Water Conservation and Agricultural Policies: Synergies in the Upper Guadiana (Spain)

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***Abstract* — In the last decades the Common Agricultural Policy has evolved towards a less intensive approach based in a multifunctional agriculture respectful with the environment. At the same time, following the enacting of the Water Framework Directive in 2000, water policies and management regimes are also evolving towards more integrated water management with an active stakeholders' involvement.**

In this context, the aim of this paper is to analyze the impact of water conservation policies and agricultural policies (Cross-Compliance: Nitrates Directive) in the Upper Guadiana River basin (Spain), where intensive irrigated agriculture resulted in the overexploitation of the Western La Mancha aquifer and the subsequent degradation of the highly valuable wetlands, and in an important nitrates' pollution. Focus is made on farmers' vulnerability to these policies and the synergies between them.

The methodology combines qualitative and quantitative aspects defined by the integration of an economic and an agronomic model (CropSyst), and a vulnerability analysis. The economic model (mathematical programming model) simulates farmers' behaviour facing different policy options. The results of the economic model are used as an input for the analysis of farms' vulnerability based on farm income indicators, through the elaboration of a vulnerable farms classification tree using CART (Classification and Regression Trees).

The results of the model show that farm income is more sensitive to water use limitations than to nitrogen restrictions. Farm size and Water Authority's policy enforcement capacity are key variables in determining farmers' vulnerability, being small and legal farms the most vulnerable ones.

***Keywords*— water and agricultural policy, economic model, vulnerability analysis**

I. INTRODUCTION

During the last 15 years the Common Agricultural Policy (CAP) has largely evolved towards a less intensive approach based in a multifunctional agriculture more respectful with the environment. After the CAP reform of the Agenda 2000 and the subsequent 2003 Luxembourg reform with the compulsory cross-compliance scheme, the next step in the CAP evolution (highlighted by the CAP "health-check") is the better integration of agricultural policy with environmental policies and specifically with water policies. At the same time, following the enacting of the Water Framework Directive (WFD) in 2000, water policies and water management regimes are also evolving towards more integrated water management with an active stakeholders' involvement, to ensure the good ecological status of all water bodies.

In this context of increasing policy integration, it is relevant to know the impact of each policy option to better evaluate their cost-effectiveness and to value synergies and between them.

II. THE CASE STUDY AND THE POLICY CONTEXT

In the Upper Guadiana basin (UGB), located in the southern central plateau of Spain, agriculture consumes 90% of all renewable water resources. In the last decades, the use of groundwater has allowed a rapid development of irrigated agriculture and an important socioeconomic development. Ground water irrigation expanded in the area as a response to the combination of agricultural and rural development policies (which promoted intensification and irrigation), and the development of drilling and pumping technologies, which permitted easy access to ground water sources at reduced abstraction and well

drilling costs [1][2]. However, this huge increase of water abstractions led to the overexploitation of the Western La Mancha aquifer, water pollution and the degradation of the highly valuable wetlands associated to the aquifer.

In addition, intensive agriculture led to nitrates' pollution in the region of Castilla La Mancha, being this region the main polluted area in Spain by nitrates from agriculture.

These environmental problems are the basis for the policy framework analyzed in this research:

- The Water Abstraction Plan (WAP): The WAP was launched during the early 90's to recover the over-exploited aquifer by establishing annual water quotas that restrict water extractions. The WAP has reduced the historical water rights of the private irrigators causing strong opposition among them. In consequence, the Spanish authorities have not been capable to fully implement and enforce the WAP leading to important institutional and social conflicts in the area and to the continuation of excessive water mining above the legally permitted levels.
- The Nitrates Directive (ND): in the region of Castilla La Mancha there are six nitrate vulnerable zones, whose action program establishes the maximum permitted nitrogen application and the agricultural practices required to minimize nitrogen leaching. Among the Statutory Management Requirements included in the Cross-Compliance scheme, the ND is the one with the lowest degree of compliance [3].

III. OBJECTIVE OF THE RESEARCH

The aim of this research is to analyze the impact of water and agricultural policies in the UGB by focusing on farmers' vulnerability. The study will focus on the understanding of how these policies and agricultural policies (e.g. ND) affect different farmers and farm types. Specifically, the study analyzes how some farms have a larger capacity to adapt to the policies applied in the region and to what extent the capacity that the Water Authority has to enforce the strict water quota system is determinant for reducing farmers' vulnerability.

IV. METHODOLOGY

Figure 1 shows the methodological framework in which qualitative aspects are combined with quantitative aspects defined by the integration of an economic and an agronomic model.

The main parts of this methodology are:

1. Elaboration of a knowledge base based on an ample field work developed in three phases in 2005, 2006 and 2007, expert consultations, and stakeholder meetings. Selection of a representative farms typology that represents irrigation agriculture in the area of study in selected Irrigation Communities. Table 1 shows the representative farms' main characteristics.

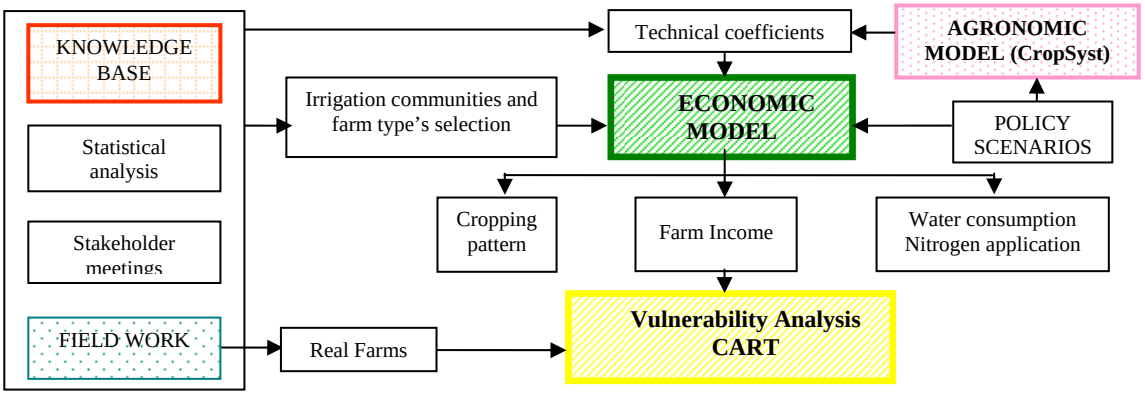

Fig. 1 Methodological Framework

Table1: Irrigation communities (IC) and selected farm types

Farm	IC	Surface (has)	Level of coverage in the IC (% of area)	Level of coverage in the sub-region of La Mancha (% of area)	Cropping patterns
F1	Alcázar de San Juan	150	40	51	43% Rain fed / 37% Extensive irrigated Crops / 20% Horticulture
F2	Daimiel	70	16	51	10% Rain fed / 57% Extensive irrigated Crops / 33% Horticulture
F3	Herencia	19	22	20	10% Rain fed / 74% Extensive irrigated Crops / 16% Horticulture
F4	Manzanares	40	19	23	5% Rain fed / 24% Extensive irrigated Crops / 31% Horticulture / 40% Vineyard
F5	Tomelloso	45	29	23	11% Rain fed / 89% Vineyard

2. Calibration and validation of the agronomic model CropSyst for the area under study, and simulation of agricultural policy scenarios (cross-compliance: ND).
3. Specification of an economic model (MPM) that describes farmers' behaviour in different water conservation policies and agricultural policies scenarios. The model is a non-linear, farm-based model of constrained optimization which maximizes farmer's utility subject to technical, economic and policy constrains. The model integrates risk parameters that take into account market and climate variability. The scenarios simulated include (i) water policy scenarios which comprise the current WAP (water quotas system), the actual water use volumes (water quotas + overpumping) and the historical water allotment rights, and (ii) agricultural policy scenarios (Cross-compliance ND).
4. The results of the economic model are used as an input for the analysis of farms' vulnerability based on two farm income indicators [4], for 25 real farms. The two income indicators correspond to (i) the relative income loss (%) and (ii) the absolute impact of the WAP on farm income as the difference with the minimum survival income (m.s.i.) (calculated as the minimum income that would allow the farmer to continue with his activity). The elaboration of a vulnerable farms classification tree using CART (Classification and Regression Trees) [5] [6] allowed to obtain the vulnerability prediction variables. The variables included structural and agronomic parameters (farm size, crop diversification and irrigated area), water consumption decisions, and institutional factors such as the policy enforcement impact.

V. RESULTS

The results of the model show that the WAP induces important income losses to most farms (figure 2). In aggregated terms the WAP results in an average income loss of 25%, while the nitrates directive produces a 5% of income loss in the reference situation and just a 2% when the WAP is already being fulfilled (figure 3).

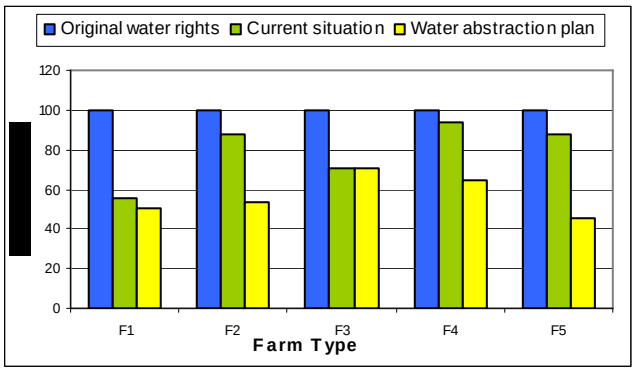

Fig. 2 Effect of the application of Water Policies on farm income across farm types

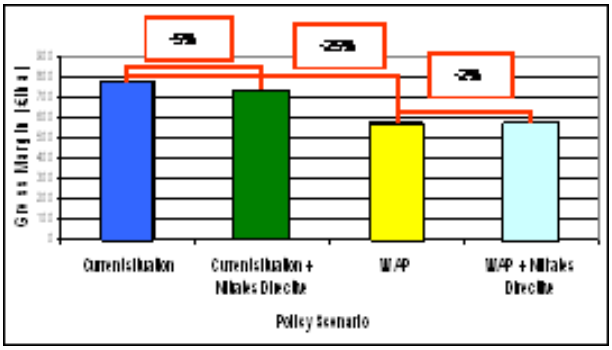

Fig. 3 Aggregated effects of the WAP and the Nitrates Directive on farm income

The results across farm types show that bigger farms with a high percentage of irrigated area face higher income losses, as water quotas are proportionally lower in larger farms. However comparing total farm income with respect to the m.s.i., small farms are more vulnerable to relatively lower income losses and farms that feature a rigid cropping pattern, such as vineyards, are prone to abandon irrigation production.

The output of the CART analysis is a vulnerable farms classification tree which highlights the main variables for vulnerability prediction. The tree shows that farm size plays a major role, evidencing that economies of scale are present for some farm size strata. Small farms of less than 20 ha are extremely vulnerable to water constraints. Medium-size farms (20-30 ha) are the less vulnerable farms. This trend is reverted for larger holdings that present high vulnerability in the range of 30-350 ha and very high vulnerability in farms over 350 ha.

The water policy enforcement impact is a key variable in the vulnerability assessment. This indicator shows farmers' illegal behaviour as a way to cope with water stress to minimize their vulnerability. A farm that operates legally and complies with the water quotas of the WAP, will be more vulnerable the lower the capacity of the Water Authority to enforce the quotas system.

VI. CONCLUSIONS

- Farm income is much more sensitive to water restrictions than to nitrogen restrictions, being water the main limiting factor for agricultural production in this region as well as in other Mediterranean regions. However, both the water conservation policy and the ND lead to less water intensive cropping patterns and diversified farms tend to loose a lesser proportion of their farm income as their capacity to adapt is higher.
- Small and legal farms are the most vulnerable. Illegal pumping will need to be eliminated. This quotas system would only be effective if the policy enforcement capacity of the Water Authority increases and a new management regime is put into practice. Therefore, policy enforcement is a key variable for vulnerable farms protection and for the aquifer recovery.
- In the current changing policy environment integration and coordination between policies is an important priority. In this context it is important to emphasize the role of the synergies between water and agricultural policies**.** In this area of Spain, water use limitations is promoting the substitution of water demanding crops with less water intensive crops which require also lower nitrogen dosages.

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