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Assessing telemetry and remote control systems for water users associations in Spain

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ABSTRACT

A decades-long policy for irrigation Telemetry and Remote Control (TM/RC) systems in Spain has led to installations for approximately 260 Water Users Associations (WUAs), with a total estimated area of 1.0 M ha of agricultural land. This is believed to be the largest deployment of such technologies in the world. These systems have been installed in financial cooperation between public administrations and WUAs. This paper set out to characterize these systems, assess the causes for their individual success or failure, consider their future evolution and support policy updates. A survey with 110 questions was addressed to 84 WUAs distributed throughout the country. Further, an interview with four questions was addressed to 24 selected stakeholders intervening in irrigation TM/RC projects: from policy makers to farmers. The results provide a detailed overview of these systems in Spain, characterizing the WUAs in which they are installed, their technological traits, their maintenance, the problems they face in their daily operation, their current use, the factors limiting wider use, and the willingness of the WUAs to continue bearing the costs to use TM/RC features in the future. A large majority of TM/RC systems are regularly used to improve WUA water and energy management, and receive proper maintenance. However, in 15% of WUAs, farmers are not satisfied with the TM/RC system, and in 19% of the WUAs the TM/RC system cannot operate half of the hydraulic valves connected to them. We found that early technology applications failed more than recent applications, evidencing a process of technological maturity. The standardization of TM/RC systems, adaptation of the system to WUA specificities, training of WUA personnel, and a sufficiently long guarantee period stood as critical variables for success in the implementation of these technologies.

1. Introduction

The first scientific references to Telemetry and Remote Control Systems (TM/RC) date back to the 1950s: medical, industrial and environmental applications were soon identified as promising economic sectors for this incipient technology (West, 1952; Hanes, 1959; Barr and Voas, 1960). Later on, agricultural water management became a target for TM/RC developments due to the geographical dispersion and low density of control and information points (Playán et al., 2014). The first step was mechanical automation, which started in pressurized irrigation in the 1960s with the development of hydraulic control valves. Mechanical devices were soon combined with electronic controllers for on-farm irrigation using solenoids and mini-hydraulic control circuits. By the end of the 20th century, TM/RC systems were installed in large farms and – particularly – in the infrastructure of Water Users Associations (WUA). The technical goals were to control large irrigation networks and to acquire data for water management purposes. A typical TM/RC system for an irrigation network is composed by a control

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station (usually a PC) and a number of nodes distributed throughout the irrigated area and communicated with the control station. Depending on system topology, some nodes can concentrate the information of other nodes and then report this information to the control station (and vice versa). Nodes are connected to a series of actuators (typically hydraulic control valves) and sensors (i.e., pressure, volume).

As a demonstrator of these incipient technologies, in the 1980s, the Ministry of Agriculture of the Government of Spain (MAPAMA) installed a TM/RC prototype in the 100-ha experimental farm of the National Irrigation Technology Centre (CENTER). Despite the complexity of the technology available in those days, the system permitted to remotely open/close valves, operate continuous-move irrigation machines, sprinkler solid sets and drip irrigated fields, read water meters and supervise farm-wide irrigation operation. Maintenance of the TM/RC prototype was not an easy task, requiring intense dedication by engineers and technicians. The TM/RC system at CENTER was operated as a demonstration unit and as a laboratory for irrigation development and irrigation modernization policies.

At the end of the 20th century, irrigation development plans were slowing down owing to growing limitations in irrigation water supply. At the same time, National Irrigation Modernization Plans were implemented by MAPAMA (2002, 2010). In addition, most Regional Governments designed and applied their own irrigation modernization plans.

These plans targeted irrigation modernization at the WUA level, typically replacing canals and ditches by pipelines, and building pumping stations and reservoirs within the irrigated area. These new WUA infrastructures are often called “collective networks” (Zapata et al., 2007). They extend from the WUA water intake(s) to the hydrants located at the farms. Consequently, these networks do not belong to individual farmers, but to the WUA.

MAPAMA (2015) estimated that irrigation modernization had affected 1.5 M ha since 2000. The total investment in collective infrastructure was 3815 M€, supported by the National Government (46%), Regional Governments (23%) and WUAs (31%) (MAPAMA, 2015). In addition, farmers invested in new on-farm irrigation equipment (mostly sprinkler and drip), occasionally counting on subsidies by Regional Governments.

The application of these irrigation modernization policies in the 21st century had a profound effect on irrigation systems in Spain. The annual survey of crop area and yield performed by MAPAMA (2016) since 2002 permits assessing the changes in irrigated area and irrigation method (Fig. 1). According to these official data, in 2016 drip irrigation was used in 50% of the irrigated area, with surface and sprinkler irrigation amounting to 26% and 24% of the area, respectively. It can be presumed that in the period 2002–2016 a large part of the surface irrigated area was transformed to sprinkler and drip irrigation, while some sprinkler irrigated area was transformed to drip irrigation. The survey reports on a strong association between irrigation methods and crops, which was also observed in similar analyses performed in California (Tindula et al., 2013).

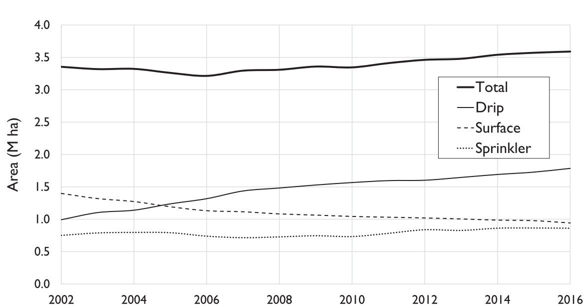

Fig. 1. Time evolution of irrigated area by irrigation method in Spain in the period 2002–2016.

The modernization of collective irrigation infrastructure involved the participation of national or regional public companies created to manage this process in cooperation with the WUAs. Until 2010, irrigation modernization projects commonly included a TM/RC system for use by a WUA. From 2010 onwards, public funds were not abundant, and TM/RC systems were only installed in selected WUAs. Some TM/RC systems were installed in Spain before the National Irrigation Modernization Plans that were implemented in the 21st century. These systems used adaptations of industrial or urban technology supplied by just a few multinational companies. During the first years of systematic installation of TM/RC systems, a national industry flourished, with about twenty companies developing products for collective irrigation networks. In many cases, products were not completely developed and tested at the time of the contract, and the last phases of product development were actually financed through contracts with public irrigation companies. This case can be regarded as an early, involuntary implementation of the “Public Procurement of Innovative Solutions” processes currently implemented in Europe (European Commission, 2017).

In general, the installation of TM/RC systems in Spain responded to the drive of Public Administrations, which saw this as a key technology to modernize irrigation operation and management. Many WUAs showed interest in these systems, which could improve water management and intensify the use of modern technologies. The research community also saw potential in the installed TM/RC systems to address bottlenecks that limited improvements in water use efficiency and in farmers’ revenue. These include optimizing water and energy efficiency (Rodríguez Díaz et al., 2012; Tarjuelo et al., 2015; Zapata et al., 2017), automating irrigation scheduling at the WUA scale (Playán et al., 2014), or implementing regulated deficit irrigation (Ballester et al., 2014) in collective networks. In addition, TM/RC systems have also proven useful to analyze water use at the WUA and farmer levels with unprecedented detail (Lorite et al., 2013; Stambouli et al., 2014), as well as to forecast irrigation water demand in collective pressurized networks (Pulido-Calvo et al., 2007; González Perea et al., 2015).

During the first years of TM/RC system deployment in WUA-managed irrigation systems, it was clear that the technology needed to improve in terms of reliability. At the same time, applications were unavailable at that time to exploit the databases created by the TM/RC systems. Finally, most WUA employees lacked the required ability to maintain and exploit TM/RC systems, particularly when simultaneously dealing with a new collective network and the new irrigation methods.

Widespread installation of TM/RC systems in Spain constitutes a case study of technology deployment for irrigation. This technology brought new perspectives to agricultural water managers. At the same time, the risks of such technological deployment were relevant, and could have led to rejection or to reduced application. Fifteen years since the onset of the irrigation modernization plans that supported the generalization of TM/RC systems, this paper sets out to evaluate the TM/RC systems installed in Spanish WUA-managed irrigation systems, pursuing the following objectives:

1. Assess the nature, use and maintenance of the TM/RC systems;
2. Establish causes for success and failure of individual TM/RC systems;
3. Identify changes required to make TM/RC systems more useful for water and energy conservation;
4. Consider the evolution of these TM/RC systems in the near future; and
5. Support policy development for TM/RC system implementation.

2. Materials and methods

The information analyzed in this paper was obtained through a survey of WUAs having TM/RC systems and through interviews with selected stakeholders. While the survey provided in-depth information