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Assessment of irrigation water management in the Genil-Cabra (Córdoba, Spain) irrigation district using irrigation indicators

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ABSTRACT

This paper examines irrigation water management in the Genil-Cabra Irrigation District of the Province of Cordoba (southern Spain) using three irrigation indicators: relative irrigation supply (RIS), relative water supply (RWS), and relative rainfall supply (RRS). The three indicators are calculated both globally and by grouping the data according to crop type, irrigation method, soil texture, and plot size. Then, it is possible to determine the influence that each individual factor has on irrigation management and take subsequent measures to improve irrigation performance. All of the information regarding agronomic and hydraulic variables has been included in a geographical information system (GIS) to facilitate data management.

The results show that irrigation is deficit given that the mean value of the RIS indicator is relatively low, around 0.60. However, the RWS indicator achieves higher mean values, normally above 0.80, indicating that evaporation demand can be met throughout the crop development cycle. The RRS indicator shows less variability with mean values around 0.40. This indicator, together with the RWS indicator permits the evapotranspiration fraction covered by rainfall to be determined.

The mean values of the calculated indicators are very useful for gaining a better understanding of irrigator behavior and general irrigation trends, although the study sample is still insufficient to characterize a large irrigation area as a whole.

1. Introduction

Water resources are under enormous pressure due to increasing demands for more and better quality water; demands which are in turn conditioned by social, political and environmental factors. The growing difficulties to ensure that water demands are met have led to greater competitiveness for scarce water resources among traditional sectors of water users, namely agriculture, industry and urban supply. This competitiveness for water use is already placing constraints on the development of many countries. Moreover, the increasing scarcity of water resources has led to higher competitiveness between regions or countries for available water resources.

As a result, water has come to be considered an increasingly scarce and valuable resource requiring rigorous management and extreme care. One of the keys to overcoming these problems lies in the agricultural sector given that irrigation – particularly in arid and semiarid areas – is the chief consumer of water; accounting for 70% of consumption worldwide. According to data from the *Federación Nacional de Comunidades de Regantes* (National Federation of Irrigator Communities) (IDAE, 2008), water consumption in Spain has dropped from 80% to 67% thanks to the on-going efforts of farmers and official bodies to save water through better irrigation practices and greater investment.

Nonetheless, in Spain, a much larger amount of water is allotted to agriculture than to other types of activity (Roldán, 2007). For this reason, it is of interest to determine the water management practices of irrigation communities having a large volume of available water as farmers may not implement the best water management practices or water use may be inefficient. By correcting such practices, it will be possible to use water more efficiently.

Attempts to adapt farmers' water demands to real crop demands could lead to more efficient water use as it would permit water to be delivered only when necessary without reducing crop productivity, while sustaining and/or increasing farmer income.

In recent decades many authors have developed and applied irrigation performance indicators and benchmarking techniques to identify the best irrigation practices and to compare different and complex irrigation systems (Levine, 1982; Molden and Gates, 1990; Bos et al., 1994; Burt, 2001, among many others). Also, different indicators have been standardized and the definitions of the parameters that form these indicators have been adjusted so that

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comparisons between the different water irrigation districts (WID) can be generalized (Burt et al., 1997; Malano and Burton, 2001).

Two are the main objectives that have attempted to fill these jobs: on the one hand, indicators at the level of WID have been applied to measure its efficiency (Burt and Styles, 1999a; Malano et al., 2004), on the other hand, benchmarking techniques have been used in different WID so that, from their comparison, water use in such systems was improved. Thus, for example, Holden et al. (1998) and Burt and Styles (1999b) compare WID located in several countries, while other authors works at a local scale (Akkuzu et al., 2007; Pérez Urrestarazu et al., 2009; Córcoles et al., in press). In the latter group may also include Rodríguez Díaz et al. (2008) who study WID with similar characteristics using multivariate data analysis techniques.

In this paper, we aim to analyze irrigation water demand and examine possible measures for modifying and rationing demand in order to achieve an efficient water management policy. To do so, it is necessary to assess water management bearing in mind existing agronomic and hydraulic processes; develop a geographical informational system in the irrigation district that relates the geospatial location of the plots with the data obtained for them; and study theoretical water requirements and their discrepancies with farmers' actual water demands using irrigation performance indicators at plot scale.

The main contribution of this paper is the study of irrigation performance indicators discriminating by type of crop, irrigation method, soil type and plot size. This allows to determine the influence of each of these factors on the irrigation and, consequently, to improve their performance. An analysis of mean RIS for greenhouse crops during crop cycle periods was also conducted in a Mediterranean greenhouse area (Fernández et al., 2007).

2. Materials and methods

2.1. Description of the Genil-Cabra Irrigation district

To analyze discrepancies between real water demands and actual crop water requirements, we have studied the Puente Genil Irrigated Area of the Genil-Cabra Irrigation District (Fig. 1) located in the Province of Cordoba (southern Spain).

The Genil-Cabra Irrigation District, and the irrigator community that manages the district, were created and began to operate in 1989 under a public initiative. The irrigation district, which belongs to the Guadalquivir River Hydrographic Basin, covers a total of 40,085 ha. The district is located on the right bank of the Genil River; the main tributary of the left bank of the Guadalquivir River. Of the total area that comprises the irrigator community, only 37,010 ha are apt for use in irrigated agriculture. The irrigator community will soon deliver water to approximately 22,000 ha and will therefore supply almost 60% of the total forecasted demand. The community is composed of 1696 users, with an average plot size of 8.9 ha. The irrigated surface area currently comprises 15,963 ha, of which 8780 ha belong to the Puente Genil Irrigated Area where this study has been conducted.

The main canal supplies water to each of the network's discharge pump stations. The canal currently runs more than 30 km in length and has a slope of 1:10,000. The canal has a capacity of 1.1 hm^3, of which 800,000 m^3 are available for agriculture. The canal has a parabolic section with a maximum width of 22.86 m, a depth of 4.15 m, and is capable of conveying 40 m^3/s of water.

Water is distributed by means of a pressurized system through an underground piped network. Irrigation water is delivered on demand, thus providing farmers greater flexibility in terms of the *frequency*, *volume* and *duration* of irrigation and permitting them to

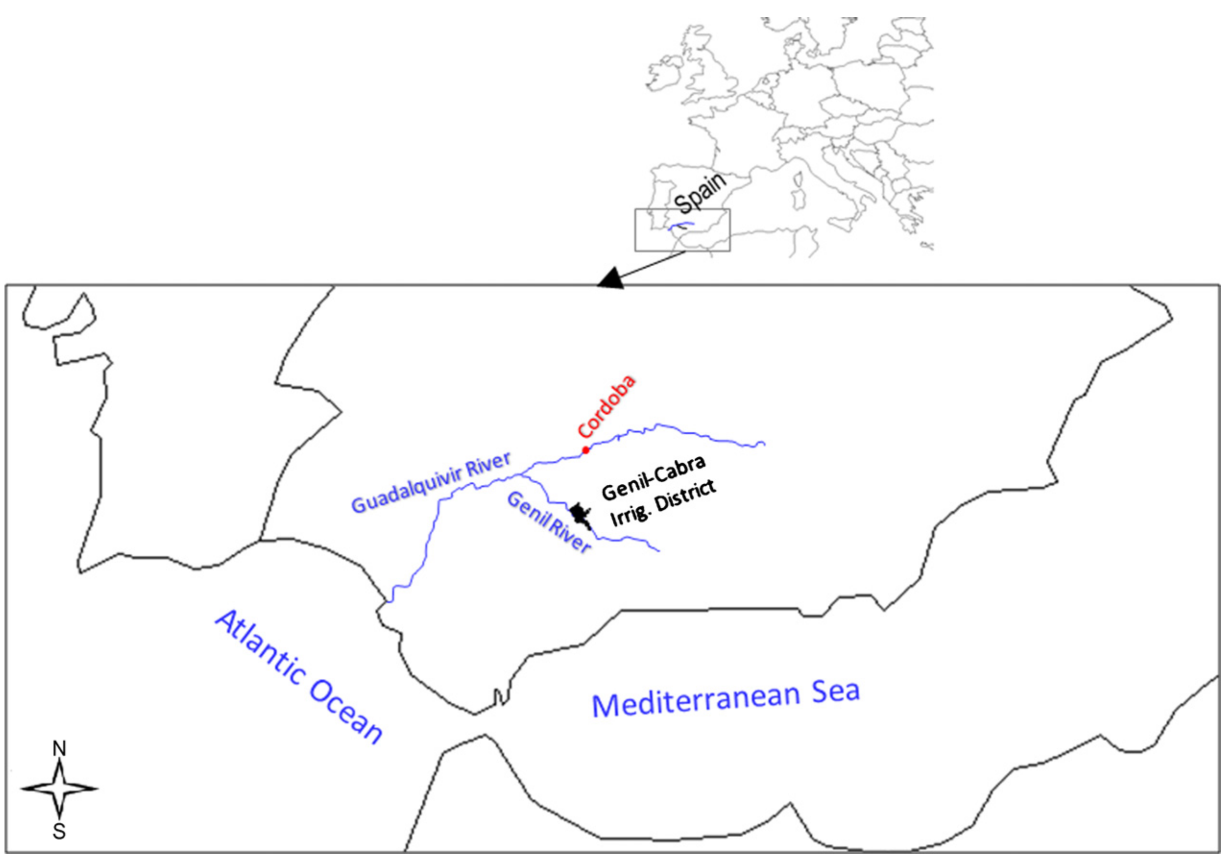

Fig. 1. Location of the Genil-Cabra Irrigation District in Spain.