Positive incentives for managing groundwater in the presence of informal water markets: perspectives from India

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India is the world’s largest user of groundwater, the bulk of which is used for irrigation (Hirji et al 2017). Groundwater-based irrigation was an enabling factor for the Green Revolution, which has increased food security and reduced poverty; but with abstraction exceeding recharge, 28% of administrative blocks in India have aquifers classified as over-exploited, critical, or semi-critical (Mukherjee 2018). Governments have recently been attempting to use positive incentives to reward farmers for reducing abstraction, but such policy approaches often ignore the presence of informal groundwater markets (IGMs), where wells owners supply irrigation services to other farmers for a charge, in addition to irrigating their own fields. IGMs may undermine incentive programs; and implementing incentive programs in the presence of IGMs may have unintended welfare consequences. Better data and research on IGMs is needed for managing groundwater in India.

1. Groundwater abstraction data is poor and standard solutions to reduce abstraction are difficult to implement

Groundwater in India is abstracted from 27 million private wells that are unmetered for water and largely for energy as well (Hirji et al 2017). Changes in groundwater storage can be estimated using satellites, which generate data with high coverage but poor resolution and low reliability. Monitoring wells could generate high resolution, reliable data but their coverage is poor, as only 15 640 monitoring wells exist for 27 million wells. Importantly, data from satellites and monitoring wells often lead to different insights about groundwater abstraction (Akhtar et al 2022).

A history of subsidized well-drilling and pumps; subsidized or free energy (electricity in particular); and minimal restrictions on well installation; in a landscape characterized by millions of smallholder farmers; renders standard ‘market-based’ policy instruments such as water pricing, purchase and trade of water quotas, and fines for exceeding quotas are challenging to introduce from a cost, political and institutional perspective (World Bank 2010, Shah et al 2012, Sidhu et al 2020). Regulating groundwater abstraction has historically focused on restricting electricity supply and voltage for electric pump owners and rationing subsidized fuel for diesel pump owners; these have not been effective at reducing groundwater overdraft.

Recently, federal and state governments are experimenting with positive incentive programs—rewarding desirable behaviors (‘carrots’) rather than penalizing undesirable ones—which draw from payments-for-ecosystem-service approaches that have been used in different geographies. For example, farmers using electric pumps in Punjab and Gujarat are being provided energy entitlements which are purchased by the utility if unused (Fishman et al 2016, Mitra et al 2022). This approach is deemed desirable by the government as the cost of supplying subsidized energy is much higher than the price at which unused units are purchased by the utility; and farmers are no worse off since they are rewarded and not penalized (Mitra et al 2022). Similarly, the federal government’s flagship solar irrigation program (KUSUM) is encouraging diesel and electric pump owners to switch to solar pumps that are connected to the grid and net-metered; thereby converting a variable-cost subsidy on fossil fuels to a fixed-cost capital subsidy on the solar pump, and reducing the fiscal burden on the state, while incentivizing energy evacuation through net-metering to encourage farmers to reduce groundwater abstraction.

Whether such programs will reduce groundwater abstraction depends on the state of IGMs. Importantly, acknowledgment of such IGMs is largely
missing in policy, and consequently being overlooked in the design of these types of programs.

2. While IGMs are extensive, data is poor and outdated

While India’s National Agricultural Census and the National Sample Surveys record irrigated areas, they do not elicit information on irrigation sources. The Minor Irrigation Census records the number of groundwater wells and their ownership, but not whether well owners supply irrigation services to other farmers. Consequently, estimates of irrigation service sellers and buyers have come from limited case studies and surveys conducted for research purposes. For example, the share of irrigated area served by IGMs was estimated to be 80% in North Gujarat (largest producer of cotton and oilseeds in India), 60% in Uttar Pradesh (largest wheat and second-largest rice producer), and 30% in Tamil Nadu; based on which Salem (2004) estimated that at least 15% of the country’s area irrigated by groundwater in the early 1990s was through IGMs. While experts agree that this share has increased considerably over time, current estimates do not exist, creating a gap in understanding of how widespread IGMs actually are. Recent studies are few; for example, Mukherji et al (2022) estimate that 75% of all groundwater irrigators in West Bengal (largest producer of rice) purchase irrigation services from well owners, suggesting that in some Indian states, IGMs are ubiquitous. However, there is likely to be variation in their incidence across and within states.

Since wells are not metered, it is not possible to know what volumes of water are traded in IGMs. Therefore, case studies and surveys conducted for research purposes tend to elicit from buyers the number of times their crop was irrigated in the season; while asking sellers to report the number of clients served, and the number of times they ran their pump for other farmers. Collecting such data is time-consuming and expensive, and the data is likely to have recall bias.

The case studies suggest heterogeneity in the functioning of IGMs (Dubash 2002, Mukherji 2007). Pump owners may either allow others to use their pump and well for a fee or may deliver water themselves, depending on the pump (electric, diesel or solar) and the ability to lay pipes or furrows to convey water (which depends on distance, slope, soil-type, farm density and land fragmentation). Payments can take different forms; they may be made in cash (per irrigation or per season) or labor (supplying labor to cultivate the pump owners’ lands); or through sharecropping (where buyers owe sellers a share of harvest). Payments can be levied in advance or after harvest, or spread in installments through the season, depending on the form of payment. The pricing of irrigation services can be competitive, monopolistic or oligopolistic (Easter et al 1999, Dubash 2002). Factors such as fragmentation of land holdings; local norms related to ‘sharing’ water; caste and kinship; capital costs of well installation; and energy tariff structures faced by pump owners have been identified as affecting the pricing of irrigation services (Kasiya and Saruki 2005, Mukherji 2007).

3. While IGMs have been ‘pro-poor’ in a static sense, it is unclear if they will be over time

IGMs typically emerged in geographies where farmers face significant barriers in installing private wells such as, high costs of well-drilling in hard rock and deep aquifers (e.g. Northern Gujarat; Kumar 2000); regulatory permits for installing wells (e.g. West Bengal, Buisson et al 2021); or fragmentation of land-holdings that prevent farmers from installing wells on each plot (Shah and Ballabh 1998). Cross-sectional research shows that IGMs have transferred water to more efficient water users and have had ‘pro-poor effects’ as they extend irrigation access to smaller, marginal farmers, who otherwise would not have irrigated their plots (Manjunatha et al 2016, O’Donnell and Garrick 2019, Buisson et al 2021).

However, it is unclear if IGMs would still be ‘pro-poor’ over time. As more smallholder farmers have gained access to groundwater, drawdown has also increased, and groundwater levels have fallen (Endo et al 2018). Consequently, over time, irrigation prices in IGMs are likely to rise as pumping costs increase. Against the backdrop of weakly defined rights to groundwater, distribution of access may change, especially for smaller sellers and buyers who may be excluded from informal markets (O’Donnell and Garrick 2019). There is a need for research that tracks entry and exit into IGMs over time.

4. In presence of IGMs, effectiveness of positive incentives is uncertain, and they might detrimentally affect water buyers

The implementation of positive incentive programs in the presence of IGMs may not only be ineffective in reducing groundwater abstraction but might also reduce welfare of water buyers. For example, in Northern Gujarat, where groundwater is deep and IGMs are active, a pilot program provided electric pump owners with electricity entitlements that would be purchased by the utility if unused (Fishman et al 2016). There was no reduction in use of electricity or groundwater pumping, at least in the short term, as well-owners felt socially obliged to provide water to buyers (Fishman et al 2016). However, over time, this might change. Pump-owners might decide to sell electricity units back, thus affecting the livelihoods of smaller farmers. The program might also incentivize pump-owners to raise the price of irrigation services,
especially if the IGM is oligopolistic or monopolistic, as pumps owners can earn incomes from selling electricity back to the utility instead. Given that the demand for irrigation water is fairly inelastic, not only would such a program fail to reduce groundwater abstraction, it would also have detrimentally changed the distribution of welfare between service sellers and buyers, exacerbating existing inequalities in access to water. In contrast, in Punjab (second largest wheat and third largest rice producing state), where there are no IGMs, a similar pilot scheme reduced electricity use for pumping between 7% and 30%, thus reducing groundwater pumping, at least in in the short-term (Mitra et al 2022). For similar reasons, it is not obvious if connecting solar pumps to the grid and paying farmers for energy evacuated would necessarily limit groundwater extraction where IGMs are active.

Positive incentive programs may not be effective in reducing groundwater abstraction in areas that have active IGMs. Additionally, the challenges of designing and implementing such programs are likely to be significant in the presence of IGMs. For example, determining individual entitlements of electricity where no metering has historically existed is harder if well-owners have also been selling water to neighbors. Similarly, with grid-connected solar pumps, setting the purchase tariff for evacuated units will need to account for the income pumps owners have been making from selling irrigation services to smallholder farmers in their communities.

5. Better data on IGMs is needed to conduct research and address groundwater depletion

Groundwater in India is rapidly depleting, and abstraction needs to be reduced. The livelihoods of millions of farmers depend on this resource, including those who do not own wells and pumps but access groundwater through IGMs (Shah et al 2012). Balancing these objectives is difficult, and federal and state governments are exploring various options. Positive incentive programs that reward reductions in abstraction are viewed as politically attractive, and economically feasible. However, the design of such programs ignores the presence of IGMs. This is a major oversight as not only does the success of such programs depend on the presence and functionality of IGMs; such programs may unwittingly endanger the welfare of farmers by disrupting existing IGMs.

One important reason for such an oversight is the paucity of data. While satellite data may be used to estimate changes in water storage (without being able to separate groundwater from surface water) or evapotranspiration; neither can be used to estimate the volume of water that was applied on agricultural land at any resolution, let alone whether that water was procured through an IGM. The only way to understand the extent and functioning of IGMs is through survey data. India’s Minor Irrigation Census, and the National Agricultural Sample Survey elicit basic data on irrigation, and both are appropriate avenues to collect representative and systematic data on whether farmers sell and purchase water, including the manner in which payments are made, and the challenges that sellers and buyers encounter. This data would be vital for furthering research on how IGMs might affect the feasibility of positive incentive programs; and to what extent IGMs are likely to be disrupted by positive incentive programs, helping policy makers understand tradeoffs between reducing abstraction of groundwater and its welfare implications for sellers and buyers of irrigation services.

These perspectives from India are also relevant to the region of South Asia, where groundwater levels are declining; and IGMs in Nepal, Pakistan and Bangladesh are widespread, but overlooked in data and policy (Hirji et al 2017).

Data availability statement

No new data were created or analysed in this study.

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