NeWater

AGRO-ECONOMIC MODEL FOR ANALYZING POLICY SCENARIOS AND COST-EFFECTIVENESS OF POLICY MEASURES, LINKING WATER AND AGRICULTURAL POLICY

Development of a prototype model

Report of the NeWater project -
New Approaches to Adaptive Water Management under Uncertainty

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Preamble

This report has been completed at the Universidad Politécnica de Madrid (partner nº 38), which is involved work package 1.7 of the NeWater project. Some parts of the work leading to this report have been carried out in close collaboration with other NeWater partners, especially in the framework of the continuous and close collaboration with the Universidad Complutense de Madrid (UCM), the Geological Survey of Spain (IGME) and also, in the specific part of the hydrological component, with the Stockholm Environmental Institute (SEI). We gratefully acknowledge their contribution. We would also like to thank all stakeholders who have participated in the process for the time and effort dedicated to this research, especially the Guadiana River Basin Authority and the Irrigation Communities of the La Mancha Aquifer in the Upper Guadiana.

We would also like to gratefully acknowledge the support of the European Commission in providing funds for this research and to the Spanish Ministry of Education and Science for providing complementary funds for this project.

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NeWater project
December 2006

Policy Summary

Overview[1]

Our research is integrated in work package WP 1.7 of NeWater project, which aims to develop a conceptual framework for adaptive management to be applied to integrated water resources management. On this purpose, it investigates, with the involvement of stakeholders, different strategies that can be followed to make management regimes more responsive to changes.

More specifically, deliverable D1.7.5b contributes to task 1.7.6b, which comprises the development of an agro-economic model for analyzing policy scenarios, both agricultural policies and water policies as well as the cost-effectiveness of policy measures linking water and agricultural policies. This model has been applied to one specific case study: the Upper Guadiana river basin in the central plateau of Spain. Based on this first modeling structure, the subsequent research developments will permit a more elaborated analysis that will focus on the adaptive capacity of different policy options as well as on comparisons with other models developed under WP1.7.

Water management in the Upper Guadiana river basin

Water scarcity is becoming a serious problem in many regions in the world of arid and semi-arid climate. Efficient management of water resource is becoming a major policy-relevant issue for the administration, the policy makers and civil society.

Our research consists on the analysis of the joint application of different agricultural and water policies and their effects on farmers' decisions, regarding changes in cropping patterns, in water use and the consequent effects on the state of water resources. (Section 2)

In the Mediterranean basin, irrigation agriculture is a key sector of the economy but it consumes a large proportion of all available water resources, in countries where water is scarce. One example of this situation is the Upper Guadiana Basin, an area in which agriculture is dependent on groundwater and where abstractions exceed the recharge capacity of the aquifer. Water use has lead to long-lasting social and political conflicts (Section 2.1). Regional, National and European policies have been implemented on the purpose of solving these conflicts, but the solution has not been found so far (Section 2.2).

Objectives and methodology

The objective of this research is to analyze the effects of the implementation of different agricultural policy and water policy options in the Upper Guadiana River Basin (Section 3). In order to achieve this objective, a methodology has been developed, based on an integrated vision of water resources management, where the stakeholders' participation is one key issue,

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[1] Tasks explained in NeWater DoW

as it is considered as essential to achieve an adaptive management. More specifically, our methodological framework is based on the combination of a qualitative and a quantitative component. The qualitative stage consists basically on the development of a participation process in which all stakeholders get involved. The quantitative stage consists on the elaboration of an integrated agro-economic and hydrologic model. Several policy scenarios have been chosen and simulated, in order to get the impacts that the different policy options would have on the different components of the system. Both kinds of analysis have been supported by a wide empiric work in the area of study. (Section 4)

Results and discussion

The last section of this report includes the results obtained from the simulations of the models (Section 5). The analysis of the results of simulations includes private and public economic impacts (respectively, farm income and public expenditure), agronomic impacts (changes in cropping patterns) and environmental impacts (effects on the aquifer) of the implementation of the different policy scenarios tested.

Results show (Section 6) that water policies based on quotas (Water Abstractions Plan: WAP) can lead to important reductions in water consumption with a relatively low public cost, but with a high private cost, which produces social unrest and opposition from farmers. Water conservation policies that include, in addition to the quotas, income compensation payments (Agri-Environmental Program: AEP) can reach the abstractions reduction level needed for the recharge of the aquifer when a high number of farmers decide to join the program. These measures have a better social acceptance than WAP when compensatory payments are high enough. Nevertheless, results indicate that compensation offered in the new AEP is not enough to make farmers join the program and, consequently, it has low effect on abstractions reduction in the basin. From the point of view of the public sector, these programs have a high public cost, presenting uncertain cost-effectiveness.

Nevertheless, results show that all current water conservation policies in the Upper Guadiana basin, even when they can contribute to an important reduction on water consumption, they will not be able to attain the recovery of Mancha Occidental aquifer if other additional measures, aiming to reduce illegal abstractions, are not put into practice.

We can also conclude that one more integrated application of water policies and agricultural policies is a key issue in water resources conservation. The field work carried out in the area, as well as the stakeholders' meetings, indicate that conservation policies need to be designed and implemented in a coordinated way and with a higher public and stakeholders' participation, trying to select efficient and socially acceptable instruments that can contribute to improve the adaptive capacity of the Upper Guadiana river basin to a changing environment.

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1 Introduction

As part of NeWater project, this research contributes to the analysis of the water resources management regimes in different European countries, as well as to exploring new ways of facing water management challenges. We will focus on investigating the vulnerability and the adaptive capacity of the system face to changes in the natural environment or in the policies applied. The final aim of the project is to contribute to the implementation of adaptive water management, an alternative to traditional ways of managing water resources which takes into account the interrelationships between the different elements of the system and their vulnerability to changes.

One important issue considered in our work is the adoption of a social learning approach in the aim of promoting the exchange between the scientific experts involved in the WP and all project participants, especially stakeholders with experience in the river basins studied. This is in line with the new conception of “management” as a “learning” process, instead of control. It becomes therefore necessary to develop a participation framework that incorporates all stakeholders in the decision-making process.

The specific task of the UPM team in this project is to analyze the economic impacts of the implementation of agricultural and water policies in the Upper Guadiana basin, where agricultural uses of water are in conflict with preservation of protected natural sites of high ecological value. The analysis of water management in the Guadiana basin is held with the participation of a big group of stakeholders, that comprises representatives from the Ministry of Environment, the Water Basin Authority, the Regional Government, water users’ associations, environmental NGOs, etc. With the collaboration of stakeholders, simulation models will be constructed as a tool to analyze water management regime and to investigate the effects of different policy scenarios.

2 General framework

Water is becoming an increasingly scarce resource in many regions and countries. Past common policies in many countries have fostered the development of irrigation (Varela et al, 1998). That is the case of Spain, where agriculture consumes 80% of available water resources. The restoration of watercourses affected by these problems demand, in the European agricultural policy context, the implementation of integrated policies that encourage environment protection and sustainability. That is to say, policies of regulations and incentives are needed within an adequate institutional framework (Mejías et al, 2004)

In this context, our analysis will focus on the joint application of different water policies in different context of agricultural policy. Within this policy integration framework, we will take into account water availability in the basin, which is determined by hydrological parameters and constitutes one of the most important sources of uncertainty when farmers try to decide their production plans.

This research will be centered on the analysis of the strategies followed by farmers when they are faced to the implementation of these policies, such as changes in cropping patterns, in the distribution of rain-fed and irrigated surfaces, the intensification or extensification of production techniques and water management in the farm.

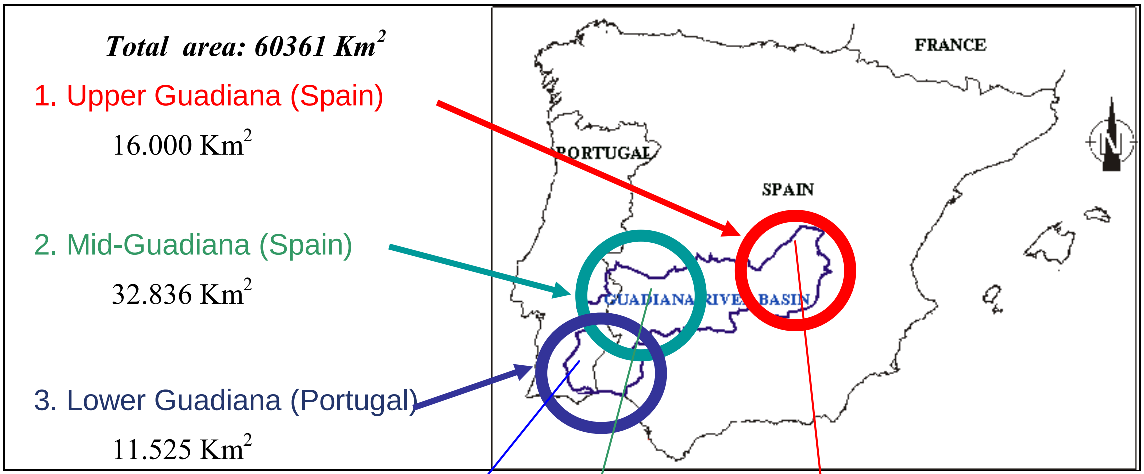
In summary, we aim to contribute with our work to clarify some of the aspects related to the joint implementation of agricultural and water conservation policies, to which European countries are currently confronted.

2.1 The Upper Guadiana Basin case study

General Characteristics of the basin

The Guadiana basin extends over an area of 60.361 Km^2, 50.000 Km^2 of which correspond to the Spanish territory and 11.000 Km^2 to Portugal. The Guadiana basin can be divided into three distinct areas as shown in Figure 1 below: the Upper Guadiana in the Spanish territory, the Mid Guadiana covering Spain's western segment of the basin down to the Portuguese border, and the Lower Guadiana in the Portuguese territory.

Figure 1: The Guadiana Basin



Source: Llamas and Martinez-Santos (2005)

Main Physical Characteristics:

- Annual water supply 6168 Hm3
- Total capacity 9114 Hm3
- Number of reservoirs and dams (>1 Hm^3) 86
- Secondary rivers and streams 186
- Natural Parks and Special Protected areas 215527 ha
- Others reservoirs dams (<1 Hm^3) more than 200
- Number of hydrogeology's units: 14
- Water Balance -304 Hm3
    - Water in-flow: 824 Hm^3
    - Water out-flow: 1.128 Hm^3
- Number of wells 60.847

The Upper Guadiana Basin

The Upper Guadiana sub-basin is characterized by the following socio-economic and environmental features:

- Irrigation agriculture is the main water user consuming up to 90-95% of total available water covering around 200,000 ha that are almost totally dependent on groundwater (Mancha Occidental aquifer)
- Intensive groundwater development over the last 30 years was carried out under private initiative responding to policy-driven economic incentives (CAP programs). It has exceeded the management capacity of the River Basin Authority to control further mining of illegal wells that currently exist.
- Expansion of irrigation has produced positive socio-economic effects in the area contributing to economic development, labor creation and social stability.
- Groundwater has proven to have a high resilience to drought impacts, and therefore has played an important role as crop production risk shelter, thus mitigating extensively farm income loss.
- Expansion of irrigation has produced negative environmental effects due to the overexploitation of the aquifer and the degradation of the associated wetlands and aquatic ecosystems.
- The Mancha Occidental aquifer was declared overexploited by law in 1989 and 1990 and water abstractions were subject to specific restrictions to the irrigators. Enforcement of this legal provision has proven to be inefficient due to the strong legal and practical opposition form the irrigators and the consequent high transaction costs involved for control and administration.
- Water is perceived as a very scarce resource and a basic input for farming activity and income gains. Therefore water use has led to long-lasting social and political conflicts.
- Water use conflicts arise at all levels: between regional and national governments, between basins, between the RBA and the farmers (over closing of illegal wells), between farmers and environmental interests (agricultural development vs environmental value of wetlands), between farmers (small vs large land owners, legal vs illegal well owners...)
- The present challenges in the area are:
    - (i) *technical challenges*: increased modernization of existing irrigation schemes, adoption of water-saving irrigation techniques, increase water use efficiency (technical and economic) and improvement of crop production techniques.
    - (ii) *policy-driven challenges*: (a) response to the application of the Special Plan of the Upper Guadiana (recently enacted by the RBA in 2006) that includes a strict water quota system and a socio-economic re-structure plan in the area. (b) response to the requirements of the EU WFD, such as the cost-recovery of irrigation services as well as the maintenance of the good ecological status of the aquifer. (c) response to the requirements of the new CAP by developing market-oriented crop diversification, socio-economic feasibility of farming systems and environmental sustainability (reduction in agro-chemical contamination).

Main issue: Irrigation expansion and wetland conservation:

It is worth noting that one of the most remarkable examples of wetland deterioration has been the case of the wetlands in the “Tablas de Daimiel” National Park situated in the Mancha Occidental aquifer in the Upper Guadiana basin. This fragile ecosystem was progressively degraded as a result of overexploitation of the aquifer by the intensively irrigated adjacent farms. This valuable wetland had gained a considerable international reputation for its great ecological value as a habitat of European and African aquatic birds and hibernating waterfowl. Catalogued in the Wet Areas of Europe, UNESCO Biosphere reserve, RAMSAR agreement, EU Birds Directive and Habitats Directive, the area has attracted much international attention (Lowe and Baldock, 2000). Recovering these lost wetlands requires effective policies aimed at promoting environmental sustainability by eliminating excessive ground water use.

For more information, see Baseline Condition Report: document Guadiana_Baseline.pdf, in NeWater web page http://www.newater.info/folders/1998

2.2 Analysis of the on-going application of water policies (EU WFD) and agricultural policies (CAP reform)

The National Policy has established from 1991 water quotas for irrigation (maximum water volumes are specified every year), with the objective of protecting natural water system. The Water Abstractions Plan (WAP) limits the water abstractions by the establishment of a quotas' system without economical compensation. The limits of water abstractions are established as a function of the farm's size, so that the largest farms have the biggest limitations.

In the current year (2006), the WAP allows a maximum of 213.4 hm^3 for agricultural abstractions. These abstractions are distributed in the following way (Table 1):

Table 1: Water Abstractions Plan in 2006.

Surface (ha)	Maximum water volume (m^3/ha)
0- 30	2.640
30-80	2000
>80	1200

SOURCE : CHG (2005)

The maximum average volume permitted is much lower than usage concessions to farmers (the average consumption in one irrigated hectare is 4200 m^3, CHG 2005). Quotas are compulsory and farmers do not get any income compensation for the losses caused by the irrigation limitation. This program has generated an important social opposition (Varela *et al.* 2003, Varela 2003).

In the last years, EU environmental polices are also targeted to secure water conservation and wetland recovery through Agri-Environmental Programs. These programs started in 1993 and proposed voluntary water reduction percentages (50, 70 and 100%) accompanied by economic compensations for farmers willing to reduce irrigation. In opposition to the water quotas, the voluntary character and the compensation payments of the Agri-Environmental Program resulted in social acceptation, which was traduced in a high adoption rate and a bigger effectiveness. On the other hand, water reduction is attained by means of a high public expenditure.

Since 2003, the Agri-Environmental Program was modified, so that the 70% water volume reduction option was suppressed. Furthermore, a modulation of the subsidies was established, depending on the farm surface. We have to remark that reductions indicated in the Agri-

Environmental Programs for water volume are determined from the basis of quotas indicated in Water Abstractions Plan for the current year. These modifications have not had a good acceptance from the farmers, and the surface joining the program has been reduced with respect to the previous years. The consequences of these changes have been a reduction in the surface adopting the program and, as a result, an increase in water abstractions.

The following table shows the evolution that Agri-Environmental Programs have suffered since their origin up to now:

Table 2: Evolution in UE Agri-Environmental Programs between 1993 and 2006: level of reduction water abstractions considered and compensation payments associated

Level of reduction in water consumption	**Compensation payments (€/ha)**			
	1993	1997	2001	2003 …2006 modulation
50%	156	164	179	1-40 ha: 209 € 40-80 ha: 125 € > 80 ha: 63 €
70%	258	271	296	--
100%	360	379	414	1-40 ha: 518 € 40-80 ha: 311 € > 80 ha: 155 €

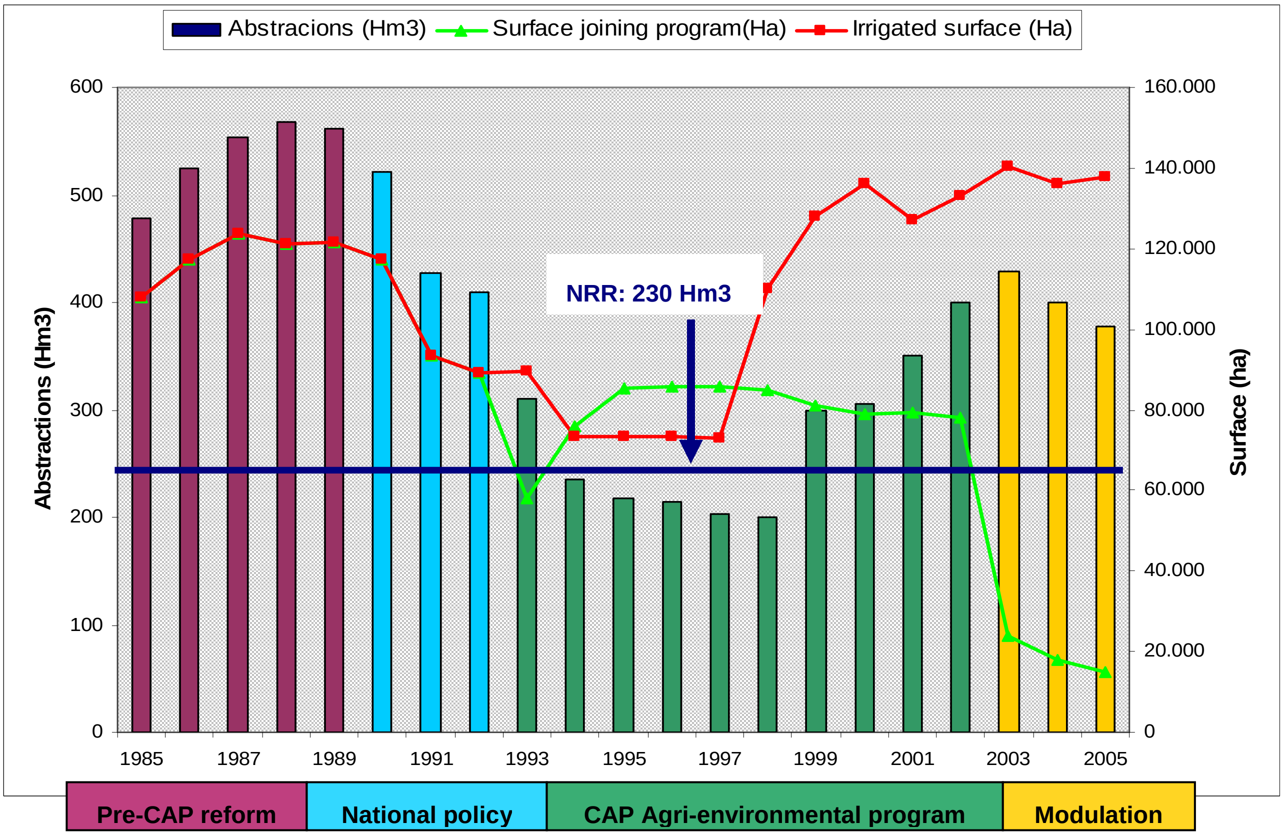
SOURCE: Junta de Castilla la Mancha (Regional Government) (2006)

2.3 Irrigation development and groundwater use in the Upper Guadiana Basin

The EU CAP programs applied have resulted in an increase of the irrigated surface and mounting water abstractions in some areas, as a consequence of the establishment of production-based subsidies which have encouraged the development of high water-demanding crops. That is the case of the Upper Guadiana Basin, where the application of these policies has contributed to the acceleration of the depletion of aquifer 'Mancha Occidental' and the consequent loss of wetlands in the National Park 'Tablas de Daimiel'. This aquifer was declared overexploited in 1987, as the first action taken by the Government aiming to protect water resources in the area. (Coleto et al, 2003)

The following figure shows the evolution of the water abstractions volume and the irrigated surface in the Upper Guadiana Basin, as a consequence of the different policies applied from 1985 to 2005:

Figure 2: Evolution in water abstractions volume and in the irrigated surface between 1985 and 2005 in the Upper Guadiana basin



NRR = Natural Recharge Rate of the aquifer

SOURCE: own elaboration from data provided by the CHG (Confederación Hidrográfica del Guadiana) (River Basin Authority)

The figure shows clear changes in farmer's behaviors, depending on the policies applied in each period. Consequently, the evolution in water abstractions is a direct consequence of agricultural and water policies implemented. Our research will be centered on the evaluation of effects resulting from the combination of these policies on water use (resource conservation), on farm income (private sector) and on the public sector (effectiveness of public costs).

3 Objectives of the research[2]

The general objective of this research corresponds to WP 1.7 purposes, which are as follows:

1. The development of a conceptual framework of the adaptive management in the context of an integrated water resources management
2. Exploring the combinations between different strategies, policies and management practices, so that water management regimes become more flexible and more capable to respond to changes, in different scales of time, and for different aggregation scales
3. The development and application of conceptual models as a tool to analyze the complex dynamics and the uncertainties that affect one river basin. These models allow us to work with institutional, legal, cultural and environmental frameworks at different scales, facilitating the transition process to an integrated and adaptive management
4. Encouraging stakeholder participation processes in river basins. This is part of the implementation strategies in adaptive management, which takes into account the interaction of social, cultural, economic, institutional, ecologic and technological aspects.

The specific objective of UPM research in NeWater is:

1. The development of an integrated framework of an agro-economic and a hydrologic model, which will be used to analyze the joint effects of environmental and policy changes in the Upper Guadiana basin.
2. The analysis of socio-economic, agronomic and environmental effects that the implementation of agricultural and water policies would have on different agricultural systems and on different types of farms.
3. The analysis of the cost-effectiveness of different water policy measures.
4. The development and application of methods to enhance stakeholder participating process

[2] Based on NeWater DoW

4 Methodological framework

As stated in previous chapters, the objective of this research is to analyze the effects of the implementation of different agricultural policy and water policy options in the Upper Guadiana River Basin. On this purpose, we have built a mathematical programming model that simulates farmers' behavior and their response to these different policies. Simulations will allow us to anticipate farmers' response to policy changes produced in the region, as well as the effects of these policies on water resources conservation. The construction and validation of these simulation models demand the participation of stakeholders at different stages.

4.1 Methodological scheme

The methodology used in this research is based on the integrated vision of water resources management supported by the WFD (Water Framework Directive). This integrated perspective considers water as a component of the ecosystem, as well as a natural resource and an economic and social good, these characteristics determining the nature of its uses.

Coherent with this theory, our methodological framework is based on the combination of a qualitative methodology (stakeholders' analysis) and a quantitative methodology consisting on an integrated agro-economic and hydrologic model. Both kinds of analysis have been supported by a wide empiric work in the area studied. The combination of qualitative and quantitative methodologies allows generating a combination of different kinds of information (institutional, social and environmental) relevant to the analysis of policies.

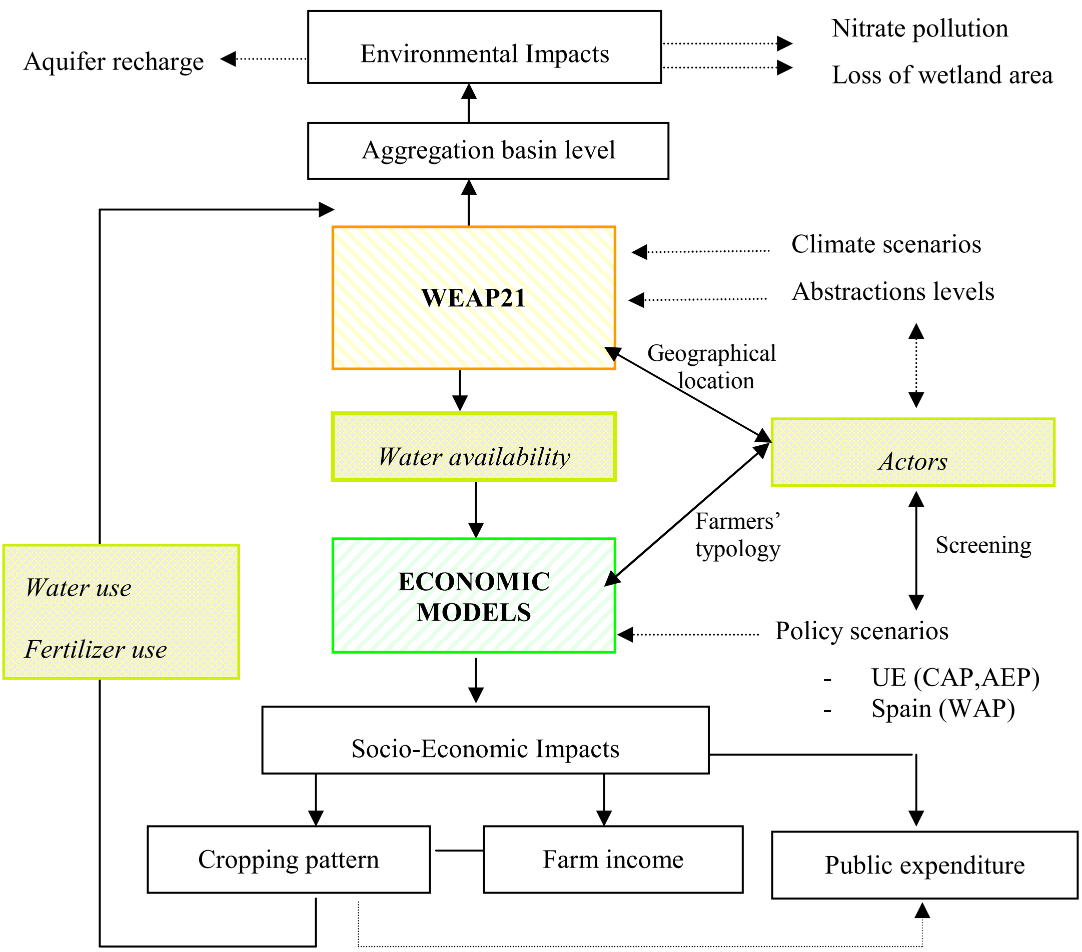
Specifically, methodology followed in our research can be summarized in the next steps:

1. Elaboration of a "base of knowledge" as a result of the development of an "institutional mapping". This mapping has been in the basis of interviews, consultations and surveys carried out with representatives of the different stakeholders' groups.
2. Development of stakeholder analysis through the organization of meetings and discussion forums. Elaboration of a "conceptual model" with the results obtained from the meetings and validation of this model in an iterative process.
3. Selection of the farm types which are representative of the basin, as well as selection of the scenarios of agricultural policy (Agenda 2000, 2003 CAP reform) and water policy (reference scenario, Water Abstractions Plan, Agri-Environmental Program).
4. Development of an economic model of mathematical programming, that allows us to simulate the farmers' behavior and to predict their response to changes in the natural system or in the policies implemented. Technical coefficients have been obtained from the field work carried out in the area.
5. Development of a hydrologic model using WEAP (Water Evaluation and Planning System), which has been adapted, calibrated and validated for Guadiana river basin. The hydrologic model allows us analyzing the different hydrological parameters in different climatic and policy scenarios.

6. Integration of the hydrologic and economic models on the purpose of analyzing the joint effects of climatic and water policy scenarios. This integration has been carried out by simulation of the same policy scenarios in both models. It allows aggregating, at the basin level, the results from the economic model through the hydrologic model and analyzing, for the different climatic scenarios, water resources availability for the whole basin, the recharge capacity of the aquifer and the protection of the wetlands.

In a future step, an agronomic model will be added to this integrated modeling framework, which will allow us to evaluate variations in crop yields when environmental conditions change, as well as other parameters related to environment health, such as lixiviation of nitrate. So far, the prototype model has been constructed following the schema showed in figure 4 below, which shows the joint use of the economic model and the hydrologic model (WEAP21). It shows, as well, the type of input necessary for each of the models and the output obtained from their simulations, indicating the linkages between them:

Figure 3: Methodological scheme of the work



SOURCE: own elaboration

4.1.1 Field work[3]

The field work started in 2005, but the surveys took place between April and July 2006. This stage of our work has been developed together with the Universidad Complutense (UCM) team, in charge of the Upper Guadiana Basin case study in NeWater project. With this field work, we have intended to:

- Identify and contact the stakeholders in order to define their role in water management.
- Get the information needed to build the mathematical programming model. On one hand, we intended to identify the situation of the wetlands in the area and to discern how water resources are managed in the Upper Guadiana Basin. On the other hand, we intended to get the information needed to select our farm types, to determine their representativeness and to find out the technical coefficients of the model. The following table shows the characteristics of the representative farms chosen for the irrigation community of Daimiel:

Table 3: Characteristics of the four farm types defined for the irrigation community of Daimiel

	F-1	**F-2**	**F-3**	**F-4**
Area (ha)	8	24	30	70
Soil quality	low	high	medium	medium and low
Cropping pattern	Vine (100%)	Winter Cereals (30%) Maize (5%) Horticulture (30%) Melon (20%) Set-aside (15%)	Winter Cereals (25%) Maize (5%) Melon (25%) Vine (30%) Set-Aside (15%)	Winter Cereals (58%) Maize (2%) Veget & melon (30%) Set-aside (10%)
Coverage (% area)	22	19	28	31

SOURCE: own elaboration from field work data and from data provided by INE (Instituto Nacional de Estadística, 1999)

For detailed information about field work, see complementary report: "Field work report in the Upper Guadiana Basin": file NW_D1.7.5b(II).doc, in NeWater website http://www.newater.info/folders/1723

[3] Information from complementary report: "Field work report in the Upper Guadiana Basin": file NW_D1.7.5b(II).doc, in NeWater website http://www.newater.info/folders/1723

4.1.2 Stakeholders' analysis[4]

All information about the structure, methodology, objectives and outcomes of the stakeholders' meeting on economic aspects in the Upper Guadiana Basin can be found on one of the three additional reports to main Deliverable 1.7.b, called:

"Stakeholder meeting 2: Economic and agronomic aspects of water management in the Upper Guadiana basin": file NW_D1.7.5b(III).doc, available in NeWater website: http://www.newater.info/folders/1723

4.1.3 Economic model

Within the variety of methods and instruments for investigating the impact of agricultural and environmental policies, a mathematical programming modeling (MPM) approach and the problem-solving instrument GAMS (General Algebraic Modeling System) have been chosen (Brooke et al. 1998).

As any other model, it is an instrument that imitates a simplified reality (Hazell & Norton, 1986); MPM can be used to analyze the foreseeable effects and consequences of different policies depending on the instruments used as well as to reproduce the behavior of representative farmers in a given regional context (Flichman & Jacquet, 2004). In this view, as both general and individual equilibrium modeling are amply used for analyzing policy impacts, individual equilibrium farm models have been developed, which describe the behavior of farmers confronted with different policy scenarios and policy instruments (Varela et al, 2006).

The model developed is a non-linear single-year static model with a risk component. *Decision-making variables* "X" represent the area defined by a given crop (c), by a soil (k) and by a given associated production technique (r).

First, a series of *production activities* "c" has been included, which represent the area defined by each crop (barley, wheat, sunflower, maize, sugar beet, peas, melon, garlic, pepper, potato, vineyard and set-aside). Within these activities, a *production sub-activities* "cop" has been defined, consisting on a subset of "c" that covers cereals, oilseed and protein crops. In addition, two *types of soil* "k" have been considered, which correspond to the soils present in the area: low quality and good quality soil. Relating to *production techniques***,** "r", we have defined four, corresponding to the usual ones in the area: rain-fed, sprinkler extensive irrigation, sprinkler intensive irrigation and drip irrigation. And finally, two *periods of the year* "p" have been defined, winter and summer, which are representative of the seasonal distribution of the labor characteristic of the region.

[4] Information from complementary report "Stakeholder meeting 2: Economic and agronomic aspects of water management in the Upper Guadiana basin": file NW_D1.7.5b(III).doc, available in NeWater website: http://www.newater.info/folders/1723

The structure basically consists of maximizing the objective function subject to given technical, economic and policy constraints. This model is defined by:

1. Objective function

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

$$MaxU = Z - \phi \cdot \sigma \qquad (1)$$

where:

- U : utility
- Z : net income level
- ϕ : risk aversion coefficient
- σ : 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 Income function

The income equation is as follows:

$$Z = \sum_c \sum_k \sum_r gm_{c,k,r} \cdot X_{c,k,r} + \left[\sum_c \sum_k \sum_r subs_{c,r} \cdot X_{c,k,r} \cdot coup + sfp \right] \cdot mdu - foc \cdot \sum_p fla_p - hlp \cdot \sum_p hl_p - wac \cdot wc - canon \cdot sirrg - nwell \cdot twell \qquad (2)$$

where:

- Z : net income level (in euros).
- $gm_{c,k,r}$: represents the gross margin (€/ha) obtained by crop type (c), by soil (k) and technique (r).
- $X_{c,k,r}$: decision-making variables that represent the growing area (in hectares) by crop type (c), soil type (k) and technique (r).
- $subs_{c,r}$: CAP support (€/ha)received by crop type (c) and selected technique (r) that is coupled to production.
- *coup*: support coupling level. It can have different values depending on the adopted policy It will take value of 0 in the case of full decoupling and a value of 0.25 in the case of partial decoupling.
- *spf*: 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.
- *mdu*: Percentage of support modulation, 4% during 2006.
- *foc*: is the family labor opportunity cost (€/h). This cost has been assumed to be somewhat lower than paid labor obtained from surveys to prevent all labor being allotted to family labor.
- fla_p: represents the family labor availability (in hours) depending on the period of the year in question. Its value will be higher in winter than in summer.
- *hlp*: is the hired labor price (€/h)
- hl_p: is hired labor measured in hours labor is hired for.

- *wac*: water abstraction cost (€/m3).
- *wc*: water quantity consumed (m3/ha)
- *canon*: canon paid to water users associations (€/irrigated ha).
- *sirrg*: irrigated surface (in hectares)
- *nwell*: number of wells per farm
- *twell*: tax paid in euros by well.

1.2 The risk equation in the model is as follows:

$$\sigma = \left[\left(\sum_{sn} \sum_{sm} Z_{sn,sm} - Z \right)^2 / N \right]^{1/2} \quad (3)$$

where

- $Z_{sn,sm}$: random income, function of the state of the market (sm) and of the state of the nature (sn)

- Z: average farm income expected

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

2. Constraints

2.1 Land constraints

Several land constraints have been considered, so that the model keeps the cultivated surface under the limits of the available surface and that the irrigated surface does not exceed the number of hectares declared for irrigation.

Total land constraint

$$\sum_{c} \sum_{k} \sum_{r} X_{c,k,r} \leq surf_k \quad (4)$$

where

- $X_{c,k,r}$ represent the growing area (in hectares) by crop type (c), soil type (k) and technique (r).
- *surf*: is utilized agricultural area (in hectares) by soil type (k).

Irrigated surface constraint

$$\sum_{c} \sum_{k} \sum_{ri} X_{c,k,r} \leq sirrg \quad (5)$$

where

- $X_{c,k,r}$: represent the growing area (in hectares) by crop type (c), soil type (k) and technique (r).
- *sirrg*: is the irrigated surface (in hectares)

2.2 Labor constraints

Labor needs have to be covered by the family labor availability and hired labor on the market in each period.

$$\sum_{c}\sum_{k}\sum_{r} lr_{c,r,p} \cdot X_{c,k,r} \leq fla_{p} + hl_{p} \tag{6}$$

where

- $lr_{c,r,p}$: labor needs (h/ha) by crop type (c), technique (r) and period (p).
- $X_{c,k,r}$: represent the growing area (in hectares) by crop type (c), soil type (k) and technique (r).
- fla_p: represents the family labor availability (in hours) depending on the period of the year in question. Its value will be higher in winter than in summer.
- hl_p: is hired labor by period measured in hours labor is hired for.

2.3- Water availability constraints

The crop water needs have to be met by the water that really reaches the plot, which will be equal to the gross allotment (allotment granted by the Water Basin Authority to the farmers), taking into account a technical efficiency coefficient.

$$\sum_{c}\sum_{k}\sum_{r} wneed_{c,k} \cdot X_{c,k,r} \leq wava \cdot sirrg \cdot h_{r} \tag{7}$$

where

- $wneed_{c,k}$: water needs (m^3/ha) by crop (c) and soil (k).
- $X_{c,k,r}$: represent the growing area (in hectares) by crop type (c), soil type (k) and technique (r).
- *wava*: water availability (m^3).
- *sirrg*: irrigated surface (in hectares).
- h_r: the technical efficiency coefficient.

2.4- Policy constraints

i) 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 must be maximum 10% of the whole irrigated surface.

$$\sum_{k}\sum_{r} X_{sg,k,r} \leq ssug \tag{8}$$

where

- $X_{c,k,r}$: represent the growing area (in hectares) for the sugar-beet crop by soil type (k) and technique (r).
- *ssug*: sugarbeet limited surface (in hectares).

ii) Vineyard surface limitation

Because our model is a one-year model, vineyard surface is considered as fixed, that is, the farmer cannot change this surface to grow another culture. This surface has to be maintained:

$$\sum_k \sum_r X_{vi,k,r} = svig \qquad (9)$$

where

- $X_{c,k,r}$: represent the growing area (in hectares) for the vineyard crop by soil type (k) and technique (r).
- s*vig:* vineyard limited surface (in hectares).

iii) Set aside rate

There is a compulsory minimum and maximum land set aside rate for the COP growing area. This set aside area must be between 10 and 30% of total cop cultures surface.

$$\sum_k \sum_r X_{set,k,r} \geq setmn \cdot \sum_{cop} \sum_k \sum_r X_{cop,k,r}$$
$$\sum_k \sum_r X_{set,k,r} \leq setmx \cdot \sum_{cop} \sum_k \sum_r X_{cop,k,r} \qquad (10)$$

where:

- $X_{set,k,r}$: number of "set aside" hectares, for each soil type (k) and technique (r).
- *setmn:* minimum set aside rate (10%).
- *setmx:* maximum set aside rate (30%).
- $X_{cop,k,r}$: cereals, oilseed and protein crops growing area (in hectares) by type of soil (k) and technique (r).

b) 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 (Flichman et al. 2004). The calibration process consists on the determination of the parameters or coefficients which make the model reproduce the real situation of the system studied. The method used for this calibration has been the integration of the risk through the expected value and the standard deviation, where one parameter of 'risk aversion' (*phi*) has been included. This element comprises the unexplainable differences between the model and reality, such as the psychological characteristics of farmers (Varela et al. 2006, Blanco et al. in press). As a consequence, a good choice of the right risk aversion coefficient allows our model functioning as reality. In our case, the risk aversion coefficient (*phi*) resulting from the calibration of the model is 1.55 for all the farm types.

The validation process consists on the comparison of the results of the model with those really obtained in other reference years. If the model responds to the stakeholders' behavior according to the farmers' behavior in reality, then we can say that the model is validated. In our case, the validation has been carried out through the comparison of the results of the model with the field work data. The variables considered in the validation have been the crops surfaces and the marginal values of land, water and labor.

4.1.4 Definition of scenarios

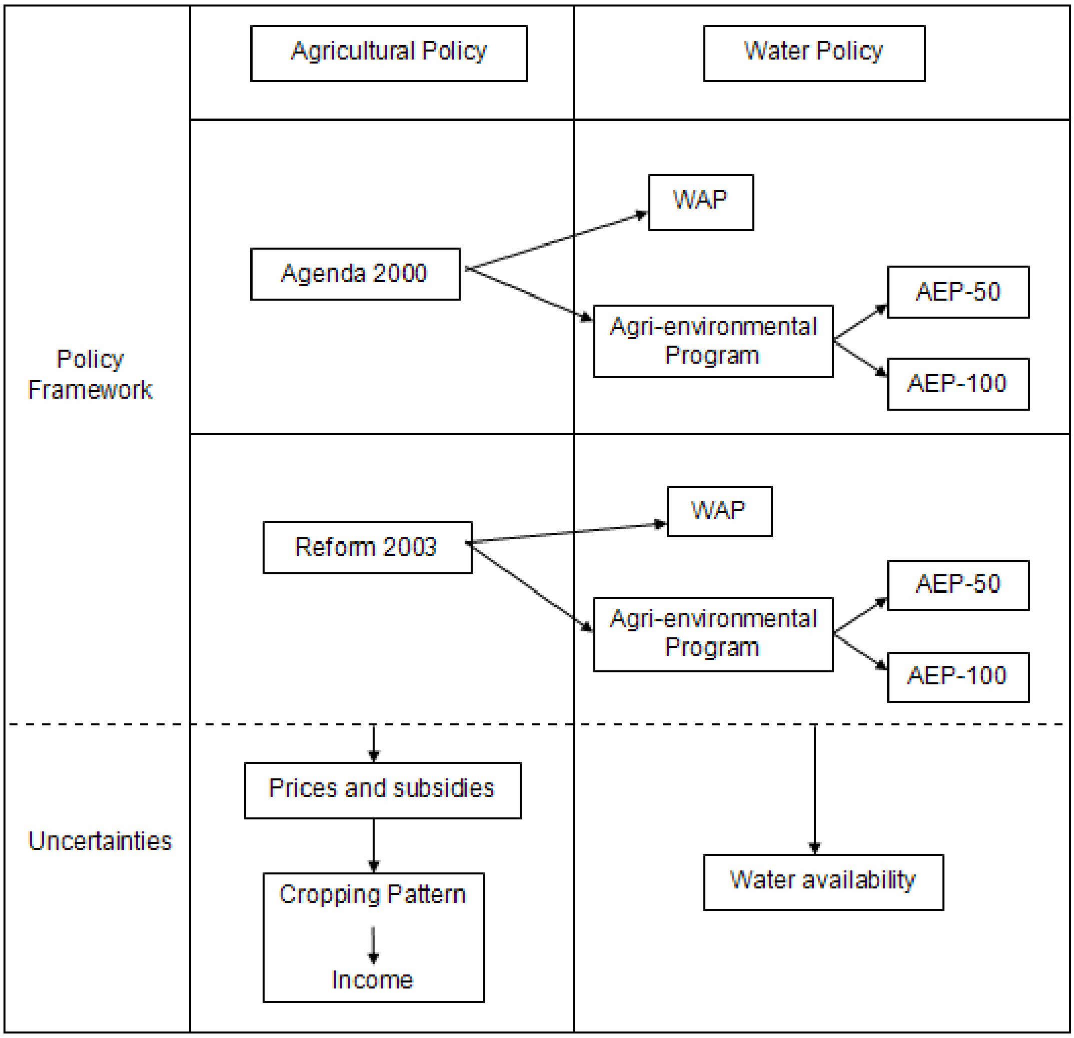
In order to figure out the response of the farmers to the different policies and the consequences to these policies in terms of water conservation and economic impact, simulations for every farm type have been carried out, considering several scenarios:

- Two scenarios of agricultural policies:
  - Agenda 2000, with crop subsidies coupled to production
  - The new CAP reform (2003), with 25% of payments coupled to production, while 75% is decoupled (independent from the quantities produced, but linked to the farm surface instead)

- Four options of water policies:
  - Reference policy: full water volume allotment
  - WAP: Water Abstractions Plan, where a quota is established for water consumption.
  - AEP 50: Agri-Environmental Plan, with 50% reduction of water volume out of the volume indicated as the quota in WAP and a compensation payment for farmers.
  - AEP 100: Agri-Environmental Plan, with 100% reduction of water volume out of the volume indicated as the quota in WAP, that is, a complete change to water fed agriculture, and a compensation payment.

The following figure (figure 4) shows a schema of these scenarios, as well as the uncertainties derived from the application of each of the two types of policies:

Figure 4: Schema of the different scenarios simulated in with the economic model.



SOURCE: own elaboration

The application of the different agricultural and water policies involves uncertainties regarding farm income, public expenditure and water consumption (and its effect on the aquifer), that are also expressed in figure 5. In this sense, uncertainties about agricultural policies have a direct effect on agricultural prices and subsidies, which are two key issues for the farmer when taking the decision of the cropping pattern. At the same time, this cropping pattern will determine the income that the farmer will get. On another side, uncertainties about water policies affect directly the water volumes that will be available for the farm, what will be again an important factor in the choice of the cropping pattern.

All these interrelationships reveal the complexity of the system and, consequently, the necessity of using tools to help us to better understand the effects of the implementation of the different policies. By means of the simulation of these scenarios, the aim is to clarify the consequences of the implementation of the different agricultural and water policy options, in terms of socio-economic impact on farmers (farm income and changes in production techniques), environmental impact (with the two consequences: water availability and wetlands health), as well as the impact on public expenditure. All these results are discussed in the following chapter.

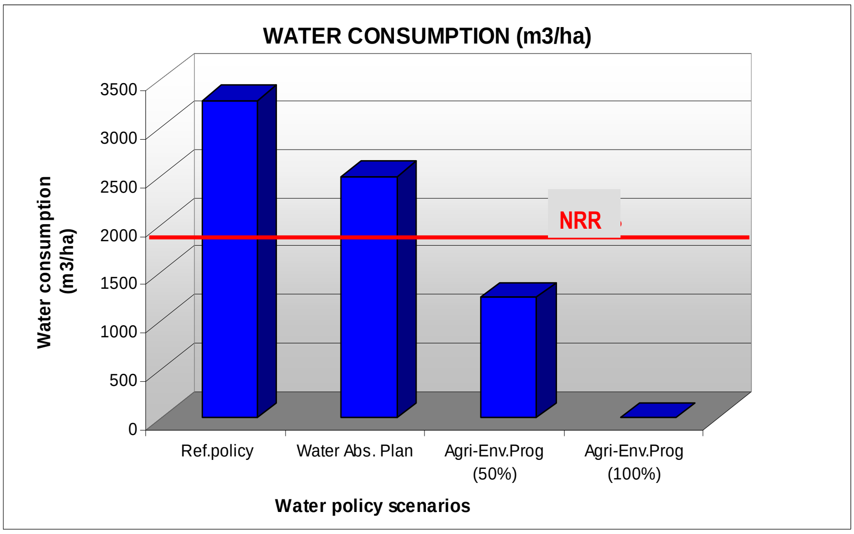
5 Results and discussion

5.1 Effects on water consumption

One of the outputs obtained from the simulations with the agro-economic model is the water volume consumed. These results allow us to compare water consumption in the different scenarios, for the different farm types and, when individual values are aggregated, for the whole region. The comparison between the aggregated water consumption in the different scenarios will show which policy options fit with the objective set by the River Basin Authority, which is a reduction of abstractions up to 213.4 hm^3, equal to the natural recharge rate of the aquifer (CHG, 2006).

The following figure (Figure 5) shows the total volume of water consumed in the area of study with the different water policy tested: reference policy, Water Abstractions Plan and Agri-Environmental Program with 50% and 100% water volume reduction), and Agenda 2000 as the agricultural policy applied.

Figure 5: Volume of water consumption per hectare in the Upper Guadiana basin for the different scenarios in Agenda 2000.



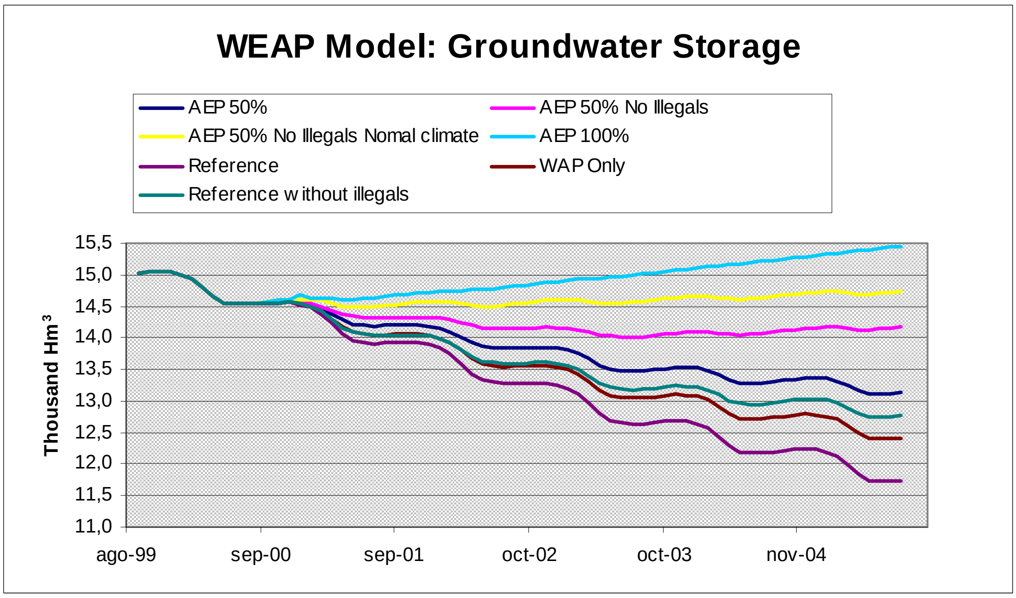
NRR = Natural Recharge Rate of the aquifer

SOURCE: own elaboration from results of simulations with the economic model

These results show that neither the reference policy nor the Water Abstractions Plan is able to reduce water consumption under the Natural Recharge Rate of the Aquifer. Within the different water policies tested, only those that combine water quotas with income compensation payments (Agri-Environmental Policies), achieve the Environmental aims.

Effects of different policies on water availability are further studied with the hydrologic model, which performs the up-scaling of water use and provides us with results at regional level.[5] For these simulations, the departure point in the reference scenario "Current Accounts (2000)" considers an initial storage capacity to the aquifer of 15.000 Hm^3, a value with which the aquifer is considered full and the wetlands recovered. From this "ideal situation", different policy and climate simulation scenarios have been analyzed, regarding the groundwater storage.

Figure 6: Groundwater storage in aquifer UH_04.04, for the different water policy scenarios tested



SOURCE: own elaboration from results of simulations with the hydrologic model

As we can see in figure 6, the reference scenario is the one that reduces the most the groundwater storage. This is reasonable, considering that no limitations to water abstractions or to illegal irrigation are imposed. During the period 1999-2005, groundwater storage diminished 3.300 Hm^3. These figures are within the order of magnitude of the figures provided by the Guadiana River Basin Authority that estimates 624.48 Hm^3/year abstractions, much higher than the abstractions for irrigation that would be consistent with the natural recharge rate of the aquifer (260 Hm^3/year) (PEAG, 2005).

The Water Abstractions Plan start-up reduces the quantity of water abstracted and it supposes a 700 Hm^3 improvement compared to the reference scenario. The additional inclusion of the

[5] Results from the simulations with the hydrologic model are taken from the additional report called "Adaptive management of water resources: Stakeholder participation for vulnerability and adaptation analysis using WEAP. Report of the WEAP21 use for water management in the upper Guadiana basin (Spain)."File NW_D1.7.5b(IV).doc, in NeWater website http://www.newater.info/folders/1723

Agri-Environmental Program still favors the aquifer recuperation, but it is not enough for stabilizing the groundwater storage, which goes on dropping in the period considered.

The scenario “reference without illegals” shows the importance and the weight of illegal abstractions in the aquifer. The progressive elimination of illegal abstractions, up to their extinction in 2005, succeeds to stop the fall on water storage in the aquifer up to values which are similar to those obtained with the application of the Water Abstractions Plan to all the legal irrigators, and considering that two farm types accept voluntarily the 50% reduction in water consumption of the Agri-Environmental Program (scenario F3&F4 AEP Program).

But certainly, the scenarios which best fit with the objective set are “All AEP with no Illegals” and “All AEP, no Illegals, all normal climate”, that get to revert the continuous depletion on water level in the aquifer between years 2004-2005.

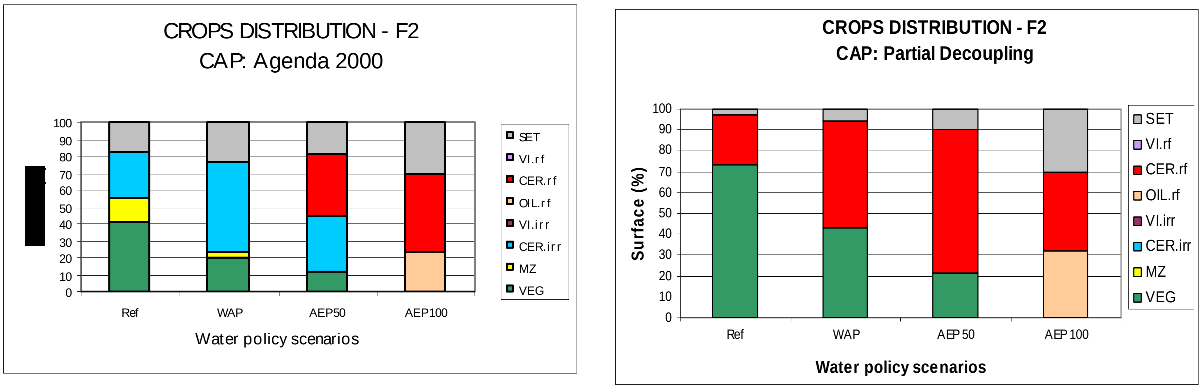
More details on the hydrologic model can be found in one of the three additional reports (four of four) to main deliverable 1.7.5b, called “Adaptive management of water resources: Stakeholder participation for vulnerability and adaptation analysis using WEAP. Report of the WEAP21 use for water management in the upper Guadiana basin (Spain).”File NW_D1.7.5b(IV).doc, in NeWater website http://www.newater.info/folders/1723

5.2 Effects on cropping patterns

As another result of simulations, the agro-economic model provides the cropping pattern which optimizes the farmer’s utility, taking into account the constraints specified in Section 2.2.4. All the farms are initially 100% irrigated (with Agenda 2000 and full water allotment, which corresponds to the situation observed in the field). When the new conditions, corresponding to the different policies tested, are introduced in the model, we get as the outcome a new cropping pattern, which is the optimum with those new constraints.

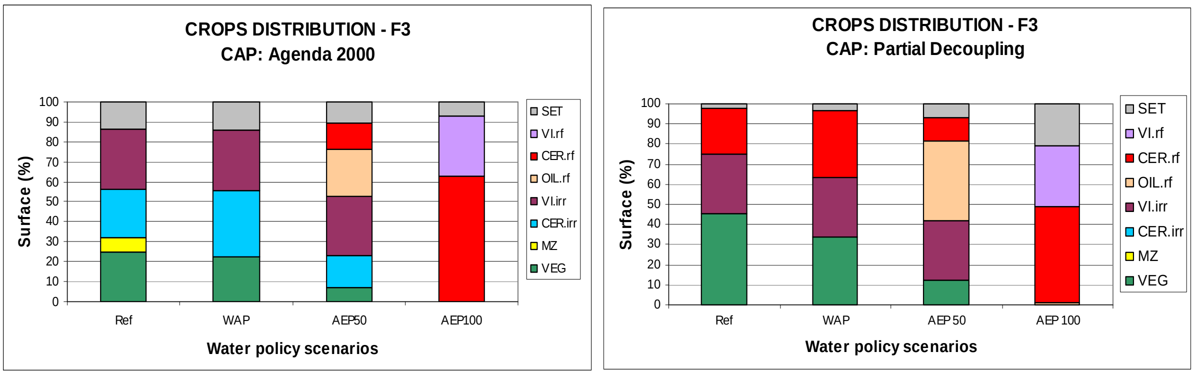
Some examples of the choices taken in the different scenarios are presented in the figures 7 and 8, that show the crop patterns for farms F2 and F3 when the application of the different water policies is tested for both Agenda 2000 and Partial Decoupling agricultural policies

Figure 7: Crop patterns in farm type F2



SOURCE: own elaboration from results of simulations with the economic model

Figure 8: Crop patterns in farm type F3.

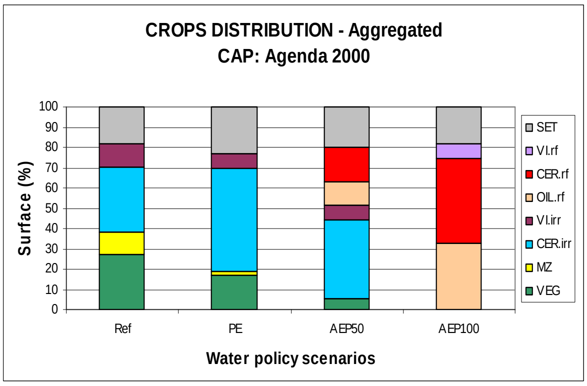


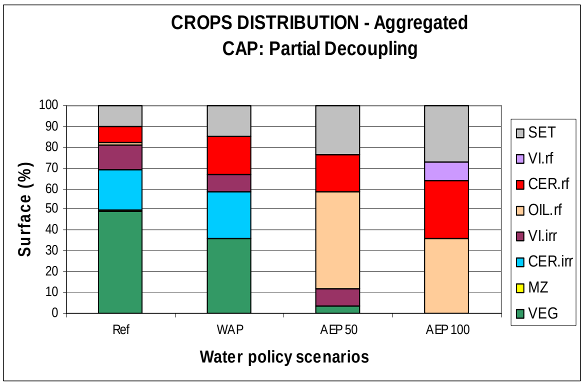
SOURCE: own elaboration from results of simulations with the economic model

These figures show that both in Agenda 2000 and in Partial Decoupling, the percentage of irrigated cultures decreases as water volume available is reduced. In addition to this, when comparing crop patterns for the different agricultural policies, it shows that just the fact of partially decoupling the aids has an effect of an extensification, as rain fed-crops occupy a higher percentage of the farm surface than in the Agenda 2000 scenarios. Moreover, high water demanding crops as maize disappear with the partial decoupling option, when they stop receiving the high subsidies that were linked to them within Agenda 2000 (Varela-Ortega et al. 2006, Blanco and Varela-Ortega, in press).

Aggregated results confirm the tendency shown by the individual farm types, as shown in the figure 9 below, which represents the crop patterns for the whole region, resulting from the aggregation of the output of the economic simulation for the four different farm types, when the application of the different water policies is tested for both Agenda 2000 and Partial Decoupling agricultural policies.

Figure 9: Crop pattern of the region, after aggregation.



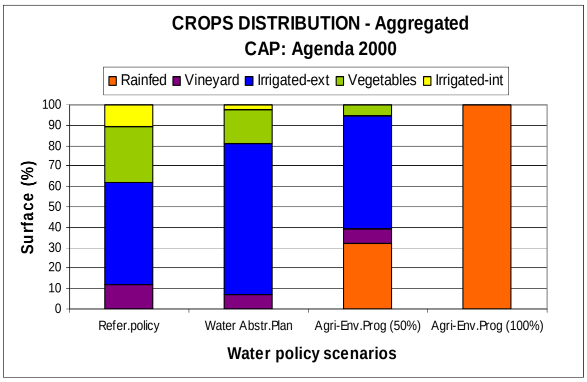


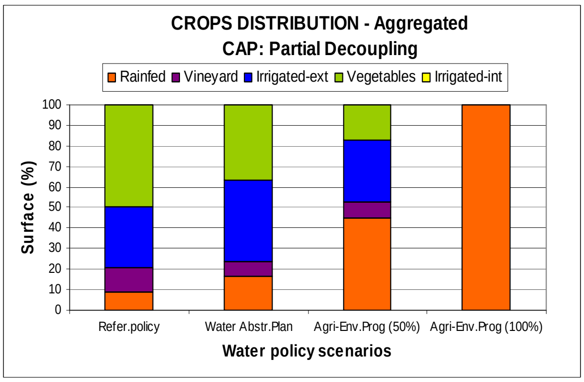
SOURCE: own elaboration from results of simulations with the economic model

These results show an increase of rain-fed crops as the availability of water decreases. But figures also manifest that the only fact of decoupling payments to production could be a possible measure for saving water: with this agricultural policy, rain-fed crops appear earlier, in scenarios with less availability of water than with Agenda 2000.

This tendency to grow less water demanding crops with the "partial decoupling" scenarios is more clearly represented in figure 10 below, in which crops have been grouped following a criteria based on the level of water demand. It shows the crop patterns for the whole region, resulting from the aggregation of the output of the economic simulation for the four different farm types, when the application of the different water policies is tested for both Agenda 2000 and Partial Decoupling agricultural policies. In this case, the crops have been grouped by their level of water demand:

Figure 10: Crop patterns for the region, aggregated in group of crops.





SOURCE: own elaboration from results of simulations with the economic model

As shown in these figures, not only water policies, but also the agricultural policy applied can have an important effect on water consumption, by encouraging the choice of the different types of crops. In this sense, the decoupling of payments is shown to have as a consequence the selection of less water demanding cropping patterns in this area (following Mejías et al. 2004, Varela-Ortega et al. 2006, Blanco et al. in press):

- First, the percentage of land cultivated with rain-fed crops is higher with "partial decoupling" policy than with Agenda 2000, considering the same water policy scenario.
- Comparing irrigated crops in both agricultural policy options, results form simulations show that the decoupling of subsidies lead to the suppression of crops like maize, which have high water needs but had an important payment linked to it with Agenda 2000.
- The third consequence of the decoupling of payments is the increase on the surface of vegetable crops, such as potato and pepper, which were not subsidized with Agenda 2000. Due to this fact, the EU considers in Council Regulation (EC) nº 1782/2003 the possibility of forbidding farmers to re-orientate their productions towards the cultivation of vegetables and fruits, in order to avoid market disruptions. This consequence would not fit with the aims of 2003 CAP Reform, which intends to reduce irrigated crops and the reduction on water consumption. The aim was to make farmers substitute intensive subsidized crops, such as maize, by non-irrigated crops and not by other high water-demanding crops.

5.3 Effects on farm income

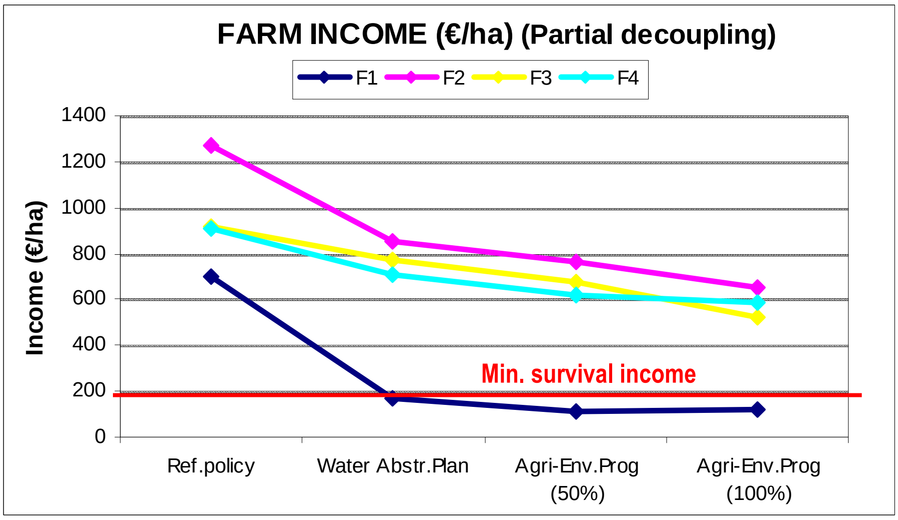
The next index that has been analyzed within the output from simulations is the farm income, which will inform about the capacity of adaptation of each type of farmer to the different agricultural and water policies. The implementation of the different policies has an effect on farm income by means of two aspects:

(1) Agricultural and water policies will have an implication on water availability. This will condition the crop pattern choice and, consequently, the associated cost and revenues

(2) Agricultural polices and also water policies (those ones that combine quotas with income loss compensations) will determine the subsidies that the farmer will obtain

The following figures show the income variation for each farm type when the different policies are applied:

Figure 11: farm income for the different farm types



SOURCE: own elaboration from results of simulations with the economic model

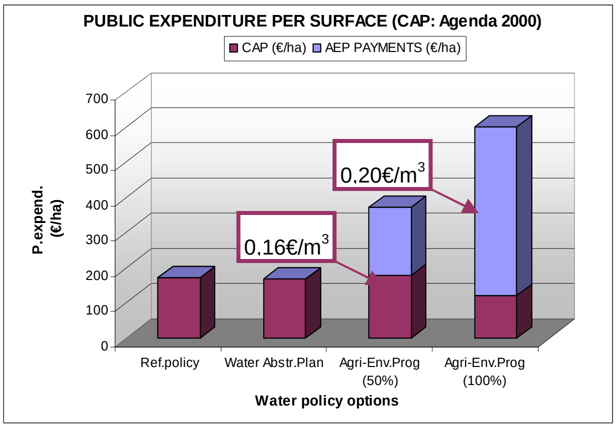
The first important conclusion that can be taken from these results is that not all the farm types have the same capacity to adapt to changes in policies. Farm type F1, which is a small farm practicing monoculture of vignard, should stop production when water volume available is reduced, in view of the fact that all scenarios except the reference (with full water allotment) present a farm income lower than the minimum survival level. This minimum survival level has been calculated dividing the minimum salary established by the Spanish legislation (UGT, 2005: http://www.ugt.es/DatoBasico/smi2005b.htm), by the average farm surface. From these results, it can be affirmed that small farms with vineyard in monoculture are not capable of adapting to water restrictions imposed by the water volume reduction programs (as it has been confirmed by stakeholders during our meetings).

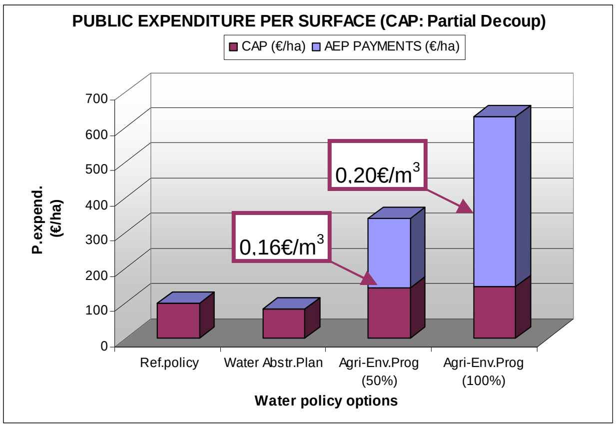
For the other farm types, income decreases, as well, when water availability is reduced, but they keep over the “minimum survival income” level. This reduction is more important when water policy changes from “full water allotment” to scenarios with water restrictions than when changing from one type of restriction policy to another, for all farm types. Comparing the different farm types, it is shown that type F2, which is the smallest and the one with the highest income in the reference scenario, suffers the most important reduction in income when changing from the reference scenario to the Water Abstractions Plan. From the W.A.P. scenario to the Agri-Environmental Plan with 50% water volume reduction, all three types loose income in the same proportion, but when going to 100% rainfed, even though all farm incomes descend, types F3 and F4 change positions. This fact shows that F4, which has the highest surface, is the type that suffers least the change on water volume restriction from 50 to 100%. This difference between farm types depending on their size reveals the existence of “scale economies”: big farms are more flexible and suffer more gradual changes face to a reduction on availability of water. Moreover, F4 does not have vignard, differently from F3, a circumstance that facilitates adaptation in the short term.

5.4 Effects on public expenditure

Another important factor to be analyzed in order to find out the sustainability of the different policy options is public expenditure. On this purpose, two types of subsidies have been compared for the different scenarios: the Common Agricultural Policy payments and those payments linked to water reduction compensation in the Agri-Environmental Programs. The following figure (Figure 12) shows the results given by the simulations in terms of public expenditure, including CAP payments and payments derived from the water reduction programs:

Figure 12: Public expenditure (€/ha) for the four different water policy scenario tested.





SOURCE: own elaboration from results of simulations with the economic model

Results from the simulations show that public expenditure is much higher with Agri-Environmental Programs than with the reference policy or the Water Abstractions Plan, in which water reduction was achieved through the establishment of quotas (without economic compensation). In contrast, Agri-Environmental Programs combine the quotas with a subsidy aiming to compensate the income losses derived from the reduction on water volume. In this case, public expenditure reaches up to 600€/ha for the suppression of irrigated crops (scenario A.E.P. with 100% water reduction).

If the costs of agri-environmental payment are calculated, per cubic meter of water reduced, the result obtained is 0.16 €/m^3 for 50% water reduction option and 0.20€/m^3 for 100% water reduction. Farmers will only join the program when this compensation is higher than the water productivity they get, that is to say, when the compensation received from saving one certain volume of water is higher than the income they loose when reducing that volume. Considering the low enrollment of the farmers to these programs, it can be deduced that subsidies do not get to compensate income losses, despite the high public expenditure. From these results' view, the conclusion is that these programs have low cost-effectiveness.

Comparing the two agricultural policy options, figures show that the whole of CAP subsidies is lower for Partially Decoupled Payments This can be explained because subsidies are not completely depending on the crop choice any more, so the farmers stop cultivating crops like maize, which are high consuming and were profitable thanks to the high subsidies linked to them. Decoupling payments to crops seems to be the less expensive option for the public sector.

6 Conclusions

Summing up the different results obtained:

- Results from the economic-hydrologic integrated analysis show that, in general, conservation policies that are being implemented in the Upper Guadiana basin, even when they can contribute to reduce to a big extent farms' water consumption, they will not be able to achieve, in the aggregated, the recuperation of the aquifer Mancha Occidental if additional measures aiming to reduce illegal abstractions are not put into practice. This situation would worsen in case of droughts.

- While the reference policy, with Agenda 2000 payments and full water allotment, was the most profitable situation for farmers, this water management scenario results to be unsustainable from the environmental point of view, as it has lead to the fast descent on the water table. This descent on the aquifer level has important consequences, like the descent on water availability and the degradation of wetlands of high environmental value.

- Results from the models show that agricultural policies also have a big influence on water consumption and, consequently, on the water table. While Agenda 2000 payments have favored the cultivation of high water-demanding crops, the new CAP reform of 2003, which introduces the decoupling of payments to production, seems to better perform for water consumption by encouraging higher percentages of rain-fed or low water-demanding crops.

- Several policy measures have appeared, with the specific aim of controlling the aquifer depletion. These water policies can be classified in two groups: (1) policies based on the establishment of quotas, such as the Water Abstractions Plan (WAP), and (2) policies combining quotas with compensation payments, aiming to cover income losses derived from water restrictions, such as the Agri-Environmental Programs (AEP). Both strategies would be capable of reaching the reduction on water abstractions needed for the recuperation of the aquifer (if illegal abstractions are controlled), but there are significant differences between them: WAP is compulsory and it forces the farmers to reduce water volumes without any compensation; this has led to important to social conflicts when trying to put it into practice. On the other hand, while the voluntary character of the AEP and the existence of the compensation payments make it more socially accepted, these programs result much more expensive for the public sector. In addition, as water restrictions in AEP are based on WAP water volumes, the reduction in water volumes is too high to maintain farm incomes, even with the existence of the compensation payments, and the number of farmers willing to join the program is too low.

- One more integrated application of water policies and agricultural policies is a key issue in water resources conservation. In fact, the field work carried out in the area, as well as the stakeholders' meetings, indicate that the new CAP is having an influence on crops distribution and on water uses, and that the combined effects with water abstractions limitation programs must be analyzed. Consequently, conservation policies applied in the area need to be designed and implemented in a coordinated way and with a higher public and stakeholders' participation, trying to find synergies, to define common objectives and to select efficient and socially acceptable instruments. In this context of public participation, it is necessary to carry out technical, economic, social, institutional and environmental analysis that can contribute to improve the adaptive capacity of the Upper Guadiana river basin to a changing environment.

- It is urgent to achieve not only a good coordination of the different types of policies, but also a reinforcement of the laws, which has caused so many conflicts so far. At this point, it is important to remember the importance of stakeholders' participation in the water management decision-making process, not only to searching for new management options, but also to make them feel one part of this management process.

7 List of references

Baseline Condition Report: document Guadiana_Baseline.pdf, in NeWater web page. http://www.newater.info/folders/1998 (Llamas R. and P. Martínez Santos, 2006)

Blanco, I. (2006). Impacts de politiques alternatives dans la gestion durable des eaux souterraines pour l'agriculture : le cas de l'aquifère de la Mancha Occidental (Bassin du Guadiana-Espagne). Msc Thesis. Faculté de Sciences Economiques - Montpellier I, France.

Blanco, I. and Varela-Ortega C. (in press). Integrating strategies for an efficient water management under uncertainty: empirical evidence in Spain. Submitted to WASAMED Conference (14-17 february 2007), Bari, Italy.

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

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

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

CHG (Confederación Hidrográfica del Guadiana) (2005) Régimen de Explotación para el año 2006 de la Unidad Hidrogeológica de la Mancha Occidental y de un perímetro adicional de la Unidad Hidrogeológica de la Sierra de Altamira. Ministerio de Medioambiente. Guadiana RBA. Available online: http://www.chguadiana.es/

CHG (Confederación Hidrográfica del Guadiana) (2006). Plan Especial del Alto Guadiana: borrador del documento de directrices. Ministerio de Medioambiente. Available on-line: http://www.chguadiana.es/publica/index.htm

Coleto, C., Martínez Cortina, L., and Llamas, J.R. (eds) (2003). Conflictos entre el desarrollo de las aguas subterráneas y la conservación de los humedales: la cuenca alta del Guadiana. Fundación Marcelino Botín, Ediciones Mundi-Prensa, Madrid.

Flichman, G., and Jacquet, F. (2004) Séminaire de recherche : Modélisation des systèmes agraires, IAMM, Montpellier ; ENSAM, Montpellier.

GAMS (General Algebraic Modeling System). GAMS Development Corporation, Washington, D.C. (http://www.gams.com)

García-Rodríguez, M., and Llamas-Madurga, M.R. (1992) Aspectos hidrogeológicos en relación con la génesis y la combustión espontánea de las turbas en los “Ojos del Guadiana”. Actas III Congreso Geológico de España y VIII Latinoamericano de Geología, Salamanca, tomo 2, 285-289.

Hazel, P. and Norton, R. (1986). Mathematical programming for economic analysis in agriculture. New York: MacMillan Publishing Company.

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

Junta de Castilla La Mancha (2006). Consejería de Agricultura y Medio Ambiente. Comunidad de Castilla-La Mancha, Toledo

Lowe, P., and Baldock, D. (2000). Integration of Environmental Objectives into Agricultural Policy Making in CAP Regimes and the European Countryside (eds. P. Brouwer and P. Lowe).

MAPA (Ministerio de Agricultura, Pesca y Alimentación) (2003) Anuario de estadística agraria.

Martínez Santos, P., and Llamas, R. (2005). Upper Guadiana Case Study. Presentation in Madrid NeWater-Aquastress meeting, 20 July 2005. Spain.

Mejías, P., Varela-Ortega, C., and Flichman, G. (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 *Water Resources Research*, Vol. 40, No. 7 (2004) (W07S03, doi: 10.1029/2003WR002877).

Varela-Ortega, C. and J. Sumpsi (1998), CAP and the environment in Spain, in F. Brouwer and P. Lowe (eds), CAP and the rural environment in transition. A panorama of national perspectives, Wageningen: Wageningen Pers, pp. 201-240.

Varela-Ortega, C., Sumpsi, J., Garrido, A., Blanco, M., and Iglesias, E. (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, Sumpsi J and Blanco M, (2002). Water availability in the Mediterranean region. In: Brouwer F. and van der Straaten, J.(eds). Nature and Agriculture in the European Union: New Perspectives on Policies that Shape the European Countryside. Ed. Edward Elgar Publishing Ltd. Cheltenham (UK). Pp 117-140

Varela C., 2003. Assessment of agricultural policy options for sustainable ground-water management: a case study of wetland conservation in Spain. Options Méditerranéennes, Sér. A / n°52 – Libre-échange, agriculture et environnement. 18 p.

Varela-Ortega C, Sumpsi JM and Blanco M, (2003). Analisis económico de los conflictos entre el regadío y la conservación de humedales en el Alto Guadiana. In: Coleto C., Martinez-Cortina L. and Llamas MR.(eds). Conflictos entre el desarrollo de las aguas subterráneas y la conservación de los humedales. Fundación Marcelino Botín. Ed. Mundiprensa. Madrid. Pp 257-276

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). ISBN 92-9079-636-7. Center for Eurpean Policy Studies. Brussels

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

8 List of figures

9 List of tables

10 Annex I: Complementary documents

This main report is complemented by the following reports, which are also uploaded in NeWater website as independent documents:

- Field work report in the Upper Guadiana Basin: file NW_D1.7.5b(II).doc, in NeWater website
  http://www.newater.info/folders/

- Stakeholder report: file NW_D1.7.5b(III).doc, in NeWater website
  http://www.newater.info/folders/

- Adaptive management of water resources: Stakeholder participation for vulnerability and adaptation analysis using WEAP. Report of the WEAP21 use for water management in the upper Guadiana basin (Spain). File NW_D1.7.5b(IV).doc, in NeWater website
  http://www.newater.info/folders/

11 Annex II: UPM contribution to the WP 1.7.

Reference to the 18 months plan of WB 1:

WP 1.7 Methods for Transition to Adaptive Management

Work package number	1.7	**Start date or starting event:**				1
Activity Type	RTD/Innovation activities, Training activities					
Participant id	USF	ICIS	IRSA	ECO	GEUS	Alterra	Cemagref
Person-months per part	12/30 12/24	10/20 12/18	5/10 7/10	1/3 2/2	1.5/4	1/2 1/1.5	1/3 1/2.5
Participant id	SEIOX	IIASA	COPP	MMU	UNEXE	VUIVM	SEECON
Person-months per part	2/4 2/4	5/10 5/8	11/21.5 15/21	5/10 5/10	5.5/10 7/9.5	0.5/2 1/1.5	1/2 1/2
Participant id	UTW	FEEM	ZEF	UPM			
Person-months per part	3/8 5/7	5/10 7/9	2/8 4/5	4/8			

Description of work

Task 1.7.6b Development of an agro-economic model for analysing policy scenarios and cost-effectiveness of policy measures linking water and agricultural policy. Scenarios on adaptive capacity of different policy options linking agricultural and water policy and management options. Cross-cutting task with WPs 1.1 and 2.5 (***UPM***)

Guadiana:

Evolutionary model (Task 1.7.4a) developed in participatory setting.

Agro-economic model (Task 1.7.6b)

D.1.7.5b Agro-economic model for analysing policy scenarios and cost-effectiveness of policy measures linking water and agricultural policy (month 20)

Reference to the tasks chronogram of UPM : **Completed tasks in gray**

WP 1.7 Methods for Transition to Adaptive Management
WORK PLAN (UPM) . 18 months (June 2005 - January 2007)

Task 1.7.6b Development of an agro-economic model for analysing policy scenarios and cost-effectiveness of policy measures linking water and agricultural policy. Scenarios on adaptive capacity of different policy options linking agricultural and water policy and management options. Cross-cutting task with WPs 1.1 and 2.5 (UPM)

1. General framework
   - 1.1. General overview of the agronomic, socioeconomic and policy framework in the Mediterranean countries in the EU context
   - 1.2. Specific overview in the Guadiana basin.
   - 1.3. Analysis of the on-going application of water policies (EU WFD) and agricultural policies (CAP reform).

2. Field work in the study area (Upper Guadiana basin)
   - 2.1. Data base elaboration: surveys to different stakeholders
   - 2.2. Survey to Experts in the area (Directors of Water User associations, Farm Union representatives)
   - 2.3. Survey to farmers
   - 2.4. Survey to Water User Associations
   - 2.5. Survey to the Government agencies (central and regional): River Basin Authority. Agricultural and Environment Departments of the Regional Government of Castilla-La Mancha

3. Selection of representative farms of the study region. (Upper Guadiana basin and potentially the Lower Guadiana area)

4. Selection of policy scenarios:
   - 4.1. Agricultural policy scenarios
   - 4.2. World Trade scenarios (WTO reform proposed by the EU)
   - 4.3. Water scenarios (EU Water Framework Directive, and National Water Policies: National Irrigation plan)
   - 4.4. Adaptive capacity scenarios

5. Development and elaboration of the bio-economic model
   - 5.1. Elaboration of a prototype model
   - 5.2. Calibration and validation of the model

     DELIVERABLE: (Month 15) report (preliminary)_______________ *09/2006*

   - 5.3. Complete Scenario-based model

6. Results and policy analysis
   - 6.1. Effects on the environment , Effects on the private sector (The farmers)
   - 6.2. Effects on the public sector (Cost-effectiveness of policies)
   - 6.3. Analysis of robustness of policies
   - 6.4. Analysis of Adaptive capacity

     DELIVERABLE (month 18): Report__________________________ *01/2007*

See planning and timetable chart below

CHRONOGRAM OF TASKS FOR WP 1.7 b – **COMPLETED TASKS IN GREY**

		2005							2006												2007
	Tasks	jun	jul	ago	sep	oct	nov	dic	ene	feb	mar	abr	may	jun	jul	ago	sep	oct	nov	dic	ene
1	**The overview of the agronomic, socioeconomic and policy framework**																				
2	**Field Work: survey elaboration**																				
22	Survey to experts																				
2.3	To the farmers																				
2.4	To the Water User Associations																				
2.5	To the government agencies																				
3	**Selection of representative farms**																				
4	**Selection of policy scenarios:**																				
5	**Development and elaboration of the bio-economic model:**																				
5.1	Elaboration of a prototype model																				
5.2	Calibration and validation of model																				
5.3	Complete Scenario- based model																				
6	**Results and policy analysis**																				

12 Annex III: Contributors to the report

This report is the result of the researches of UPM partners in the NeWater consortium. It has been edited by Consuelo Varela-Ortega. The following persons have contributed to the whole report:

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Irene Blanco-Gutiérrez, UPM.