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# Improving water-efficient irrigation: Prospects and difficulties of innovative practices

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ABSTRACT

Innovative irrigation practices can enhance water efficiency, gaining an economic advantage while also reducing environmental burdens. In some cases the necessary knowledge has been provided by extension services, helping farmers to adapt and implement viable solutions, thus gaining more benefits from irrigation technology. Often investment in technological improvements has incurred higher water prices, however, without gaining the full potential benefits through water efficiency. Farmers generally lack adequate means and incentives to know crops' water use, actual irrigation applications, crops' yield response to different water management practices, and thus current on-farm water-efficiency levels.

Those general difficulties are illustrated by our two case studies investigating options, stimuli and difficulties to improve water-efficient practices. The two areas have strong stimuli for improvement but lack a knowledge-exchange system to help farmers and resource managers identify scope for improvements. Partly for this reason, farmers' responsibility for efficient water management has been displaced to hypothetical prospects, e.g. extra supplies from reuse of treated wastewater or a long-term low water pricing. In both cases a displaced responsibility complements the default assumption that farmers' irrigation practices already have adequate water-use efficiency. Under current circumstances, agricultural water management will maintain the unknown water-efficiency level and farmers will have weaker incentives to make efforts for more efficient practices. A continuous knowledge-exchange is necessary so that all relevant stakeholders can share greater responsibility across the entire water-supply chain. On this basis, more water-efficient management could combine wider environmental benefits with economic advantage for farmers.



## 1. Introduction

Irrigation systems have been under pressure to produce more with lower supplies of water. Various innovative practices can gain an economic advantage while also reducing environmental burdens such as water abstraction, energy use, pollutants, etc. (Faurès and Svendsen, 2007). Farmers can better use technological systems already installed, adopt extra technologies, enhance their skills in soil and water management, tailor cropping patterns to lower water demand and usage, reduce agrochemical inputs, etc. Water-efficient practices potentially enhance the economic viability and environmental sustainability of irrigated agriculture, without necessarily reducing water usage. To inform such practices, experts have developed various models of water efficiency, yet these are little used by farmers.

Through two case studies in the EU context, this paper will address the following questions:

- When an irrigation area invests in innovative technology, how can its operation help farmers to achieve the full potential benefits together, e.g. an economic advantage, greater water-use efficiency and lower resource burdens?
- Why are innovative technologies often applied in ways which miss the full potential benefits?

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• What tensions arise among various objectives and potential benefits?
• How can these difficulties be addressed?

The paper first surveys analytical perspectives on irrigation efficiency – especially the means, incentives and limitations – as a basis to analyse two cases and draw general conclusions.

## 2. Innovative irrigation practices: Analytical perspectives

Innovative irrigation technology is generally promoted as raising water-use efficiency along with multiple benefits, but these remain elusive in practice, as outlined in the first sub-section below. The limitations have fundamental reasons, as outlined in Section 2.2. To address these issues, our case studies are introduced in Section 2.3.

### *2.1. Practical limitations of water-efficient irrigation technology*

EU policy frameworks place great expectations upon technologies to improve water efficiency. The European Commission emphasises 'technological innovation in the field of water, given that water efficiency will be an increasingly important factor for competitiveness' (CEC, 2008). According to the European Parliament, solutions should be found in 'clean technologies that facilitate the efficient use of water' (EP, 2008).

Such technological expectations arise in expert reports on agricultural water use:

> Water-efficient irrigation, irrigation on demand and irrigation using brackish water are technologies that will enable the better husbandry of more scarce freshwater resources. Technological developments in respect of irrigation will encompass sensors and communication, intelligent watering systems and high-efficiency delivery mechanisms for water and nutrients, as well as the means of incorporating all of these elements into irrigation 'packages' (EIO, 2011: 25).

Likewise water efficiency can be enhanced by better using current installations and/or by adopting new equipment (WssTP, 2012: 9).

The main European farmers' organisation has likewise advocated technological means to increase water efficiency. In particular this needs 'investments in more efficient irrigation systems, use of new technologies (e.g. soil moisture and canopy sensors) to better match irrigation with plant needs, and good agricultural practices', such as conservation tillage, management of soil fertility and water retention capacity, and scheduling of irrigation during night to reduce evaporation (COPA-COGECA, 2007: 4). The basis for improvement is described as follows:

> . . . water efficiency measures that provide complementary benefits, such as reduced energy needs or other environmental benefits, will also deliver better results. In many Member States, efforts are being made to increase the water storage capacity of soil under agricultural land use. The modernisation of irrigation systems has steadily progressed and water productivity has also improved considerably (COPA-COGECA, 2013: 3)

As indicated above, greater water-use efficiency depends on better agricultural practices alongside extra technology. Yet companies generally promote irrigation technology as if it inherently brings all the benefits (interview, COPA-COGECA, 08.07.13). Improperly managed 'hi-tech' systems can be as wasteful and unproductive as poorly managed traditional systems (Perry et al., 2009). When incorrectly applied, irrigation technology 'can cause losses arising on investments made by farmers, thus decreasing the economic water productivity index and the overall sustainability' (Battilani, 2012).

Beyond a problem-diagnosis of inefficiency, moreover, intensive farming practices can degrade soil and water resources, especially through more input-intensive farming in crops such as maize, vegetables, orchard and vine cultivation:

> Intensive arable production is partly responsible for poor soil structure, soil erosion, loss of soil OM [organic matter] and pollution from fertilisers and pesticides. . .. The expansion of maize cropping and the move to growing winter cereals in particular have contributed to soil erosion even further (Miller, 2007: 44–45).

Such harmful practices have been driven and supported by EU policies. In past decades CAP subsidies have tended to favour crops with high water demands, such as maize, thus increasing the risk of water shortages under climate-uncertain conditions (Garcia-Vila and Fereres, 2012). Either as price-support or area-based, CAP subsidies likewise have ensured the profitability of some water-intensive crops such as cotton which otherwise would be phased out under a market-orientated scenario; likewise water-price subsidies.

In some cases, water-price increases have induced farmers to adopt technology and appropriate practices for conserving water (Caswell and Zilberman, 1985). Yet water-pricing policies often have been ineffective means to reduce water demand (Molle and Berkoff, 2007; Molle, 2008). Farmers experience rising water prices as an extra penalty. Rather than higher water prices, administrative water allocation or re-allocation lowering the supply often has led farmers to adopt water-efficiency practices (Molden et al., 2010). If agricultural water demand is inelastic, then policies which encourage changes in cropping patterns can be more effective than higher prices (Fraiture and Perry, 2007; Iglesias and Blanco, 2008; Kampas, 2012).

Inelastic water demand results from farmers' perspectives on water benefits. Water-use efficiency (WUE) and water productivity (WP) are often used interchangeably but have different meanings. WUE specifically means the ratio of biomass produced per unit of irrigation water used, i.e. the sum of transpiration by the crop and evaporation from the soil (Sinclair et al., 1984). By contrast, WP means the ratio of above-ground biomass per unit of water transpired by the crop (Steduto, 2007). Both terms have relevance to farmers' economic goals. WUE interests mainly the water districts or management agencies, while WP interests more farmers and research community. WP better speaks to perspectives linking water usage with production levels and economic benefit (interview, COPA-COGECA, 08.07.13).

Yet even WP remains distant from farmers' perspectives. They generally perceive 'irrigation efficiency' as maximising net revenue rather than saving water (Knox et al., 2012). Policies seek to lower water usage, and river basin managers try to allocate limited supplies, yet water-saving is not a priority for most farmers (Luquet et al., 2005). They manage labour and other inputs to get better economic gains (Molden et al., 2010). Towards that economic aim, most growers make irrigation decisions by relying on subjective judgements, based only on their practical experience and observation (Knox et al., 2012). Consequently, there have been limited benefits from irrigation technology, as well documented in the technical literature; the following examples compare various techniques.

For example, mobile-laboratory evaluations compared the distribution uniformity and irrigation efficiency of various irrigation systems in California. Although microirrigation systems are seen as 'efficient technologies', they were performing less well than traditional surface irrigation methods such as furrows and borders. To gain the extra benefits of such technology, most important is