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# Modelling farmer choices for water security measures in the Litani river basin in Lebanon

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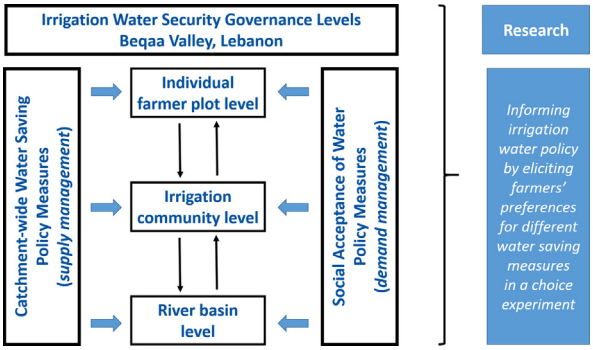
## HIGHLIGHTS

- Farmers are asked for their water security needs and preferences in a survey.
- New water saving technologies are proposed at plot and irrigation district level.
- Farmers are willing to pay higher water fees to secure water supply in the future.
- New irrigation technologies and policies at plot level are preferred.
- Investment costs can be recovered from water pricing policy reform.

## GRAPHICAL ABSTRACT

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## ABSTRACT

Lebanon is facing an increasing water supply deficit due to the increasing demand for freshwater, decreasing surface and groundwater resources and malfunctioning water governance structures. Technological and policy changes are needed to alleviate the impact of water scarcity and secure water in the future. This paper investigates farmers' preferences and willingness to pay (WTP) in a choice experiment for a series of water saving measures at plot and irrigation district level, including more timely information of water delivery. These measures are expected to strengthen water security and use water more efficiently. Farmers are willing to pay higher water prices of $0.32/m$^3$ and $0.22/m$^3$ to support the implementation of water saving measures at plot level and the installation of water metering devices across the irrigation district, respectively. They are not willing to pay extra for obtaining information related to their water delivery earlier in time if this means that they will also have to pay earlier in the year for the water. Farmers with higher income and education levels who decide on their cropping pattern based on expected rainfall data are more interested in taking action than farmers whose cropping decisions are primarily based on last year's sales prices. The study shows that when aiming to design more effective sustainable water management strategies, accounting for farmers' needs and preferences, their age also has to be considered: younger farmers (<40 years) are on average more interested in and willing to pay more for new water saving measures than older farmers (>40 years).



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## 1. Introduction

Irrigated agriculture accounts for nearly 85% of the total consumptive use of water by humans worldwide (Gleick, 2003). A small improvement in irrigation water use could result in a substantial reduction in global freshwater withdrawal (Grant et al., 2012). However, such improvement depends on both supply and demand management strategies aimed to achieve efficient and sustainable use of water. Like in many parts of the world, dealing with water scarcity is one of the major water policy challenges in the European Mediterranean region.

On the supply side, it is common practice to use a combination of groundwater and surface water sources for irrigated farming. In times of water scarcity, groundwater pumping is intensified in order to supplement the deficit created by drying surface water sources. Therefore, groundwater sources become even more depleted. Years of pumping have led to overexploitation of some of the aquifers that require strict government regulation to manage groundwater abstraction (Gómez and Perez, 2012).

On the demand side, all farmers know how essential water is for crop production and that any shortage may have a negative impact on crop yield. Farmers may be risk averse and choose to over-irrigate to avoid water-related yield losses, and ignore the adoption of water saving practices, especially when the economic cost of the water saved does not outweigh the investment. The introduction of modern drip technologies that increase water application efficiency and distribution uniformity together with water allocation and management strategies aimed to ensure profitable production levels could be the solution for eliminating unsustainable water use behaviour (Cason and Uhlaner, 1991; Skaggs, 2001).

At the irrigation district level, the adoption of water metering is a key element for controlling water withdrawal and improve water allocation. However, the implementation of metering devices is usually hindered by monitoring and surveillance challenges (Molle and Berkoff, 2007), and the water charges may not cover the costs of implementing the metering system (Tsur and Dinar, 1997). Installing surface or groundwater meters at farm level would allow the adoption of a volumetric water tariff system that promotes incentives for water saving because payments are directly linked to actual water delivered (Dono et al., 2010).

In Mediterranean countries, the adoption of more efficient irrigation technologies is affected by institutional and financial factors such as water supply and pricing policies (Alcon et al., 2011). Water pricing is seen as an incentive for water saving and enhancing the sustainability of water use (Turner et al., 2004; Dinar and Mody, 2004), but its effectiveness depends on other water policy initiatives embedded in an institutional context. Policies aimed to reduce uncertainty around water resources management based on transparent sharing of information have become more relevant in recent years (Molden, 2007). In this context, the use of economic valuation has been advocated to assist the design of efficient, equitable and sustainable policies for water resources management (Birol et al., 2006).

Contemporary studies on economic valuation of irrigation water have primarily focused on the intrinsic attributes of water supply, such as the quantity or quality of the supplied water (e.g. Rigby et al., 2010; Birol et al., 2008; Alcon et al., 2014). The institutional aspects and characteristics of water management have been underexposed in the existing valuation literature, and irrigation water governance has only recently received more attention (e.g. Speelman et al., 2010; Tesfaye and Brouwer, 2016). There is a lack of information on how smallholder irrigators respond to climate change and water scarcity and adopt water policy measures and new water saving technologies (Shiferaw et al., 2008). This study tries to fill this gap by focusing on farmers' attitudes and preferences for different possible water management measures at field, irrigation community and river basin scale. This will allow us to assess not only the social acceptance of these water policy measures, but also at which scale their adoption is going to be most successful.

In Lebanon, the quantity and quality of water resources are subject to severe pressures driven by over-extraction, inefficient use and pollution due to a fragmented sectoral management approach. To alleviate these pressures and improve water resources management, the Lebanese public administration launched a water sector reform in the year 2000, aiming to regroup 22 autonomous water offices (AWO) and 210 local irrigation committees into four regional public water organizations. These organizations are formally financially independent but fall under the responsibility of the Ministry of Energy and Water (MEW). As part of the proposed reforms, the implementation of Water Users Associations (WUAs) in irrigation schemes was considered one of the most urgent and necessary reforms. Nonetheless, more than a decade after ratification of the reform law, the improvement in operational efficiency, the reduction of water management failures and the negative impacts on environment and human wellbeing remains very limited. The reform seems to have focused more on restructuring the existing organizational structure than strengthening it. The shortcomings of the reform are reflected in fuzzy institutional boundaries, marked by gaps and overlaps (El Kadi, 2012). Improved understanding of farmer's water use behaviour, water management needs and preferences would help water managers and policy makers to move an important step closer towards designing and implementing more sustainable and efficient water use programs based on a combination of available supply and demand management options.

In this context, the objective of this paper is to evaluate farmers' acceptance of and willingness to pay for a series of catchment-wide water saving measures using a choice experiment. These proposed measures are designed to help farmers use water more efficiently, better plan when to irrigate, and communicate more effectively with the irrigation district or river basin authority. The overall goal of these measures is to ensure that farmers have guaranteed access to irrigation water so as not to compromise farm productivity and output in the future. The South Beqaa region in Lebanon is used as the case study area.

## 2. Methodology

### 2.1. Case study description

Lebanon has been known as an oasis of abundant water resources, but the actual water distribution infrastructure, political situation and the lack of governance has led this country to experience water shortage problems. The Litani River is the longest and most important river in Lebanon with an estimated average discharge rate of 8-cubic meters per second (Saadeh et al., 2012), used for irrigating some 77,000 ha of agricultural land, as well as for tourism and domestic water use. Geomorphologically, the Litani basin is divided into two sub-basins, namely the upper (USB) and lower sub-basin (LSB). The irrigated agricultural area in the USB varies from 33,000 to 45,000 ha every year. An annual water deficit is already present and considerable declines in ground water levels have been observed, reaching >50 m in some cases (USAID Report, 2011). This situation is mainly driven by the use of surface water for irrigation over a long irrigation season of 6–8 months, the absence of sufficient precipitation and any water metering or pricing policy, and poor awareness among farmers to improve irrigation water productivity.

In the USB, the 2000 ha irrigation scheme called the “South Bekaa Scheme” (SBS) is a demonstration project aimed to highlight the potential of a collective irrigation network in terms of precision farming, water guarantee to farmers and increased water and crop productivity. The present study took place in the SBS as this is the first fully irrigated area since the water policy reform in the year 2000. The current phase is part of a bigger ongoing development project intended to ultimately serve a total of 8600 ha on the left bank of the Litani River (Fig. 1).

The SBS has a total of 450 to 500 famers. Each farmer owns on average 15.1 ha of agricultural land (LRA, 2017). Nearly 60% of all the agricultural land in the SBS is used for growing horticultural crops