Irrigation Water Value Scenarios for 2015: Application to Guadalquivir River

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Abstract

This paper reviews the application of a scenario for the 2015 agricultural policy and markets for the irrigated agriculture in Europe. Scenarios for irrigated agriculture 2015 are also described in detail including Reformed CAP and biomass demand. It is applied at the basin level for the Guadalquivir River in southern Spain. The methodology is based upon residual value of water and it combines budget and farm analysis at municipality level, with the Guadalquivir basin divided at 50 'comarcas'; in each of them 24 possible crops are selected with specific 'comarca' data bases. The 2015 scenario studies the present level of water use and value, and makes an analysis for 2015.This model allows the knowledge of water value and irrigated agriculture at 'comarca' level and 'aggregated basin level'.

Keywords: Water pricing, Irrigated agriculture, Value of water, Scenario analysis

1. Introduction

Irrigation in Southern Europe is an indispensable input for agriculture as in most of the world arid and semiarid environments. In Mediterranean countries, irrigated farming accounts for a large share of total water withdrawals (83% in Greece, 68% in Spain, 57% in Italy, and 52% in Portugal). The irrigated area in the EU has grown from about 6,5 million hectares (Mha) in 1961 to nearly 12 Mha in 1996.

Current management of water resources is subject to uncertainty and scarcity and new institutions and technical tools are used, among them the implementation of Directive 2000/60/EC 'Water Framework Directive' (WFD) in whose preamble states that water supplies to the population in most European countries are threatened by human-induced pressures and that aquatic ecosystems are undergoing severe processes of quality deterioration. As we will see below, reversing these trends is the main objective of the WFD.

WFD enhance the use of economic analysis of water resources and uses and it supports the achievement of economic objectives, specifically cost recovery for water services, including environmental and resource cost within each of the three sectors: agriculture, industry and domestic. The meaning of this sentence has been defined in detail in the WATECO guide (2003) that develops the concept of full cost recovery based on the concept of cost recovery related to 'water services'.

In any case, WFD recognized the fact that water management should include economic analysis of alternatives. This is even more urgent in regions where water scarcity is a critical issue as it is in Mediterranean regions. This paper will use two economic instruments to study the demand of water in the Guadalquivir basin (Southern Spain). For a recent publication of European's water scarcity regions including an analysis of Guadalquivir situation, see Strossner et al, (2007).

The value for humans of any ecosystem goods or services (such as water or any other factor of production), is justified because they enter the utility function (Brown et al, 2006). The economic

value of something is a measure of its contribution to human well-being. In economic theory, the value of water can be treated as an 'economic rent', i.e. it may be considered an input factor similar to land.

Heal et al. (2005) provide a detailed description of methods that are available for valuation of ecosystem goods and services and many other available sources are available give complete descriptions, among them the production function approaches that are used for estimating the value of inputs in the production of a marketed good.

2. Case study

The case study Guadalquivir river basin in southern Spain has a surface of 57.527 Km^2 and a population more than 4,2 million people in 476 municipalities. The Hydrological Plan for Guadalquivir outlines the general management of the basin and indicates that the average basin's renewable water resources (surface and groundwater) are around 6300 hm^3/year (Ministerio Medio Ambiente, 2006), while the gross consumption for 2002 was estimated at 3583 hm^3/year (82% surface and 18% groundwater). The basin is highly regulated, and supply is supplemented with reservoirs regulating 35% of natural superficial resources as well as the base flow and exploitation of aquifers reaching 49% of renewable water resources. The level of water extracted is high and rainfall fluctuates; therefore, the guarantee for accomplishing user's water allocation rights is low. Agriculture is by far the biggest user of water (uses 86% of water in the basin) and the map shows where the main irrigated areas are located (Figure 1).
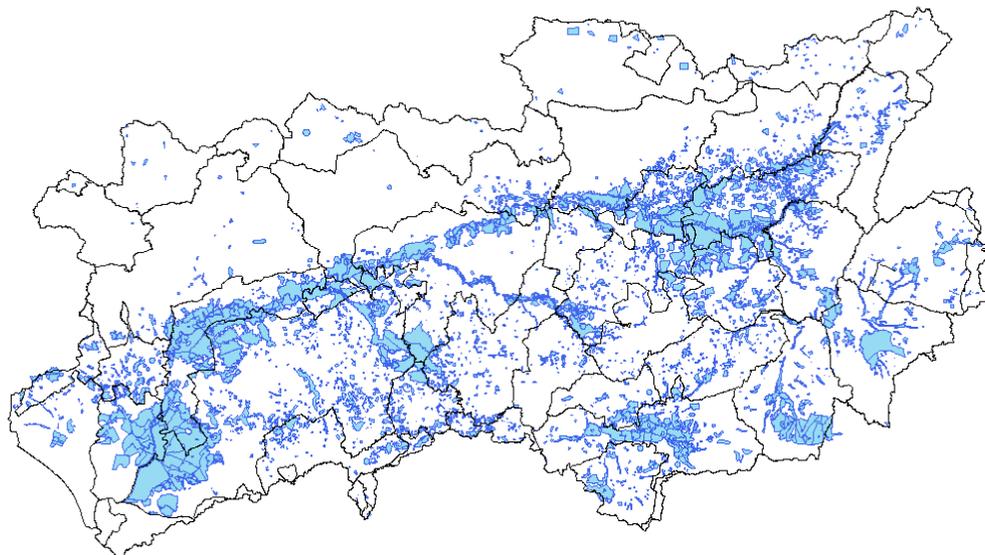

Figure 1: Irrigated areas in Guadalquivir River (Ministerio Medio Ambiente, 2006)

Six crops represent 81% of irrigated area and 82% of irrigated water demand. Regarding irrigated area, olive tree uses 45% of area (31% of water use), cotton is 10% of area (17% in water use); rice 5% of area (12% of water); maize 6% of area (10% of water); vegetables 6% of area (7% of water); and winter cereals (mainly wheat) 8% of area (6% of water).

Current policy in the basin is to improve farm irrigation systems, (changing to trickle irrigation) and also improve the distribution system level (pressurized networks). Each farmer receives an amount of water assigned by the water authority as a 'water right' or concession. Water concessions are usually assigned for a 'standard year' at 6000 m^3/ha; however, in the Guadalquivir they rarely receive the full right and are often allowed to use only a much smaller allocation.

3. The method or residual value of water

We will use the residual value of water for agriculture in the Guadalquivir in order to study allocation of the resource. Among the difficulties for implementing the technique we have the estimation of all costs and the existence of multi-output production systems. The hypotheses underlying the residual value method are part of the neoclassical economic theory, i.e. producers maximize profits and the total value of the product may be assigned to each input according marginal productivity. The mathematical expression is shown in (1):

$$Y = f(X_M, X_H, X_K, X_L, X_W) \tag{1}$$

Where Y is output and it is a function of material inputs (X_M), human capital and labour, (X_H), built capital such as buildings, tools, roads, and vehicles (X_K), land, (X_L), and water (X_W). If we consider technology as constant but all factors variable, then we have the total value of production as:

$$(Y \cdot P_Y) = (VMP_M \cdot X_M) + (VMP_H \cdot X_H) + (VMP_K \cdot X_K) + (VMP_L \cdot X_L) + (VMP_W \cdot X_W) \tag{2}$$

Where $Y \cdot P_Y$ represents value of product Y; and VMP_i is the value of marginal product of each factor, i.e. we assume the hypothesis of the total value of the product may be assigned to each input according to marginal productivity. The other hypothesis is the profit maximizing behavior, therefore we deduce the optimum solution as the point where farmer will consume each factor up to until VMP_i=P$_i$, so that we substitute P$_i$ by VMP_i in equation.

$$(Y \cdot P_Y) = (P_M \cdot X_M) + (P_H \cdot X_H) + (P_K \cdot X_K) + (P_L \cdot X_L) + (P_W \cdot X_W) \tag{3}$$

If we are able to obtain a good estimation of all prices and uses of each factor, except water, we may estimate the value of water ($P_W \cdot X_W$) as the only unknown variable in equation (3). As the water consumption per crop may be known for each location, we get the residual value of water as P_W:

$$P_W = \frac{(Y \cdot P_Y) - [(P_M \cdot X_M) + (P_H \cdot X_H) + (P_K \cdot X_K) + (P_L \cdot X_L)]}{X_W} \qquad (4)$$

Expression (4) is the basis for the residual method (Young, 2005) and finally we get the value of water ($€/m^3$).

As we mention, we have selected for estimating the water value, the residual method, starting with expression (4) we compute all factors in a hectare basis, with a minor improvement shown in equation (5). This modification is necessary as the value of the water may be computed 'at source' or 'at farm', and we will use first alternative according to the expression:

$$R^{W1} = [Y \cdot P_Y] - [(P_M \cdot X_M) + (P_H \cdot X_H) + (P_K \cdot X_K) + (P_L \cdot X_L) + C + E] \qquad (5)$$

If we divide the rent R^{W1} by **W** (water consumed per hectare) we get the value of water ($€/m^3$.). Application of the model is quite straightforward, and next section shows the results for individual crops and the basin as a whole.

4. Baseline scenario for 2015

Scenario analysis is not a tool for future prediction, on the contrary the objective of scenario analysis is to support the present decision making process by estimating possible evolutions of the world. We are interested in the analysis of irrigation water demand and water value evolution for 2015 horizon as that year is supposed to be a new framework after revision of present CAP normative that will be operating for the period 2007-2013.

There are many precedents for scenario analysis; we may quote Foresight Futures UK (Berkhout et al., DTI: 1999, 2002), Scenar 2020 (European Commission, 2007), "FFRAF Report" (*Foresighting Food, Rural and Agri-Futures*) (SCAR, 2007), *Prospect for Agricultural Markets and Income (2006-2013) in the European Union* (European Commission, 2006), *OECD-FAO Agricultural Outlook 2007-2016* (OCDE-FAO, 2007), *Ethanol expansion in the United States* (USDA,v2007) and WADI (Berbel, J. and Gutiérrez, C., 2004).

For our 2015 scenario we start by using the recent trend and normative for period 2001-2004 that is extrapolated to 2015, obtaining the baseline scenario. This scenario has been done firstly by a qualitative description and later by defining quantitative value for main parameters.

Qualitative analysis implies the definition of driving forces and we found that crop plan and technology is defined by farmer expectations, which depends upon different policies in European Union.

The main factor is the Common Agricultural Policy design influenced by Environmental policies (especially Water Framework Directive) and determining farm behavior through cross-compliance measures. Main external factors are EU Commercial Policy, both the Doha Round and WTO

agreements and preferential trade with MERCOSUR, ACP, Mediterranean countries. Also the EU enlargement with integration of Eastern European countries will impact significantly to agricultural markets for 2015. Finally, Energy policy will affect significantly agricultural markets through fiscal policy on biofuels.

This qualitative scenario must be translated into quantitative parameters in order to proceed to modeling results. We have used Agricultural Outlook FAO-OCDE report corrected by Gohin (2006) and USDA (2007). All of them agree in commodities Price increase (e.g. wheat and maize increases by 7% over 2005 levels); also soy and rape seed increase as the demand for biodiesel impacts these crops.

Regarding inputs we consider the present trend observed by Eurostat, where we can see that energetic inputs increase meanwhile non-energy dependant inputs decrease.
We have considered not yield increase for crops and the trend in permanent crops area observed in (2001-2004). Next table illustrates price increases for main crops:

Table 1: Quantitative parameters for baseline scenario 2015

Baseline	
Prices	% increase 2015/2005
Wheat	107
Maize	107
Rice	103
Oil seed	105
Olive oil	104
Sugar	103
Linked subsidies	0
Inputs prices	
Seeds & plants	94
Energy	103
Fertilizer	103
Pesticides	95
Machinary	98
Labour productivity	100
Area	
Wheat	115
Maize	115
Rice	80
Oil seed	110
Olive oil	120
Sugar	90
Cotton	70
Cítrus	110

Source: own data

5.- Results

Data for application of model is based upon secondary information for production functions, input and output prices, technical coefficients and crop cultivated areas. The year for the residual value analysis is 2005.

For the aggregation of residual values at basin level we use 50 territorial units called 'comarcas' (around 10 municipalities each), each of these territorial unit has 24 possible crops so that we have 1200 possible residual values of water, but some of the crops are not cultivated in all the basin, as an example rice is only cultivated near the river estuary (4 'comarcas'), citrus is limited by climate to be cultivated only in 10 'comarcas' and olive is not possible in the lower river basin, so that finally we have around 600 residual values, each of them associated to a water consumption. We integrate this data to compute the aggregated water value vs. water consumed in the basin; this is shown in figure 2 below.

The result is an average value of 0, 25 €/m^3 and 0,17 €/m^3 for 2005 y 2015
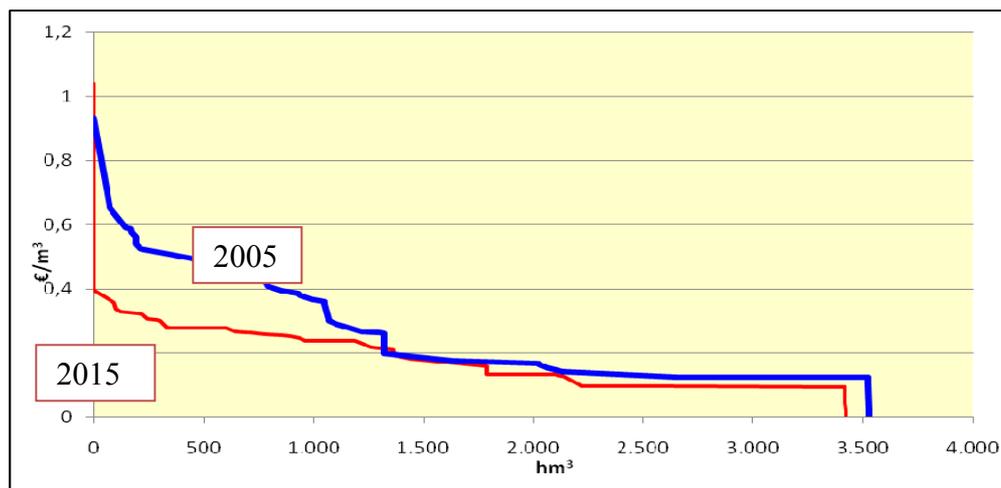

Figure 2: Residual value of irrigation water Guadalquivir 2005-2015

The basis for the model is the product exhaustion, i.e. what is defined in equation (5), and distribution of net margin between the production factors for 2005 is as follows: water takes 62%, land (rainfed value) is 20%, family labor is 8%, management 5% and owned capital is 4%. Values change in 2015 and they are 62 % for water, land decreases to 12%, family labor increases up to 12%, management 6% and owned capital is 7%.

What is relevant is that the value for water decreases by 30%, so that theoretically the new CAP will reduce pressure on the resource, at short term. A weakness of the analysis is that we have supposed a growth in perennial crops according to recent trend, which implies that the area of olive will increase by 20% and citrus by 10% for the period 2005-2015 by substituting herbaceous crops. Therefore we assume that water moves from low-value crop (cereals) to high value (citrus and olives) but the speed of transformation is supposed to be similar to the recent past, and it maybe accelerated by the impact of reformed CAP.

6. Concluding remarks

We have presented in this paper the valuation of water under different scenarios. Aggregated basin value is given as the function relating water value (price) and irrigated consumption.

Impact of CAP reform and evolution of world agricultural markets seem to reduce pressure on water resources for irrigated use, according to our valuation. We believe that this is a good new for the environment even if there are some economic losses, and illustrates how the high level of support given by CAP to farm production is partly responsible for the dramatic increase of irrigated areas in Europe.

Finally, we should remark that water value share in the Gross Added Value of Guadalquivir irrigated agriculture is around 30% which highlights the importance of the resource creating value in the agricultural system.

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