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# Performance evaluation of groundwater management instruments: The case of irrigation sector in Tunisia

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ABSTRACT

Around 27% of aquifers in Tunisia are being overexploited. Groundwater extractions is mainly for the irrigation sector, where more than 40% of the water used for irrigation comes from GW sources. The objective of this study is to critically review and analyze GW management instruments adopted in Tunisia during the last four decades. Evaluation of current instruments was based on a set of criteria (the impact of the instrument on increasing water productivity, reducing aquifer withdrawals, acceptability of the instrument and its implementation cost) assessed through interviews with policy makers and experts, in addition to discussions at farmers' focus groups. Results show that regulatory instruments are widely used but weakly enforced, which can explain their limited impact. To be more effective, economic instruments need a better vertical interplay between different stakeholders. Analysis of stakeholders' participation shows limited awareness by farmers and a lack of collective actions for GW management at local levels. The alignment of GW policies to other cross-sectorial policies, the enhancement of the vertical interplay between water users' associations and local and national water administrations, and the horizontal integration of different water users and managers at the local and regional levels, are among the main recommendations of this study.



## 1. Introduction

To date, the management of groundwater (GW) around the world has been hampered by a variety of uncertainties linked to climate change and socioeconomic growth, as well as by ineffective governance structures affecting resource use, regulation and protection (Knüppe, 2010). Effective GW governance is suggested by many authors as being among the most important challenges to ensure long-term sustainability of the sector Llamas and Martınez-Santos 2005 (Kretsinger and Narasimhan, 2006; Llamas and Martınez-Santos, 2005; Shah, 2005; Wang et al., 2006); and most of the globally observed constraints to sustainable GW management can be attributed to the failure of its governance (Bakker and Koo, 2008; Rogers and Hall, 2007). Governance refers both to setting objectives, principles and rules for managing the resource, and to processes for implementing the rules (Ross and Martinez-Santos, 2010). In line with this definition, GW governance can be described as the process by which GW is managed through the application of responsibility, participation, information availability, transparency, custom, and rule of law (Moench et al., 2013; Robert et al., 2013). However, while knowledge of hydrology and hydro-geology linked to GW management has advanced, relatively little is known about the socioeconomic impacts of instruments and institutions governing GW use (Mukherji and Shah, 2005), as well as methodologies to assess their performances.

The problem of GW management is especially relevant for developing countries (Faysse et al., 2011; Siebert et al., 2010; Braune and Xu, 2009) where institutions and management instruments are poorly designed and enforced. Even in developed countries, there are as yet few well-established examples of good practices and effective GW management (Kemper, 2007). In the MENA (Middle East and North Africa) region, GW withdrawal rates have been rising quickly (Faysse et al., 2011; Wijnen et al., 2012). This quick increase has been driven by the general policy trend of extending irrigated areas and decreasing the vulnerability of agricultural sectors to variable climate conditions. GWIn one of the latest briefs of the World Bank (World Bank, 2007), it is clearly stated that not only physical water scarcity matters in the region, but also the related institutional and organizational failures of the sector. The report adds that technical investments for water development (and sanitation) in the region have not always been accompanied by the

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necessary institutional and policy changes, and are often not generating optimum economic returns. This is particularly true for the non-oil countries of the region including Tunisia, Morocco, Jordan, and Yemen (Faysse et al., 2011; Wijnen et al., 2012; Basu and Van Meter, 2014; Kharraz et al., 2012; Molle et al., 2008). For these countries, even though different instruments for GW management have been developed and applied (Faysse et al., 2011) in parallel with GW development, a systematic and comprehensive review of these instruments as well as their performances in achieving sustainable GW use, is missing in the specialized literature.

This is also the case in Tunisia (Faysse et al., 2011) where around 43% of irrigation water is GW (MARH (Ministère de l'Agriculture et des Ressources Hydrauliques), 2007). Overall water resources in the country are estimated to be around 4700 $Mm^3$ per year (Al Atiri, 2007) including 650 $Mm^3$ of non-renewable GW resources (13.8% of the total water resources) especially located in southern Tunisia. In 2008, annual surface water is estimated to 2700 $Mm^3$ while annual GW resources are estimated to be around 2000 $Mm^3$ (INS (Institut Nationale des Statistiques), 2010). GW in Tunisia is also characterized by unequal allocation and variable quality in terms of salinity. Most shallow GW resources (55%) are situated in the north of Tunisia, while most deep (aquifer) resources (58%) are in the south (Benabdallah, 2007). Good quality GW is only found in 8% of the shallow aquifers and 20% of the deep aquifers. If it is assumed that water with a salt content up to 3 g/L can be used in the agricultural sector and for the production of drinking water, then approximately 36% of all GW resources are unsuitable (Benabdallah, 2007). Drought is another phenomenon with a significant effect on quality. In periods of drought, the salinity of water in shallow aquifers can reach 3.5 g/L, in some cases due to overextraction, as resources are drawn down for both domestic and irrigation purposes.

Shallow aquifers in Tunisia have been under increasing pressure, especially during the last three decades. Irrigated areas from wells and boreholes are slightly increasing and many aquifers are failing "everyday" (MARH (Ministère de l'Agriculture et des Ressources Hydrauliques, 2007; TICET Tunis International Center for Environmental Technologies), 2009). This pressure was particularly high in the coastal (Cap Bon, Sahel and Gabes) and central regions (mainly Kairouan and Sidi Bouzid) (Al Atiri, 2007). The number of wells with traditional water pumps in Tunisia went from 60415 in 1980 to 128,400 in 2000 with an increase of 5.6% annually. This trend was also observed for wells equipped with solar-driven water pumps, of which the number increased from 23,061 in 1980 to 86,965 in 2000, a total increase of 19% annually. As a result there are many signs of aquifer depletion all over the country: of about 273 aquifers, 71 are overexploited at an average rate of 146% (46% higher than their natural recharging rate) (TICET (Tunis International Center for Environmental Technologies), 2009). In contrast, GW policies in Tunisia are considered to be insufficient (Faysse et al., 2011). According to Faysse et al. (2011), it is rather clear that policy and institutional setting in Tunisia have been developed but their performance and effectiveness remains questionable and under-investigated. This takes us again to the need for a critical assessment of GW management instruments as well as their comprehensive performances assessment.

The objective of this paper is to contribute to the existing literature on the evaluation of GW instruments, through the case study of Tunisia. We particularly aim to provide a generic framework that can be used for systematic review and comprehensive assessment of GW management instruments and provide insights on how to improve their outcomes and effectiveness. To be able to provide such framework, we developed a set of performance indicators against which the performance and effectiveness of GW instruments can be assessed. The application of this analytical approach for the case of Tunisia is grounded on different information and primary/secondary data sources, including interviews with policy makers and experts, focus groups with farmers in different regions of Tunisia, as well as on official public documents and ministry reports. It is worth noting that the assessment of the performances of different GW instruments in this study is made based on the information collected from these different sources, including explicit perceptions and opinions of farmers and other stakeholders.

## 2. Theoretical framework

### 2.1. Levels of GW governance for analyzing management instruments

The critical assessment undertaken in this paper of GW management instruments in Tunisia is based on the "Framework for Analyzing and Assessing GW Governance", developed by Wijnen et al. (2012) in the framework of the "Water Partnership Program", led by the World Bank. Particularly, we will consider the three levels of GW governance analysis as stated by Wijnen et al. (2012). First, the national level (also called "level for setting policies") is highly important since it is the level where GW policies and management instruments are determined within the overall water policies. It also refers to the processes by which a nation establishes its objectives for GW and integrates these instruments with water, land and environment, and align and harmonize them with other related policies. The second level is called "strategic level" and corresponds to the governance functions. At this level enters the setting up of institutions and instruments needed to align stakeholders' behavior and actual outcomes to the GW policy objectives. Laws, rights, regulatory instruments, incentives, and other instruments of support to local water management, should all be considered as components of this strategic level. The final level is called "local level governance", which corresponds to the organizations and institutions that control actual outcomes on the ground and which responds (in varying degrees) to the rules and incentives from the strategic governance level (Wijnen et al., 2012). This level includes: (1) public agencies, which are expected to reflect the national policies and instruments at the local level; (2) local collective management institutions, including local organizations; and (3) individual well owners, whose behavior is supposed to reflect the final outcome of the GW governance.

GW management instruments at the "strategic level" of governance can be divided into two main types (Shah, 2005; Foster et al., 2010; Giordano, 2009; Kemper, 2007; Theesfeld, 2010): regulatory or command-and-control policy instruments (e.g. GW access and use codes and GW use rights); and economic policy instruments. Economic policy instruments make use of financial sanctions and incentives such as GW pricing, transferability of water rights or pollution permits, subsidies and taxes (e.g. reducing pumping energy subsidies and tuning crop guarantee prices). Different types of instruments can be ideally combined for effective GW management (Esteban and Dinar, 2013).

At the local level governance, voluntary/advisory instruments, determined through community participation are considered to be supplementary tools for GW management. They include formal and informal instruments that motivate voluntary actions or behavioral changes without use of direct financial instruments.

### 2.2. Different management instruments for different development[1] levels of GW extraction

GW policies in different regions around the world have progressed and changed in parallel with development and often

[1] The term of GW development is used by the WB to indicate the level of GW use at national level.