Journal of Arid Environments 98 (2013) 41–51

Contents lists available at ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

Two Mediterranean irrigation communities in front of water scarcity: A comparison using satellite image time series

Pere Serra*, Xavier Pons

GRUMETS Research Group, Department of Geography, Universitat Autònoma de Barcelona, Edifici B, Campus de la UAB, 08193 Cerdanyola del Vallès, Barcelona, Spain

ARTICLE INFO

Article history:
Received 14 December 2011
Received in revised form
5 June 2013
Accepted 26 July 2013
Available online 23 August 2013

Keywords:
Catalan Drought Decree
Crop phenological dynamics
Remote sensing images
Stored water in reservoirs
Wetness index

ABSTRACT

Although a number of studies have analysed the methods to monitor crop water needs, the integration of phenological dynamics and irrigation using water stored in reservoirs has received little attention. This study is an example of such analysis applied to two irrigation communities (IC) located in a Spanish Mediterranean area, one with less water resources than the other, which it was carried out between 2002 and 2008. These years comprised periods of water surplus and water scarcity including the 2007–2008 drought considered by the Catalan public water authority the worst since 1944. The dynamics of maize, alfalfa, fruit trees and poplars were analysed using greenness and wetness extracted from remote sensing data. A statistical analysis was applied in order to find out the relationship between crop wetness and stored water. Results show that the IC used two methods for water-saving: crop substitution, by decreasing the area of maize, and timing the crop cycle, delaying or advancing sowing depending on water availability. In conclusion although one IC is drier in rainfall terms than the other, a similar crop wetness status was detected and no difference was observed between periods of water scarcity and water surplus.

1. Introduction

In Spain, as in many Mediterranean countries, the agricultural sector is the largest consumer of water with nearly 68% of total consumption (Barbero, 2006). According to Berbel and Gómez-Limón (2000) this is especially true in those areas with elderly irrigation systems such the Spanish irrigation infrastructure where 70% is over 90 years old. Another important evidence to add to this fact is that the Mediterranean climate shows a complex spatial and seasonal variability pattern, exacerbated by the unpredictability of rainfall from year to year or within the year (Ramos and Martínez-Casasnovas, 2006). The changes in precipitation distribution can have negative effects on water availability for crops, producing water scarcity. In these cases, storage reservoirs play an important role in the optimum use of water resources (Ruiz, 1990), being necessary good information on irrigated areas, cropping patterns and the history of water use (Bastiaanssen et al., 2000; Alexandridis et al., 2008).

Furthermore, it is well known that remote sensing has some advantages for mapping and monitoring vegetation, erosion or desertification processes compared with traditional methods: cost effectiveness and temporal resolution are probably the most important (Ambast et al., 2002; Jafari et al., 2008). In the case of agricultural land-use, archive satellite data provide the opportunity to reconstruct longer and continuous time series of irrigation conditions, as well as mapping and measuring crops and fallow lands. As a consequence, a great number of studies have used remote sensing data to detect and classify crops in general, and irrigated crops in particular (Thenkabail et al., 1994; Ortiz et al., 1997; Senay et al., 2000; Martínez and Calera, 2001; Van Niel and McVicar, 2004; Xie et al., 2007; Yuping et al., 2008, among others). Therefore, remote sensing can be especially interesting in large study areas, where field work is too expensive and some generalisation of agricultural dynamics needed.

From the demand management point of view there are many ways to reduce water requirements in general and under conditions of water scarcity in particular. These can take several forms, such as agronomic, economic and technical (Pereira et al., 2002). For example, from an economic point of view some studies emphasize the price of water as a contributing factor to waste reduction (Chohin-Kuper et al., 2003; Pujol et al., 2006). Technical interventions include the improvement of catchments and conveyance or of irrigation systems (micro-irrigation, etc.) or the reuse of wastewater, among others. Other options are related to improving water productivity: these may be more productive per-unit transpiration, e.g. changing crop varieties, crop substitution or better

* Corresponding author. Tel.: +34 93 581 32 73.
E-mail address: pere.serra@uab.cat (P. Serra).

0140-1963/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jaridenv.2013.07.011

timing of the crop cycle. An example of this latter option is the study by Oweis and Hachum (2001) in Syria, an example of a rainfed Mediterranean-type environment, where farmers tend to sow wheat later than the optimal date because of a delay in the arrival of initial rains. Other technical options are reducing non-beneficial evaporation (e.g. drip irrigation, mulching or planting dates to match periods of less evaporative demands), reducing pollution (e.g. the presence of salts), reducing uncommitted outflows (e.g. storage in reservoirs) and reallocating water to crops with higher water productivity (Hamdy et al., 2003).

This study emphasises the analysis of crop phenological dynamics and irrigation practices provided by reservoirs. Although it is well known that farmers usually adapt their cultivation practices to overall water availability, the dynamics on water management in front on water scarcity for large irrigation communities have been few studied. The specific objective of this paper is to compare farmers' practices in two Mediterranean irrigation communities (IC), one drier (with an average annual rainfall about 500 mm) than the other (with about 600 mm), in conditions of water scarcity, from 2002 to 2008. These two IC are located in the north-east of Spain, in Catalonia, where a very recent example of intense water scarcity occurred. The methodology applied for analysing crop phenological dynamics and irrigation management is based on the work from Serra and Pons (2008), using satellite images. Two reasons recommended this remote sensing approach: cost effectiveness, because they are large IC, and temporal resolution, because seven years are analysed.

2. Study area

Catalonia is a region located in the northeast of Spain, being Barcelona its administrative capital (Fig. 1). The hydrological regime is characterized by the irregularity of its rainfall pattern typical of the Mediterranean climate. One of the largest irrigated areas in Catalonia is located in the Empordà region, where six IC exist, covering an area of about 17,000 ha. An IC is a grouping of all the owners of the same irrigable zone, united by law for the independent and common administration of public waters (Pujol et al.,

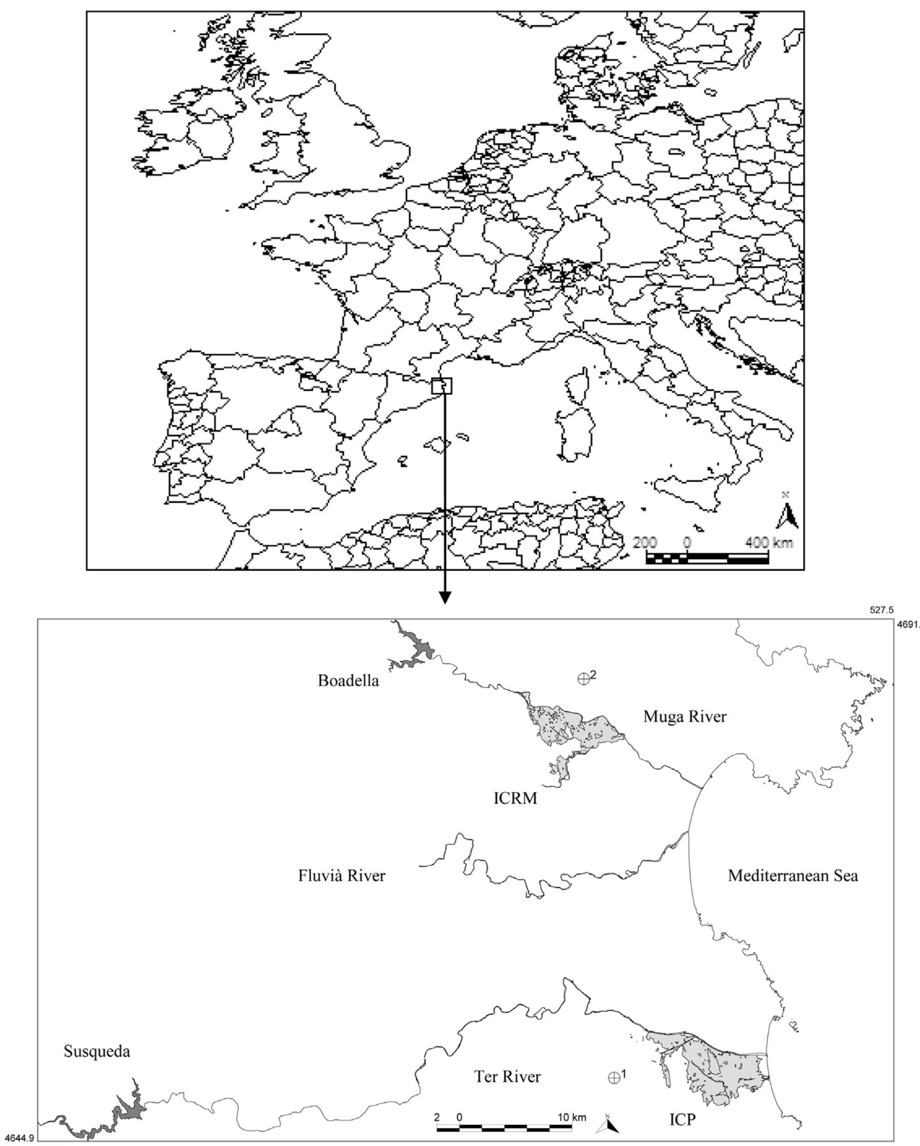

Fig. 1. Study area, located in the northeast of Spain (in Catalonia). Irrigation communities (the irrigation community of right bank of the River Muga, ICRM, and the irrigation community of Pals, ICP) are shown in hatched polygons. Ter, Fluvià and Muga rivers are depicted as continuous lines whereas Susqueda and Boadella reservoirs are coloured in grey. Numbers 1 and 2 correspond to the location of the nearest meteorological stations.