

# Water demand management in the Mediterranean, progress and policies

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**PAPER**

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*Ador: a software for water management in irrigation districts*

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# **Ador: a software for water management in irrigation districts**

by

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Surface and geographical/administrative level: *Irrigation districts in Spain*

## **Abstract**

*In the last decade irrigation districts in the Ebro Valley of Spain have started to use database applications to enhance their management operations. Such applications often put more emphasis on administrative issues than on water management issues. A new irrigation district management software called “Ador” is presented in this paper. This database application has been designed to promote water traceability and demand management. Ador can be used in irrigation districts independently of the type of irrigation system (surface, sprinkler or trickle) and the type of irrigation distribution network (open channel or pressurised). It can even be used in irrigation districts combining different types of irrigation systems and different types of irrigation distribution networks. The goals are to manage detailed information about district water management and to promote better on-farm irrigation practices. Ador is currently used to enhance management of 62 irrigation districts accounting for some 173,000 hectares in the Ebro Valley.*

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## **Introduction**

Improvements in irrigation equipment must be combined with improvements in agricultural water management to achieve excellence in the use of water resources. Recently, Burt and Styles (1999) and Vidal et al. (2001) highlighted the role of water management in the achievement of irrigation sustainability and functionality. Consequently, the improvement of district management standards is an investment in the future of irrigated agriculture. Water demand management can be an important tool to address the problems of water scarcity in semiarid irrigated areas.

One challenge for irrigation districts is to introduce the use of computers to manage water. In many areas of the world, the costs of water distribution are still charged to farmers per unit of irrigated area. However, society is increasingly demanding better water use policies, including billing water costs proportionally to the volume of water used. In some areas of the world, penalty systems are used in conjunction with proportional billing to discourage the excessive use of irrigation water. These management strategies can benefit from using computers and specialised databases. The Ebro Valley is one of the most important watersheds of the Iberian Peninsula. Located in the northeast of Spain, its irrigated area exceeds 800,000 ha. Local irrigation districts are characterized by large variability in irrigation technology and management practices. This variability results from the long history of irrigation development in the region.

In this work, a database for the management of irrigation districts in the Ebro Valley - the "Ador" software - is presented. The Ador software has been designed and programmed since 1998 with the objective of supporting irrigation district efforts to increase water management standards in the study area. More detail on Ador development and dissemination can be found in Playán et al. (200X).

## **Water management and water use in the Ebro Valley**

A number of studies have been performed on irrigation water management in the Ebro Valley. In the Almodívar irrigation district, Faci et al. (2000) documented problems in water allocation resulting in excessive water use. This problem was particularly relevant in the case of small plots: the smallest plots (accounting for 5% of the district area) used three times more water than the average plot. In other cases, such as in the Loma de Quinto irrigation district (Dechmi et. al, 2003), deficit irrigation is performed due to the relevant energy costs. In this particular district, the water allocation system did not permit to trace water allocation, since the district software did not permit to allocate water to all plots owned by a farmer.

Despite all these difficulties in water allocation and management at the district level, there are solid grounds to conserve irrigation water in the Ebro Valley. Lecina et al. (2005) evaluated global irrigation efficiency at the irrigation district V of the Bardenas irrigation project during the years 2000 and 2001. While 2000 was an average year in terms of water availability and crop water requirements, 2001 was a dry year. In 2001, farmers were advised by the district of the water limitations they would face. Limitations were eased during the summer, and farmers did not perceive yield losses. However, the estimated global irrigation efficiency (crop water requirements vs. irrigation water allocation) jumped from 49% in 2000 to 66% in 2001. This increase

was related to a reduction in the irrigation time (which in 2000 was much longer than required). These data highlight the grounds for water conservation via irrigation management in the Ebro basin.

### **Quality in irrigation district management**

Several authors have noted the importance of improving the service quality of irrigation districts. Clemmens and Freeman (1987) analyse how irrigation districts influence the performance of an irrigation project, noting the relevance of bidirectional information flow between the district and its farmers. Dedrick et al. (1989) propose the concept of the Management Improvement Program as a procedure to develop managerial skills and enforce water conservation policies in irrigation districts. Limited research efforts have been devoted in the past to the improvement of irrigation district databases. Merkley (1999) developed "Waters", a computer software designed to support the accounting and water delivery activities of irrigation districts. This software is intended to be a basic tool for irrigation districts operating canals and processing water orders from farmers. Sagardoy et al. (1999) and Mateos et al. (2002) present "SIMIS", a scheme irrigation management information system. This software is in the category of decision support systems, although it includes utilities for water allocation and administrative management. These research efforts represent contributions to irrigation district management, but none of them is adapted to the management of the wide variety of irrigation districts present in the study area. A new development was required.

### **Design of the specialized database Ador**

Ador has three primary components: 1) a comprehensive database structure; 2) a diagram of the water distribution network; and 3) a GIS module. Technically, Ador is a Microsoft Access<sup>TM</sup> application composed of 118 interconnected tables. The GIS module is implemented using the MapObjects LT<sup>TM</sup> software by ESRI. Ador is being developed in the Spanish language. The software and the users' manual can be freely downloaded from <http://www.eead.csic.es/ador>.

### **Water users and cadastral plots**

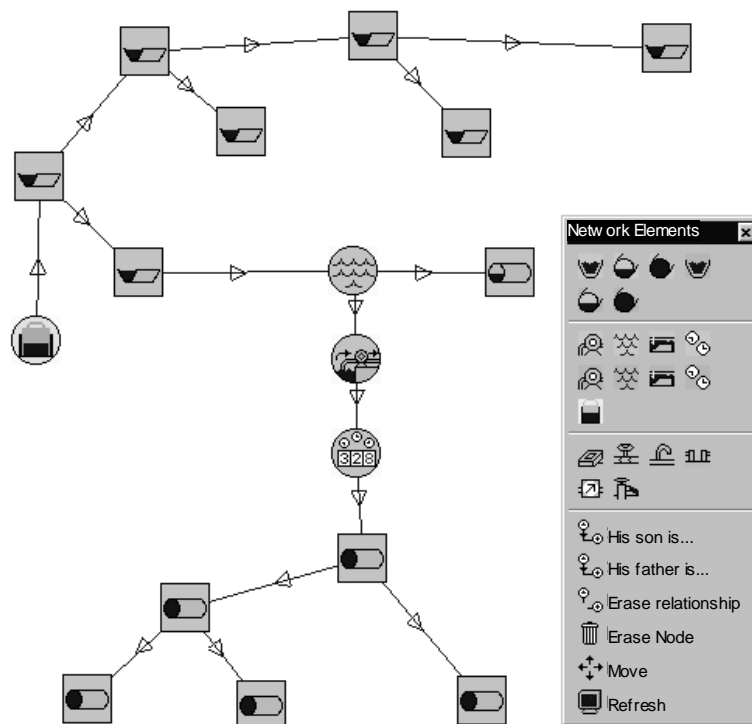
A water user is a person or company with a role in the irrigation district. This role may be related to any water use category, such as: agricultural, animal farming, industrial, and urban. A water user can be a landowner, a grower or an industrialist. Water users perform their activities in district plots.

The territory of Spain has been divided by the Government into cadastral plots. Each plot is identified by a unique alphanumeric code. Farms often are divided into several cadastral plots. Cadastral information is used to identify plots in Ador, because this information has legal strength and is regularly updated by Government offices. Use of cadastral information in an irrigation district is not a perfect solution to the identification of land tenure, but might be the best option available in Spain. One of the problems related to the use of cadastral information is that farmers often distribute their crops disregarding cadastral information. Finally, a cadastral plot can be the physical basis of several water uses of different categories (two crops, one animal farm, an alfalfa processing factory and the farmers' residence). The district database needs to accommodate all these features.

## Irrigation and drainage network

The irrigation distribution and drainage networks are addressed using a diagram the district manager can modify and extend. This diagram is not in scale, and is intended to represent the functionality of the irrigation and drainage networks. Primary network elements include canals, pipes, reservoirs, pumping stations and water meters. Longitudinal primary elements (pipelines and open channels) can contain secondary elements (hydrants, checks, siphons, valves, air release devices and manometers). Figure 1 presents a simplified example of the diagram of an irrigation district using both open channel and pressurized elements.

**Figure 1.** *The diagram of the primary elements of an irrigation network. Water flows from the icon representing the water source diversion to a branching canal network. One of the canals flows into a reservoir. Water flows out of the reservoir to a low pressure pipe and to a branching network of pressurized pipes, through by a pumping station and a general water meter. The figure also presents the toolbox used to build and manage the diagram.*

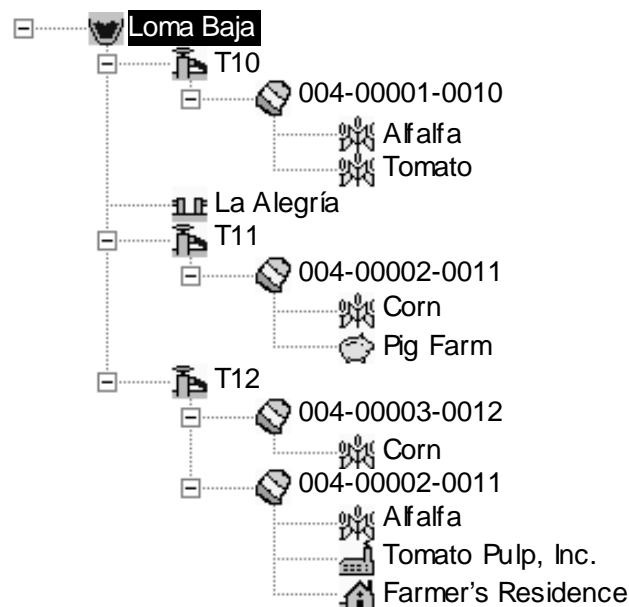


The primary elements are grouped in management units (areas sharing management traits). One of the characteristics of management units is the water delivery time step. In the Ebro Valley many state-developed irrigation projects were designed to deliver water to the farmers for durations multiple of 24 hours. Other districts operate with a delivery time step of an hour. Finally, districts operating on demand using water meters are not subject to delivery time step restrictions. Management units have a maximum conveyance capacity, which sets a limit on the discharge that can be serviced at the same time within an irrigated area. The last characteristic of a management unit is the type of water delivered to the water users: two management units can be used in a district to separate areas with different water prices, perhaps resulting from different energy requirements.

## Water uses

Several water uses are possible in a given plot. When a plot is created in Ador, one agricultural water use is automatically created for all of the irrigated area of the plot. Additional agricultural water uses can be created subsequently. The sum of the area of all agricultural uses must be equal to the irrigated area of the plot. Each water use is related to two users: 1) the user paying for water; and 2) the user paying the fixed costs (by default this second user is the plot owner). For each agricultural water use the database can store the crop grown and a detailed description of the on-farm irrigation system. Figure 2 describes the role of primary elements, hydrants, cadastral plots and water uses.

**Figure 2.** Example of the detail offered by the diagram about a primary element of the irrigation water distribution network. In this case, the primary element “Loma baja” (a canal reach) has three hydrants (turnouts), related to one, one, and two plots, respectively. Plot 004-00002-0011 receives water from hydrants T11 and T12.



## Water delivery

Water distribution can be performed in an irrigation district following a number of different delivery schedules (Clemmens, 1987; Clemmens and Freeman, 1987). Ador has been designed to accommodate the following water delivery schedules, typical in the Ebro basin:

- On demand irrigation with volumetric water meters;
- Arranged irrigation based on prepaid water;
- Arranged irrigation based on previous water orders; and
- Rotation irrigation.

These delivery schedules are physically implemented by phone calls, visits to the district office, water meter readouts, telemetry systems or hand-held computers.

### Establishment of water demand limitations

While the previous delivery schedules are designed to operate in conditions of adequate water availability, measures can be adopted to manage scarce water. The software incorporates a tool to establish water demand limitations fixed at a certain allocation threshold expressed in units of m<sup>3</sup>/ha. A report is produced listing agricultural water users and their current level of water use. The report is ordered by water use, separating the users exceeding the allocation threshold, those who are close to the threshold and finally those who have used a limited amount of water. The report is then used to guide further water allocation in the district. Figure 3 presents the dialog box used to establish water demand limitations.

**Figure 3.** Dialogue box for the establishment of a limitation of 4,000 m<sup>3</sup>/ha. A report is produced indicating the users who have reached the limitation, the users within 20% of the limitation and the rest of the users.

### Crops, crop water requirements and the estimation of irrigation efficiency

The Ador software contains a database with reference crop water requirements (reference evapotranspiration,  $ET_0$ , in mm/day) calculated with the average climatic data for different locations (Allen et al., 1998). The Seasonal Irrigation Performance Index ( $SIFI$ , %) is a simple irrigation performance concept that can be considered as an estimate of irrigation efficiency (Faci et al., 2000; Dechmi et al., 2003). The  $SIFI$  can be determined as follows:

$$SIFI = \frac{\text{Crop water requirements}}{\text{water billing}} 100 \quad [1]$$

### Water billing utilities

Water prices are described in Ador using a two-dimensional matrix including the type of water and the category of water use. Different water types can be established in a district to reflect differences in water quality, origin or energy input. Each management unit delivers a particular type of water. In the Ador software fixed and variable costs are considered separately during the billing process. The reason for separation is that often irrigation water must be paid to a higher Public Entity (the Watershed Authority) by the district, while fixed costs are generated and distributed internally. Another reason

to separate both costs is that some farmers often decide not to irrigate their farms, but still want to secure their right to irrigate in the future. By paying fixed costs farmers retain their water right without incurring additional variable costs. In general, fixed costs are proportional to the area of each agricultural use. The increasing complexity in irrigation districts and escalating water costs require flexibility when assigning costs, so that fixed costs can be billed – for instance - to the users of a particular canal that has undergone rehabilitation work.

Many district managers regard the water bill as the main goal and the end of their activity. In our opinion, the bill is the starting point to promote the improvement of irrigation water management. This is possible if the bill provides information about how water is used by the farmer and by other farmers in the district. The Ador water bill informs the farmer of his individual water use, but also includes statistics about water consumption in the district. The contrast between water use in a certain plot, crop water requirements, and the average water use in the district by crop, irrigation system, and soil type helps the farmer to evaluate his level of irrigation water management.

### **Database reports and charts**

Several reports and charts have been built in Ador to provide information on the status of the district. To customize the information, the forms for reports and charts include a wide range of options, enabling the filtering of information to particular items like users, plots, primary network elements, or dates. Additionally, the information displayed in Ador charts can be grouped by management units, primary network elements, or crops.

### **The GIS interface to Ador**

Geographic Information System (GIS) coverages of the cadastral plots and irrigation network can be used to display the database cartographically. GIS coverages of cadastral plots are available in many irrigated areas of the Ebro Valley. However, districts must adapt the coverages by selecting plots belonging to the district and producing a water conveyance coverage. The maintenance of the GIS information cannot be performed from Ador, because the module does not include coverage editing utilities. Figure 4 presents the GIS interface of Ador.

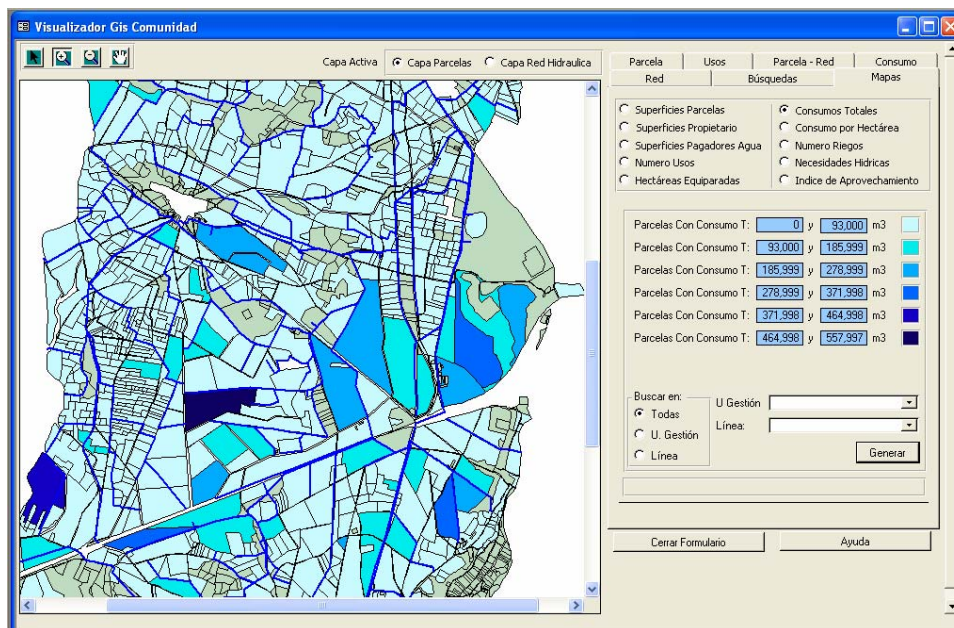
### **Dissemination of the specialized database**

Ador is being used in 62 districts accounting for more than 173,000 ha. These districts cover a wide range of irrigation technologies and water delivery schedules. Software dissemination started in the “Comunidad General de Riegos del Alto Aragón” Project (CGRAA), which includes 53 irrigation districts and 124,000 ha in the provinces of Huesca and Zaragoza. CGRAA also supplies urban water to more than 100,000 persons, and to several industrial factories and animal farms. In 2001, CGRAA decided to make Ador the standard software for managing their irrigation districts.

The objectives of the Ador-CGRAA project were to: 1) Implement Ador progressively in the CGRAA irrigation districts; and 2) Develop a specific data centralization unit at the main CGRAA office. Achieving these objectives required contracting the services of companies specialising in Ador application and development. By the end of 2001 the *Oficina del Regante* (OdR, the irrigation extension office of the Government of Aragón) started its operations, and took part in the activities of Ador in CGRAA. Since its onset,

the project has been managed by a multidisciplinary steering board. This type of steering board was identified by Dedrick et al. (1989) as being critical to the success of management improvement in irrigation districts. The discussions held in the steering board and the bi-directional communication with district managers have made Ador a widely participative programming effort. A total of 40 CGRAA irrigation districts (115,000 ha) currently use Ador. Since 2002, the OdR has been performing several tasks related to Ador. In addition to hosting most of the Ador software development and supporting the activities at CGRAA, the OdR has implemented Ador in 22 additional irrigation districts (58.000 ha) in the Aragón region of the Ebro Valley.

**Figure 4.** GIS interface to Ador, showing a graduated colour map of water use per cadastral plot. Other options permit to display land ownership, types of water uses or the hierarchy of the conveyance network.



### Lessons learned from Ador development and dissemination

- The key to the success of the Ador software is its participative nature. If it had not been for the close cooperation with the irrigation districts, administration and private companies, the software would have been just another research product without practical application.
- The *Oficina del Regante*, has been particularly important to the implementation of Ador. A specific irrigation extension body, the *Oficina* has developed the trust required to advise districts and to maintain mutually beneficial communication.
- Ador has resulted in better water management in the irrigation districts. Water is now more traceable, and farmers receive bills indicating every dater diversion to their fields. The bills establish local water benchmarks (average water use) that farmers can use to evaluate their water use. In water scarce years, the establishment of water demand limitations has helped to avoid conflicts and to guarantee equity in the access to water.

- In the years of Ador application district managers have developed skills that have much improved their water management, and have given them more recognition among the farmers and the water administration. As a consequence, a group of motivated, skill water managers have emerged and are becoming relevant in local water discussions.

### **Acknowledgement**

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