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Water metering for groundwater management

Groundwater metering is one among a set of tools for groundwater management. However, metering by itself is not going to reduce water consumption; it will require a combination of regulation, enforcement and incentives. For example, in the highlands of Jordan, the government has attempted to meter all wells for both electricity and water use; and yet groundwater levels continue to decline by 1 meter every year (Al Naber and Molle, 2017).

Groundwater metering is a precondition for volumetric pricing of groundwater, and can be an important tool for piloting, testing and improving groundwater monitoring and management. However, it is technically difficult to install modern metering devices on thousands of semi-constructed wells with narrow boreholes and low horsepower pumps, when there has been no history of metering water. This is the status of most wells in the North China Plain. A recent survey showed that less than 10% of 1.17 million wells in Hebei province have been equipped with metering devices, and it costs US$ 500-700 for each well to be installed with modern metering devices equipped with data transmission function. Maintenances costs are estimated at a minimum of US$ 30 to have low failure rates. These costs make the direct metering of groundwater water in the North China Plain infeasible.

An economically feasible alternative is to proxy groundwater use through metered electricity consumption. One such approach is being piloted in Hebei province in China. Using pumping tests, the emperical relation between electricity consumption and groundwater pumping is being established, which depends on several factors such as the geology of the groundwater table, size and age of pumps, and the irrigation season. Ideally, a conversion factor would be obtained for all pumps and this would be updated dynamically, but this is expensive to achieve. Therefore, a percentage of wells representative of the region are being tested in real time. Results from this pilot have produced an average Electricy-to-Water conversion factor of 2.62 m^3/kWh for shallow aquifers and 1.32 m^3/kWh for deep aquifers (W.Kinzelbach, 2021).

Proxying water consumption using electricity consumption can be convenient under certain circumstances. This method can be quickly replicated in a context where wells are metered for electricity but installing metering device is technically challenging. However, if wells are shared by farmers, then there are challenges around how the electricity and water fees should be shared by farmers (Sun et al., 2016; Fishman et al. 2016).

>>> In 2016, the State Council of China commenced the reform of agriculture water prices, including charging groundwater use for irrigation.

>>> Since 2017, the "Electricity-to-Water" method has been widely promoted in Hebei province as the method is simple and easy to be implement at scale. Around one million wells were metered through electricity use, and about 502,000 water users were designated as taxpayers for groundwater resources.

>>> Through 2018-2019, pumping tests have been conducted over 1744 wells to establish an inventory of Electricity-to-Water conversion factors for Hebei province.

>>> In 2019, the national Action Plan recommended the use of "Electricity-to-Water" method for regions that are not equipped with water meters or do not have conditions to install groundwater metering devices.

There are tradeoffs between proxying water consumption using electricity, compared to methods that would directly meter water use. These tradeoffs are listed in the table below.

Criteria	Direct Water Metering	Energy Metering + Pumping Tests on all Wells	Energy Metering + Pumping Tests on Selected Wells
Cost	High	Medium	Low
Implementation	Very Difficult	Medium	Easy
Accuracy	High (±5%)	Medium (±20%)	Low (±20% to ±50%)

Source: W.Kinzelbach, 2021

A Public-Private Partnership (PPP) business model between the local water authority, a meter manufacturing firm and farmers in the Heihe river basin has shown potential.

In Zhangye, farm sizes are larger than those in othe parts of the North China Plain, making it feasible to install smart meters. The PPP model works as follows: The local water authority and meter manufacturing firm co-invested to produce metering devices. The local water authority also contracts the firm to install the meters, develop a groundwater charging system, implement and maintain the operations. Farmers pay water fees to local authority who then uses the collected fee to purchase the service from the firm.

An increase in groundwater levels has been observed in the region over the last few years.

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Dr. Yu LI graduated from Politecnico di Milano with a Ph.D degree in Information Technology. His main research interests focus on water resources management using modern informatic techniques, such as agent-based modelling, multi-objective optimization, visual analytics, data mining, etc. Since late 2016, he was recruited as a post-doc by Prof. Wolfgang Kinzelbach from ETH Zürich, working on the Swiss-China project about mitigation of groundwater over-pumping in North China Plain, where Dr. Yu Li played an active role in the development of decision support system, groundwater serious game and groundwater management models. He returned to China in 2016, and has been working as a lecturer in the Center for Water Research in Beijing Normal University at Zhuhai.