize (MI)	21.02	20.5	19.21	23.38
Special crop (CS)	23.3	23.3	23.3	23.3
Strip	-	-	-	2.6
Fallow	5	5	5	5

Table14. Cross-compliance simulation - Farm type no. 2

	Full decoupling (% ha)	***Partial decoupling (% ha)***	***Baseline situation (% ha)***	***Cross-compliance (% ha)***
Durum Wheat (TD)	25.7	25.3	28.3	23.8
Soft Wheat (TB)	17.19	12.8	14.2	18
Cotton (AG)	11	10.75	14	9.5
Maize (MI)	15.9	15.5	13	16.75
Sunflower (GI)	11.2	11.2	11.2	11.25
Chickpeas (GB)	6	6	6.3	5.3
Special crop (CS)	8.1	8.1	8.1	8.1
Strip	-	-	-	2.13
Fallow	5	5	5	5

Table15. Cross-compliance simulation - Farm type no. 3

	Full decoupling (% ha)	***Partial decoupling (% ha)***	***Baseline situation (% ha)***	***Cross-compliance (% ha)***
Durum Wheat (TD)	29.8	29.8	30.75	30
Soft Wheat (TB)	18.6	18.6	16.75	16
Maize (MI)	6.75	6.75	6.25	5.5
Chickpeas (GB)	17.50	17.50	17.50	17.50
Special crop (CS)	23.75	23.75	23.75	23
Strip	-	-	-	3
Fallow	5	5	5	5

Table 16. Farm income variation in the partial decoupling plus cross-compliance scenario

FARMS	***VARIATION (%)***
Representative farm No. 1	-8.86%
Representative farm No. 2	-2.79%
Representative farm No. 3	-1.17%

Table 17. Farm income variation in the full decoupling plus cross-compliance scenario

FARMS	***VARIATION (%)***
Representative farm No. 1	-2.07%
Representative farm No. 2	-2.79%
Representative farm No. 3	-20.88%

Table 18. Simulated effects of a tax on nitrate fertilizer - Farm type no. 1

	Baseline situation (% ha)	***Cross-compliance (% ha)***	***Tax (% ha)***
Durum Wheat (TD)	37.8	32.38	32.37
Soft Wheat (TB)	0	13.31	14.37
Cotton (AG)	14.2	-	-
Maize (MI)	19.21	23.38	23.3
Special Crop	23.3	23.3	23.3
Strip	-	2.6	-
Fallow	5	5	5

Table 19. Simulated effects of a tax on nitrate fertilizer - Farm type no. 2

	Baseline situation (% ha)	***Cross-compliance (% ha)***	***Tax (% ha)***
Durum Wheat (TD)	28.3	23.8	23.21
Soft Wheat (TB)	14.2	18	18.21
Cotton (AG)	14	9.5	9.5
Maize (MI)	13	16.75	16.9
Sunflower (GI)	11.2	11.25	11.25
Chickpeas (GB)	6.3	5.3	5
Special crop (CS)	8.1	8.1	8.1
Strip	-	2.13	2.13
Fallow	5	5	5

Table 20. Simulated effects of a tax on nitrate fertilizer - Farm type no. 3

	Baseline situation (% ha)	***Cross-compliance (% ha)***	***Tax (% ha)***
Durum Wheat (TD)	30.75	30	30.01
Soft Wheat (TB)	16.75	16	16.25
Cotton (AG)	6.25	5.5	5.71
Maize (MI)	17.50	17.50	17.50
Sunflower (GI)	23.75	23	23.02
Strip	-	3	3
Fallow	5	5	5

Table 21. Farm income effects of a partial decoupling scenario with cross-compliance measures and a tax on nitrogen fertilizer

FARMS	***Tax 0.5 (euros/kg)***	***Tax 0.3 (euros/kg)***	***Tax 0.15 (euros/kg)***	***Tax 0.06 (euros/kg)***
Representative farm No. 1	-14.07%	-8.7%	-4.5%	-1.8%
Representative farm No. 2	-15.9%	-9.83%	-4.9%	-1.86%
Representative farm No. 3	-15.5%	-9.34%	-4.53%	-1.6%

Table 22. Crop prices reduction scenario - Farm type no. 2

	Crop prices reduction (10 %)	***Cross-compliance situation (% ha)***
Durum Wheat (TD)	21.67	23.8
Soft Wheat (TB)	19.13	18
Cotton (AG)	5.14	9.5
Maize (MI)	6.26	16.75
Sunflower (GI)	8.00	11.25
Chickpeas (GB)	13.90	5.3
Special crop (CS)	8.50	8.1
Strip	2.13	2.13
Fallow	5.00	5

ANNEX 3. RESULT TABLES FOR CASTILLA Y LEÓN

- **Agenda 2000-Partial Decoupling**

Table 23. Crop distribution in the two policy scenarios

CROPS (%)	VSC WUA AREA (%)		CD WUA AREA(%)	
	AGENDA 2000	PARTIAL DECOUPLING	AGENDA 2000	PARTIAL DECOUPLING
BARLEY.INT	9.5	13.8	6.5	6.8
BARLEY.EXT	5.8	12.4	12	14.1
WHEAT.INT	11.4	8.2	-	-
WHEAT.EXT	12.7	6.2	38.3	36.4
MAIZE	37.3	34	12	9.8
SUGARBEET	7.6	7.6	12.6	12.6
SUNFLOWER.INT	5.6	4.4	-	-
SUNFLOWER.EXT	-	-	0.1	0
POTATO	1	4.6	10.9	12.8
FALLOW	9.1	8.8	7.6	7.5

Figure 4. Crop distribution in the two policy scenarios (VSC WUA)

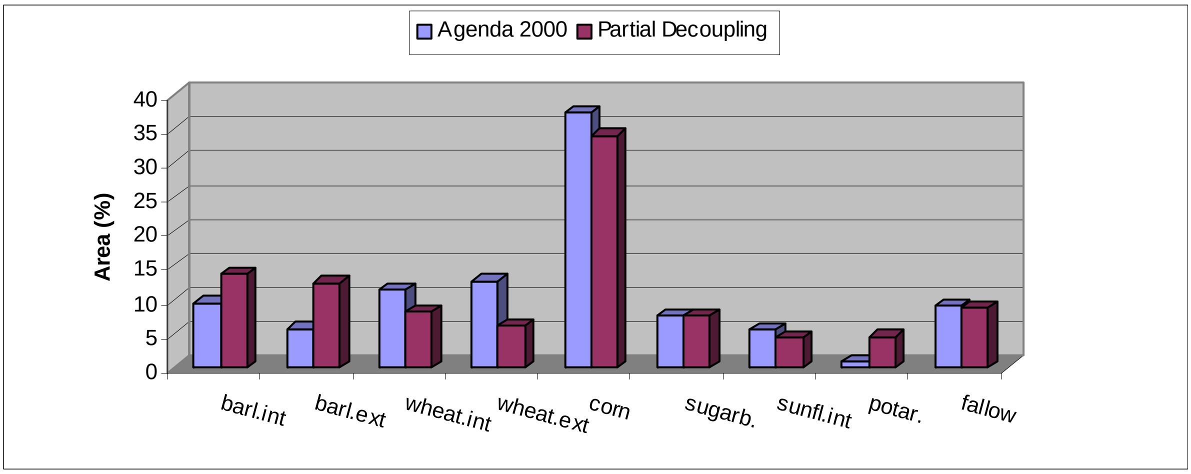
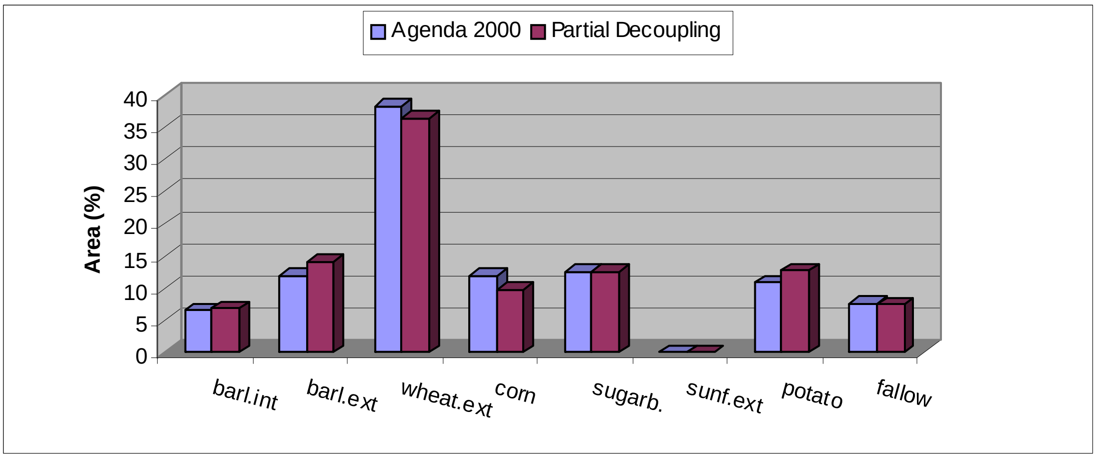


Figure 5. Crop distribution in the two policy scenarios (CD WUA)



- **Water Pricing**

Table 24. Effects of the application of water prices in the Agenda 2000 scenario (VSC WUA)

Tariff	WATER PRICE (€/m^3)	WATER CONSUMPTION (m^3/ha)	EXPECTED INCOME (€/ha)	LOSS OF EXPECTED INCOME (%)	FARM GROSS MARGIN (€/ha)	WUA REVENUE (VARIABLE) (€/ha)	WUA REVENUE (TOTAL) (€/ha)
1	0	4650	461,43	100	480,43	0	77
2	0.015	4650	408.42	88.51	427.42	69.75	146.75
3	0.03	4650	355.41	77.02	374.41	139.5	216.5
4	0.045	4650	302.40	65.53	321.40	209.25	286.25
5	0.06	4650	249.39	54.047	268.39	279	356
6	0.075	4650	196.38	42.55	215.38	348.75	425.75
7	0.09	4417.66	143.58	31.11	161.66	397.59	474.59
8	0.105	4304.85	93.384	20.23	111.30	452.01	529.01
9	0.12	2363.08	58.742	12.73	71.27	283.56	360.56
10	0.135	2068.75	34.246	7.42	49.56	279.28	356.28
11	0.15	1470.52	12.798	2.77	24.90	220.57	297.57
12	0.165	0	7.19	1.55	18.2	0	77
13	0.18	0	7.19	1.55	18.2	0	77
14	0.195	0	7.19	1.55	18.2	0	77
15	0.21	0	7.19	1.55	18.2	0	77
16	0.225	0	7.19	1.55	18.2	0	77
17	0.24	0	7.19	1.55	18.2	0	77
18	0.255	0	7.19	1.55	18.2	0	77
19	0.27	0	7.19	1.55	18.2	0	77
20	0.285	0	7.19	1.55	18.2	0	77

Table 25. Land distribution effects of the application of water prices (Agenda 2000, VSC WUA)

TARIF.	P (€/m3)	FALL. (%)	WH.INT (%)	WH.EXT (%)	BARL.INT (%)	BARL.EXT (%)	MAIZ E (%)	SUGARB . (%)	SUNF.INT (%)	POTAT. (%)	PEA. (%)
1	0	9.13	11.41	12.69	9.53	5.7	37.2	7.6	5.6	1.02	0
2	0.015	9.13	11.41	12.69	9.53	5.7	37.2	7.6	5.6	1.02	0
3	0.03	9.13	11.41	12.69	9.53	5.7	37.2	7.6	5.6	1.02	0
4	0.045	9.13	11.41	12.69	9.53	5.7	37.2	7.6	5.6	1.02	0
5	0.06	9.13	11.41	12.69	9.53	5.7	37.2	7.6	5.6	1.02	0
6	0.075	9.13	11.41	12.69	9.53	5.7	37.2	7.6	5.6	1.02	0
7	0.09	9.17	10.2	13.3	14.12	5.0	34.9	7.6	4.9	0.64	0
8	0.105	9.2	0	16.2	24.4	2.1	35.1	7.6	4.7	0.36	0
9	0.12	9.24	5.8	9.3	48.55	14.6	4.79	7.6	0	0	0
10	0.135	9.24	0	9.0	59.16	14.9	0	7.6	0	0	0
11	0.15	9.32	0	18.7	34.2	30.8	0	6.78	0	0	0
12	0.165	10	0	35.3	0	31.75	0	0	0	0	22.8
13	0.18	10	0	35.3	0	31.75	0	0	0	0	22.8
14	0.195	10	0	35.3	0	31.75	0	0	0	0	22.8
15	0.21	10	0	35.3	0	31.75	0	0	0	0	22.8
16	0.225	10	0	35.3	0	31.75	0	0	0	0	22.8
17	0.24	10	0	35.3	0	31.75	0	0	0	0	22.8
18	0.255	10	0	35.3	0	31.75	0	0	0	0	22.8
19	0.27	10	0	35.3	0	31.75	0	0	0	0	22.8
20	0.285	10	0	35.3	0	31.75	0	0	0	0	22.8

- **Crop prices reduction**

Table 26. Farmers' strategy for partial decoupling, full decoupling with crop prices reduction and full decoupling with crop prices reduction and limit on potato growing (Vegas de Saldaña y Carrión WUA)

CROPS (%)	PARTIAL DECOUPLING	FULL DECOUPLING + CROP PRICES REDUCTION	FULL DECOUPLING + CROP PRICES REDUCTION + POTATO LIMIT
BARLEY.INT	13.8	2.1	-
BARLEY.EXT	12.4	-	-
WHEAT.INT	8.2	15.39	-
WHEAT.EXT	6.2	19.86	18.72
MAIZE	34	-	14.03
SUGARBEET	7.6	7.6	7.6
SUNFLOWER.INT	4.4	20.9	43.57
SUNFLOWER.EXT	-	-	-
POTATO	4.6	27.69	7.6
FALLOW	8.8	6.46	8.48

ANNEX 4. MODEL SPECIFICATION

Both models have the same overall structure: a farm model where the farmer maximises his/her objective function subject to different kinds of constraints.

The model includes some specificities for each of the regions, which will be explained as applicable.

The Castilla y León model is defined by:

1. Objective function

The objective function is defined by a utility function that represents the net margin (income) less the farmer's risk represented by the standard deviation depending on different states of nature and the market. The objective function is defined by the following equation:

$$MaxU = Z - PHI \times \sigma \qquad (1)$$

where:

U: is the utility
Z: is the net income level
PHI: is the risk aversion coefficient
σ: is the sum of the standard deviations as a function of different states of nature and different states of the market assuming the distribution to be normal.

1.1 The risk equation in the model is as follows:

$$\sigma_{iz} = (\sum_n (V_{in} - V_i)^2)^{1/2} + 1) / N \quad (2)$$

where N=100 because of the combination of the 10 states of nature representing agronomic variability and 10 states of the market representing economic variability.

1.2 Income function

i) Castilla y León region model:

- A series of **production activities** "c", which represent the area defined by a given crop.
- **production sub-activities** "cop", subset that covers cereals, oilseed and protein crops.
- two, typically Spanish, **production techniques** "t", rain-fed and irrigation.
- **decision-making variables** "X", which represent the area defined by a given crop and by a given associated production technique.
- two **periods of the year** "p", winter and summer, representative of the seasonal distribution of the labour characteristic of the region.
  The income equation is as follows:

$$Z = \sum_{c=1}^{n}\sum_{t=1}^{m} MB_{ct} \times X_{ct} + \sum_{c=1}^{n}\sum_{t=1}^{m} PRIMA_{ct} \times X_{ct} \times ACOP \times MODUL + \\ + DPU \times MODUL \times (1 - ACOP) - TM3 \times QA - THA \times SREG - \\ - CANON \times SREG - CO \times \sum_{p=1}^{r} DMO_p - PMO \times \sum_{p=1}^{r} MOC_p \qquad (3A)$$

where:

- MB_{ct} : represents the gross margin obtained by crop type and activity type in €/ha.
- X_{ct} : decision-making variables that represent the growing area (in hectares) by crop type (c) and activity type (t).
- $PRIMA_{CT}$: CAP support received by crop type and selected technique (in €/ha) that will continue to be coupled to production.
- $ACOP$: support coupling level. This is a scalar that can have different values depending on the adopted policy. A value of 0 in the case of full decoupling and a value of 0.25 in the case of partial decoupling.
- $MODUL$: Percentage of support modulation (3%, 4% and 5%).
- DPU : represents the single farm payment. This payment is calculated as the mean support received during the 2000/2001/2002 and is received irrespective of production and growing area.
- $TM3$: refers to the unit cost of water in €/m^3. This is the values that will be simulated in the model for different water tariffs.
- QA : is the amount of water used expressed in thousands of cubic metres. It will be a variable to be defined by the model that depends on crop irrigation water needs and the technical water distribution efficiency coefficient.
- THA and $CANON$: are the prices in €/ha paid by farmers to the water user associations and the Hydrographical Confederation, respectively[3].
- $SREG$: irrigated area in ha, which will be defined for each model farm.
- CO : is the family labour opportunity cost (€/h). This cost has been assumed to be somewhat lower than paid labour obtained from surveys to prevent all labour being allotted to family labour.
- DOM_p : represents the availability of labour (hours) depending on the period of the year in question. Its value will be higher in winter than in summer and greater on larger than smaller farms.
- PMO : is the price of hired labour (€/h), that is, paid labour.[4]

- MOC_p : is hired labour measured in hours labour is hired for. It will be a variable to be determined by the model.

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[3] These data have been obtained from WUA and INE surveys (2002).

[4] Values have been obtained from farmer surveys and data from real farms run by the farm management firm 'INAGRO' in Castilla León.

ii) Andalucía region model:

$$
\begin{aligned}
Z = & \sum_a \sum_s \sum_t X_{ast} \times AIDS_{2004\ ast} \times DECOUP \times alpha \\
& + SFP \times (1 - DECOUP) \times alpha \\
& + \sum_a \sum_s \sum_t X_{ast} \times PDT_{ast} \\
& - \sum_a \sum_s \sum_t X_{ast} \times CO_{ast} \\
& - \sum_a \sum_s \sum_t X_{ast} \times CWATER_{ast} \times CTWATER \\
& - CFIX
\end{aligned}
\qquad (3B)
$$

where:

-X_{ast} *:* is a variable of area by activity (A), soil type (S) and technique type (T).
-PDT_{ast}*:* represents the product of each of the possible combinations, calculated by multiplying the mean yield of each crop, depending on soil type and technique type in each case, by the mean price[5].

-$AIDS_{ast.}$: volume of support for each of the crop combinations that will continue to be coupled to production. As in the other cases, it has been calculated for each activity as the mean support received for the four crops in each rotation.
-*DECOUP*: support coupling level. This is a scalar that can have different values depending on the adopted policy. A value of 0 in the case of full decoupling and a value of 0.25 in the case of partial decoupling.
-*Alpha*: Percentage of support modulation (3%, 4% and 5%).
-*SFP*: represents the single farm payment. This payment is calculated as the mean support received during the 2000/2001/2002 and is received irrespective of production and growing area.[6]

-CO_{ast} *:* set of direct costs by activity, soil and technique.[7]
-$CWATER_{ast}$: water consumption of each combination (by activity, soil and technique), calculated as the mean for each combination.[8]

-*CTEWATER*: is the water price value that is multiplied by the volume of water consumed. In this case, we have assumed that all three farms consume water from wells at different costs in each simulation (from 0.03 to 0.9 euros/m^3 depending on depth).
-*CFIX*: represent the fixed costs of each farm, obtained in the same way as direct costs. To assure that the calculation of the fixed costs was representative at the level of the model farms, we consulted the study entitled *Análisis del impacto de diversos sistemas de ayudas directas sobre al campiña de Córdoba* (Analysis of the impact of several direct payment schemes on the countryside of Cordoba) (Castillo et al., 2001), which determines the costs by farm size and activity.

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[5] See Table 4, Annex 2.

[7] See Table 5, Annex 2.

[7] It has been calculated from real data obtained in the yield work survey and from the farm management firm 'INAGRO' taken from their accounting data. (Seville).

[9] See Table 6, Annex 2.

[10] See Table 7, Annex 2.

2. Constraints

2.1 Land constraints

i) Total land constraint (4)

$$\sum_a \sum_s \sum_t X_{ast} \leq UAA$$

where UAA is utilised agricultural area.

For the Andalucían model, we also introduced constraints for each soil type, such that the number of hectares did not exceed the amount of land available for each soil type:

$$\sum_a \sum_t X_{ast} \leq SBs$$
$$\sum_a \sum_t X_{ast} \leq SB_i$$
$$\sum_a \sum_t X_{ast} \leq SM_s$$
$$\sum_a \sum_t X_{ast} \leq SM_i$$

(5), (6), (7) and (8)

ii) Irrigated land constraint

In the Castilla y León model there is a constraint on the area of irrigated land:

$$\sum_{c=1}^{n} X_{c,\text{int}} \leq SREG \quad (9)$$

2.2 Labour constraints

This constraint is only included in the Castilla y León model:

The labour needs (NMO_{ct}) have to be covered by the availability of family labour (DMO_p) and hired labour on the market in each period (MOC_p).

$$\sum_{c=1}^{n} \sum_{t=1}^{m} NMO_{ct} \leq DMO_p + MOC_p \quad (10)$$

2.3 Water availability constraints

In the case of the Castilla y León model, the crop water needs ($NAGUA_{ct}$) have to be met by the water that really reached the plot, which will be equal to the gross allotment (*DOT*: allotment granted by the Hydrographical Confederation to the water users association) taking into account a technical efficiency coefficient (*h*).

$$\sum_{c=1}^{n} \sum_{t=1}^{m} NAGUA_{ct} \times X_{ct} \leq DOT \times SREG \times h \quad (11)$$

In the case of Andalucía, irrigation water availability has been expressed as follows:

where:

$$\sum_{a}\sum_{s}\sum_{t} X_{ast} \times CWATER \leq VOLWATER \quad (12)$$

-*VOLWATER*: volume of water available in m^3/ha.[9]

2.3- The policy constraints

i) Crop limitation in the Castilla y Leon region

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.

$$\sum_{t=1}^{m} X_{remol,t} \leq CUPO \quad (13)$$

-*CUPO*: sugar beet hectares (maximum).

ii) Set aside rate

There is a compulsory minimum and maximum land set aside rate for the COP growing area. The minimum compulsory set aside rate may vary, but has been set at 5% for the 2003/2004 season.

$$\sum_{r}\sum_{s}\sum_{t} X_{rst} \geq SCOP \times TXR \quad (14)$$

$$\sum_{i}\sum_{s}\sum_{t} X_{rst} \leq SCOP \times 0.3 \quad (15)$$

where:

-*TXR*: minimum set aside rate (10% or 5%)
-X_{rst}: number of farmed hectares “set aside” for each soil type and technique.
-*SCOP*: Cereals, oilseed and protein crops growing area.

iii) Cross-compliance constraints

Two equations have been introduced that will translate some of the measures to be introduced in the spanish legislation bill on the application of cross compliance in CAP direct payments.[10] The first concerns the maintenance of a given COP growing area land for buffer strips. The second condition concerns the maintenance of biodiversity, that is, the prohibition of mono-cropping which, in this case, will only affect maize mono-cropping, as it is the only activity that has been assumed to be possible in a mono-cropping system.

[9] For this research, we have opted for allotments assuming a localised irrigation method with a State Coordinated Plans irrigated areas channel head.

[10] Spanish Council 2352/2004 of 23th December 2004.

where:

$$\sum_{b}\sum_{s}\sum_{t} X_{sst} \geq SCOP \times TXECO \quad (17)$$

$$\sum_{am}\sum_{s}\sum_{t} X_{amst} \leq SAU \times 0.9 \quad (18)$$

-X_{bst}: number of hectares for the ‘strip’ activity (b), each soil type (s) and technique type (T).
-X_{amst}: number of hectares for the ‘mono-cropping activity’ (am), each soil type (s) and technique type (T).
-*TXECO:* Cross-compliance rate: 0.3

iv)Tax upon nitrogen fertilizer buying:

$$\sum_{a}\sum_{s}\sum_{t} X_{ast} \times Nitro_{ast} \times Tax = TAXINPUT \quad (19)$$

where:
-$Nitro_{ast}$: number of nitrogen units per activity, soil type and technique
-*Tasa*: tax levied in euros/kg
-*TASINPUT*: total tax in euros.

About ENARPRI

ENARPRI is a network of European agricultural and rural policy research institutes formed for the purpose of assessing the impact of regional, bilateral and multilateral trade agreements concluded by the European Union or currently under negotiation, including agreements under the WTO, EU accession, Everything But Arms (EBA), EuroMed and Mercosur. It also addresses the wider issues of the multifunctional model of European agriculture and sustainable development of rural areas. Participants in the project include leading national institutes and research teams from 13 countries (11 EU member states and 2 accession countries).

Aims

- Creation of an institutional structure linking key research institutes with major benefits for improved exchange of information and policy analysis both in the short and long run,
- Development of improved tools for impact assessment,
- More effective impact assessment of trade agreements on a variety of important social, economic, and environmental indicators and an assessment of multifunctionality, and
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