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Groundwater management through pricing

Water prices are meant to improve distributive efficiency. Pricing is an economic instrument that is used to encourage water to be re-allocated to uses and users with highest economic returns. When this occurs, it does not necessarily mean that less groundwater is abstracted or used; it means that inefficient use of water is reduced and that the returns from using groundwater are being maximized.

There is not one way to set groundwater prices. Conceptually, the economic price of water should be equal to its social marginal cost[1]. However, this is a hard approach to implement, and in practice, simpler methods are often used. For example, one pricing approach can be based on recovery of costs pertaining to operations, repair and maintenance; these costs can be recovered by distributing them equitably between farms or by land area and crop type; or through metering.

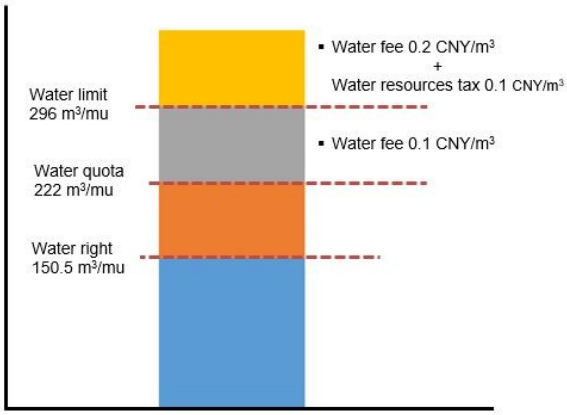

Figure 1: Three-tiered pricing system proposed for the North China Plain

Data availability, technical capacity, managerial capabilities, and socio-political realities will determine how prices are set. For example, a 3-tiered groundwater pricing system has been proposed for the North China Plain (Figure 1) with the water right, quota and water limit defined for each region according to available water resources, cropping structure and efficiency of water saving techniques. A 0.1CNY/m^3 water fee is charged if use is over 222 m^3/mu (quota level for Guantao county). An increased water fee of 0.2 CNY/m^3 and a resource tax is collected for use beyond 296 m^3/mu (water limit level for Guantao county). Water trading is possible for water use below the quota. Technical capacity in China has allowed such a scheme to be designed. In practice, however, it is difficult to implement because it depends on metering all wells and users (managerial capacity), ensuring acceptance by farmers (socio-political realities) and reasonable administrative human cost to collect fee or tax.

Milestones of agricultural water pricing reform

→ *In 2007, China's Central Government embarked on a pilot to reform pricing system for agricultural water use. The aim was to recover water supply cost, and promote water conservation. A nested approach was employed, where centralized planning allocated shares of water to different parts of the county, and county governments used quotas to provide water to different villages and users.*

→ *In 2016, the State Council of China provided "Opinions on promoting comprehensive reform of agricultural water prices" after ten years of piloting, aimed at limiting agriculture water use by strictly implementing water quotas and improving water use efficiency.*

→ *In 2016, the "Notice on the promotion of resource tax reform" was issued, to pilot the levying of a groundwater tax in Hebei province.*

→ *In 2018, the Central Government issued the "Opinions on innovation and improvement of price mechanism to promote green development".*

→ *From Dec. 2021, China will implement the Groundwater Management Ordinance.*

[1] *The social marginal cost can be defined as the private cost of providing water for irrigation along with the cost of any environmental externalities associated with providing water for irrigation. These are hard to calculate empirically.*

When groundwater is priced, reductions in abstraction do not necessarily take place. This is because when prices are introduced or increased, two types of changes occur. The first at the *intensive* margin—the change in the amount of water used if the farmer changed nothing else about the production process. The second change is at the *extensive* margin—the change in the amount of water used due to changes that the farmer makes in the production process (changes in cultivated area, crop type, irrigation technology, use of other inputs). The combination of these two changes determines if water pricing would reduce groundwater abstraction, or not. Empirical studies from China indicate very low price elasticity of demand for groundwater irrigation in the North China Plain, ranging from -0.18 for wheat to -0.35 for rice (Sun Tianhe, 2017), implying the current groundwater price level may not result in water savings.

The ability of groundwater prices to reduce groundwater abstraction also depends on metering, the price of energy, well sharing, and water sales. If energy is subsidized, wells are shared, water is sold informally by well owners to other farmers, and meters are not installed for each user, then pricing may have a minimal impact of abstraction, and create increasing equity issues.

- Jordan set groundwater prices, and an additional tax on every unit extracted beyond 150,000 m^3 per well per year, in a context where wells are not shared, water is not sold by well owners to other farmers, and where wells are metered. Farmers with smaller land holdings never exceeded this limit, and never paid the tax. Farmers with large land holdings upgraded drip irrigation systems which reduced water use and irrigation costs at the intensive margin, allowing them to expand cultivated areas and increase net income. Counterintuitively, the groundwater tax increased groundwater abstraction and overall use (Venot and Molle, 2008; Al-Naber and Molle, 2017; Balasubramanya et al. 2021).
- In Mexico, a water tax was introduced without installing water meters in a context where wells were shared, electricity is heavily subsidized, and no prices were previously paid for water. Without being able to meter each individual user (and not just the well), the tax did not have an effect on groundwater abstraction (Sun et al., 2016).
- In contrast, in the High Plains Aquifer in Kansas in the United States, there has been a history of unsubsidized energy (electric, gas, diesel); historical individual water rights set by the doctrine of prior appropriation (first-come-first-serve); no sharing of wells or sales of water; and historical metering. In this context higher groundwater prices have reduced groundwater abstraction at the intensive margin; and reduced cultivated area of crops and water use at the extensive margin; amounting to a reduction in the abstraction and use of groundwater (Pfeiffer and Lin, 2014).

To conclude, groundwater prices by themselves may not be sufficient to reduce groundwater abstraction. Energy prices, well sharing arrangements, water markets, historical water rights and pricing schemes, current cultivation decisions and irrigation technology, and the ability to meter all uses and users will determine whether an increase in prices leads to a net reduction in abstraction. Groundwater pricing will have to be accompanied by quantity limits on groundwater abstraction and strong enforcement of regulation to reduce abstraction (Yu et al., 2021).

"Raise first then Refund"

Incentive mechanisms to implement groundwater price reform were tested. For instance, the "Raise first then Refund" policy was piloted in Taocheng country in the North China Plain.

By increasing the electricity price by about 30% ("Raise"), as incentive to reduce electricity cost, it was hoped that farmers would change their irrigation behaviour, reducing groundwater consumption by increasing irrigation efficiency or changing cropping structure. The increased fee part was kept by the Water User Association (WUA) and was designed to "Refund" to all farmers according to their land size by end of the year.

Implementation results showed that groundwater consumption for winter wheat and cotton were reduced by about 20% (Jinxia Wang, 2016). However, scaling up this policy was challenging because without governmental subsidy contributing to the pool of refund, the actual income of farmers would be less than before.

Therefore, successful implementation of groundwater pricing reform in agriculture sector would require a complementary government subsidy program to offset farmers' additional electricity expenses, which is challenging because it places a fiscal burden on the government.

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