IWMI- TATA
Water Policy Program

21
2005

Water Policy Research

Highlight

Cost of Energy for Irrigation and Agrarian Dynamism in Eastern Uttar Pradesh

Avinash Kishore
and
Keshari Nandan Mishra

A comparison of water markets and agricultural productivity between villages dominated by electric and diesel pumpsets in eastern Uttar Pradesh (UP) shows that water buyers, most of whom are marginal and sub-marginal farmers, are hit the hardest by high cost of energy for groundwater pumping.

This paper shows that increasing pump density does not improve the terms of groundwater access for water buyers when the fixed costs are low. Shifting to electricity as source of energy for irrigation will be a better strategy. It will improve the net returns of poor water buyers by 20-25 percent even if no yield gains are realized. Such a shift will have a huge redistributive impact in UP since 57 percent of all food crop cultivators in this state are water buyers.

Download this paper from
http://www.iwmi.org/iwmi-tata

Cost of Energy for Irrigation and Agrarian Dynamism in Eastern Uttar Pradesh[1]

Research Highlight Based on a Paper with the same Title

Rapid expansion of groundwater irrigation is at the heart of agrarian dynamism experienced by eastern UP since late 1980s which so far formed the western frontier of the agriculturally stagnant eastern India. The region has come a long way from the days when the British had to force farmers into using irrigation once they had invested into canal systems. Today, 90 percent of farmers in the state irrigate both rabi and kharif crops. Government-supported free boring scheme, which has become a model for the rest of eastern India, has helped broaden the access to groundwater irrigation. While pump density has increased rapidly, pump capacity utilization and irrigation intensity remain quite low resulting in lower productivity. This is in spite of plenty of groundwater being easily accessible at shallow depths throughout the year.

Growth rate in production and yield have started stagnating at levels much below the region's agronomic potential leading to the hypothesis that irrigation induced growth has been short-lived and unsustainable because the underlying agrarian structure has not changed. Transformation from semi-feudal to capitalist agriculture is incomplete and therefore the structure is constraining the technical possibilities.

Our contention is that the water buyer's cost of irrigation is more sensitive to the price structure of energy than pump-owners. Therefore, even if power subsidy benefits pump-owners (who are often large and medium farmers) more, its absence hurts poor sub-marginal and marginal water buyers the most.

Research Hypothesis and the Sampling Plan

We contend that it is the high and rapidly rising cost of energy (diesel) for irrigation in the area, where most of the farmers (77 percent) are marginal and sub-marginal and purchase water for irrigation from monopolistic rent markets, which is responsible for re-stagnation of agriculture after a period of rapid growth in eastern UP. This can be proven if we find that, within the same agro-climatic region, there is significant difference in productivity, irrigation intensity, choice of crops, and cropping intensity between farmers having electricity and diesel as predominant sources of energy for irrigation. We carried out primary survey in eastern UP to compare the crop economics of farmers in villages having a sizable number of electric pumpsets with those in villages dependent entirely on diesel pumpsets for irrigation. Five-six years ago, Tushaar Shah (personal communication) tried to do a similar study in Gorakhpur *mandal* of eastern UP but they could not find sizable number of electric pumpsets in their study area. Due to improvements in rural power supply in parts of eastern UP in last few years[2], we were able to find villages dependent mainly on electric pumpsets in Mau, Ghazipur and Faizabad districts. We selected 6 villages from 5 districts of eastern UP out of which 3 were dependent entirely on diesel pumpsets and other 3 on electric pumpsets for irrigation.

In the sample, we also included 72 water buyers because they are the dominant category in UP's

[1]The research covered by this IWMI-Tata Research Highlight was carried out with generous support from Sir Ratan Tata Trust, Mumbai under IWMI-Tata Water Policy Program. The research paper can be downloaded from the IWMI-Tata Website http://www.iwmi.org/iwmi-tata.

[2]Recent data suggests a reversal in the trend towards dieselization in eastern UP with the proportion of electric pumpsets again on rise even if only marginally.

Table 1: Sampling Plan

Village (District)	Diesel Pumpset	Electric Pumpset	Water Buyers
Audwalia (Siddharthnagar)	18	0	11
Darhiya (Gorakhpur)	13	0	14
Dhanaiya (Gorakhpur)	12	0	8
Bhavanpur (Mau)	0	11	14
Devkathia (Ghazipur)	1	18	11
Dilawarpur (Faizabad)	4	11	14
Total	**48**	**40**	**72**

Table 2: Farm Size Category-wise Pump-ownership Pattern in our Sample

Land Holding Size Category	Diesel Pumpset	Electric Pumpset	Water Buyers
Sub-Marginal (< 0.5 ha)	12	0	38
Marginal (0.5-1.0 ha)	12	5	12
Small (1-2 ha)	6	18	17
Medium (2-4 ha)	10	10	5
Large (> 4 ha)	8	7	0
Total	**48**	**40**	**72**

agriculture, irrigating 59 percent of the estimated area under five major crops. Our contention is that the water buyer's cost of irrigation is more sensitive to the price structure of energy than pump-owners. Therefore, even if power subsidy benefits pump-owners (who are often large and medium farmers) more, its absence hurts poor sub-marginal and marginal water buyers the most.

Marginal and sub-marginal farmers own half of all diesel pumpsets in the sample while electric tubewell ownership shows a definite elitist bias as no sub-marginal farmer and only 5 marginal farmers owned electric pumpsets. This trend is also visible in a state-level survey conducted by NSSO in 1999 (Table 3). Besides the relatively higher cost of installation, the need to extract favors from the electricity board, which sub-marginal and marginal farmers find quite difficult, might be a possible reason for this skewness in the ownership pattern of electric pumpsets.

Source of Energy, Cost Structure of Irrigation, and Groundwater Markets

Uttar Pradesh is one of the only five major states of India where the number of diesel pumpsets exceed the number of electric pumpsets. West Bengal, Bihar, Orissa, and Rajasthan are other states.

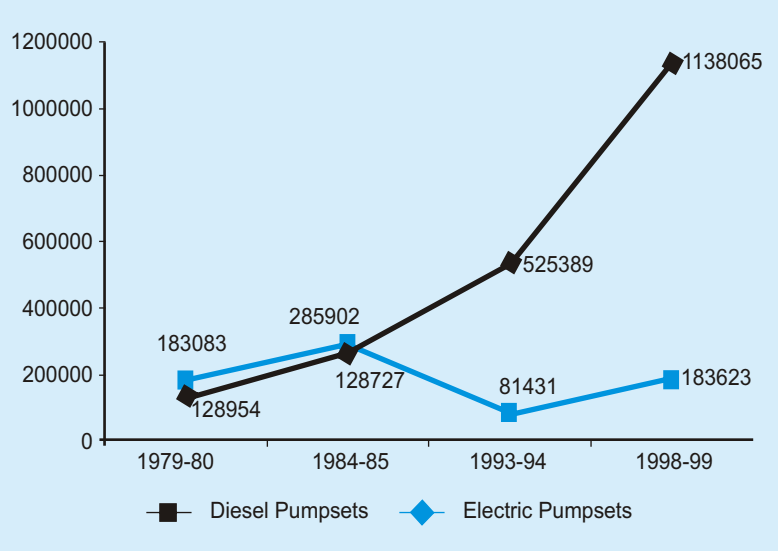
Rural areas of eastern UP experienced deterioration in power supply in the 1980s and 1990s. Therefore, a large number of farmers own diesel pumpsets today and the share of diesel pumpsets has increased over the years. In fact, there were more electric pumpsets in eastern UP till 1985 (52.5 percent of total pumpsets). However, since 1980, the proportion of electric pumpsets has declined from 58.7 percent to 13.4 percent (Figure 1). At the state level also, UP is one of the only five major states of India where the number of diesel pumpsets exceed the number of electric pumpsets. West Bengal, Bihar, Orissa, and Rajasthan are other states.

Table 3: Landholding Class-wise Electric and Diesel Pump ownership in Uttar Pradesh

Landholding size category	< 0.01 ha	0.01-0.2 ha	0.02-0.5 ha	0.5-1 ha	1.1-2.0 ha	2.1-4.0 ha	4.1-10.0 ha	>10.1 ha
Ratio of diesel to electric pump ownership	11.1	6.6	5.3	5.7	5.3	3.2	2.9	1.9

Source: NSSO, 1999

Figure 1: Progressive Dieselization and De-electrification of Groundwater Pumping in Eastern UP



Source: Table 4 in Pant (2004)

Variable cost of irrigation is very high when water is pumped using diesel as a source of energy. This even when the groundwater table is shallow and energy intensity of groundwater irrigation (units of energy required to pump unit volume of water) is quite low as in eastern UP. The fuel cost of producing 1 kWh of energy through a diesel pumpset is about Rs. 7.00[3]. Taking an average discharge of 35 m^3/hour in the region; cost of irrigation is about Re. 0.85/m^3 for pump owners and Rs. 1.42/m^3 for water buyers which is quite high compared to what farmers pay in most other regions of India.

Variable cost and monopoly power are key determinants of price at which water is sold in the water market. Monopoly power, among other things, is influenced a great deal by the cost structure, i.e. ratio of fixed and variable cost in the operational cost. Large fixed operating costs (*operating leverage*) means that breakeven sales volume is high; every additional unit of sales beyond the breakeven point essentially represents straight operating profit to the entrepreneur and a change in volume of sales results in more than proportional change in operating profit or loss. Against that, high variable costs and low fixed costs mean low pressure and poorer incentives for increasing capacity utilization. Monopoly power is high when variable cost is high and fixed cost is low. In the case of diesel pumpsets in eastern UP; while the variable cost is very high, the fixed cost is quite low because of low capital investment required for installation of water extraction systems (pumpsets plus tubewells) and longer life of wells and pumpsets. High monopoly power of pump owners results in water buyers paying Rs. 25-30 per hour over and above the marginal cost of pumping in diesel pumpset dominated villages. This may be the probable reason why even marginal and sub-marginal farmers are inclined to have a pumpset of their own resulting in high pump densities in such villages. High price of water leads to lower demand for irrigation. Thus the cost structure of groundwater pumping from diesel pumpsets explains why average pumpage rates of diesel pumpsets is much lower (Table 4) and owners are not adopting an aggressive price-cutting strategy to increase pumpage. It also explains increasing investment in pump capital, notwithstanding the low capital use efficiency.

From a purely operational point of view, one would have expected pump density to be higher and pumpage to be lower for electric pumpsets since they have to cope with rationed and uncertain power supply. However, in our sample, villages depending mainly on electric pumpsets had much lower pump density (Table 4). This difference is there even when farmers, pump owners as well as water buyers, in villages with electric pumpsets use more hours of irrigation per acre of land.

Annual pumpage data in Table 4 shows that capacity utilization of electric pumpsets was much higher than diesel pumpsets which are operated for just about 200-400 hours in a year compared

[3]Diesel price taken at Rs. 26/litre; 1 litre diesel is burned by a 5 hp pumpset in an hour.
It is assumed that a 5 hp diesel pumpset is equivalent to a 3 hp electric pumpset. This assumption is justified because of inherent differences in efficiency of the two types of pumpsets: 15-30 percent for diesel pumpsets and 40-60 percent for electric pumpsets
[4]A pump-owner in Mehsana in north Gujarat pays just about Re. 0.75/m^3 for water when the pump discharge is only 1.17 m^3/hp while it is about 10 m^3/hp in eastern UP.

Table 4: Breadth, Depth and Efficiency of Water Markets

Village	No. of electric tubewells in village	No. of diesel tubewells in village	Pump density (No./ 100 acre)	Annual pumpage* (hours)	Purchase/ buyer/ acre of NSA* (hours)	Electric tubewell water rate* (Rs/hour)	Diesel tubewell water rate* (Rs/hour)
Audwalia	1	42	10.75	415.72	30.11	40	60
Darhiya	0	60	15.71	210.83	52.25	-	60
Dhanahiya	0	33	24.39	269.82	40.62	-	60
Bhavanpur	12	6	3.51	1423.29	85.4	15-20	50
Devkathia	65	20	3.15	2444.29	62.1	12	40
Dilawarpur	10	5	10.40	1045.29	70.4	15-20	50

* For the sample
Source: Primary Survey

to 1000-2450 hours of operation of electric pumpsets. It is clear that electric pumpsets run longer hours, irrigate more areas, and serve larger number of farmers in spite of electricity supply rationing and uncertainty. This difference between the two types of pumpsets is visible even within the same village. For example, in Dilawarpur in Faizabad district, yearly operation of electric and diesel pumpsets was 1142 hours and 500 hours respectively. Similarly, average hours of water selling were 642 hours and 250 hours for electric and diesel pumpsets respectively. It is important to note here that hours of water selling by electric pumpsets are not only higher in absolute terms but also as proportion of total hours of pump operation. This is notwithstanding the fact that a large number of diesel pump owners are marginal and sub-marginal farmers with minimal self-requirement while electric pumpsets, in general, are owned by relatively larger farmers with greater self-requirement.

Diesel pump owners sell water at prices three to four times higher than electric pumpsets. Another important point to notice here is that pump density in the village seems to have had no influence on the going price of water in the village water market. It is more or less the same for the same category of pumpsets across the villages. This suggests that increase in pump density is not resulting in increased competitiveness and efficiency in the water market. Time line data of cost of pumping and water price in UP and Bihar also show the persistence of high monopoly rents in diesel pumpset dominated water markets in spite of significant increase in the number of pumps. Monopoly power measured as a ratio of water price to the variable cost of pumping has come down and today a one rupee rise in diesel price leads to a lower increase in water price than before. But if we calculate the monopoly rent transferred from water buyers to water sellers per hour of water selling as the difference between the water price and the long run marginal cost of pumping, we find that it has not changed significantly in real terms.

While increased diesel pump density does not lead to reduced monopoly rents, presence of electric pumpsets in the village does. In villages where the market is dominated by electric pumpsets (like Bhavanpur, Devkathia, and Dilawarpur), water price of diesel pumpsets is lower by Rs. 10-20/hour. This is so even when diesel pumpsets operate in parts of a village which do not have option of purchasing water from electric pumpsets. This shows some evidence of the village specific character of water market and the morality of the village boundary. At the same time, the only electric pumpset owner in Audwalia charged Rs. 40/hour: almost double the price charged by similar operators in other villages.

Does the Differential Cost of Irrigation Make a Difference?

Farmers in our sample can be arranged according to their cost of groundwater irrigation: electric pump owners, water buyers from electric pumpsets (ETW buyers), diesel pump owners, and water buyers from diesel pumpsets (DTW buyers) in ascending order. Electric pump owners incur the lowest cost of irrigation while buyers from diesel pumpsets pay the highest price. In terms of cost of pumping, buyers in villages with good electricity supply are better off than pump owners in villages where diesel pumps are the only source of irrigation.

We looked at the irrigation use pattern of all the four groups of farmers. Access to irrigation also influences the use of chemical fertilizers and hence has a more significant impact on crop yields. Accordingly, we also looked at the difference in use of fertilizers and the average yields received by different groups of farmers in our sample. Total irrigation use per acre of both wheat and paddy is the highest for electric pumpset owning farmers who get the cheapest irrigation and the lowest for water buyers from diesel pumpsets whose cost of irrigation is the highest. Among water buyers, ETW buyers with cheaper access to irrigation use more water. Fertilizer use and crop yields also follow the same pattern. Therefore, the cost of irrigation does seem to make a significant difference to the use of irrigation and complementary inputs and hence crop productivity. Several studies on water markets have shown water buyers using less irrigation but having higher productivities implying that higher marginal cost of irrigation induces buyers to make more economical use of water and complimentary inputs. Our data and data from several other recent studies in the area betray this pattern. Water buyers are systematically found to be having significantly lower yields than pump owners suggesting that water buyers are overeconomizing on the cost of irrigation. This may have resulted because of a steep rise in diesel price (and hence water price) in last few years resulting in widening of the gap in cost of irrigation between diesel pump owners and their water buyers. In the case of ETW buyers, poor control over timeliness of irrigation might be a possible reason for lower yields.

We also found that cost, though important, is not the only factor, as is evident from comparing diesel pump owners and water buyers from electric pumpsets. Diesel pump owners' cost of irrigation is almost double that of ETW buyers and accordingly they use less hours of irrigation in both paddy and wheat. But they use higher amounts of chemical fertilizers and get higher yields. This means that their water as well as land productivity is higher than ETW buyers. We think that this difference is because of diesel pump owners' better control over irrigation. Power supply is rationed and erratic in eastern UP and water buyers are the residual users in the sense that the pump owners give first preference to their

Table 5: Irrigation, Fertilizer Use and Crop Yields for Different Categories of Farmers

Farmer category	Cost of irrigation* (Rs/hour)	NPK use (Kg/acre of NSA)	Paddy			Wheat		
			No. of irrigation	Total hrs /acre	Yield Q/acre	No. of irrigation	Total hrs /acre	Yield Q/acre
ETW Owner (40)	5-7	197.93	4.54	58.28	16.67	2.73	31.06	14.54
ETW Buyer (23)	12-20	138.94	3.81	49.08	14.42	2.61	25.43	13.34
DTW Owner (45)	35	157.81	3.22	38.06	18.91	2.09	22.76	14.06
DTW Buyer (46)	60	122.33	2.53	26.88	14.75	2.11	22.09	11.58

Figures in brackets in the first column show the number of farmers in the sample in each category.
* This includes only cost of fuel, repair and maintenance cost, and operator's wages.
Source: Primary Survey

own irrigation. Therefore, access to irrigation for ETW buyers is cheaper but of a rather indifferent quality which also makes difference to productivity. Similar results were obtained on comparing electric and diesel pump owners in Kheralu, Gujarat.

In the case of paddy, yields obtained by diesel pump owners and DTW buyers were more than the electric pump owners and ETW buyers respectively even when they (irrigators with diesel pumps) used less irrigation. This was because the districts in our sample with diesel pumps as the dominant mode of irrigation get higher rainfall and are known for favorable agro-climatic conditions for paddy. The need for irrigation in the kharif season is lower and, in years with good and timely rainfall like 2003, marginal contribution of irrigation to yield becomes less important. However, even in good rainfall years, this contribution is not insignificant as is evident from lower yield obtained by buyers in both regions. Also the yield gap between pump owners and water buyers is higher in the region with diesel pumps as the dominant mode of irrigation. Cheaper access to groundwater irrigation is likely to encourage farmers to go for early sowing of paddy without waiting for early monsoon rains which in turn will improve the productivity of the paddy-wheat cropping system.

We would like to note here that while farmers with cheaper access to irrigation used more irrigation and got higher yields, they did not go for more water-intensive crops or more intensive cultivation of land. Paddy-wheat was the dominant cropping system for almost all farmers in our sample. Third crop was rare and often limited to a very small part of the total landholding even for those who had access to cheap irrigation through electric pumpsets. Clearly, the region faces other constraints to increased intensification of agriculture apart from cost of irrigation.

Policy Implications

A recent large scale national sample survey on cultivation practices and several other recent surveys including the current one clearly show universal access to groundwater irrigation in eastern UP. Now, the challenge is to improve the terms of access for large number of water buyers in the region to ensure more intensive groundwater use on equitable terms. Our study shows that, with diesel pumpsets as the dominant mode of irrigation, increasing pump density does not lead to increased competitiveness and efficiency in water markets. Utilization of additional capacities remains quite low and groundwater use intensity also does not improve significantly. A change in the cost structure of groundwater pumping that increases the fixed cost and hence the operating leverage of pump enterprises might be helpful. This can be achieved by shifting to electricity as a source of energy for groundwater pumping.

We also find that water buyers' cost of irrigation is more sensitive to price and price structure of energy than that of pump-owners. Therefore, even if power subsidy benefits pump-owners (who are often large and medium farmers) more, its absence and hence dependence on diesel pumpsets hurts poor sub-marginal and marginal water buyers the most.

If we assume that with the shift to electricity as a source of irrigation, total hours of irrigation per acre of land under the paddy-wheat cropping system for current DTW buyers becomes at least as high as that of DTW owners (i.e. 60 hours/year) and they pay same water price as paid by current ETW buyers (Rs. 20/hour), increase in net returns only on account of savings in irrigation cost would be about Rs. 1750/acre. This is about 20-25 percent of the per acre net returns of modal group of farmers in the region. Increase in returns owing to increased yield will be over and above this. Clearly, moving from diesel to electricity as a source of energy for irrigation can have significant pro-poor impact in the region. Since UP has the largest number of water buyers in the country with two-thirds of all its irrigators and 57 percent of all food crop cultivators as water buyers, the redistributive impact of such a shift will be most widespread here.

HEADQUARTERS
127, Sunil Mawatha, Pelawatte, Battaramulla, Sri Lanka
Mailing Address : P. O. Box 2075, Colombo, Sri Lanka
Telephone : +94 11 2787404, 2784080
Fax : +94 11 2786854; E mail : iwmi@cgiar.org

REGIONAL OFFICE FOR SOUTH ASIA
C/o ICRISAT, Patancheru 502324
Andhra Pradesh, India
Telephone : +91 40 30713071
Fax : +91 40 30713074; E mail : iwmi-southasia@cgiar.org

NEW DELHI
South Asia Liaison Office
2nd Floor, NASC Complex, DPS Marg
PUSA Campus, New Delhi 110012, India
Telephone : +91 11 25840811-2
Fax : +91 11 25841294; E mail : b.sharma@cgiar.org

NEPAL
Department of Irrigation, Room # 412 and 413
Jawalkhel, Lalitpur
GPO 8975 EPC 416, Kathmandu, Nepal
Telephone : +977 1 5542306
Fax : +977 1 5536219; E mail : d.pant@cgiar.org

CHINA
Center for Chinese Agricultural Policy
Chinese Academy of Sciences
Building 917, Datun Road, Anwai
Beijing 100101, China
Telephone : +86 10 64889440
Fax : +86 10 64856533; E mail : i.makin@cgiar.org

REGIONAL OFFICE FOR CENTRAL ASIA (Pakistan)
12KM, Multan Road, Chowk Thokar Niaz Baig,
Lahore 53700, Pakistan
Telephone : +92 42 5410050-53
Fax : +92 42 5410054; E mail : iwmi-pak@cgiar.org

REGIONAL OFFICE FOR CENTRAL ASIA (Uzbekistan)
Apartment No. 123
Home No. 6, Murtazaeva Street,
Tashkent 700000, Uzbekistan
Telephone : +998 71 1370445
Fax : +998 71 1370317; E mail : m.hassan@cgiar.org

REGIONAL OFFICE FOR SOUTHEAST ASIA
P. O. Box 1025, Kasetsart University,
Bangkok 10903,Thailand
Telephone : +66 2561 4433
Fax : +66 2561 1230; E mail : iwmi-sea@cgiar.org

REGIONAL OFFICE FOR AFRICA
Private Bag X813, Silverton 0127, Pretoria, South Africa
Telephone : +27 12 845 9100
Fax : +27 12 845 9110; E mail : iwmi-africa@cgiar.org

SUB REGIONAL OFFICE FOR WEST AFRICA
IWMI Ghana, PMB CT 112, Cantonments, Accra, Ghana
Telephone : +233 21 784752-4
Fax : + 233 21 784752; E mail : iwmi-ghana@cgiar.org

IWMI-Tata Water Policy Program

The IWMI-Tata Water Policy Program was launched in 2000 with the support of Sir Ratan Tata Trust, Mumbai. The program presents new perspectives and practical solutions derived from the wealth of research done in India on water resource management. Its objective is to help policy makers at the central, state and local levels address their water challenges – in areas such as sustainable groundwater management, water scarcity, and rural poverty – by translating research findings into practical policy recommendations.

Through this program, IWMI collaborates with a range of partners across India to identify, analyse and document relevant water-management approaches and current practices. These practices are assessed and synthesised for maximum policy impact in the series on Water Policy Research Highlights and IWMI-Tata Comments.

The policy program's website promotes the exchange of knowledge on water-resources management, within the research community and between researchers and policy makers in India.

IWMI-Tata Water Policy Program
Elecon, Anand-Sojitra Road
Vallabh Vidyanagar 388120, Gujarat, India
Telephone: +91 2692 229311-13
Fax : +91 2692 229310
E-mail: iwmi-tata@cgiar.org
Website: http://www.iwmi.org/iwmi-tata

IWMI
International
Water Management
Institute

FUTURE
HARVEST
IWMI is a Futures Harvest Center
Supported by the CGIAR