The application of the Water Framework Directive where farmers have alternative water sources

Dono G. [1] and Severini S. [1]

[1] Università della Tuscia – DEAR, Viterbo, Italy

Abstract— **This paper evaluates the possible consequences of decreasing in the amount of water provided by the irrigation board to the farms, and increasing in the unitary water charges that the irrigation board applies to the farms. The study has been conducted in a Mediterranean region of southern Italy where farmers can use water delivered by an irrigation board and by privately owned wells. The results of the analysis, performed by means of a mathematical programming model, show that in both cases farmers substitute the water supplied by the irrigation board with that extracted from farm wells. This generates an over-extraction of resources from the aquifer leading to likely negative environmental consequences. This also endangers the economic sustainability of the irrigation boards, which are institutions whose activity can be monitored and influenced by public administration bodies.**

Keywords— **Water Framework Directive; farmers behaviour; mathematical programming.**

I. INTRODUCTION

The EU Water Framework Directive (WDF) is expected to increase the water rates and to reduce the amount of water traditionally allocated to the agricultural sector [1] [2]. Specific problems arise where farmers have alternative water sources such as irrigation boards and privately owned wells. This generates an imbalance for public control on the use of water given that the lack of legislation and the high enforcement costs make difficult to monitor and control withdrawals from private wells.

In those conditions, this paper evaluates the possible consequences of: a) a decrease in the amount of water provided by the irrigation board to the farms, and b) an increase in the unitary water charges that the irrigation board applies to the farms.

The study has been conducted in a Mediterranean region of southern Italy, using a mathematical programming model. Results show that in both cases farmers substitute the water supplied by the irrigation board with that extracted from farm wells. This generates an over-extraction of resources from the aquifer leading to likely negative environmental consequences. This also endangers the economic sustainability of the irrigation boards, which are institutions whose activity can be monitored and influenced by public administration bodies.

II. MATERIAL AND METHODS

The study area is located in the North-Western part of Sardinia (Italy) and includes 34,492 ha of agricultural land where around 2,900 farms receive water from an irrigation board (Nurra Consortium) which distributes the water of two artificial lakes. The available water is shared between agricultural and urban usages. During water scarce years, allocation rules privilege urban usage and farmers utilise water from private wells when available.

The agriculture of the area is represented by 24 representative farming systems in a typical linear, regional mathematical programming model1. Production technologies for crop and livestock activities are defined on the basis of the main crop and livestock activities observed in the area. For each irrigated crop, different irrigation techniques are considered. Number, location and technical characteristics of farm-owned wells (including the cost of pumping water) have been identified by means of direct surveys [3].

The objective function of the model, to be maximized subject to several economic and technical constraints, is the sum of the gross margins of the farms in the area. Some constraints, such as those related to land availability, crop rotation and labour

1. [1] These farm typologies differ in size, production orientation, presence of wells and localization in the area. Details on the chosen farm typologies and on the structure of the model can be provided directly by the Authors.

availability, act at farm level while others operate over the whole area. In particular, water availability has been estimated for each irrigation period on the basis of data recorded by the irrigation board. The model has been calibrated and validated by comparing its results in terms of land uses to the observed crop patterns obtained by using remote sensing data (CASI4 database) and field surveys. In both cases, the shares of different crop groups have been used to compute a Finger and Kreinin similarity index [4]: a value higher than 90% has been obtained[2]. The model has been further updated to account for the introduction of the CAP Single Farm Payment. This latter form is the baseline to be compared with simulation results.

Water distribution costs of the irrigation board are calculated by using a cubic cost function estimated by using data on the irrigated land, water use, and costs in another irrigation board with technically similar distribution systems [5].

III. SIMULATION RESULTS

Two scenarios are considered. The first one decreases the availability of water distributed by the irrigation board: reductions of 10% and 20% from the baseline levels are shown. The second scenario raises the unitary water charges applied to the farmers by the irrigation board: 50% and 100% increases above the baseline levels have been considered here.

The reductions of water availability increase the amount of water pumped from farm owned wells (table 1) while the use of water provided by the irrigation board decreases.

With the 10% reduction in water availability, the total water use does not vary significantly. With further decreases, it becomes more difficult to use water from wells because unitary pumping costs increase and, in some cases, all pumping capacity is used.

The possibility to extract water from the wells reduces the impact of those limitations on farm income. The reduction in the water delivered by the irrigation board decreases both farm payments and water distribution costs. However, the combined impact of both factors reduces the share of distribution cost covered by water payments (table 1) worsening the economic situation of the irrigation board.

The increase in the unitary water charges applied by the irrigation board also causes a raise in water that farmers pump from their wells a decrease in the use of water provided by the irrigation board (Table 2).

This reduces the water distribution costs of the irrigation board but it raises in the unitary water charges. Farm payments remain almost at baseline level with 50% raise in unitary charges and it significantly increases with a 100% raise. Notice that, because the raise in water charges is justified by long term, resource and environmental costs caused by the farm water usage, the additional charges are transferred to the regional administration. This explains why the net payments retained by the irrigation board drastically decline compared to the baseline situation. In particular, doubling the water charges reduces of 54% the water payments that the irrigation board can use to cover water distribution costs (Table 2). This could have very negative consequences on the economic situation of the irrigation board. In particular, this causes a strong decline in the ratio between the received net payments and the water distribution costs (Table 2).

IV. CONCLUSIONS

In the studied area, farmers can use both the water supplied by the irrigation board and the water extracted from their owned wells. This could generate outcomes in contradiction with some basic objectives of the WFD, like the protection of the water resources from over-exploitation, or a higher coverage rate of the water services' distribution costs.

The analysis confirms that significant failures in reaching the WDF objectives are likely. On the one hand, the increasing exploitation of the underground aquifers could have negative consequences on the environment. On the other hand, when additional water charges are imposed in order to recover a larger share of the costs of water services (as required by the art.9 of the WFD), this could have very negative

2. [2] The index ranges from 0 to 100%: it reaches 100% when the observed cropping patterns and the one obtained by the model are identical.

consequences on the financial situation of the irrigation boards. This should be avoided because these institutions have been proved useful especially in allocating water under severe scarcity conditions that prevail in most Mediterranean countries.

Table 1 Simulation results: reduction in water availability

	Absolute values			% changes on *Baseline*	
	Baseline	10%	20%	10%	20%
Total water use (1,000 m^3)	21,898	21,688	20,267	-0.96	-7.45
of which:					
from the irrigation board (1,000 m^3)	18,486	17,340	15,614	- 6.20	15.54
from private wells (1,000 m^3)	3,412	4,348	4,653	27.43	36.37
Farm gross margins (1,000 €)	56,012	56,006	55,992	-0.01	-0.04
Irrigation board financial situation:					
Water distribution costs (1,000 €)	782	740	675	-5.37	-13.71
Net farms' water payments (1,000 €)	453	426	383	-5.96	-15.45
Net payments/ distribution costs (%)	57.9	57.6	56.8	-0.62	-2.02

Table 2 Simulation results: increase of irrigation board water cost

	Absolute values			% changes on Baseline	
	Baseline	50%	100%	50%	100%
Total water use (1,000 m3)	21,898	17,483	16,955	-20.16	-22.57
of which:					
from the irrigation board (1,000 m3)	18,486	12,085	10,976	-34.63	-40.63
from private wells (1,000 m3)	3,412	5,398	5,979	58.21	75.23
Farm gross margins (1,000 €)	56,012	55,812	55,677	-0.36	-0.60
Irrigation board financial situation:					
Water distribution costs (1,000 €)	782	533	491	-31.84	-37.21
Gross farms' water payments (1,000 €)	453	444	537	-1.99	18.54
of which:					
Additional charges (1,000 €)	0	182	330	-	-
Net payments from farmers (1,000 €)	453	262	207	-42.16	-54.30
Net payments/ distribution costs (%)	57.9	49.2	42.2	-15.14	-27.22

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Corresponding author:

- Gabriele Dono
- Università della Tuscia - DEAR
- Via S. C. De Lellis, snc
- Viterbo
- Italy
- Email: dono@unitus.it