European water directive evaluation and decision support system to improve irrigation management: RISP-IDRIC Project

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European water directive evaluation and decision support system to improve irrigation management: RISP-IDRIC Project

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Abstract. The safeguard of water resources is becoming a major environmental priority, because water is an essential mean of production for agriculture and a basic element for the survival of all human activities. The recent reform of the Common Agriculture Policy is oriented towards an ecologically-sound agriculture and to a reasonable use of the production factors (technical features, including water), without waste, without releases of pollutants in water, soil and products. In this context, the Water Directive n. 60/2000 introduces in the water resources management new principles such as "polluter pays", the full cost and volumetric pricing. Implementation of the directive could have important effects on the agricultural sector and management.

The "Consorzio della Bonificazione Umbra", authority, located in Central Italy, is responsible for soil reclamation and conservation, protection of land and the environment, with special reference to water resources for the improvement and transformation of production systems. The "Consorzio" comprises 128.000 hectares with a total irrigated area of 4.181 hectares and 64.700 farms.

The RISP-IDRIC is a research project, funded by Italian Ministry of Agricultural, Food and Forestry Policies (2007-2010) and it will achieve two main goals:

– To find the most efficient solutions (and less expensive) to meet the targets set by European Water Directive n. 60/2000, giving a methodological support for application of national and regional water directives, testing the impact of different scenarios of contributory systems, consortia remediation and, consequently, agricultural system.

– To develop a web irrigation decision system to improve the efficiency of irrigation technology, streamline procedures for irrigation and optimization of the use of water resources, providing specific guidance to farmers for irrigation supply (time and amount) offering them a tool that exploits the advantages of new technologies.

In the paper a description of the project and the methodology that will be used has given.

Keywords. Water directive – Irrigation water management – Software – Water cost.

Evaluation de la directive européenne de l'eau et développement d'un système d'aide à la décision pour améliorer la gestion de l'irrigation : projet RISP-IDRIC

Résumé. *La sauvegarde des ressources en eau est l'une des priorités environnementales majeures, car l'eau, essentielle pour les productions agricoles, est un élément base pour la survie des activités humaines. La réforme récente de la Politique Communautaire de l'Agriculture est orientée vers une agriculture respectueuse de l'environnement et raisonnable dans l'utilisation des facteurs de la production, sans gaspillage et sans la pollution de l'eau, du sol et des produits agricoles. Dans ce cadre, la directive de l'eau n. 60/2000 introduit de nouveaux principes de gestion de la ressource : « le polluant paye », « le coût complet » et le « prix volumétrique ». L'application de la directive peut avoir des effets importants sur l'agriculture et sa gestion. Le « Consorzio della Bonificazione Umbra » de l'Italie centrale est responsable de la conservation du sol et de la protection de l'environnement, avec une attention particulière à le ressource eau et à la transformation et l'amélioration des systèmes de production. Le « Consorzio » de 128.000 hectares comprend une superficie*

totale irriguée de 4181 hectares et 64700 exploitations. Le projet de recherche RISP-IDIRC est financé par le Ministère Italien de l'Agriculture (2007-2010) et a deux objectifs principaux:

- *Trouver les solutions plus efficientes (et moins chères) pour respecter la directive de l'eau n. 60/2000, en donnant un support méthodologique pour l'application des directives nationales et régionales, tout en évaluant l'impact des différents scénarios de systèmes agricoles et de contribution*
- *Développer un système de support à la décision sur web pour améliorer l'efficience de l'irrigation et les systèmes de flux, optimiser l'utilisation de la ressource, guider les agriculteurs dans le pilotage de l'irrigation et évaluer les avantages des ces nouvelles technologies.*

Cet article décrit le projet et la méthodologie utilisée.

Mots-clés. *Directive de l'eau – Gestion de l'eau d'irrigation – Logiciels – Coût de l'eau.*

I – Introduction

The preservation of water resources is becoming a major environmental priority, because water is an essential mean of production for agriculture and a basic element for the survival of all human activities.

The recent reform of the Common Agriculture Policy is oriented towards an ecologically-sound agriculture and then to a reasonable use of the production factors (technical features, including water), without waste, without releases of pollutants in water, soil and products. In this context, the Water Framework Directive (WFD) n. 60/2000 introduced a new philosophy in the water resources management, such as to protect and improve the quality of aquatic ecosystems, to promote a rational and sustainable use of the water based on a long term management of the water resources, to adopt specific measures to monitor the pollution (local discharges, emissions and losses of priority substances etc.), to reduce the pollution of the groundwater and to mitigate the effects of floods and droughts through the monitoring of waters.

1. The Water Directive

The innovative elements of the WFD are a water management based on the river basin districts, a monitoring of the water pollution, based on the limits to the emissions and on reaching the goal of water quality, an integration of all the uses, functions and values of the water, an attribution to the final user of the "full cost recovery of water", an integration of economic and financial tools with price policies for a rational use of water and a consultation of the civil society and the stakeholders in the process of water utilization. The new aspects of the directive are:

- full recovery cost of water ("polluter-pays" and "user-pays");
- incentives to the water pricing.

Basically, only the activities that cause significant impacts on water bodies and therefore pose a risk to achieving good status are covered by the definition of water uses. General experience shows that navigation, hydropower generation, domestic, agriculture and industrial activities are important water uses which may cause significant impacts and therefore have to be taken in consideration.

The WFD wants to be the reference point of the water policy in the next decades across the slimming of the European legislative framework in subject of water, the inspiration to the principles of sustainability, a very binding policy on the plan of the costs, either direct (es. new nets, expansion services) or indirect (renouncements to use the water) and with a very ambitious timetable (Tab. 1).

The "water" resource must be managed at basin level, with an approach no more sectorial, but shared by all the sectors and the allocation cost has to follow the principles of efficiency and equity.

The final objective of the directive is to reach a “good state” of the superficial and underground waters within 2015.

Most European countries provided incomplete reports on the Article 5 economic analysis. Regarding the sectors to be covered for cost recovery, the sector of households was addressed most often, followed by industry and then agriculture (Fig. 1).

Member States that have provided information on households have indicated a cost recovery rate of services for households between 70 and 100%, for industry between 40 and 100% and for agriculture between 1 and 100%. Italy is late in comparison to different fulfillments foreseen by the directive. The main crucial point concerns the incomplete transposition of directives preceding the WFD, the nitrates directive (91/676/CEE) and the directive on the treatment of urban waste water (91/271/CEE), the missed or partial realization of some key aspects of the WFD, for examples the identification of the water bodies strongly modified, the diffused pollution, the guardianship of the groundwater, the economic analysis (Fig. 2).

Table 1. Timetable of realization of Water Directive

Year	Issue	WFD Reference
2000	Directive entered into force	Art. 25
2003	Transportation in national legislation	Art. 23
	Identification of river basin districts and authorities	Art. 3
2004	Characterization of river basin: pressures, impacts and economic analysis	Art. 5
2006	Establishment of monitoring network	Art. 8
	Start public consultation (at the latest)	Art. 14
2008	Present draft river basin management plan to public	Art. 13 & 14
2009	Finalize river basin management plan including program of measures	Art. 13 & 11
2010	Introduce pricing policies	Art. 9
2012	Make operational program of measures	Art. 1 1
2015	Meet environmental objectives, first management cycle ends	Art. 4
2021	Second management cycle ends	Art. 4 & 1 3
2027	Third management cycle and last extension of deadlines ends	Art. 4 & 13

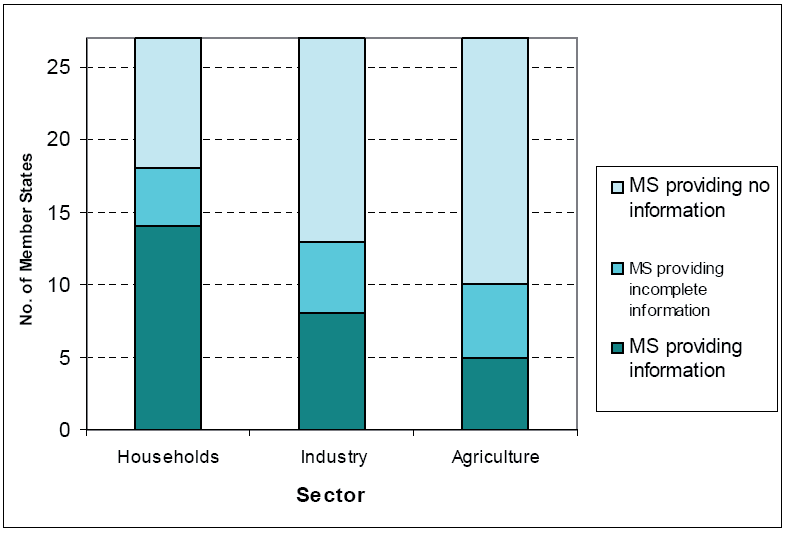

Figure 1. Level of information provided by Member States on sectors to be covered in cost recovery of water services.

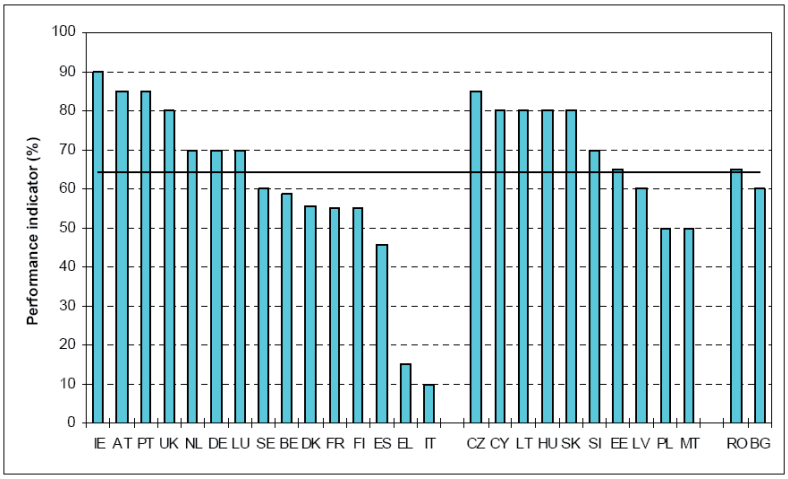

Figure 2. Indicator per Member State regarding its reporting performance and the EU-27 average (based on Member States' reports).

2. The "Consorzio della Bonificazione Umbra"

In this context, the RISP-IDRIC project wants to give **a** contribution to the realization of the WFD, verifying the applicability of some aspects related to the distribution of the water for irrigated use in the "Consorzio della Bonificazione Umbra", central Italy.

It is located in Spoleto (Umbria region) (Fig. 3) and it is responsible for soil reclamation and conservation, protection of land and the environment, with special reference to water resources for the improvement and transformation of production systems.

The "Consorzio" performs the functions and duties assigned by the Act and the activities that are still necessary for the achievement of its institutional tasks. It comprises 128.000 hectares with a total irrigated area of 4.202 hectares (on 3100 ha sprinkler method is used and on 1102

surface one) and 64.700 farms. The costs for the implementation, maintenance and operation of land reclamation projects, as well as those relating to the other purposes of the “Consorzio” are allocated on the basis of specific plan standings.

The “Consorzio” substantially applies from 2007 two ways of tariff method: a base fee (65 €/ha) for all the field in the consortium area, and supplemental fee for irrigated field only (65 €/ha), declar by farmers and controlled by consortium’s employers.

The Law n. 183 (1989) for soil preservation in the Umbria region created three basin authorities:

- Tevere river, 95% of the territory;
- Arno river, 3% of the territory;
- Marche region, 2% of the territory.

This law was finalized to the defense of the hydrogeological risk and it has been set up to assess three main aims:

- guaranteeing the maintenance of the hydraulic defense system to avoid that the deterioration could reduce the efficiency of the actual hydrographic network;
- preventing the flood events, using systems of monitoring in real time to notice the risk in its initial phase, in order to put on alert the competent authorities and to apply the necessary measures of safeguard.

The Hydrogeologic plan of the Tevere river has been adopted in 2000, while in 2007 the definitive plan by the Umbria Region has been approved; the plan of the Marche region has been approved in 2004 and the plan of the river Arno (Tuscania region) has been adopted in 2008.

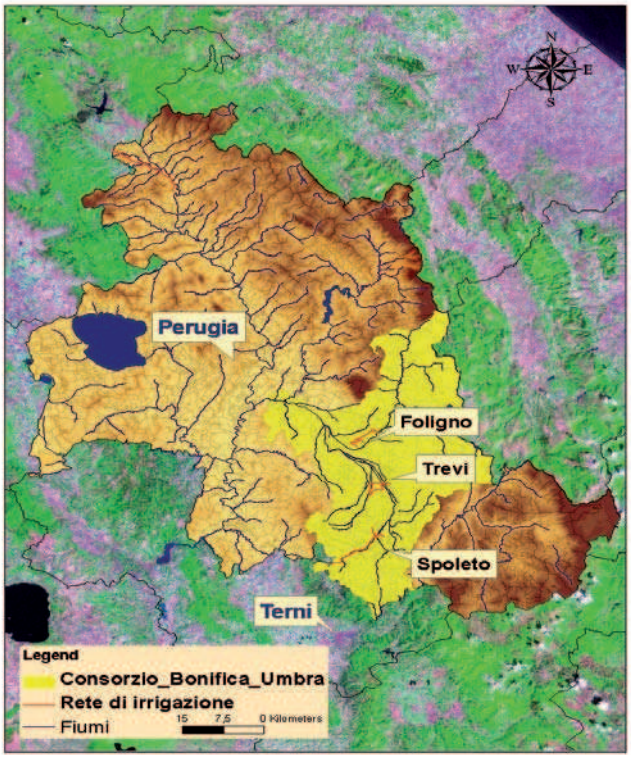

Figure 3. Umbria region, with the indication of Consorzio’s area (yellow area) and the three main irrigation districts.

II – The RISP-IDRIC Project

The RISP-IDRIC project has been funded by Italian Ministry of Agricultural, Food and Forestry Policies (2007-2010), coordinated by "Consorzio della Bonificazione Umbra" and in cooperation with CRA-SCA of Bari and several research institutes. It is a research project and it will achieve the following main goals:

- To find the most efficient solutions (and less expensive) to meet the targets set by European Water Directive n. 60/2000;
- To give a methodological support for application of national and regional water directives, testing the impact of different scenarios of contributory systems, consortia remediation and, consequently, agricultural system.
- To develop an analysis method to validate operational criteria for quantification of the cost (full) of water in agriculture.
- To assess the effects of changes in the contributory system on the agricultural sector and consortia.
- To analyze all the possible strategies of sustainable application of the directive and drafting the final report.
- To develop a web irrigation decision system to improve the efficiency of irrigation technology, streamline procedures for irrigation and optimization of the use of water resources, providing specific guidance to farmers for irrigation supply (time and amount) offering them a tool that exploits the advantages of new technologies.

For a correct application of FWD the quantification of the "Full cost recovery of water" needs to be carried out. It derives by the sum of financial, environmental and opportunity costs.

"Financial costs" of water supply are the current or operating costs, and all the expenses for staff, consumable material, motive power, ordinary maintenance of the buildings, etc. should be taken into account. The quantification of the "Financial current costs or operating costs" presents several problems. They are usually the costs that the administration support yearly to supply the water to the users. Usually these data can be collected from the economic balance sheets of the consortium administration. Costs for the depreciation of immobilized capitals and all the costs of the extraordinary maintenance of the buildings, equipment, needed for water utilization, should be taken into account. In this case, the monetary quantification is more difficult, because it's needed to define:

- which investments to consider;
- which time to consider for the depreciation;
- how to share the costs among the different activities of consortium.

The cost of use of the capital (or opportunity cost, when own money are used) requested for the distribution of the water, should be also considered. In this case, the monetary quantification is quite easy, because in the presence of loans or debts, the rates will be related to the interest rates paid by the consortium; in the case of own resources, the cost of capital will be determined on the base of the "opportunity cost"; the subdivision of the cost of capital in the different sectors of the consortium administration is still a problem.

Environmental cost of the water subtraction, the environmental impact (quantitative and qualitative), that the resource water produces as a function of its utilization, should be quantified in monetary terms. Different matters it needs to face:

- if environmental costs should or not include social costs;
- if costs and benefits "upstream" or "downstream" of the point where water is available have to be considered;

- if environmental benefits of water use should be subtracted from the total cost;
- which methodologies could be adopted for the monetary evaluation of environmental externalities.

The opportunity cost of alternatives water uses, or, in other terms, the cost of the resource if, in presence of specific demand, it is devoted to alternative uses, should be evaluated in monetary terms. It needs to be defined: when the water is really scarce? How much value the water for the alternative uses? Must the alternative uses of the water be real or potential? How the marginal opportunity cost of the water vary? How can we determine the payment based on the real consumption? How can we measure the consumed amounts (and at what price)?

1. Impact of the water pricing on irrigated agriculture

This last question, about measuring of water consumed amount, is crucial in FWD application (the principle "user pays"). Few consortia in Italy apply a correct rate based on real water consumption. The most of them use a fixed fee per field area, but in this way no increase in water productivity could be expected.

In the Project oral and written question forms will be submitted to the farmers, in order to evaluate the reaction of the agricultural users to a payment criterion different by the present one.

Probably, the new pricing policies will determine an increase in the water costs for irrigated agriculture. The marginal farms will incur the main economic damages and the introduction of other restrictions to the production should be avoided. In this case another question rises up: should the economic, social and environmental effects caused by the reduction of agricultural activities in marginal areas be considered in the "full cost recovery of water"?

The correct quantification of water price is fundamental in marginal areas, to maintain agriculture, environmental care and to avoid depopulation.

2. Technical support to irrigation management

The scientific and technical support in the Project is guaranteed by Agricultural Research Council of Bari (CRA-SCA), "Consorzio per la Sperimentazione e la Divulgazione delle tecniche irrigue" (Vasto, CH) and University of Milano Department of Agriculture Production institutions: meeting and training courses will be carried out, with the aim to improve the technical knowledge of the farmers about irrigation management and, in particular, the irrigation systems and the time and amount of irrigation supplies.

The project will provide the creation and implementation of web software for irrigation management at field level. It calculates daily water balance including the following items:

- Rainfall;
- Water table arising, as a function of root depth, soil and crop;
- Crop water use (ETa) is estimated by daily weather data (temperatures), by mean of ETref (Hargreaves model) multiplied by crop coefficients to estimate ETa. If meterological network allows for solar radiation, wind and relative humidity data, Penman-Monteith approach is used;
- Drainage, the water that overflows below root depth;
- Rain intercepted by the crop;
- Runoff;
- Water stored in the soil, as a function of hydrological soil characteristics.

From water balance, a daily estimation of soil moisture is calculated; then water deficit is obtained as difference from soil field capacity. From water deficit the suggestion to irrigate or not derives

and how much water the crop needs, according to full satisfaction of crop water demand, or a different water saving strategies. The software is feed by input data: a crop database is available, for both field and tree crop, but a new one can be also added.

For field crops, the database has the following information:

– Base temperature [°C];

– Optimal temperature [°C];

– Heat units to emergence [°C];

– Heat units to flowering [°C];

– Heat units to harvest [°C];

– Crop coefficients at maximum LAI [-];

– Critical value of soil water below which the plant transpiration is reduced [% of crop soil water];

– Maximum root depth [m];

– Capability of the crop to use water table [-].

– For the tree crops, the database has the following information.

– Crop coefficients in specific growth stages;

– Plant spatial disposal and size of canopy projection [m];

– Shape of tree canopy [-].

The soil key variables are the field capacity and the wilting point in different soil layers. If they are not available a set of pedo-transfer function can be used using the textural composition, and, optionally, organic matter contents and bulk density.

Irrigation management: the user has to define for each “field/crop” combination the following information:

- irrigation criteria;
- irrigation system;
- size of irrigated field;
- irrigation height;
- initial soil moisture.

The final information to the user will be the time and amount of irrigation water to apply, considering the weather, the soil, the crop, the previous irrigation supplies and the irrigation system.

The possibility to indicate the real amount of water supplied, and to change the irrigation from the scheduled one are implemented. Graphical tools a possibility of “what-if” analysis is also implemented, to check the effects of water saving strategies.

The software can run stand alone, but with a weather daily data population from web (a database of climatic station of the consortium). Similarly, it could be feed from a database of soil characteristics, or, in alternative, it could run directly on the consortium web server.

III – Conclusion

In this paper a research project about the application of European Water Directive 60/2000 in a consortium of Central Italy is reported; the methodology and the main questions that will be faced are analyzed and described.

The problematic of quantification of cost of water, the reaction of users to a different water pricing and the research effort to support a better water use are the main aspects that characterize the RISP-IDRIC project.

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