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The integrated use of surface, ground and recycled waste water in adapting to drought in the traditional irrigation system of Valencia

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ABSTRACT

Successful farmer-managed irrigation systems are known to exist in various parts of the world, and they are generally based on the sharing of surface or river water. However, it is unusual to find examples of both "integrated" and "adaptive" agricultural water management. This paper describes how one of the most famous systems, the irrigation system of the *huerta* (vegetable garden) of Valencia in Spain, has integrated ground and recycled water use. It analyzes the conjunctive use of every kind of resource and how this was crucial in adapting to the recent drought occurring between 2005 and 2008. Several operating principles, such as autonomy, contiguity, uniformity and proportionality, have been identified in previous research and shown to govern the allocation and use of water in different parts of the world, including Valencia. These principles produce conditions of equity and transparency. In order to investigate the perceptions of stakeholders in Valencia, interviews were conducted with farmers and the management boards of Irrigation Communities (ICs) and Groundwater User Associations (GUAs). The results show that the existing supplementary resources, such as recycled wastewater or Drought Emergency Wells, do not drastically change the way that the farmers manage the system. The main difference occurs in the regularity of the supply. On the other hand, the principles of autonomy, proportionality and transparency are also present in the ordinary use of groundwater from GUAs, although proportionality is defined differently in some GUAs. The farmers follow clearly defined rules, which produce an equitable and efficient use of the resource and create transparency. Results show that both existing organizations have devised a community-based system that is successful at managing water resources.

1. Introduction

As climate change continues and water supplies in many regions of the world grow increasingly scarce, scholars in several fields are showing great interest in the study of irrigation. On a theoretical level, discussion among irrigation specialists often focuses on adaptation—the means farmers employ of coping with less water in adapting to major fluctuations in the supply—particularly on revealing the ways in which farmers modify their use of diverse kinds of water resources. A consensus seems to have emerged that agricultural water use in the 21st century should be both "integrated" and "adaptive" in these respects (Pahl-Wostl et al., 2007). An integrated management should include the use of the resource in a broad perspective (e.g. water for irrigation, preservation of groundwater, flood risk and integrity of ecosystems). In addition, adaptation refers to changes in the processes or structural elements of the governance of water resources as a response to changes in societies or the natural environment (Pahl-Wostl, 2007a, 2007b, 2009).

However, very few concrete examples of such sophisticated practices appear to exist. This paper focuses on one case—the irrigation system belonging to farmers of the famous *huerta* (vegetable garden) of Valencia in Eastern Spain—where the use of water involves the integrated use of multiple sources, and where traditional use is being modified in order to cope with droughts that appear to be caused by human-induced climate change.

Valencia is one of the best-known examples in the vast literature that now exists on successful farmer-managed irrigation systems in different parts of the world. Maass and Anderson (1978)

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describe the operating rules in Valencia. Sales-Martínez (1988) studies how the traditional Valencia system has, over the past few decades, included land that formerly had no rights. And Ostrom (1990), based on Maass and Anderson (1978), has drawn attention to the conditions under which farmers' groups manage water successfully. In addition Garrido (2011, 2012) has reviewed, based on historical data, the evidence used in the work of Ostrom (1990) for the study of irrigation institutions in eastern Spain.

Several studies of irrigation focus on operating principles through field empirical case studies (Lam, 1998; Mabry and Cleveland, 1996; Ostrom, 1990, 1992, 2002; Tang, 1992) and also on ethnographic research (Coward, 1976, 1979; Hunt, 1989; Hunt and Hunt, 1976; Trawick, 2001, 2008; Wade, 1989). Moreover, Boelens and Hoogendam (2002) pay further attention to how individual and collective rights are created in peasant farming systems, and other authors have reviewed the relation between inequality, heterogeneity and cooperative behaviour in irrigation systems (Bardhan, 2000; Bardhan and Dayton-Johnson, 2002). Regarding multi-source management the case of Tehuacan valley shows a case were cooperation between individuals and organizations took place to manage multiple water sources (Palerm Viqueira and Martínez Saldaña, 2000).

In the studied case of Valencia, nine ICs define a unique irrigation system with around 4100 ha because they act conjointly in decisions concerning deriving water and water sharing. In addition, channels and derivations of upstream and downstream ICs are connected. This complex system contrasts with the smaller and more homogeneous irrigation systems, usually managed by a single IC, that generally predominate in that growing literature.

However, the irrigation system of the *huerta* of Valencia comprises two different kinds of organizations. On the one hand, the nine old and traditional ICs which derive surface water from the Turia River, who recently began to use other resources in drought situations, such as Drought Emergency Wells or recycled wastewater. On the other hand, the Groundwater User Associations (GUAs) which are independent organizations located within the *huerta* area, although they are smaller and use groundwater exclusively.

Based on comparative ethnographic research, Trawick (2001, 2005, 2008), has argued that profound similarities exist among the rules that local farmers have worked out for sharing scarce resources in different parts of the world. He suggests that equity and transparency—two system characteristics that are vital to adaptive success and long-term sustainability—can often be created by applying a relatively simple set of principles. These principles may turn out to be the same for a great variety of systems, regardless of their scale and level of structural complexity, including the Valencian system.

The principles proposed by Trawick (2001, 2008): autonomy, contiguity, uniformity, proportionality and transparency (Table 1), are known to be applied to surface water use in the *huerta* of Valencia—where cooperative use has always been the foundation of the local irrigation system—as Glick (1970), Maass and Anderson (1978), Ostrom (1990) and others have shown. However, in the pages that follow, we will study how other water resources such as groundwater or recycled water, which in recent decades have become increasingly important to the farmers of the *huerta*, affect the operation of Trawick's principles.

Valencian farmers have been able to integrate groundwater, recycled and traditional surface water use in a single system. When this occurs, conflict among uses and users has to be solved, new rules may arise for the two new water sources, interacting with the traditional water system. As has been pointed out by some authors, this is not a trivial matter (Blomquist et al., 1994, 2004; Schlager, 2007). In a number of instances, farmers have stopped contributing to the management and maintenance of surface water irrigation systems once groundwater became available (Shah, 1993, 2012). In addition, the reuse of recycled water has been shown to be a valuable strategy to adapt to water scarcity, even though it poses some challenges where farmers' perceptions play an important role (Carr et al., 2011).

Table 1
Basic principles of irrigation in Huaynacotas adapted to La Vega de Valencia (Trawick, 2001, 2008).

Autonomy: The community has and controls its own flows of water. The ICs have exclusive competence on managing the water resources according to their own rules or institutions.
Contiguity: In this irrigation system, when surface water is used, water distribution follows a contiguous pattern and irrigation order takes place based on the location of each plot. In order to irrigate farmers follow an order of irrigation from top to bottom, canal by canal and plot by plot, until water reaches the end of the sector and one irrigation cycle is finished.
Uniformity among water rights and in technique: Everyone receives water with the same frequency and everyone irrigates in the same way. When a whole irrigation cycle has run and all plots have received water if needed, irrigation can be retaken again upstream ensuring that all parcels have right to irrigate with the same frequency. By obeying the rules and conserving water, farmers are maximizing the frequency of irrigation for themselves and for anyone else; as they will be able to irrigate more often in the long run making the irrigation cycle will run as fast as possible.
Proportionality among water rights and duties: No one may use more water than the amount to which the extent of their land entitles them; nor can they legally get it more often than everyone else. People's contributions to canal maintenance must be proportional to the amount of irrigated land they have. Proportionality is a consequence of the order of irrigation because the rules establish that no one can irrigate upstream until all parcels downstream in a sector have already irrigated.
Transparency: Everyone knows the rules and has the capacity to confirm with their own eyes whether or not those rules are generally being obeyed, to detect and denounce any violations that might occur. In Valencia irrigation is a social issue where farmers discuss and keep attention on each other as they are waiting for their surface water turn to irrigate. In addition to free-riding detection, for surface water, effective sanctions or conflict resolution mechanisms under the respected *Tribunal de las aguas*, are also important to provide security to the water users.

The integrated use of those three kinds of resources was crucial in adapting to the recent drought occurring between 2005 and 2008, an extreme event that is highly likely to recur as climate change continues, as we shall see. Thus, the present work aims to provide a more complete view of this local irrigation system, providing insights about how farmers have integrated ground and recycled water into a traditional irrigation system, to successfully adapt to the drought emergency context occurring between 2005 and 2008.

2. Method

In order to understand the irrigation system rules and underlying principles, but focusing on users' perceptions and opinions, data was collected through a series of in-person interviews with farmers, water officials and members of the management boards of the ICs and GUAs during the summers of 2008, 2009 and 2010. 23 individuals were interviewed about groundwater use in GUAs. The 23 interviewees were members of 34 out of the 75 GUAs. For recycled wastewater, 35 farmers were interviewed. The sampling was purposive, with the purpose of including interviewees from the different ICs and having access to the different water sources. Interviewees were contacted while they were irrigating in the different areas. All interviews were conducted using a semi-structured interview guide. The guide included questions where interviewees had the option to show agreement or disagreement, on a 5-point Likert scale, and multiple-choice questions, but they were additionally asked to include any considerations and comment on the statements. Furthermore, interviews were conducted