SANDEE
South Asian Network for Development and Environmental Economics

POLICY Brief

Number 18-07, February 2007

Ground Water Irrigation and Sustainability – Water Markets, Institutions and Power Supply in Northern India

In South Asia concerns about water scarcity have been mounting for some time, particularly in rural areas where food productivity critically depends on irrigation. Sustainable water consumption is therefore a key development goal, otherwise any strategy that aims to guarantee food security or tackle rural poverty will ultimately fail. This is, however, a particularly big challenge as there are many factors that influence water supply and demand; this means that it is often difficult to decide what strategic approach should be taken to make sure that water sources are used efficiently and sustainably.

A new SANDEE study from India, has investigated the impact of water pricing, institutions and unreliability of power supply on crop output of the small-scale farmers in Western Uttar Pradesh. The study finds that water supply, farm productivity and electricity supply are all interlinked. It suggests an economic strategy that will provide farmers with a dependable supply of electricity to drive irrigation pumps and a pricing mechanism that will help ensure that water is used sustainably.

The present system of erratic power supply limits irrigation. One would expect the limited water supply to be inefficiently favoring farmers who irrigate using their own pumps, over those who buy water. Surprisingly, the study finds this is not the case — water allocation is efficient across farmers and plots. Farmers seem to have evolved social institutions that govern irrigation efficiently, subject to the poor electricity supply. Nevertheless, reliable electricity supply can increase output by 8-10%. The current electricity pricing involves a flat fee unrelated to quantum of electricity used; a poor incentive to supply electricity. The study shows that a unit-based pricing system with reasonable rates can incentivise the power supplier to supply adequate power, and increase farmers' profits net of additional power payments. This alone will not solve the problem of water overuse. In order to reduce water use to sustainable levels over time, a possible market-based strategy could be to markup the unit electricity charge by about 15%.

THE IRRIGATION CHALLENGE

Water scarcity is a huge concern in rural India, where 80 percent of the country's water use occurs. This study is based in Tabelagarhi village in the state of Uttar Pradesh. Here, the popularity of water intensive crops, such as paddy and sugarcane, is responsible for depleting groundwater tables. Overexploitation of groundwater resources raises concerns about the future sustainability of agriculture. It is therefore becoming increasingly important that any groundwater is used efficiently. To work out how this can be done the researchers look at the institutions that govern water allocation. They assess how well these institutions perform and suggest how water use can be improved in terms of efficiency and sustainability.

Tabelagarhi is located in the sugarcane belt of Western Uttar Pradesh and faces many of the key development issues common to the region. In particular villagers predominantly use groundwater drawn from tube wells for irrigation. A low and declining water table makes it uneconomical to use

This policy brief is based on SANDEE working paper No. 19-06, 'Groundwater Irrigation in North India: Institutions and Markets' by A.Banerji, J.V. Meenakshi and Gauri Khanna from the Centre for Development Economics at the Delhi School of Economics. The full report is available at www.sandeeonline.org diesel to fuel the pumps that run the wells. Electric pumps are therefore used to draw water up from depths of over seventy feet or more. The region also suffers from an erratic and inadequate electricity supply and consequently an erratic supply of irrigation water. Many farm plots, particularly smaller ones, do not have tube wells. As a result, a lot of plots are irrigated using water purchased from villagers who have tube wells on their farms.

The study is based on a sample of 73 tube wells and a survey of all the plots serviced by these wells. These 326 plots belong to 105 farmers. Three types of data are used: tube well-specific, plot-specific, and farm household-specific. Plot-specific data is used to estimate the demand for irrigation water, tube well data to estimate water supply characteristics, and household data to identify how the farmers themselves affect production.

GROWING SUGARCANE IN TABELAGARHI VILLAGE

Tabelagarhi village, the subject of this study, is in the Baghpat district, in the sugarcane belt of Western Uttar Pradesh. Sugarcane is one of the most water intensive crops widely cultivated in North India and, by and large, groundwater is the only source of irrigation for crops grown in and around Tabelagarhi. The crop is therefore a major reason why the water table in this area has witnessed a steady decline over the last few decades.

Tabelagarhi has 165 households that cultivate sugarcane. Sugarcane yields more than one harvest after a sowing; after the first harvest, the crop is known as rattoon sugarcane (as opposed to freshly-sown or plant-cane). Sugarcane sowing takes place in April-May, and harvesting is between February and April. Rattoon sugarcane, on the other hand, is harvested between late October and January. In this region, the first yield is lower than from the rattoon sugarcane. Most farmers typically have plots of both crops in the field.

Sugarcane is a water-intensive crop requiring one irrigation before sowing, and regular irrigations thereafter. Conversations with experts and farmers at the site indicate that pre-monsoon irrigations are particularly crucial for plant growth. In 2004, the monsoon was delayed, and there was no rain in June and July. In this situation, the general opinion was that one irrigation every 20 days was needed. Water from tube wells is transported to plots largely via unlined channels. So there are seepage losses; but these are restricted by the relative proximity of other tube wells.

Tabelagarhi, as is the norm in many parts of India, is subject to erratic power supply. For example, power can fluctuate from between 3-5 hours a day to between 8-10 hours a day. As explained, for sugarcane, timely irrigations early in the season are critical to crop growth; thus the lack of regular electricity supply means that in summer months with no rain, tube wells need to be kept running flat out whenever power is available.

INVESTIGATING GROUNDWATER USE

The study first looks at how efficiently groundwater in Tabelagarhi is allocated among the farm plots. Although there is some inefficiency, mathematical simulations show that re-allocation of water may not lead to significant productivity gains. One can infer from this, and through direct observation, a form of social contract at work, that helps to allocate water efficiently. Villagers work together informally to fix water prices at the beginning of a growing season since they often double up as buyers and sellers in the water market due to fragmentation of land. Given the fairly low water price and the relative shortage of water (due to paucity of electricity), tube well owners wanting to maximize profits from water sales could choose to sell little water, using most of it on their own plots. It is remarkable that tube well owners actually do not try to maximize profits in this fashion. They sell substantial volumes of water even though it would make better economic sense to use the water to boost the productivity of their own land. This is a striking finding that stands in sharp contrast to much of the literature on this issue in South Asia. Many studies argue that tube well owners exercise some monopoly power over water buyers, leading to inefficient water allocation and inequality.

The social contract in evidence in the Tabelagarhi region makes sense. Land holding in the region is fragmented and this means that practically all water sellers also have plots for which they themselves have to buy water. What a water seller loses by selling water 'below value' on his own plot, he can make up by buying 'cheap' water from another supplier. Simulations also show that agricultural yields in the region would be about 18% lower if tube well owners tried to maximize their individual economic profits (see Table). As the Table shows most of this reduction would come from a reduction in the yields of buyers of water. It is thought that farmers in the region have been able to develop and implement this effective water allocation system, thanks to the relative social homogeneity of Tabelagarhi and surrounding villages.

TABLE : A COMPARISON OF CURRENT YIELDS WITH PROJECTED YIELD IF EACH TUBEWELL OWNER ACTED AS A PROFIT MAXIMISER (PER BIGHA)

Plot Category	Sample Yield	Projected (Simulated) Yield
All Plots	59.27	48.25
Plots with Single-Owner TW	60.36	61.95
Plots with Joint-Owner TW	59.77	61.10
Plots that bought water	53.41	16.36

THE ELECTRICITY PROBLEM

Despite the existence of the social contract system in and around Tabelagarhi, it is clear that the region's erratic and inadequate power supply does have a significant impact on agricultural productivity. There is strong evidence that many farmers receive an inadequate water supply and that water is, in effect, rationed. This is shown by the fact that when the marginal value product of water on a plot is compared with the price of water (if the plot uses purchased water) or the marginal cost of water extraction (if the plot has a tube well on it), then the marginal value product is, on average, twice the cost of water supply. In other words, farmers could increase profits by using more water (if it was available).

This water rationing has many implications. Many key land preparation decisions are made in the first few summer months, before farmers get to know how power availability will affect irrigation over the season. This uncertainty means that many farmers do not apply optimal levels of fertilizers and other agricultural inputs. If farmers could be confident about power and water supply they would have the confidence to use more agricultural inputs which could increase yield by 8%-10% on average.

SANDEE

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SANDEE SPONSORS

Swedish International Development Cooperation Agency

This policy brief is an output of a research project funded by SANDEE. The view's expressed here are not necessarily those of SANDEE's sponsors.

STABILISING POWER SUPPLY

In Tabelagarhi, farmers pay a flat annual charge (based on the horsepower of their pumps) in return for the right to use as much power as they require. This gives no incentive to the power provider (here, the State Electricity Board) to provide adequate power. The water rationing in the Tabelagarhi region is therefore symptomatic of the pan-Indian problem of poor power infrastructure, and a lack of good incentives to produce and supply adequate power. If power prices were based on the amount of electricity that farmers use, it would give more incentive to the power producer to supply adequate, reliable power. If instead of a flat charge, a unit-pricing mechanism at reasonable levels was followed, it would improve irrigation supply and yields could go up by as much as ten percent. Increased productivity would pay for the higher irrigation costs that farmers might have to bear due to higher power prices.

This scenario obviously leaves the challenge of sustainability unanswered. With an improved electricity supply and electricity unit costs set at a reasonable level, irrigation volumes will continue to seriously deplete the water table. It is clear that with the speed of growth in the region, traditional rights of water use are proving inadequate as a mechanism to govern water use, since individual farmers are ignoring the negative impact their actions have on the communal water resource. As none of the standard suggestions for water conservation (such as water pricing) have been tried in the region, there is clearly a need for more research.

MAKING WATER USE SUSTAINABLE

Increasing the price of electricity supplied to farmers may be one possible way forward. This study suggests that an electricity price marked up about 15% over the unit cost of electricity may reduce farmers' water extraction to a socially optimal level. The resulting decrease in farmers' incomes could, in principle, be compensated through lump sum transfers.

The implementation of such a proposal will, unsurprisingly, be problematic. The local power provider lacks credibility and, while it is likely that sugarcane cultivation in the study area will be profitable even with substantially higher energy costs, this may not be true for all parts of the sugarcane belt. Deeper structural changes, such as allowing competition between multiple power providers, may be the ultimate answer, but this would require a huge regime change. Despite these significant challenges, it is important to forge ahead, perhaps with a few experiments and more careful and broader studies, because the water crisis has to be addressed.

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