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Volumetric water control in a large-scale open canal irrigation system with many smallholders: The case of Chancay-Lambayeque in Peru

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ABSTRACT

Volumetric water control (VWC) is widely seen as a means to increase productivity through flexible scheduling and user incentives to apply just enough water. However, the technical and social requirements for VWC are poorly understood. Also, many experts assert that VWC in large-scale open canals with many smallholders is not feasible. This article debates the practice of VWC, drawing on field studies in the arid North Coast of Peru. Here the large-scale Chancay-Lambayeque irrigation system achieved high allocation, distribution and financial performance with on demand delivery to some 22,000 smallholdings, under a VWC approach, with full cost recovery for operation and maintenance. This study shows there are options to promote VWC if its different elements – volumetric allocation, distribution, metering and pricing – are planned together.

1. Introduction

Water is increasingly a scarce resource in many parts of the world, with irrigation often a key user. More and more, irrigation is targeted as a sector that should produce more with less water, where changes in operational management of large-scale irrigation systems can improve performance (Molden, 2007).

A system of irrigation management that could potentially support good performance of large scale irrigation systems is volumetric water control. We define volumetric water control (VWC) in general as a system of water allocation, delivery, metering and charging where exact volumes are assigned on request to individual plot holders or groups of irrigators. There are different practices possible within these dimensions of VWC, but it is important they allow some freedom to the user in scheduling the timing and quantity of water turns. Restrictions on unlimited on-demand purchases may also be present in which case they are not based on "free market" principles, mostly for reasons of social acceptability across users (see also Molle, 2009).

This paper emphasises how the elements of allocation, delivery, metering and charging need to be designed together in VWC to achieve good performance. In a VWC system the water users pay per unit of ordered (or received) water that they request. This system requires precise water distribution and metering of the flows. It equally requires registration and charging for the water delivered to each water user. The farmers, thus, are aware of water allocation and have, if unit prices are sufficiently high, an incentive to apply no more water than needed by the crop.

In this paper we discuss a VWC system where farmers apply for water within certain overall volumetric restrictions based on crop zoning and specific crop water allowances and water availability in the river. It presents a brief review of arguments for and against VWC, then the findings of research on the practice of VWC in the large-scale Chancay-Lambayeque irrigation system (CLIS) in the arid North Coast of Peru. The CLIS system was selected as one of the few applying VWC in a large scale system with open canals and many smallholders. This system achieves good delivery and financial performance despite a number of challenges. Field research was undertaken in CLIS from 1998 to 2000 (see Vos, 2002) with an update in March 2010 to study the continuation of the high performance in water allocation, delivery and service fee recovery found in the earlier field study. The field research included flow measurements, questionnaires with water users and interviews with farmers, operators, Water Users' Association (WUA) board members, and government officials. The conclusions summarise the key management dynamics enabling VWC to work in this system.

2. The concept of volumetric water control: difficulties and options

There are two main reasons for promoting VWC. The first reason is improving field application efficiency, improving productivity

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of diverted water, and reducing risks of waterlogging and salinity (FAO, 1996; Merriam et al., 2007). The idea is that water users will request only the volumes of water that the crops require and not more. With increased field application efficiency the reduction in water applied would not affect production.

This outcome requires a charge per unit of water sufficiently high to induce the farmers to change their farming practices – for example by no longer using water as a substitute for labour or other inputs (Levine, 1980).

The second reason to promote VWC is that a better water delivery service (adequacy and timeliness) increases the legitimacy of irrigation service fee payments. Thus, flexible delivery might also induce more effective accountability mechanisms and increase fee recovery rates (Malano and Van Hofwegen, 1999).

This practice of VWC is not without difficulties. Writers like Cornish et al. (2004), Laycock (2007) and Molle (2009) point out the challenges of measuring and monitoring water in large-scale systems with open canal systems and many small users. Most authors assume a device for metering has to be installed to charge users per delivered volume (Sampath, 1992; Burt, 2007). It is very difficult and costly to measure and register all water flows to many smallholders, who may also steal water, informally exchange water turns or take water in relatively small quantities. Metering at the level of the individual users in large scale irrigation systems can mostly be found in modern piped systems in richer countries, which use water from dams or pumped water. Indeed for example in Spain, Italy, Morocco, Australia and USA several such systems can be found.

The challenge is to find a procedure to verify quantities delivered that is acceptable both to the farmers and to the operating agencies without being unduly expensive. Volumetric charging can also be done by methods of payment per hour using an approximate flow rate (without need of an exact measurement of the flow rate). If provider and user can agree on the approximate flow rate actually delivered, the payment can be made per day or hour of delivery. This is done in Turkey (Murray-Rust and Svendsen, 2001) and in Peru (for example in the Río Cachi and CLIS systems, see Vos, 2002).

Similarly, the distribution of exact volumes is likely to be challenging in large-scale systems with open canals and gated systems under operator control, because of vulnerability to breakdown, constantly fluctuating flow targets, unsteady flow and tampering, especially when the canal supply is irregular (Wade, 1990; Sampath, 1992; Plusquellec et al., 1994; Horst, 1999). To be able to distribute water in precise quantities, to precise locations, at the right time, requires a high degree of institutional and physical control over the water flows. Many experts, therefore, suggest that modernisation[1] of the irrigation infrastructure is necessary, implying sophisticated water management and distribution infrastructure, like pressurised buried pipe systems (Van Bentum and Smout, 1994), automation of the operation of control structures (Plusquellec et al., 1994; Burt and Piao, 2004) and installing flow measurement structures (Lee, 1999).

For low-income countries, Horst (1999) and Mangano (1996) express concerns that automation of control structures or transformations to pressurised systems are too expensive, both in initial investments and in operation and maintenance. Volumetric distribution would imply over-sizing of the infrastructure to accommodate peaks when many users demand simultaneously and would require well-trained staff to effect the on-request scheduling. However, institutional capacities and skills of the operators should not be underestimated for gated control of open canal systems. The possibilities for volumetric control in open canal systems depend on the institutional design and specific conditions.

Grimble (1999) underlines the economic rationality of VWC, in that to make pricing an effective instrument for efficient water utilisation then the amount the user pays should relate to actual delivery (while possibly maintaining or increasing water consumption by the crop by means of better irrigation water application methods). However, a frequently mentioned problem is that no appropriate procedures are in place to establish a proper price to be paid per unit of water (Small and Carruthers, 1991; Van Steenbergen et al., 2007). The volumetric water payment should provide sufficient economic incentive to conserve water (Tsur et al., 2004). In practice almost all large scale systems apply flat fees that result in cost recovery below actual operation and maintenance costs (Molle and Berkoff, 2007). However, some irrigation systems have established volumetric fees based on metered delivery (mostly in USA, Australia, Morocco, Spain and Italy): see Cornish et al. (2004) for an overview.

In the case study below we show how volumetric allocation, scheduling, pricing and metering are made to work. We argue that VWC can only be properly understood if the specific local conditions and institutional structures are taken into account, including: the operational supply and water demand of current cropping preferences, climate, the skills of the operators, the relative water scarcity, the hydrology of the river basin, established water use rights (Levine, 1980) and financial structure. It is crucial to consider the effectiveness of the user participation and accountability mechanisms installed between agency, canal operators, and different groups of users (Levine, 1980; Vos, 2005).

3. The Chancay-Lambayeque case in Peru

The CLIS (official name: *Distrito de Riego Regulado* Chancay-Lambayeque) is an ancient irrigation system, its main canal was first constructed some one thousand years ago. The scheme is situated in the extreme arid coastal zone on the North Coast of Peru, with no effective rainfall in normal years. Only during “El Niño” years does rainfall occur. The water comes from rivers of unpredictable regime that run from the Andean mountains. The command area at present is some 100,000 ha. In 2009 a total of some 22,200 users had water rights: this ownership pattern evolved since the land reforms of 1969. At the time of research, three sugarcane enterprises had large estates in the head of the system. The rest of the users were smallholders with some 5 ha on average. They grow rice, cotton, maize, beans and other crops.

No groundwater is used in the system, as the small net returns to staple crops like rice do not support pumping costs and because of the salinity of the groundwater. Deep percolation from canals and fields contribute to water logging and return flows are hardly used because of the proximity of the irrigation system to the ocean.

Fig. 1 presents a general map of the CLIS. The canals are mainly unlined and the undershot gates are operated manually. The flows are adjusted daily according to the farmers' demand and available river supply. In 1992 the management of the CLIS was turned over from the Ministry of Agriculture to the WUA. The WUA introduced a payment per volume delivered to increase the fee recovery as subsidies on operation and maintenance were no longer received from the Ministry of Agriculture. The payment per volume also induced an increase of the cropped area.

4. Public management and operation: 1969–1992

The Ministry of Agriculture took over the management of the scheme from the large landowners after the land reform of 1969.

[1] VWC is presented as a “modern solution”, however, the idea of VWC has a long history. VWC was introduced – albeit without much success – in the large-scale irrigation systems in for example the British Bombay Presidency in 1903 (Bolding et al., 1995), in Punjab in 1917 (Erry, 1936) and with more success in Peru in 1928 (Anonymous, 1929).