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Institutional and management implications of drip irrigation introduction in collective irrigation systems in Spain

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ABSTRACT

This work focuses on the transformation occurred with the shift from surface to drip irrigation, looking at three collective irrigation systems in Valencia (Spain). The extension of drip irrigation over areas previously irrigated by systems of gravity channels entails a process of change and transformation of institutions and organizations managing irrigation. We analyze the main management changes occurred and how farmers adapt to the new technology. In order to assess these changes, interviews were conducted with farmers and managers of Water User Associations. Drip irrigation implementation policies result in unforeseen consequences, paradoxes and challenges for collective drip irrigation management. In the three cases, drip irrigation and automation has contributed to the centralization of decision-making. Besides, farmers and managers have also developed irrigation and fertigation strategies to adapt to the new technology. When some of these new operating procedures are applied, farmers obtain results closer to their own goals, but not necessarily linked to the virtues frequently attributed to drip systems.

1. Introduction

In recent years, numerous public policies have considered drip irrigation promotion as a strategic instrument to cope with water scarcity. The shift to drip irrigation, through public subsidies for individual farmers or through strongly subsidized state-led collective projects, has been promoted around the world mainly with the intention of reducing water use (Allan 1997, 1999; López-Gunn et al., 2012a; Playan and Mateos, 2006). Consequently, drip irrigation has rapidly expanded in many countries (ICID, 2015), advocated as a winning formula for increasing water productivity (Gleick, 2002; Luquet et al., 2005; Postel et al., 2001) and frequently embedded in a powerful modernization discourse (Boelens and Vos, 2012; Venot et al., 2014).

At the same time, the rapid expansion of these techniques has generated several debates on the usefulness of drip irrigation promotion. The promised water saving goals have been questioned by various authors through a revision of the efficiency paradigm (Jensen, 2007; Perry, 2007, 2008; Perry et al., 2009; van der Kooij et al., 2013), with a particular focus on the rebound effect on water demands (Berbel et al., 2015; Dinar and Zilberman, 1991; Dumont et al., 2013; Scott et al., 2014; Ward and Pulido-Velázquez, 2008). Other experts have highlighted other unforeseen effects related to drip irrigation implementation, such as rising electrical consumptions and irrigation costs (García-Mollá et al., 2014; Hardy and Garrido, 2010; Jackson et al., 2010; Rodríguez-Díaz et al., 2011). Much of this criticism arises from the fact that arguments for drip irrigation promotion have been mainly based in experimental research, whereas information obtained from farmers' fields and collective irrigation systems has been less abundant (Benouniche et al., 2014a; van der Kooij et al., 2013; Wolf et al., 1995).

In numerous cases, administrations, Water User Associations (WUAs) and farmers have massively bought drip systems without a view of the wide socio-technological system surrounding hardware on real scenarios. This limited consideration of drip technology drives users and planners to unpredictable results, performed in successful experiences (Alcon et al., 2011; Çetin et al., 2004; Ibragimov et al., 2007; Merry, 2003; Woltering et al., 2011) or in resounding failures (Karagiannis et al., 2002; Kulecho and Waterhead, 2006; Venot et al., 2014), depending on the configuration of local and regional contextual factors. When an existing technology is embedded into a new context, an intricate process of socio-technical integration occurs. In this sense, technology is

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not understood as hardware with taken-for-granted outputs but it is accommodated in a social context. Both the context and the technology influence each other. Roles and implications of the technology itself are not established, but are modified according to the context and requirements of the users (Benouniche et al., 2014b; Boelens, 2015; Garb and Friedlander, 2014).

Acknowledging the substantial interaction between infrastructure and institutional arrangements in irrigation is not new. The seminal work of Coward (1985) and Uphoff (1986) considered irrigation management as a socio-technical process where institutions shape what the technologies do. Since the 1990s, social studies of irrigation have paid attention to institutions in long-standing community managed irrigation systems in order to improve the management of large-scale bureaucracy managed irrigation schemes, by better involving users (Coward, 1976, 1979; Hunt, 1989; Maass and Anderson, 1978; Ostrom, 1990, 1992; Trawick 2010; Trawick et al., 2014; Wade, 1987).

However when looking more specifically at socio-technical perspectives, the social construction of technology (SCOT) school (Bijker and Law, 1992; Winner, 1986) and the actor-network theory (ANT) (Latour, 1987; Law, 1992) have influenced irrigation studies drawing attention to how actors define the boundaries between the social and technical issues (Bolding, 2004; Mollinga, 1998). In addition, recent works on natural resource management have also used the concept of *institutional bricolage* to explain institutional change as "a process by which people consciously and unconsciously draw on existing social and cultural arrangements to shape institutions in response to changing situations" (Cleaver, 2001; Cleaver, 2012; Cleaver and De Koning, 2015), and how this process is also shaped and expressed by the technology itself (van der Kooij et al., 2015).

Hence, understanding this socio-technical performance is critical to properly assess the introduction of drip technology and the design of public policies, in order to avoid some of the unforeseen effects produced by the implementation of a black-boxed technology (Garb and Friedlander, 2014; López-Gunn et al., 2012a, 2012b; van der Kooij et al., 2013, 2015; Venot et al., 2014). Some unforeseen effects have also been detected in the introduction of other irrigation technologies. For example, Collett and Henry (2014) have found significant management short-comings and important farmer's discomfort after the implementation of automatic sluice gates in Australia. Also, in Seguia Khrichfa (Morocco), the implementation of circular orifices as off-takes at the bottom of the channels in a State rehabilitation project, resulted in farmers not using or destroying them (van der Kooij et al., 2015).

In Spain, drip irrigation has been intensively promoted through public subsidies for individual farmers and state-led collective projects. The Spanish National Irrigation Plan (BOE, 2002, 2006, 2008), together with several regional programs (DOCV, 1995), prioritized drip irrigation among other measures to reduce water use. However, more than a decade after the implementation of these public programs, little information is available on the effects of drip irrigation performance and water use (López-Gunn et al., 2012b; OECD, 2010). Recent research shows how some transformations have resulted in increasing energy consumption and rising water use, due to the fact that drip implementation stimulates crop intensification (Rodríguez-Díaz et al., 2011, 2012a, 2012b) and facilitates irrigation expansion processes (Sese-Minguez et al., 2017). However, in some areas where regional agro-social factors prevent from irrigation expansion and crops intensification, water withdrawals substantially decrease (as noted by Sanchis-Ibor et al., 2017 for the case of Valencia) and energy consumption moderately falls (Gómez Espín et al., 2006, 2007).

The aim of this work is to assess these socio-technical changes that happened after the implementation of drip irrigation in collective irrigation systems in Spain. Beyond the national scope, we deepen into the socio-technical interactions established between drip systems and farmers, to tilt the focus towards these actors, as has been suggested by several recent works (Benouniche et al., 2011, 2014a; Garb and Friedlander, 2014; van der Kooij et al., 2013). We aim at identifying how WUAs and farmers redefine their operating procedures and organizations to adapt themselves to the new technology, but also how they manipulate drip systems (*bricolage*, according to Benouniche et al., 2014b terms) to obtain results closer to their own goals, not necessarily linked to water saving.

The paper is structured into the following sections: Section 2 presents the methods and describes the case studies; Section 3 analyzes the development of drip irrigation and the perspectives in the study area; Section 4 presents and describes selected aspects of the technical change; Section 5 presents the changes occurred in irrigation organizations, and Section 6 discusses the previous results and draws a conclusion.

2. Method

In order to understand drip irrigation uptake and use, data were collected through a series of in-person semi-structured interviews with farmers and managers of the WUAs during the summers of 2011 and 2012. In total, 82 farmers were interviewed. Interviewees were contacted in the field (60 of them) or by means of the WUA (22 of them). The 70 interviewees who had drip irrigation were further interviewed about their reasons for adopting drip irrigation, and regarding irrigation and fertigation management, training received and differences observed with gravity irrigation.

In addition, interviews were conducted with the managers of 5 WUAs: the Acequia Real del Júcar (ARJ); three WUAs belonging the Júcar-Turia Channel (JTC) and a WUA in the Vall d'Uixó Valley. The interview guide included the following subjects: general characteristics (irrigated surface, number of members and water use), reasons for adopting drip irrigation, difficulties involved in the process, training for farmers and changes in the rules in use, water delivery system and operating procedures for irrigation management. Other contextual information was collected from WUAs' internal documents and field observations. A comprehensive overview of the organizations and the water resources used in the irrigation system studied is shown in Table 1.

2.1. Case study location

The study area is located in the Valencia Region, characterized by a semi-arid climate consisting of irregular rainfall (the average rainfall ranges from 400 to 600 mm, generally involving a lack of rainfall in July and August). Seasonal summer low water takes place at the moment of maximum irrigation requirements, and drought occurs with a recurrence interval of approximately 10 years. Water resources are scarce and under increasing pressure due to competition with other agricultural, urban, industrial and environmental uses.

Irrigation in Valencia is characterized by small-scale agriculture (the average exploitation size is 2.66 ha), part-time dedication (86% of farmers dedicate less than 50% of their working time to farming activities), use of family workforce (only 23% of farmers have temporary or permanent employees) and the high age of farmers (approximately 40% of farmers are over 64 years old, 26% are between 64 and 55 years old, and only 3% are below 35 years old) (NSI, 2009). The study area encompasses 3 irrigated districts managed by different irrigation organizations.

2.2. Acequia Real del Júcar

The ARJ uses surface water from the Júcar River since 1258. As a juridical indication of its antiquity, this WUA has preference over