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Research Report

Wells and Welfare in the Ganga Basin: Public Policy and Private Initiative in Eastern Uttar Pradesh, India

Tushaar Shah

International Water Management Institute

Research Reports

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Abbreviations and Acronyms

BPL	Below Poverty Line
CSE	Center for Science and Environment
DRDA	District Rural Development Agency
DTW	Deep Tube Well
ETW	Electric Tube Well
FBS	Free Boring Scheme
GI Pipes	Galvanized Iron Pipes
GMB	Ganga-Meghana-Brahmaputra
GOI	Government of India
GoUP	Government of Uttar Pradesh
ha-m	hectare-meter
h/yr.	hours per year
HYV	High-Yielding Varieties
IRDP	Integrated Rural Development Program
IRR	Internal Rate of Return
KWh	kilo Watt hour
LI	Lift Irrigation
lps	liters per second
NABARD	National Bank for Agriculture and Rural Development
NBTDP	North Bengal Terai Development Project
OAIC	Orissa Agro-Industries Corporation
OLIC	Orissa Lift Irrigation Corporation
ORG	Operations Research Group
PTW	Public Tube Well
SC	Scheduled Castes
SEB	State Electricity Board
ST	Scheduled Tribes
STW	Shallow Tube Well
TERI	Tata Energy Research Institute
TWO	Tube-Well Owner
UP	Uttar Pradesh
yr.	Year

Summary

Eastern India is home to 88 million, or nearly a third of India's rural poor. Although its industrial economy has stagnated, the region offers vast scope for accelerated development of irrigated agriculture based especially on groundwater wells. While much of South Asia suffers from acute overexploitation of groundwater resources, eastern India has over one-fourth of India's usable groundwater resources; and less than one-fifth of it is developed. Stimulating groundwater development in the region is not only central to creating livelihoods and welfare for its poor but also to addressing its syndrome of extensive waterlogging and flood-proneness.

This report analyzes how public policies designed to promote groundwater development over the past 50 years have failed in their promise, and how initiative by private agents can generate the social welfare the region needs so direly. The report outlines a five-pronged strategy for attacking eastern India's rural poverty through fuller utilization of its groundwater resources. First, eastern India needs to scrap its existing minor irrigation programs run by government bureaucracies, which gobble up funds but deliver little irrigation. Second, while the electricity-supply environment is in total disarray, innovative ideas—such as decentralized retailing and metering of power and prepaid electricity cards—need to be piloted as part of a broader initiative to improve the quality of power supply to agriculture. Third, programs are needed to improve the unacceptably low energy-efficiency of electric as well as diesel pumps. Fourth, there is a need to promote diesel pumps under 5-hp and improved manual irrigation technologies such as treadle pumps. Finally, above all else, east Indian States need to reform their pump subsidy schemes à la Uttar Pradesh (UP) so as to ameliorate the scarcity of pump capital that lies at the heart of the problem.

Wells and Welfare in the Ganga Basin: Public Policy and Private Initiative

Tushaar Shah

Backdrop

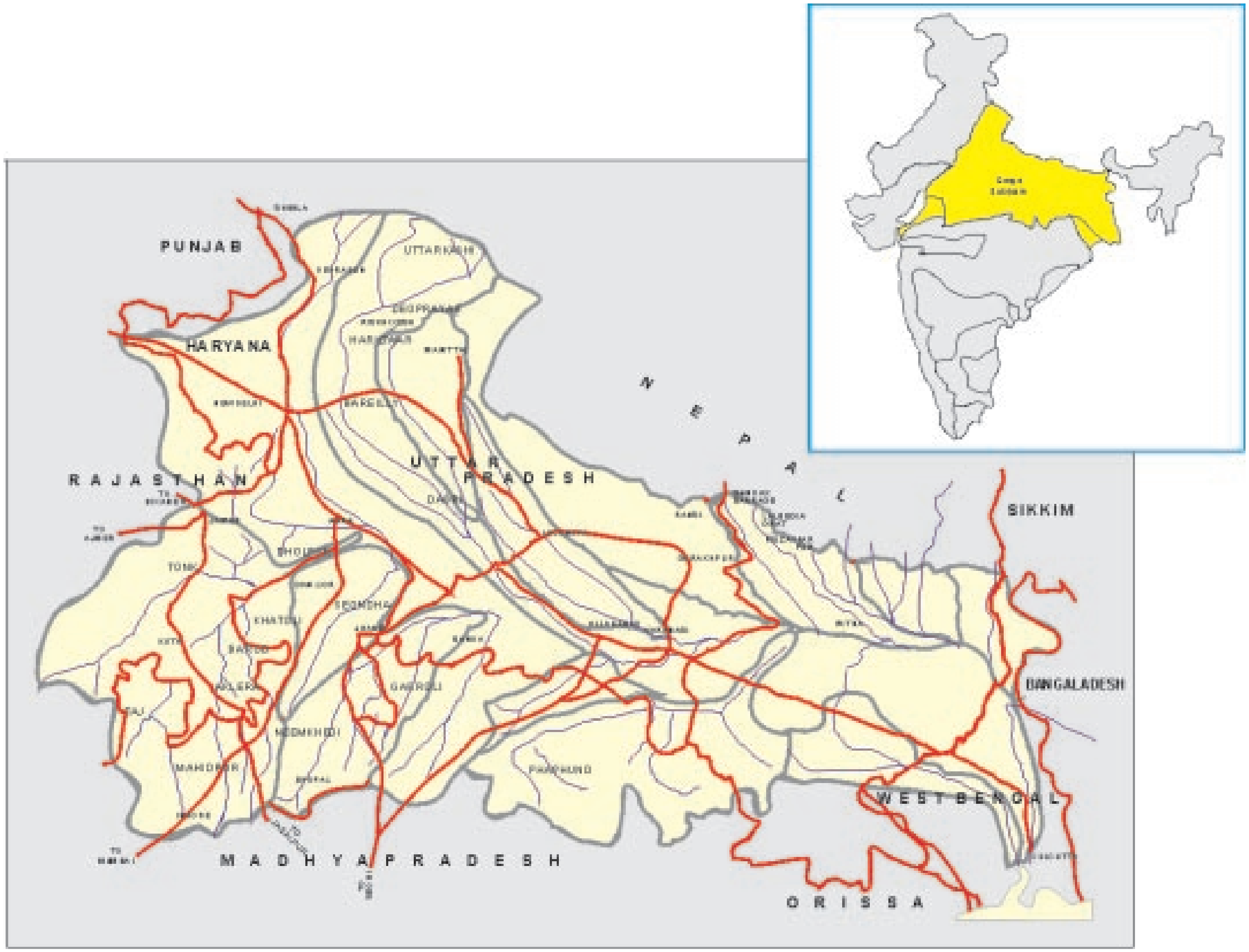
Eastern India, especially the 15 eastern districts of UP and the entire States of Bihar, West Bengal and parts of Orissa constitute a significant chunk of the Ganga-Meghna-Brahmaputra (GMB) basin that encompasses, in addition, all of Bangladesh and the terai areas of Nepal. The problem this report deals with and the strategy outlined to respond to it are analyzed in the east India context; but the analysis applies with equal force to the terai areas of Nepal as also to much of Bangladesh. The GMB basin has fertile lands, but very high population pressure (at over 830 for Bangladesh and over 600 for eastern India in 1991 compared to 285 for India as a whole) and, according to some estimates, the basin is home to 500 million people, many of whom are among the world's poorest.[1] The region is marked by high dependence of its predominantly rural population on smallholder agriculture and wage labor. In 1991, in Bihar and eastern UP, the proportion of the population dependent on agriculture was 79% compared to 66.7% for India as a whole. While western UP, Haryana and the two Punjabs (Indian and Pakistan) underwent massive agrarian transformation during the 1960s, agrarian growth in the eastern areas of India remained stagnant. A district-wise analysis of agricultural growth in India by Bhalla and Singh (1997) shows that during 1963–93, the productivity per male agricultural worker crossed the Rs 10,000 barrier in much of India;[2] but most of eastern India was not a part of it. The only region of eastern India that seems to be crossing the barrier is eastern UP (figure 1).

Eastern UP, the western-most part of eastern India and the GMB basin, is an interesting study because it has just managed to break out of its agrarian stagnation. It is also interesting because its transformation over the past 15 years has been energized largely by the rapid—and much needed—development of small-scale groundwater irrigation; and offers critical lessons about how the rest of the basin can trigger off its belated Green Revolution. The present analysis of eastern India—with particular focus on eastern UP—is essentially a study in political economy and practical policy. It is about how major public policy initiatives have actually impeded groundwater development rather than accelerating it; and how spontaneous market responses of a multitude of private economic agents produced the social welfare that public programs failed to produce. The overarching lesson is that the seeds of an effective strategy for groundwater-led

[1]These estimates seem plausible; eastern India's area of 348,000 square km is 10.6% of India's total area but its 260 million people are over a fourth of the Indian population. Add to this Bangladesh's 280 million, and we already have over 500 million.

[2]In 1993, US$1.00=Indian Rs 33.63.

FIGURE 1.
The Ganga basin.



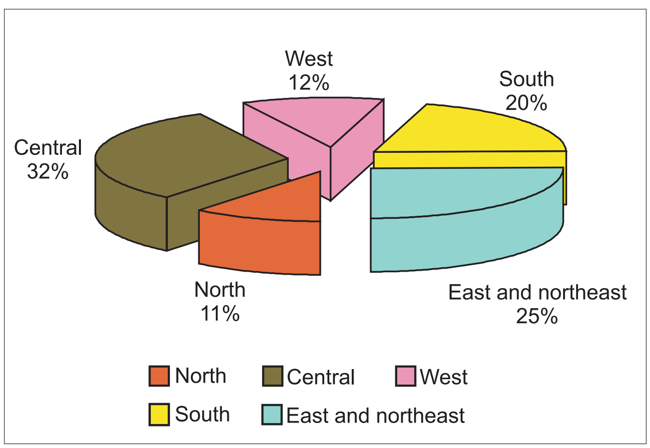
agricultural development for all of eastern India—and the GMB basin—are embedded in the lessons offered by the experience of eastern UP. In the second to the fifth sections our focus then is on learning lessons from eastern UP. In the last two sections, we explore their implications for eastern India as a whole and evolve a five-point strategy to stimulate groundwater irrigation for livelihood creation in the Ganga basin.

Groundwater Resources of Eastern India

There are abundant surface water and groundwater resources in eastern and northeastern India. Figure 2, based on estimates, which have recently been revised upward, prepared by India's Central Groundwater Board, suggests that of the total usable recharge of 325 km^3 for India as a whole, 25%, or over 80 km^3 are available to eastern and northeastern India. These values exclude 16 districts of eastern UP. If these were included, eastern India's groundwater resources would increase further to 92 km^3. Less than one-fourth of this resource is in use at present.

The groundwater resources of UP are abundant; its surface irrigation potential is estimated at some 13–14 million ha; but groundwater irrigation potential is estimated at over 20 million ha, taking the total irrigation potential to 33–34 million ha.[3, 4] All of UP falls in the piedmont zone of the Himalayas skirted

FIGURE 2.
Regional distribution of India's usable groundwater recharge of 325 km2.

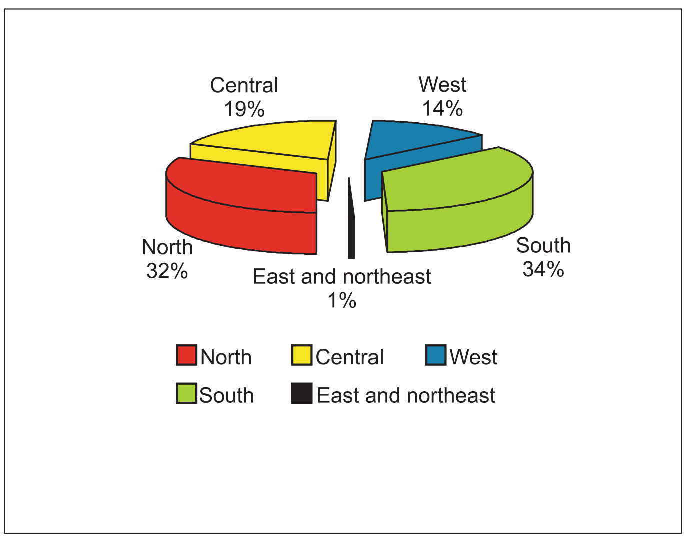


[3]The State's annual average precipitation is 33 million ha-m; after making allowances for evaporation losses, the share of other States, requirements of industry, commercial and domestic users and others, it has a surface irrigation resource potential of 14–15 million ha-m and the total groundwater resources are estimated at 8.5 million ha-m, all of which is nearly one-fifth of the all-India potential estimated at 43.18 million ha-m (GOI 1996:9). After allowing 15% of the gross recharge for nonagricultural uses, the net recharge available for irrigation is 7.74 million ha-m. Because of its inefficiency, surface water is estimated to be capable of irrigating 13.7 million ha (with a delta of well over 1 meter). In contrast, UP's groundwater resources can irrigate around 20.3 million ha (with a delta of 0.38 m), taking the ultimate irrigation potential of the State to 34 million ha.

[4]The UP State Groundwater Department monitors groundwater levels through a network of 4,000 hydrograph stations including 500 shallow piezometers located throughout the State except the hill areas (GoUP 1996b).

by an artesian belt under free-flowing conditions extending from Jammu and Kashmir in the west to Tripura in the east. "The hydrological environment and groundwater regime conditions in the Indo-Ganga-Brahmaputra basin indicate the existence of an enormous fresh groundwater reservoir at least down to 600 m or more below land surface. Bestowed with high incidence of rainfall, this groundwater reservoir gets replenished every year, the average annual recharge throughout the GMB basin ranging from 50 to 75 cm. Apart from the vertical recharge, substantial recharge occurs through horizontal absorption of water through the Bhabhar zone, a 10–20 km wide strip of highly pervious formation in the Himalayan foothills through which all Himalayan rivers must pass. The alluvial aquifers to the explored depth of 600 m have transmissivity values from 250 to 4,000 m^2/d and hydraulic conductivity from 10 to 800 m/d. Well yields range up to 100 lps and more but yields of 40–100 lps are common..." (GOI 1996:3). Overall, then, while peninsular India is searching for effective ways to control groundwater overexploitation, the need of eastern UP, as indeed of the rest of eastern India, is to step up the utilization of abundant groundwater resources for wealth creation and poverty alleviation. Of India's 7,063 blocks,[5] 599 are dark.[6] Figure 3 shows that only 1% of these are in eastern and northeastern India. Similarly, figure 4 sets out the distribution of white, gray and dark blocks in different subregions of UP. For UP as a whole, less than 2.5% of the blocks are designated dark; and nearly 80% are denoted as white, offering much scope for

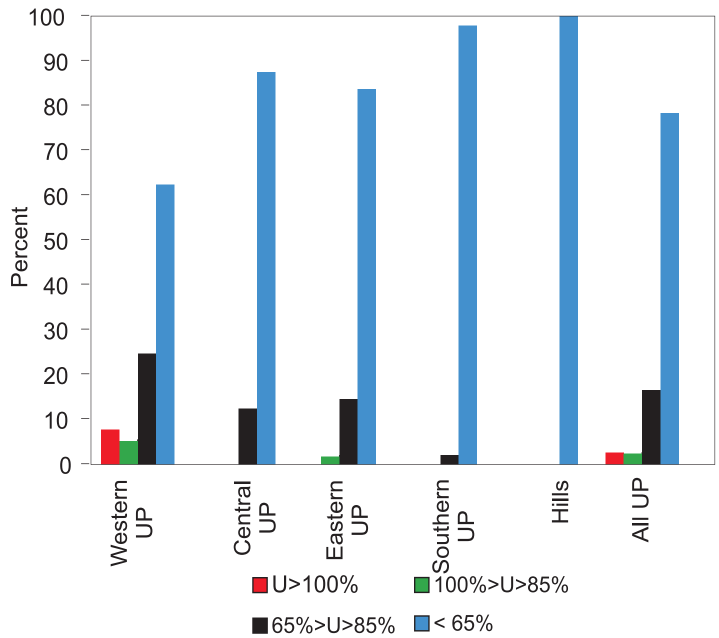
FIGURE 3.
Regional distribution of India's 599 'dark' blocks with over 85% groundwater development.



[5]A "block" consists roughly of 100 villages; and it is a basic geographic unit between a village and a district.

[6]In India, the groundwater administration classifies blocks under three categories based on the extent of groundwater development. Blocks where groundwater draft is less than 65% of the available resources are categorized as "white;" those with between 65% and 85% development are classified as "gray;" and those with more than 85% development are classified as "dark." While new groundwater development is strongly discouraged in dark areas it is encouraged in "white" areas.

FIGURE 4.
Uttar Pradesh: Distribution of blocks (%) according to level of groundwater utilization in relation to available net recharge.



tapping unutilized irrigation potential. Eastern UP offers even greater promise: 289 of its 345 blocks (84%) are white; 50 (14%) are gray and just 6 (2%) are designated dark. The problem of overdevelopment is more acute in Western UP where groundwater irrigation has developed faster than in other parts of UP over the past two decades.

If anything, this already abundant groundwater recharge of eastern UP is only further augmented by newly developed canal irrigation. A good deal—in fact, nearly one-fourth—of UP's groundwater recharge is contributed by canal irrigation, according to the estimates by the State Groundwater Department (GoUP 1996b); however, this proportion is probably even higher, for water losses through seepage are estimated to be 75% in many systems with unlined canal distributary networks. In this flood-prone region, floodwaters too contribute to recharge as do the shallow water tables to which recharge gets added.

All in all, the available irrigation potential, estimated using liberal norms for water requirements of crops, is 1.33 times the State's 1991 gross cropped area of 25.5 million ha, offering ample scope for raising the State's overall average cropping intensity from the present 148% to 200%, or even more, since the bulk of the unutilized potential is in groundwater. Already, 6 out of the 13.7 million ha potential of surface irrigation are utilized; but only 6 million ha of the 20.3 million ha (gross) of available groundwater potential are used, leaving room to bring over 14 million ha more under groundwater irrigation. The potential for further groundwater development is even greater further eastward, as in north Bihar and north Bengal where the available recharge is as great as or greater than—but whose utilization is far lower than—in eastern UP.

The Case for Stimulating Groundwater Development in Eastern India

There are compelling reasons for stimulating rapid and fuller development of groundwater resources in eastern India: first, it can be an important part of a strategy for correcting the regional imbalance in the development of the east versus the west; second, it can be a direct response to the region's rural poverty; third, undeveloped, the region's high pre-monsoonal groundwater table accentuates its condition of flood-proneness and waterlogging.

Eastern India constitutes the bulk of India's "poverty square." It is largely rural, predominantly agricultural, and has a high population density. As a microcosm of eastern India, this east-west development dichotomy is apparent in UP, too. While western UP forged ahead with the Green Revolution in the 1960s and 70s, eastern UP lagged behind in most respects (table 1). The region needs a strong push in its agriculture sector to promote wider spread of the High-Yielding Variety (HYV) seed technology, more crops under irrigated conditions, cropping pattern diversification in favor of high-value crops and a large summer crop which is by and large nonexistent.

Northern India's Green Revolution has generally been credited to early public investments made in canal irrigation in that region. However, it has also been argued that the rise of the Green Revolution in Punjab, Haryana and western UP was fueled more by the private tube-well revolution; and that its refusal to progress eastward from Lucknow, which divides western from eastern India in the north, is explained by the slow pace of groundwater development in the east (Dhawan 1982). Several reasons explain this: a) many studies—including macro-level—have shown unmistakable evidence that fertilizer use is directly and significantly related to tube-well irrigation (see, e.g., GOI 1985); b) numerous

TABLE 1.
East and West: Regional disparities in agrarian performance in UP, India.

	Eastern UP	Western UP
Population km^2 (1991)	614	602
GW potential as % of gross recharge (1990)	75	67
Gross irrigated area as % of Grass Cropped Area (GCA)	46.9	76.7
% of total irrigated area served by canal (89-90)	29.3	23.4
% of irrigated area served by tube wells (89-90)	63.2	68.8
% of all farmholdings in <1 ha (marginal)	81.3	65
Average size of the marginal holding (ha)	0.32	0.4
Fertilizer use 80-81 (kg/ha)	48.87	57.6
Fertilizer use 89-90 (kg/ha)	80.92	100.53
Wheat yield 80-81 (kg/ha)	14.62	19.4
Wheat yield 89-90 (kg/ha)	18.1	24.52
Paddy yield 80-81(kg/ha)	9.11	14.08
Paddy yield 89-90 (kg/ha)	16.13	21.73
Area under summer crop as % of GCA	2.01	4.42
Area under cash crops as % of GCA 1980–81	10.06	26.85
Area under cash crops as % of GCA 1989–90	10.37	31.61
Gross income per ha of net sown area 1988–89	8,872	11,612

Source: GoUP 1996a.

micro-level studies based on sample surveys show that pump-irrigated farms perform much better compared to those irrigated by any other source in terms of cropping intensity, input use and yields[7] (see, e.g., Dhawan 1985); and c) by common observation, this difference between areas irrigated by private tube wells and those irrigated by gravity flow canals is obviously explained by the superior quality—in terms of reliability, timeliness, adequacy—of irrigation that tube wells offer compared to other sources (Chambers et al. 1987; Shah 1993). As far back as 1985, a study group constituted by India's Planning Commission to explore agricultural strategies in eastern India noted that "one major reason for the low yield levels of eastern region States compared to the rest of India, particularly the chief rice-growing States viz., Andhra Pradesh and Tamilnadu, is the much lower level of irrigation in the former. About three-fourths of the rice area in the eastern region is still cultivated under the uncertain monsoonal conditions affected by floods as well as draughts" (GOI 1985:1).

Finally, increased density of wells can increase the welfare of the people in the eastern region through the powerful positive externality they produce by acting as an antidote to waterlogging and flood-proneness. Much of eastern India, particularly eastern UP, north Bihar, Kuchbehar and Jalpaiguri districts in north Bengal and parts of Orissa are flood-prone. According to the estimates made by the UP Groundwater Department, 3.4 million ha-m of the total 8.42 million ha-m of groundwater recharge that UP gets annually occur from canal irrigation (1.24 million ha-m), surface irrigation reflows (0.69 million ha-m), recharge from tanks, lateral recharge from flood-prone areas and from shallow water-table areas (GoUP 1996b). This surfeit of groundwater recharge increases as one moves from west to east. In eastern UP, vast areas remain inundated by flood waters for the better part of the year, and acute waterlogging characterizes the Saryu-par areas in the middle of the Ganga basin—bordered in the south by the Ghaghra river and spread over Gorakhpur, Maharajganj, Deoria, Siddharthnagar, Basti, Gonda and Bahraich districts. The entire area, which encompasses nearly a tenth of UP, has an acute problem of subsoil water drainage and, consequently, a uniformly high groundwater table at 3–5 meters. Ghaghra, Rapti, and Gandak are notorious flood-creating rivers but even smaller rivers like Rohini, Burhi Rapti, Ami, Kuwano, Gurra, Tons, Kunhra, Ghonghi, Burha Gandak, Chhota Gandak, Taraina too contribute their deluge in flooding the region (Wajih and Kumar nd). Rapti alone inundates 350,000 ha every year in Bahraich, Gonda, Basti, Siddharthnagar and Deoria (Yadav and Lal 1994; nd). Estimates made from remote sensing data of the area under flood inundation and surface waterlogging in eastern UP (within latitudes 26^{0} 0¢ and 30^{0} 0¢ N and longitudes 78^{0} 15¢ and 84^{0} 30¢ E) during September 2–6, 1988 showed that 1.089 million ha—including croplands—were

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[7] Regression equations on survey data typically have low coefficients of determination and large values for the intercept—representing the weight of the omitted variables—indicating some specification problem. Production functions based on a survey of 380 farmers in Gorakhpur, Basti, Deoria, Siddharthnagar and Maharjganj districts of eastern UP conducted by Shah et al. (1997) showed the following results:.

Paddy: $q_p = 4.840 \,.\, F_p^{0.269} \,.\, L_p^{0.128} \,.\, H_p^{0.050}$ $\qquad R^2 = 0.204$

[15.3]** [4.29]** [2.68]** [1.203]

Wheat: $q_w = 4.873 \,.\, H_w^{0.155} \,.\, L_w^{0.124} \,.\, H_w^{0.137}$ $\qquad R^2 = 0.325$

[9.059]** [2.877]** [2.972]** [3.292]**

where, subscripts p and w refer to *kharif* (rainy season) paddy and *rabi* (dry season) wheat, q refers to output/acre (kg); F refers to fertilizer use/acre (kg), L is hired labor/acre (person-days) and H refers to hours of pump irrigation used per acre. R^2 is unacceptable and the intercept term unusually large; t-ratios and the elasticities, however, are significant. The coefficient for irrigation hours was large and highly significant for wheat, that for kharif paddy was small and insignificant, presumably because kharif paddy in eastern UP is predominantly rain-fed.

"completely/partially inundated" and 0.678 million ha had surface waterlogging (Kolavalli et al. 1989: 81). Every year, floods hit over 15% of eastern UP's croplands; and over half of the region has groundwater tables of less than 5 m in the pre-monsoon period (ibid.). According to a study undertaken by the Gorakhpur Environmental Action Group, some 0.398 million ha-m of water are added to the groundwater table every year; of this, only 0.064 million ha-m (around 16%) are abstracted through various irrigation structures. Waterlogging and flood-proneness are aggravated by the large-scale erection of embankments[8] in the Gorakhpur and Deoria districts, which further impede drainage and accentuate waterlogging.[9]

Flood-proneness and waterlogging have hit the lives and livelihoods of people in a myriad ways. Between 1951 and 1981, the area cultivated in kharif in the Gandak River Project command fell from 214,000 ha to 68,000 ha due to annual flooding and surface waterlogging (Yadav and Lal nd). High flood-proneness induces risk aversion; as a result, in these areas, farmers clung to traditional mixed-crop farming technologies, which offered some insurance cover against flood risks and minimized cash costs of cultivation. The tradition of animal husbandry too has been undergoing change due to waterlogging; as grazing lands remain submerged in water for long periods, the population of large bovines has declined. Marginal farmers and landless have increasingly taken to piggery. Flooding and waterlogging have also brought in their wake a variety of health-related disadvantages; incidence of diseases like malaria, Japanese encephalitis and filaria is rampant. Moreover, due to flooding and waterlogging, soluble iodine is washed away or removed by seepage, causing severe iodine deficiency (Wajih and Kumar 1994). Over a third of the *usar* (sodic) lands of UP are largely an outcome of the rapidly rising water tables causing waterlogging conditions in extensive areas of the State. In saline lands, vegetation exists only in kharif and the pH is lower than 8.5; in saline-alkaline lands, the most common variety of usar lands, the presence of a *kankar* pan (layer of limestone and clay) causes water stagnation.

Much has been made of the need to "augment" lean season flows in Ganga; indeed, insufficiency of Ganga waters to meet the summer needs has been a major bone of contention in India-Bangladesh discussions on the sharing of Ganga waters. But as many observers have suggested, such augmentation is outside the realm of feasibility; and the best approach to achieving seasonal water balance is better and more integrated management of the basin as a whole (see, e.g., Ramaswamy 1999:2,296). The centerpiece of such a strategy has to be increased subsurface retention and storage of peak-flows for use in the lean seasons; and the most practical and cost-effective way of doing this is through rapid groundwater development.

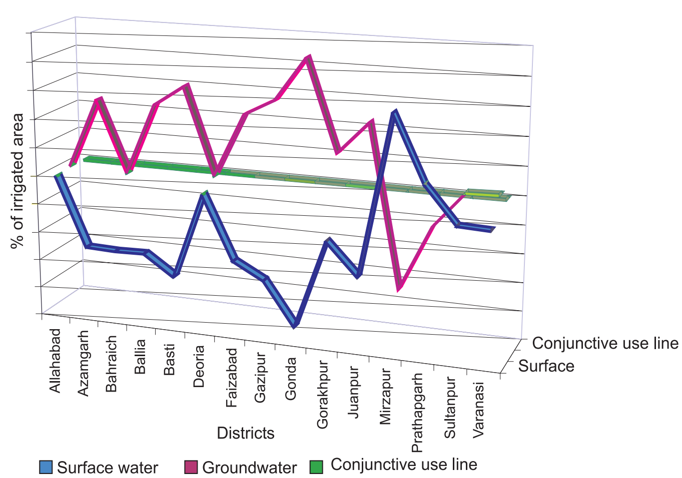
[8]With the coming of embankments, sugarcane has emerged as a popular crop in some parts; however, in recent years, sugarcane cultivators, especially small and politically lightweight ones, have got caught in an infructuous crossfire between the government and sugar mill managements; many sugar mills have closed shutters; and those which continue to operate have to ration the quota of cane supply leading to astronomical premia in the illegal markets for sugarcane supply rights (in the form of *ganne-ki-parchi* [cane purchase indent from sugar factory]).

[9]In Deoria and Gorakhpur districts, the water table has risen over the 1971–91 period by 0.63 m and 0.36 m. In Padrauna, Salempur, Hata and Deoria *tehsils* (blocks) of the undivided Deoria district, waterlogged areas increased by 60–90% over the 1971–91 period due to the Gandak canal system; in Gorakhpur Sadar, Bansgaon, Pharendra and Maharjganj tehsils of the undivided Gorakhpur district, waterlogged areas increased by 65–95% over the same period. The Gandak command has a canal network of over 10,000 km irrigating 55% of the net sown area, and giving 6 km of canals to every square kilometer (Wajih and Kumar 1994). Nearly 0.45 million ha in Sharda Sahayak command and 0.25 million ha in the Gandak command are waterlogged (GOI 1985). Nearly two-thirds of the area irrigated by Sharda Sahayak was waterlogged in 1987; and in 50,000 ha in the Gandak command, the water table depth was just around 1 meter (Yadav and Lal nd).

A major reason for eastern India's waterlogging and flood-proneness is insufficient conjunctive use of groundwater and surface water. Just as excessive groundwater draft results in drying of springs and reduced base-flow in rivers, too little of it adds to the swelling of rivers and streams at peak-flows in the form of "rejected recharge." Ideally, groundwater development should match canal irrigation, especially in ill-drained soils as encountered in much of eastern India; but as figure 5 shows, in eastern UP districts, the development of both groundwater and surface water has lacked this balance. As far back as 1948, a commission appointed by the Government of UP asserted that the flood problems of eastern UP were "due to reduction in the absorptive capacity of the soil" (Yadav and Lal 1994). This "reduction" has been magnified with the development of intensive canal irrigation during the last five decades since then. Particularly after 1950, the laying out of new canal networks, most of them unlined, has resulted in a rapid and persistent rise in groundwater tables that, in turn, has resulted in large areas being waterlogged for 5–6 months after the last of the monsoonal rains. This problem, which has bewitched the entire eastern India, was further aggravated by the construction of countless embankments, first by the erstwhile Zamindaars, and more recently under government programs, which were intended to protect communities and farmlands from flash floods but have been producing exactly the opposite impact (Mishra 1999a; 1999b). As in eastern UP, Bihar's flood-prone area too tripled from 2.5 million ha in 1954 to 6.8 million ha in 1994—which means that 70% of the population in north Bihar, some 30 million people, are at risk from floods every year (ibid.).

Many strategies have been recommended and tried out to deal with the intensification of the flood-proneness and waterlogging in eastern UP as a consequence of the growth of canal irrigation. But there has been growing consensus that the most important long-term strategy to fight flood-proneness is the rapid increase in groundwater irrigation, which will not only lower water tables but also help reduce the intensity of floods and the average period of flooding by enhancing the underground storage for flood waters, canal seepage as well as irrigation reflows. Reviewing the suggestions

FIGURE 5.
Percent of irrigated area served by surface water and groundwater in eastern UP.



made by several experts, the Delhi-based Center for Science and Environment (CSE 1991: 121–122) wrote:

> "…that active development of groundwater reservoirs by extensive irrigation pumping during the dry season can provide substantial capacity to store flood and drainage waters during the wet season. Preliminary calculations made in USA indicate that full development of conjunctive use in the Ganga basin could lead to as much as a 50% reduction in the monsoon flow of the river. Thus groundwater utilization can not only contribute to full realization of the agricultural potential of the region but would also be effective in reducing and preventing waterlogging conditions, which have come to be an imminent threat in considerable tracts of north Bihar [as indeed much of eastern India]. The measure could considerably alleviate the flood problem of the region through provision of underground storage of monsoon flows. [However], the desired development of groundwater in this area has been inhibited by the preponderance of marginal farmers who cannot afford the investment required in installation of tube wells..."

Public Policy: State and Community Tube-Well Program

The preponderance of marginal farmers and their lack of capacity to make tube-well investments have then been the central challenge in stimulating poverty-focused groundwater development in eastern India. And all government and NGO initiatives since 1950 have been designed to respond to this challenge. Early thinking was aimed at organizing the poor for collectively managing an irrigation asset or through an extensive and vigorous public tube-well (PTW) program. Eastern UP offers examples of both these institutional options, although there is only one significant case of tube wells owned and managed by farmer groups. This experiment was promoted in the Deoria district of UP and the Vaishali district in Bihar by a local NGO under the Indo-Norwegian Agricultural Development Project. Niranjan Pant who followed the rise and fall of the farmer-managed tube wells over a period spanning more than a decade, wrote in the early 1980s, "the wells owned and operated by groups of small and marginal farmers were found to be doing a very satisfying job… the management of each tube well was the responsibility of the group of farmers and the group leader…[and they] were quite successful from the point of view of accessibility of groundwater among the resource-poor farmers" (Pant 1984). But when he revisited the groups in Deoria in 1988, "to our dismay, we found many of the groups which existed in 1983 had disintegrated...The main reason... [was that] the commands of the group of tube wells were subsumed under the World Bank tube wells...the World Bank tube-well water was available at a much cheaper rate..." (Pant 1989: 97–98).

A few years later, the PTW program, which had its own shortcomings and which cannibalized the Deoria tube-well groups, itself fell to the predatory onslaught of the booming local pump-irrigation markets. By 1990, there were nearly 30,000 large PTWs strewn all over UP's countryside, constructed with financial support from the Dutch and the World Bank. Its failings however soon began to come to the fore. In the mid-1980s, the PTW program was losing around Rs 650–700 million/yr. (Kolavalli and Shah 1989); in the 1990s, the annual losses exceeded Rs 1,000 million. A new program launched in the late 1970s with World Bank-support promoted several new design features such as dedicated power supply to a cluster of 25 PTWs linked to an independent 11 kV line, buried pipelines, automatic operation of wells, tamper-proof outlets, and the system of *osrabandi* (an arrangement for rotational water supply to irrigators) for water allocation overseen by an elected farmer committee and executed by a part-time operator chosen from the area itself.

This, too, however, failed to arrest the downward spin in the performance of PTWs. They did better than conventional PTWs while they were new. However, as they advanced in age, the performance of the World Bank tube wells declined too. For instance, the average number of hours and area irrigated per tube well fell from 2,304 hours and 77 ha in 1976–77 to 780 hours and 35 ha in 1983–84 (ibid.); the downward spin continued thereafter. A study of the "new design" PTWs in Faizabad, Basti and Deoria districts by Pant concluded that only a third of the farmers in the command could depend upon the PTWs exclusively for their irrigation needs; 60% of the PTWs had nonfunctioning meters; 30% of PTWs did not have farmer committees and in the rest, the committees had seldom met; the performance of tube wells themselves was quite poor compared to what was planned; the highest realizable revenue by PTWs was less than needed to meet the operator's salary (Pant 1989).

Different researchers have found marginally different clusters of reasons explaining the failure of the UP PTW program. Kolavalli and Shah (1989) blamed insufficient and erratic power supply, inadequate conveyance systems, operator-absenteeism, failure of the osrabandi system and poor maintenance as the main reasons. In addition to all these, Pant (1989) also found the organization-design failure to be an important factor: "[operators] thought they were accountable to irrigation officials rather than to command farmers or to the Tube-Well Management Committee. Consequently, the distribution was done more or less in an arbitrary manner. The core component of water distribution system such as osrabandi, opening of one outlet at a time in a loop and beneficiary involvement were conspicuous by their absence." (Pant 1989:100). Palmer-Jones (1995: iv) concluded that, quite apart from the complex institutional issues, "DTWs were and are an inappropriate technology for the social and economic conditions encountered in developing countries of South Asia…"

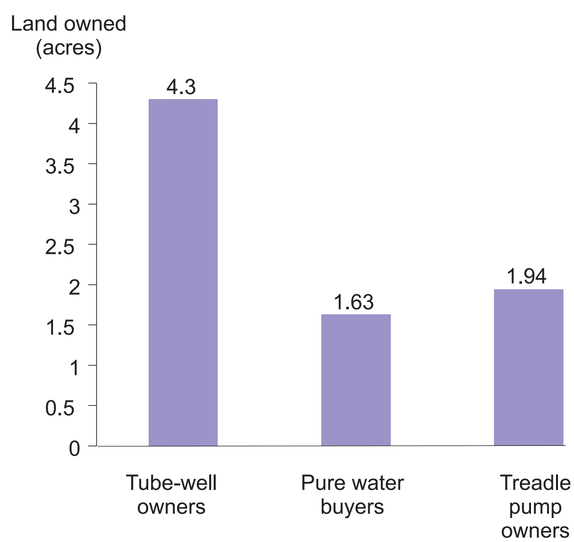
An important insight of Pant's study was that the PTWs stimulated the emergence of an active pump irrigation market in their commands, which made the PTWs themselves increasingly redundant! Contrary to a priori supposition, the number of private tube wells increased rapidly once an area got covered by a World Bank PTW command, in Faizabad, by 54% and in Deoria, by 33%. Over two-thirds of the PTW command farmers used other private tube-well irrigation; and of these, only a quarter owned tube wells, the rest purchased irrigation from private tube-well owners (TWOs) (Pant 1989:90). When the first generation PTWs came up in UP in the 1940s and 50s, private tube-well development was all but nonexistent. In fact, even in the 1970s, when the community tube-well experiment was carried out, eastern UP had very little private tube-well development. During the 1980s, however, the growth of private tube wells was truly rapid; and in their wake came the practice of water selling. Indeed, both the community tube wells and PTWs faced growing farmer apathy and disinterest because private water sellers rapidly made deep inroads into their command, established themselves as market leaders and reduced PTWs to the status of suppliers of supplemental irrigation.

Rise of Pump-Irrigation Markets: 1960–90

Even without its failings, the PTW program would not have played more than a marginal role in UP's Green Revolution. At full strength of 30,000 tube wells all working to their full capacity, the program would have developed no more than 1% of UP's groundwater potential. And a program much bigger than this would prove unmanageable in the best of conditions. Growing private investment in tube-well irrigation was thus a godsend for UP agriculture. One reason why interest in PTWs and community tube wells persisted long after they were proved unsustainable was the question of equity in access to groundwater appropriation and use by the resource-poor farmers who could not mobilize the chunky capital investment needed in tube-well installation. By the turn of the 1980s, a distinct pecking order had emerged in the organization of eastern India's groundwater economy: TWOs were typically medium-sized farmers while marginal farmers depended heavily on purchased pump irrigation and on manual lift irrigation by devices like treadle pumps. Figure 6, which reports on a 1997 survey of some 300 farmers in eastern UP, suggests this pecking order (see, Shah et al. 1997). Studies in the 1980s and 90s (Kolavalli et al. 1989; Kolavalli et al. 1992; Lall and Pachauri 1994; Pant 1992; Pant 1989; Shankar nd; Shankar 1992; Shah 1993; Shah et al. 1997), however, showed that a fitting response to this important equity issue came not from PTW programs but from private water markets.

As far back as the 1960s, purchased pump irrigation from PTW owners was an important way for the resource-poor farmers to gain access to groundwater irrigation. However, the power and reach of this new institution were beginning to get recognized only during the late 1980s as the South Asian water market debate opened up. Most of these researchers found that compared to the lackadaisical PTW operators, private pump owners were surprisingly eager providers of irrigation services, taking on their competition by lowering the price and improving the quality of service. Much emerging evidence seems to suggest that although pump irrigation markets appeared to have wrecked public and collective irrigation institutions that focused upon securing irrigation

FIGURE 6.
Scale bias in tube-well ownership: Survey of 380 farmers in eastern UP (Shah et al. 1997).



access for the poor, ironically, it was the poor water buyers who disowned PTWs and community tube wells to turn to private water markets because of their superior and more reliable—even if apparently costlier—irrigation service.

Late in the 1980s, Niranjan Pant reanalyzed his 1981 survey of 280 farmers in Deoria, Barabanki and Meerut districts and concluded that whereas only 27.7% of the farmers owned bore wells and 63.3% purchased irrigation water from pump owners. He found water trade deeper and broader in Barabanki or Meerut further west than in Deoria in the eastern parts probably because the latter had a lower pump density: “In Deoria, an average tube well served 7.1 clients; in Barabanki and Meerut, it served 2.3 and 2.6 clients, respectively. On average, 27.1 acres (of owner’s and his clients’ lands) were irrigated by a private tube well in Deoria compared to 16.1 acres in Meerut and 6.9 acres in Barabanki” (Pant 1989: 89).

In 1988, Pant explored water markets in the course of extensive fieldwork throughout the eastern region and wrote: “A common feature found in all eastern region States was sale and purchase of water on an hourly basis. The rates varied...and ranged between Rs 8 and 25/hour from a 5-hp pump/ tube well…” [Pant 1991: 276]. Further, exploring the comparative reach amongst the poor of water markets, World Bank tube wells and canal irrigation in Faizabad and Bahraich, amongst India’s poorest districts,[10] Pant concluded that “The operation of the private groundwater markets appears to be very beneficial for farmers [in <0.4 ha and 0.4< II<1.0 ha categories]” (see table 2).[11] In contrast, Pant found that both World Bank PTWs and the canal system benefited primarily the well-off. “...the World Bank-assisted tube wells in Faizabad at least cater to the needs of the poor to some extent, while in Bahraich, such tube wells cater to the needs of the relatively well-off…” And then “...canal as a public source of irrigation is worse than public tube wells and among the two districts, it is much worse in Faizabad...”

TABLE 2.
Key results of Pant 1992 on water markets in Faizabad and Bahraich districts of eastern UP.

	Faizabad		Bahraich	
	Owner	Buyer	Owner	Buyer
1. % of pump owners selling water	90.6		75.7	
2. % of water buyers owning tube wells		33.3		17.2
3. Average # of buyers per tube well	4.4		4.3	
4. Average # of sellers used by buyers		2.1		1.9
5. % of buyers irrigating wheat with purchased water		71		82
6. % of buyers irrigating paddy with purchased water		76		88

For the poorest farmers in eastern India, then, the benefits of groundwater irrigation have come through three routes: in large part, through purchased pump irrigation and, in a small way, through improved manual irrigation technologies as well as through the Free Boring Scheme (FBS). In manual technologies, the

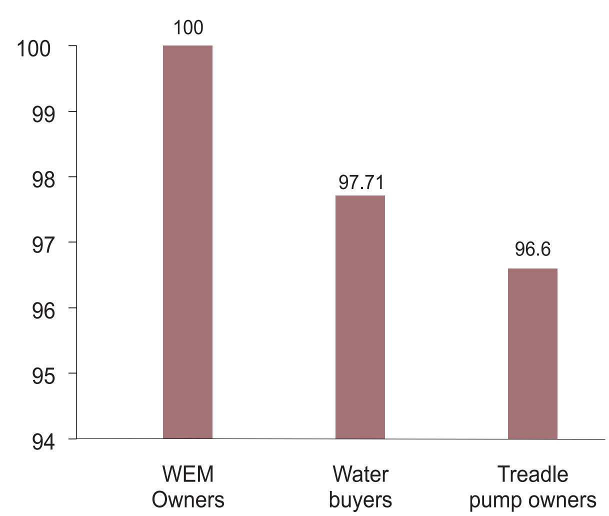
[10]Pant selected 14 villages for his study, 7 from each district of which 4 each had World Bank tube wells; two each were outside the command of any public irrigation source; and one each had a canal. Farmers with and without pumps were chosen from each of the 14 villages. Of the total sample of 247 farmers, roughly half owned private tube wells; the rest did not. Pant’s study was thus specifically designed for comparative analysis of groundwater markets versus public systems as deliverers of irrigation service to the resource poor.

[11]Further “amongst the category <0.4 ha farmers, 64% in Faizabad and 53% in Bahraich irrigate their wheat crop with water purchased from owners of private pumps. Among the category 0.4<II<1 farmers, the Faizabad data show that 42% of them depend on purchased water which is the largest single category. In Faizabad, even a great chunk (28%) of the category of 1 ha< III<2 ha farmers depend on purchased water for their wheat irrigation…” (Pant 1989).

most notable has been the introduction of the treadle pump, which is particularly suited to farmers with less than a hectare of land because it requires an investment of less than Rs 700, and can deliver up to 1 l/s without any cash cost of operation. The treadle pump has been gaining in popularity; however, it faces tough competition from private pump irrigation sellers. In fact, a 1996 survey (Shah et al. 1997) to assess the impact of treadle pumps in eastern UP showed that treadle pump owners invariably used purchased pump irrigation as well. More importantly, it was impossible for Shah et al. (1997) to find pure rain-fed farmers in eastern UP; almost every farmer who does not have own means of irrigation buys irrigation service from private TWOs. Figure 7, based on a survey of 134 TWOs, 151 farmers wholly dependent on purchased pump irrigation and 95 treadle-pump owners, shows that, thanks to the pump-irrigation markets, not having one's own tube well is not all that much of a disadvantage because over 95% of the operated area in the case of all the three categories is irrigated. Another interesting finding of this survey was the surprisingly small contribution of surface water to smallholder irrigation. Considering that the sample of 280 was chosen from 25 villages in the Deoria and Maharajganj districts, which have a large canal network, Shah et al. (1997) had expected that canal irrigation would be an important presence for the farmers surveyed. Yet, it emerged that, after own tube wells, purchased pump irrigation service was the largest provider of smallholder irrigation; of the 1,000 odd acres operated by the 380 sample farmers, 35% was served by the water market (figure 8).

The downside of water markets is the high cost of irrigation to the buyers, and the pressure on them to economize on groundwater use, especially in a region like eastern India, where as we reviewed earlier, groundwater withdrawal creates a powerful positive externality. Many studies indicate that whereas water markets have a wide reach, water buyers invariably use less water (in terms of hours pumped) compared to TWOs themselves. Figure 9, for example, shows the relative frugality of water use by water buyers in the five districts of eastern UP from which Shah et al. (1997) drew their sample of 380

FIGURE 7.
Percent of operated area irrigated: Eastern UP sample survey of 380 farmers (Shah et al. 1997).



Note: WEM = Water extraction mechanisms.

FIGURE 8.
Contribution of water markets in eastern UP agriculture: Survey of 380 farmers (Shah et al. 1997).

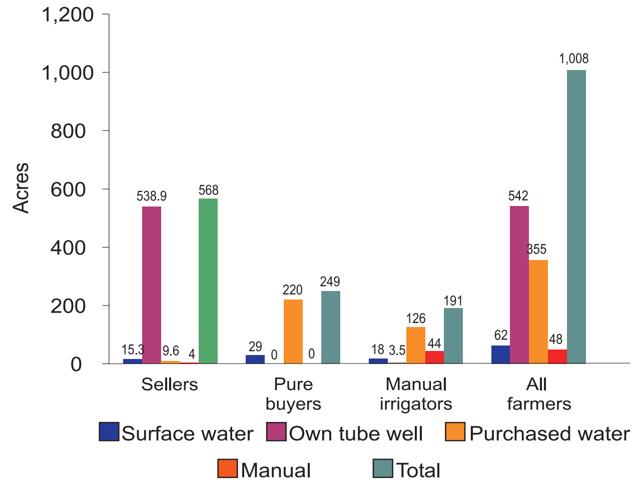
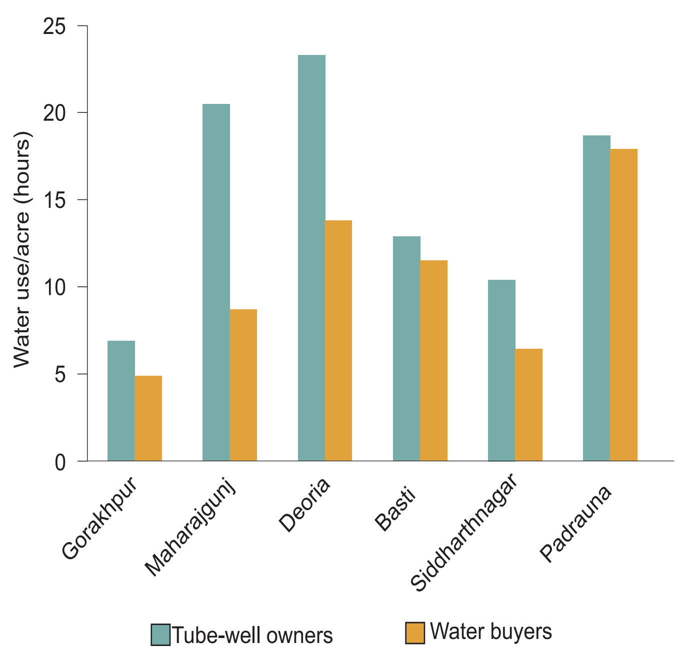


FIGURE 9.
Water use/acre by TWOs and water buyers in eastern UP: Results from a survey of 380 farmers (Shah et al. 1997).



farmers. Other studies amply confirm this finding. Based on his survey of 50 farmers in Faizabad and 70 in Bahraich, Pant (1992) similarly showed that the average water use per ha by TWOs was 98 hours in Faizabad and 36 hours in Bahraich; water use by buyers was lower at 51.5 and 25.4 hours, respectively. Based on a sample survey of 400 farmers from Gorakhpur, Sultanpur, Mirzapur and Azamgadh districts of eastern UP, Kolavalli et al. (1992) found that whereas 90% of TWOs in Azamgadh and Sultanpur gave more than 2 irrigation turns to paddy, more than 75% of water buyers gave less than two irrigation turns. Then Kolavalli et al. (1992:46) noted: "...a much smaller percentage of farmers without wells irrigated their paddy crop...It would suggest that paddy irrigation appears to be less remunerative particularly if irrigation is to be purchased."

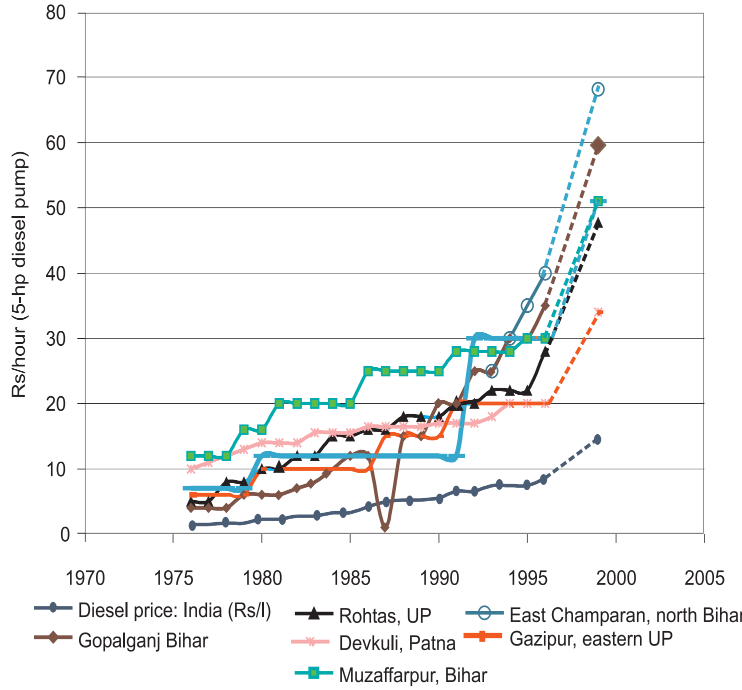
In 1996, water buyers in eastern UP paid Rs 26–30/hour of pumping from 5-hp diesel pumps with a yield of 18–20 m^3/hour. Irrigating a hectare of paddy would need 70 hours and a hectare of wheat in rabi would need 100 hours costing Rs 1,960/ha and Rs 2,800/ha, respectively. Canal irrigation rates for paddy and wheat in UP have, for years, been Rs 180/ha and Rs 70/ha, respectively. Thus irrigating wheat and paddy with purchased tube-well water is nearly 20 times costlier than canal irrigation. It is not surprising that cash-starved water buyers economize in the use of purchased pump irrigation. An important aspect is also the steeply rising cost of pump irrigation in response to the rise in diesel prices. An early hypothesis in the South Asian debate on water markets was about the relationship between energy cost and pump irrigation prices, which emanated from a water seller's profit function and yielded the relation

$$w = e/(e-1) \cdot c$$

where, w is the price of pump irrigation (Rs/hour), c is the incremental cost (Rs/hour) of pumping facing the seller—which, in the case of diesel pumps, is mainly the cost of diesel used per hour; and e is the price elasticity of demand for pump irrigation (see Shah 1993 for the derivation). Since a rational seller will sell only when e>1, e/(e-1) provides the multiple by which water price will exceed the incremental pumping cost. If e=1.4, water price will be 3.5 times the price of diesel/liter since a 5-hp diesel engine consumes, on average, 1liter/hour. And if the price of diesel increases by 10%, the price of water will rise by 35% too and not just enough to cover the increased diesel cost. In 1996, with the help of grassroots NGOs, this author constructed time series of diesel-pump irrigation prices in selected locations in eastern UP and north Bihar, which suggested that water prices increased every time diesel prices increased and the former increased substantially more than would be enough to cover the increase in diesel price. Figure 10 presents these data and also projects the likely impact of the recent 35% hike in diesel prices on pump-irrigation prices in eastern India; and depending upon the degree of competition in local water markets in different locations, we expect the 5-hp diesel-pump irrigation prices to rise to between Rs 40–65/hour from the present Rs 25–40/hour.

Overall, then, even with broad and deep pump-irrigation markets that ensure small farmers' access to groundwater, questions still remain about the cost of such access. Two aspects are pertinent: first, water buyers are under greater pressure to economize on water use than pump owners, and this differential pressure increases with every increase in diesel price; and second, there is a transfer of wealth from water buyers to pump owners with progressive increase in diesel prices. Shah et al. (1997) estimated that every hour of pump

FIGURE 10.
The impact of 35% diesel price hike on pump irrigation prices (Rs/hour: 5-hp diesel pump).



irrigation sold in eastern India contained a "monopoly rent" of Rs 10 in 1996 that would disappear if the market became perfectly competitive; assuming that each of the 2.2 million diesel pump owners in eastern India sells 100 h/yr., we can surmise that water buyers end up paying pump owners a monopoly rent to the tune of Rs 2,200 million/yr. With the 1999 hike in diesel prices by 35%, we believe this "rent" has more than doubled.

Progressive Rural De-Electrification of Eastern UP

The policy of the Government of UP on rural electrification did to catalyze pump irrigation markets what its PTW program did to initiate the revolution in the private tube wells. During the 1960s, governments as well as donors such as the World Bank placed great emphasis on rural electrification as a means to overall development, but particularly, of agricultural development through tube-well irrigation. As a result of this intensive effort, the number of electric tube wells (ETWs) rose rapidly, particularly in western UP, and to a lesser extent, even in eastern UP. The capital investment in electric pumps was higher because a portion of the cost of laying the cable from the transformer to the well site was charged to the TWOs. Diesel pumps were cheaper to buy but were less preferred because they were substantially costlier to operate. The high investment costs of ETWs encouraged their owners to operate their pumps at a high level of capacity utilization by supplying irrigation service to other farmers. Thus arose the new institution of pump-irrigation markets;

and private ETWs began playing pretty much the same role as PTWs were envisaged to do—viz., providing tube-well irrigation service to small and marginal farmers—but in a more service-oriented and economically profitable manner.

However, by the early 1970s, the logistics of metering electricity supply and collecting the tariff was beginning to prove too much for the UP State Electricity Board (UP SEB), which had hired an army of meter readers to take readings on the rapidly growing numbers of household and tube-well connections in UP's vast countryside.[12] The meter readers who were initially appointed on contract during the early 1960s soon unionized and eventually forced a populist Chief Minister to regularize them as government employees with manyfold increases in wages and benefits. Soon thereafter, the quality of meter reading declined, and so did the collection of electricity charges. It was easy to bribe or browbeat meter readers into underreporting the consumption or tampering with the meter; moreover, to beat metering, farmers began to pilfer power by hooking directly to power lines since there was little to deter them. These logistical problems multiplied manyfold when it came to dealing with metering electricity consumption for millions of tiny household users (with just 1–2 40-W bulbs). All in all, a major rethink on the logistics of metering and revenue collection in rural electricity supply had become inevitable.

Around then, a 1973 study by the Rural Electrification Corporation encompassing several States found that the cost of metering electricity consumption by farmers and rural households was over 40% of the cost of the power itself! UP was not the only State that was facing these problems; all States did. So in 1975, when the SEB decided to get rid of metering of rural household and farm users, and switch to a flat monthly tariff unlinked to actual consumption, many other State governments were watching the implications with great interest; and in the following 5 years, most other Indian SEBs followed suit and changed from a metered to a flat electricity tariff, especially for agricultural users.

The change to a flat tariff gave a powerful stimulus to pump irrigation markets; it raised the fixed cost but reduced the incremental pumping cost to almost zero. This meant that the ETW owners had a powerful incentive to sell more water; and competition amongst electric pump owners forced a lowering of the price of pump irrigation, improved the quality of service and, in general, created a buyers' market for pump irrigation. Comparative surveys across States during the 1980s showed that two 5-hp electric pump owners, one in Meerut (western UP) and the other in Basti (eastern UP), sold pump irrigation at Rs 5–6/hour whereas a similar electric-pump owner in Gujarat charged Rs 20/hour because he was paying for metered power use. Diesel pump owners in UP, who charged Rs 18–20/hour for a 5-hp pump in UP as elsewhere, began losing out in their competition with electric pump owners; there is some evidence to suggest that diesel pump owners in many areas were obliged to slash their pump irrigation prices to survive

[12]UP has 110,000 villages; and many of these have 4–5 hamlets each. Consumption-based tariff involved metering, meter reading, meter repair and maintenance and revenue collection. In an effort to reduce cost—and to secure more committed and involved ground-level staff—the SEB had recruited local people to serve as meter readers on contractual appointments at lower salaries than the SEB's staff got as State government employees. Each meter reader had to monitor and report on around 100 meters per month. Less than 2 years after this arrangement was initiated, SEB inspections revealed that many meter readers sub-contracted the work to schoolboys at a fraction of their daily allowance while they busied themselves with their farms and other businesses. Soon, they began to save on even this and stopped taking and reporting the readings at all. So farmers would be billed on the basis of their average consumption over the past months. Some meter readers began to arbitrarily report hypothetical figures of consumption. Farmers also began breaking their meters so that they could be charged on the average of low consumption reported in earlier months.

in the competition. All in all, the resource-poor farmers—who were mostly buyers of pump irrigation—had the best possible deal they could hope for in the early years after the change to a flat electricity tariff.[13]

However, this state of happiness was proven short-lived. While changing from a metered to a flat tariff, the SEB was governed by the economics of power supply as well as by the politics of power. Compared to many other States, especially in South India, where political leaders used the change to a flat tariff as an opportunity to do away with power tariff itself, either fully or largely, in UP the flat tariff was fixed at a reasonable Rs 18 (US$1.3)/hp/month at which the SEB would have been close to the breakeven point for the pre-change level of average electricity consumption, particularly since the flat tariff eliminated substantial costs of metering and pilferage associated with metered tariff. However, what the SEB had not planned for was the rapid increase in the electricity consumption per tube well after the change to the flat tariff. The very process that transformed pump-irrigation markets into a boon for the resource-poor farmers—and heralded a new promise for eastern UP's belated Green Revolution—was also playing havoc with the SEB's balance sheet. Ideally, the SEB should have put up the flat tariff with the rising of the average power consumption per tube well; and it did manage to raise it from Rs 25/hp/month in the early 1980s to Rs 30/hp/month in the late 1980s and further to Rs 50/hp/month in the early 1990s.[14] This was creditable compared to many southern Indian States that used the flat tariff to supply free electricity. However, the increases in the flat tariff implemented over the 25-year period were far less than needed to cover the full cost of agricultural power supply. The medium and large farmers, especially in western UP, who owned most of the ETWs, were getting organized into a noisy, at times militant, formation under Mahendra Singh Tikait, a Jat farmer leader from western UP; and they put paid to every move by the SEB to put up the flat tariff.

Like every monopolist, the SEB had control over either the price or the quantity of the product it supplied to a market segment but not both. In the post-flat-tariff years, the UP SEB increasingly faced erosion of its power to set the electricity price. Therefore, intuitively, it reached out for the only other lever at its command: supply. It brought in progressive restriction in the supply of power to agricultural users in an orderly and transparent manner. However, the farmer lobby quickly saw through the SEB's game and launched a fierce agitation leading the Chief Minister and other political leaders to publicly and repeatedly announce their resolve to maintain power supply to agriculture to a minimum of 18 hours/day. Something had to give; but since the government would not displease the militant Jat interests in western UP, the axe had to fall elsewhere. Thus began an invidious process of progressive rural de-electrification of eastern UP.

[13]According to Pant's analysis, some 91% of the TWOs in Faizabad and 76% in Bahraich sold pump irrigation; an average seller served 4 buyers in both districts. Some 33% and 17% of buyers in Faizabad and Bahraich, respectively, were themselves pump owners, but used purchased water to irrigate their far-flung parcels. An average buyer dealt with 2 sellers. Electrified TWOs—who had to pay a flat electricity tariff of Rs 25/hp/month—sold water at Rs 3–5/hour. Generally, 3–hp TWOs charged Rs 3/hour and 5–hp TWOs charged Rs 5/ hour. Electrified TWOs also offered a lump sum irrigation contract; the average rate was Rs 313/acre for the whole season; in this arrangement, the buyer could take as many irrigation turns as needed when electricity was available. Diesel TWOs sold only on a per hour basis: at Rs 12/hour for a 3-inch delivery pipe and at Rs 14/hour for a 4-inch delivery pipe. Pump irrigation purchased from diesel pump owners was substantially costlier. The terms of pump irrigation sale also included an offer of credit. Part-payment was made in cash; this was typically half the cost of diesel; the rest was paid at the time of harvest.

[14]This was later slashed to Rs 40/hp/month by Prime Minister Devegauda in a preelection bonanza.

While the political leadership went on promising guaranteed power supply to agriculture, the SEB, powerless to perform positive acts of commission, took to unobtrusive acts of omission, and began systematically neglecting the maintenance of power supply infrastructure in some of the most backward areas of the State where the farmers were far less organized and militant than Jats in western UP. This process of omission was slow; cessation of investment in maintenance and repair—and the resulting erosion of the element—took time to take effect; but slowly and surely it did and began to translate in declining quality and reliability of power supply. By the close of the 1980s, only 1–1.5% of transformers in eastern UP used to be "down;" in the early 1990s, 20% of the transformers were found to be nonfunctional at any point in time (Tyagi 1995). Stolen cables stopped being replaced; broken-down transformers often took 6–12 months to fix. Although, technically, the SEB supplied close to guaranteed hours from power stations, electricity available at the well-head went on a downward spin in terms of quantity; electricity was supplied 24 hours/day during the peak-monsoon and 3 hours/day in the peak-irrigation seasons to make up the required annual average. The flat tariff has many advantages for TWOs but only under an opportune electricity-supply environment in which even if rationed, reliable power is supplied at peak irrigation periods. What happened in eastern UP—and indeed in all of eastern India—during the 1980s was that agricultural power supply got concentrated during monsoons and, that too, during nights. In such an *inopportune* power-supply environment,[15] ETW owners began to find it increasingly difficult to operate their tube wells at a level of capacity utilization high enough to cover their fixed costs that included a flat tariff of Rs 40/hp/month.

Although published State government data show some growth in agricultural power connections in eastern UP during the 1980s and the 90s, all indications from the field show that these have actually declined rapidly. During the late 1970s, one could find at least a dozen ETWs in a village in the Deoria district; in the course of my 1995 fieldwork, I had to visit a dozen villages before we could interview the owner of an ETW. As early as 1989, Sharma (1989) presented a paper lamenting the "diesalization of eastern UP's groundwater sector" at a workshop in Faizabad. In the course of his 1990 survey in Faizabad and Bahraich, Niranjan Pant's stratified random sample of 50 TWOs in Faizabad (just east of Lucknow in central UP) captured 22 ETWs; but his sample of 70 TWOs in Bahraich (deep in eastern UP) captured only 2 ETWs.[16] In trying to explain why eastern UP does not use its groundwater potential fully, Kolavalli et al. (1992) randomly selected 193 TWOs for their survey in the Gorakhpur, Sultanpur, Azamgarh and Mirzapur districts of eastern UP and found only 10 ETWs to survey. For their survey of 380 farmers in five districts of Gorakhpur Mandal, Shah et al. (1997) tried to include an equal number of electric, diesel and treadle pump owners, water buyers and non-irrigators; however, they found no "pure" non-irrigators and only 4 ETW owners in 25 villages. This trend is not evident in SEB's published figures on electrified tube wells because these do not

[15]The term *inopportune* is used to contain a combination of circumstances that disable TWOs from making their tube wells economically viable. The circumstances mainly involve inadequate power supply, its unpredictability and erratic nature, most of the power supply coming in the nights, and most critically, and nonavailability of power for long periods (often running into several weeks) because of poor maintenance of power distribution infrastructure.

[16]Pant (1992:20) notes this dichotomy in his study of Faizabad and Behraich: "In fact, in majority of the villages in Bahraich electricity was not available for tube-well irrigation and was available only at places of worship like mosques...Low use of electricity in Bahraich compared to Faizabad is manifested in the fact that on 31.3.86, there were 2,936 energized private tube wells in Bahraich compared to 16,600 in Faizabad…"

deduct the disconnected tube wells, which are treated as provisional disconnections. But in private discussions, the SEB managers readily conceded that 80% of the pump electrification targets were met in western and central UP, which have most of UP's dark and gray areas. In eastern UP, there are no dark blocks; in fact, all the blocks are white; but there is little or no power there; and the pace of electrification of new tube wells has been very slow. In a field trip across UP in 1996, we (Tushaar Shah, Marcus Moench and Christina Wood) found certain divisions to be "electrically privileged;" this was true particularly in Meerut, Agra and Muradabad in western UP, and Varanasi in eastern UP, which have a significantly higher ETW density than the rest of the UP. Even within these districts, ETW density is probably much higher within small pockets, especially near towns and along roadsides, as we found in Faizabad. Away from the towns and main roads, ETW density rapidly declines even in these electrically privileged districts.

Officially, the SEB has spun an unbelievable story that goes against commonsense as well as the ground reality of eastern UP. According to the SEB values, since 1972–73, the number of private ETWs in UP has increased from 183,000 to over 700,000 in 1993–94 at a compound rate of around 10%/yr. The power supplied to these has increased at an even faster pace than their number, from 794 million units/yr. in 1972–73 to 9,500 million units in 1994–95, at a compound growth rate of 11.9%/yr. As a result, the average power consumption per ETW has gone up by over three times, from 4,072 units/yr. in 1972–73 to 11,800 units in 1994–95. The official SEB estimate of its losses from agricultural power supply shot up from Rs 1,630 million in 1993–94 to just under Rs 13,000 million in 1994–95. For every hour of pumping of an ETW, the SEB has been losing over Rs 6.[17] To break even on agricultural operations, the flat tariff would have to be raised from the present Rs 50/hp/month to Rs 209/hp/month. The story has been uncritically accepted by many. For instance, a report by Tata Energy Research Institute noted: "Because of the low agricultural tariff and high magnitude of consumption of this sector, the SEB loses heavily in terms of revenue from agricultural power sales..." (TERI 1996:73). Several studies of the World Bank have come to similar conclusions.

But several inconvenient facts remain unexplained. First, why should farmers reject ETWs as resoundingly as they have done in eastern UP had power supply been so heavily subsidized in real terms? Second, the estimates made by field researchers of the hours of pumpage by ETWs imply a level of actual power consumption, which is a small fraction of the average claimed by the SEB. Third, accepting the SEB's estimates raises important questions about what 2.2 million diesel pumps are doing in UP's countryside and why diesel tube wells are growing at such a phenomenal rate.[18] Finally, much evidence suggests that, if anything, rural power subsidies are concentrated in electrically privileged areas of western UP; in eastern UP, far from being subsidized, electric power is, in effect, heavily taxed.

Consider the following. At the SEB's value of 11,800 kWh as the average power consumption per ETW/yr., and assuming the connected load to be 6-hp on average, the average private ETW should be operating over

[17]The average revenue assessed was Rs 0.43 per unit supplied in 1994–95; the average cost was Rs 1.80 and the loss per unit, Rs 1.37. According to a recent study (Tyagi 1995), the average ETW in UP is of 6.25-hp, consuming (at 0.725 units/hour) 4.53 units causing a loss of Rs 6.20 to the SEB.

[18]Over the 1968–69/93–94 period, diesel pumps increased twice as fast as ETWs; the former have increased from 85,000 to 2,051,000 by 24 times, whereas the latter have gone up from 56,000 to 690,000, by 12 times (Tyagi 1995).

2,500 h/yr. But except in small pockets of electrically privileged districts of western UP where studies show an average of 1,300–1,500 hours of annual operation, nowhere do ETWs in eastern UP—nay, eastern India—operate for more than 600–700 h/yr. The Faizabad sample of 18 ETW owners in Pant's 1992 study reported an average operation of 665 h/yr. In Shankar's study (1992:58) of a sample of 140 households in Allahabad, ETW owners reported the average operation to be 663 h/yr. A survey of 478 TWOs from Muradabad, Barabanki and Agra districts by the Operations Research Group in 1990 indicated that 70% of the sampled ETWs operated for less than 500 h/yr.; only 8% operated for more than 1,000 h/yr. Far from 11,800 kWh, on average, ETWs consumed 1,870 kWh/yr. in their Muradabad sample, 924 kWh/yr. in the Barabanki sample and 1,990 kWh in their Agra sample (ORG 1991:23). The average cost of power to these was thus Rs 2.89/kWh, far more than any other user category of the SEB. A 1981-survey by NABARD (1988) in Allahabad district in eastern UP showed that ETW owners operated their tube wells for an average of 636 hours and the average electricity cost/hour to them was Rs 0.77/kWh when the SEB claimed it realized only Rs 0.18/kWh from agricultural consumers (UP SEB 1996: 97). But in a similar evaluation in the electrically privileged Muzaffarnagar district in Meerut division, a sample of 42 ETWs operated, on an average, for 1,034 hours at Rs 0.36/unit (NABARD 1987). Tyagi (1995) found the average power consumption by a sample of 229 ETWs from all over UP at 2,566 kWh/yr., less than 25% of the SEB estimate of 11,800 kWh/yr. At a flat tariff of Rs 50/hp/month, the average electricity cost is thus Rs 1.43/kWh, over 3.5 times the rate of Rs 0.43/kWH that the SEB claimed. Tyagi showed that for the bottom 10% of tube wells in the sample that operated for an average of 280 h/yr., the effective power cost rises to Rs 2.87/unit or Rs 13.08/hour. In the electrically privileged Kanpur district of western UP, where because of a more opportune power-supply environment, an average tube well operated for 774 h/yr., the cost declined sharply to 1.04/kWh or Rs 4.74/hour of operation. With this economics, it is not surprising that farmers in eastern UP switched to diesel engines en masse. A 6.5-hp diesel pump would cost Rs 9.50–10/hour in fuel in 1997; thus an ETW operating over 750 h/yr. is half as cheap to run as a diesel pump; but one operating at less than 300 h/yr. costs much higher to run. In the early 1990s, this made electricity sold to eastern UP's agriculture amongst the most expensive of all consumer categories: domestic users paid Rs 0.77/kWH; commercial users paid Rs 1.16/kWh; industries paid Rs 1.36/kWH; and eastern UP's agriculture paid an effective price of Rs 1.43/kWH.

Dieselization of Eastern UP's Groundwater Irrigation

Until this stage, there are strong parallels between the pattern of evolution of groundwater development in eastern UP and the rest of eastern India, in particular, in north Bihar, north Bengal and coastal Orissa, which combine large volumes of undeveloped groundwater potential with a massive concentration of rural poverty. If UP tried a PTW program, so did west Bengal, Bihar and Orissa. If UP's PTWs failed in their promise to the poor, they failed even more resoundingly in Bihar and Orissa.[19] The rest of the east Indian States mounted their rural electrification programs much the same way as UP did, but with a lag of 3–5 years. Except in southwest Bengal, elsewhere in eastern India too, private electrified tube wells grew in numbers—though not as rapidly as in UP—especially in western UP. UP changed from a metered to a flat tariff in 1975; Bihar and Orissa followed suit. Finally, as in eastern UP, a few years after the flat tariff was introduced, the power-supply environment throughout the eastern region began to deteriorate. Within each State, there were "electrically privileged" areas where the rural-electricity infrastructure remained relatively better maintained and the power-supply environment remained in a reasonably good condition. In west Bengal, southern districts had a better power-supply environment and developed dynamic agrarian economies; north Bengal, with a poor power-supply environment failed to develop its extraordinary groundwater potential and stagnated. Bihar remained electrically underprivileged throughout; yet, the central region became less electrically underprivileged than north Bihar with its massive underdeveloped groundwater resources. The Orissa, Puri and Cuttak districts became electrically privileged; western Orissa ended up with a poor power-supply environment. In most respects, then, eastern UP became the forerunner of eastern India.

But the parallels end here. With the decline in the power-supply environment, the development of groundwater irrigation in much of eastern India has all but stagnated. But in eastern UP, tube-well irrigation continued to be a boom sector. Eastern UP dealt with the crisis of deteriorating power supply by dieselizing its groundwater irrigation. Here, the number of private diesel pumps increased faster than the decline of the electric pumps. Some evidence of this trend is available in data collected at district level; however, these too only add new ETWs connected every year without deducting the number of those that are disconnected. Even so, as figure 11 shows, the pace of dieselization of eastern UP's groundwater irrigation sector is unmistakable. Equally unmistakable is the fact that the inopportune power-supply environment has been behind the strong preference for diesel pumps. A report by the Indo-Dutch UP Tube-Well Project MAC-IDTP (1989), citing Draft Annual Plan 1988–89, Volume I, of the Government of UP stated:

> "The overall shortfall in realization of the Seventh Plan target of energization of private electrical tube wells is mainly due to cultivators' preference for diesel-driven sets. This preference derives from erratic and inadequate power supply in most areas and lower initial cost to cultivators for diesel sets."[20]

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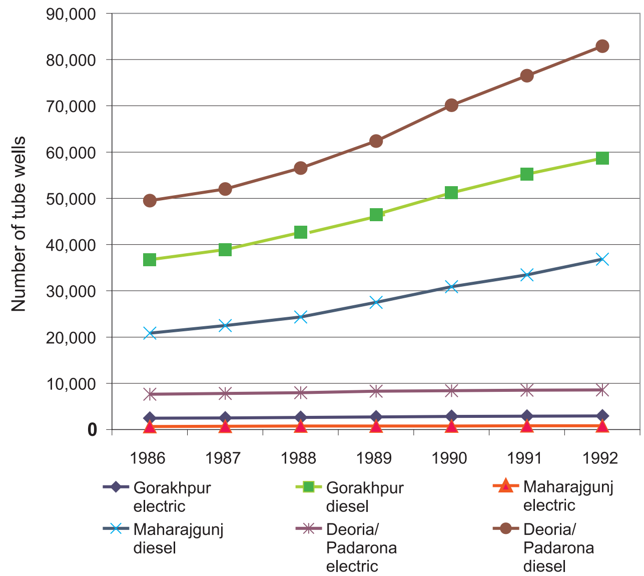
[19]Though west Bengal designed a moderately successful program of turnover of small-scale government irrigation schemes—including tube wells and river lift irrigation schemes—to beneficiary groups, in Orissa, the Lift Irrigation Corporation, which established and managed PTWs and river lift irrigation schemes, piled up huge losses and was obliged to design a turnover program that has not been as successful as west Bengal's program, especially that in southwest Bengal.

[20]The report further stated: "Public tube wells and private tube wells have to compete for relatively scarce power supply. Public tube wells constructed under the World Bank Program are connected with dedicated feeder lines while private tube wells are connected with rural feeder lines. If dedicated feeders are given priority, less electricity is available for the rural feeder lines. Shortages will become more severe and the competition for electricity will increase" (ibid.).

FIGURE 11.
Growth of electric and diesel tube wells in Gorakhpur, Maharajgunj and Deoria-Padrona districts, eastern UP.



There are many problems with the dieselization of groundwater irrigation. Diesel is a costlier energy source compared to electricity, in private as well as social terms, especially in eastern India, which produces more than half of its power from hydroelectric sources. Electricity is also cleaner compared to diesel. Electric pumps are easier and cheaper to maintain compared to diesel pumps that suffer heavy wear and tear. Finally, as we saw, diesel pumps produce a monopolistic pump-irrigation market that transfers wealth from resource-poor water buyers to pump owners, and forces the buyers to economize on the use of water whose marginal social value, in the east Indian context, is negative. Despite all these, it would be appropriate to say that nothing else has produced as much welfare for the small and marginal farmers of eastern UP as diesel-pump- driven shallow tube wells. The central issue of interest is why the rest of eastern India was unable to dieselize its groundwater irrigation as rapidly as eastern UP did during the 1985–95 period.

The Diesel Pump Dealer Dynamic

The inopportune power-supply environment was certainly a key reason behind the rapid increase in the number of diesel pumps in eastern UP during the 1980s. However, an equally important reason was the great success that the people of eastern UP made of another of the State government interventions to stimulate groundwater development. Around 1975, when the Government of UP decided to switch to a flat electricity tariff, the Reserve Bank of India, concerned about eastern India's failure to take off agriculturally, appointed a high-powered committee to explore the issue. This committee bemoaned the slow pace of groundwater development as the primary cause, and recommended a liberal subsidy to stimulate private groundwater development. Following this, the Government of UP launched a poverty-targeted FBS under which the Minor Irrigation Department was to undertake the preparation of bore-wells (shallow tube wells) free of cost for small and marginal farmers; additionally, varying levels of subsidy were offered on diesel pumps to small and marginal farmers, matching the degree of their social and economic backwardness. The banks also chipped in with a loan to cover the down payment required from the farmer under a special refinancing arrangement from the National Bank for Agriculture and Rural Development. Bihar, west Bengal, Assam and Orissa followed suit with their own variants of pump-subsidy schemes. Soon enough, the Government of India also launched the "Million Well Scheme" with precisely the same objective, and targeting socially and economically backward farmers.

Until the mid-80s, however, all these well-intentioned minor irrigation subsidy schemes had produced little minor irrigation in the most groundwater-rich parts of eastern India. When electric pumps dominated groundwater irrigation, the real barrier that kept the poorest from laying their hands on a pump was not the cost of the pump but the transaction costs, delays and the hassle of getting an electricity connection. ETW ownership during the 1970s was therefore highly scale-biased compared to the ownership of diesel pump sets during the 1980s and 90s. So, although the subsidy schemes covered electric as well as diesel pumps, the funds allocated to them remained grossly underutilized. Now that ETWs were being decommissioned in large numbers, farmers began to turn to diesel pumps, but they—particularly, small farmers from backward communities—found the hassle and "transaction costs" involved in accessing the FBS prohibitive and intimidating. A study in 1984 by the Delhi-based Society for Prevention of Wastelands Development concluded that even if all the paperwork of a small farmer were perfect, the decision on his application under the FBS took 11 months and scores of visits to the various offices involved: the Block Development Office, Minor Irrigation Department, bank offices and the District Rural Development Agency. Another set of rounds would begin once his application was approved, to get GI pipes and valves issued from the Minor Irrigation Department, diesel pumps issued from the stipulated dealers, and the bank loan released from the Lead Bank designated for each district. Several other restrictions were in force: for example, only members of the field staff of the Minor Irrigation Department were allowed to make the bore using the department's rig; only one or two predesignated brands of diesel pumps were available to the farmer. Moreover, the farmer was obliged to offer "speed money" at every office, which meant that by the time the tube well was commissioned, 35–40% of the subsidy had gone as "speed money."

This is still the situation in north Bengal, Orissa and, to a lesser extent, in north Bihar. Eastern UP however managed to break free and transformed the diesel-pump subsidy scheme into a powerful instrument of smallholder irrigation. During the mid-1980s, a series of changes occurred in the design and implementation of the FBS, which pitchforked the private dealer of diesel pumps to the role of the central coordinating mechanism for the scheme. These changes sharply reduced the transaction costs that small farmers faced in accessing the subsidy and loan scheme. The diesel-pump dealer became the one-stop-shop for farmers wanting to set up a tube well under the FBS. In the course of unstructured interviews with nearly 200 small farmers in the Gorakhpur, Maharajganj and Deoria districts of eastern UP, we found that the presence of the diesel-pump dealer was one of the best things to happen to the small farmers in the region; and that this dealer had been instrumental in transforming the much-berated FBS into a powerful intervention in groundwater development. All that an eligible small farmer has to do now is to provide his photograph and land documents to the dealer of the brand of diesel pump he prefers; the dealer then takes over and completes the entire process of getting approvals and clearances from the government departments involved and the bank. The pump and GI pipes are issued to the farmer on the same day; he is free to hire local rig operators to get his boring done, and inside of a week of applying, his tube well is commissioned. By then, the dealer has got all the formalities cleared and the transaction is completed. Scores of farmers we interviewed did agree that the cost of the pump without the subsidy would be lower by 8–10% but considered this a small *sewa-shulk* (service fee)[21] for the red carpet the dealer rolled out for them. By a rough estimate, over 800,000 small diesel-pump-operated tube wells have been installed in eastern UP under the FBS after 1985, which probably irrigate a gross area of 2.4–3.2 million ha of their owners' and water buyers' lands besides providing some much-needed vertical drainage to the region. By any reckoning, this rapid increase in the diesel-pump density is at the heart of eastern UP's belated Green Revolution, which has still proved elusive to other flood-prone areas of eastern India such as north Bengal, coastal Orissa and north and central Bihar.

What changes brought into play this virtuous "dealer dynamic" are neither clear nor fully explored. But from our discussions with pump dealers and "beneficiaries" throughout the region, the main procedural changes were: a) the requirement that only Minor Irrigation Department staff make free bores was given up, and farmers were allowed to get their bores done by numerous private rigging contractors who did the job quicker, cheaper and better; b) the insistence on the Minor Irrigation Department holding the stocks of one or two brands of pumps was abandoned; and the farmer was allowed to choose the brand he preferred; c) through another procedural modification, it was now possible for the banks to directly pay to the dealer for the diesel pump; the subsidy was adjusted in the farmer's account while the balance, treated as a loan, is to be repaid by the farmer in installments over 3 or 5 years.

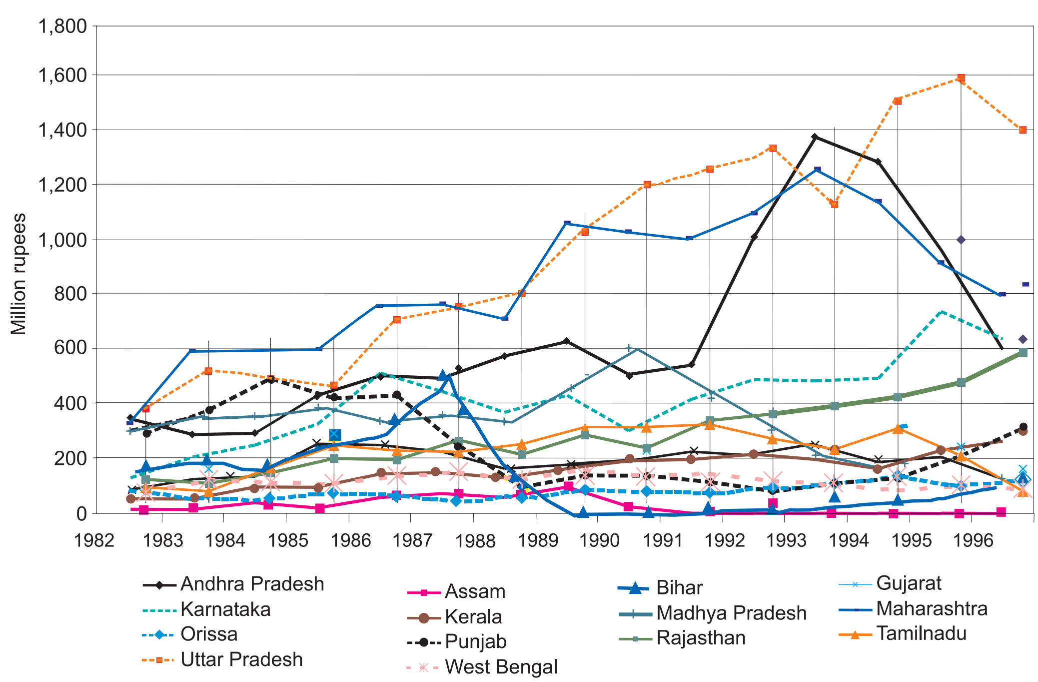
There is indicative evidence to suggest that these changes came about gradually in response to "pulls" from the dealer community to simplify the procedures for accessing the FBS. As the de-electrification of rural eastern UP gathered momentum, the demand for diesel pumps grew. The diesel-pump dealers saw a great business opportunity in the decline of ETWs; and each district and tehsil town of eastern UP saw the rise of an uncommonly large community (20–60) of diesel-pump dealers competing fiercely amongst themselves for increasing their market share in the growing market for diesel pumps. As the business grew, besides the brand-image and the dealer-image, the Unique Selling Proposition each dealer began to offer to his customers was the ease and speed of getting the FBS formalities completed at a low sewa-shulk. Large dealers

[21]A good estimate of the service charge is provided by the "discount" of Rs 700–1,800 that the off-the-shelf buyer gets compared to a farmer applying for the loan-subsidy scheme. This "discount" on direct purchase without subsidy includes a) the unofficial payments (bribes)—that pump dealers have to pay in agencies authorized to approve the loan and subsidy; b) other money and time costs—mostly of running around from office to office—involved in getting the application processed; c) interest costs incurred during the processing time—between the date of the farmer's first approach with photo and land records when he collects his engine and pump, and the date when the check gets released. The discount varies over a long interval because large dealers, who get applications processed in fair-sized lots, are able to carry out these tasks at a lower *average* cost compared to small dealers who get applications processed in ones and twos; and because of intense competition, rather than using their lower cost to increase monopoly profits, large dealers demand a lower "service charge" to attract customers and increase their market share.

with reputed brands of pumps had a head start over smaller ones and some of these sold 3,000–4,000 pumps/yr., and could, therefore, develop a different system of offering "rents" to various agencies involved in processing FBS applications; they often paid monthly installments rather than a "piece rate" that smaller dealers paid on a case-by-case basis; moreover, many large dealers began to keep a special team of staff whose sole job was to take a bunch of "subsidy files" every morning from office to office and get them cleared by the evening. Many of these large dealers thus were able to offer farmers highly rated brands of pumps under FBS for as little as 5% of the subsidy as a sewa-shulk. Smaller dealers are not as "efficient" as larger ones in cutting the transaction costs of FBS access but are restrained from levying a high sewa-shulk because of the price leadership role of large dealers in setting a reference service charge. It also seems that dealers, whom pump manufacturers offer pretty high retail margins varying from 18% to 30% of the sale price, gun for maximizing their sales and market share rather than taking a cut from the "service charge," which therefore has little or no "rent" extracted by the dealers.

How do we know that this so-called "dealer dynamic" has helped stimulate eastern UP's groundwater development? There is no direct macro-level evidence; the 1992 minor irrigation census, when it becomes available, will provide some direct district-wise data, which in comparison with the 1987 census data will provide a clearer picture. However, all field studies on well irrigation suggest that a large majority of private pumps are diesel pumps, they are owned by small and marginal farmers, they were acquired under the pump-subsidy scheme and, above all, they were installed in the late 1980s or early 1990s. Another indicative evidence is provided by the data on the offtake of institutional credit for minor irrigation (primarily, pumps and tube wells). Figure 12 shows the State-wise refinance provided for minor irrigation

FIGURE 12.
Growth of NABARD refinance for tube-well construction in Indian Sates: 1982–83/1996–97.



by the National Bank for Agriculture and Rural Development, which is a very good proxy for the offtake of pumps under the loan-subsidy scheme. Clearly, it shows that while the rest of eastern India has been lukewarm in using NABARD's refinance facility, UP has beaten even States like Andhra Pradesh and Maharashtra where private smallholder irrigation has always been a strong sector.

This transformation of the FBS into an instrument of expanding small-farmer ownership of diesel pumps and bore-wells has powerful and far-reaching ramifications. On the downside, the pump dealer has been widely discredited as the shady operator on the scene precisely because he is at the center stage of the entire scheme and lay-observers see him as the recipient of the bribe that is the sewa-shulk; even some pump manufacturers we interviewed considered them with disdain in the wheeler-dealer class; it is also likely that the reformed FBS is a trifle more prone to mis-targeting. However, the vastly beneficial overall impacts of the FBS under "dealer dynamic" have been commonly overlooked: for one, it has expanded eastern UP's pump density (measured as the number of 5-hp pumps per 100 ha of farmlands) from less than 10 in the mid-1970s to 40–50 in the early 1990s; despite room for mis-targeting, FBS has probably single-handedly done far more to put a pump in the hands of the poor than any other policy initiative ever. The increased intensity of competition among pump-irrigation sellers and its beneficial results further leverage the overall impact of high pump density for ultra-poor water buyers. Above all else, the increased diesel-pump density has greatly moderated the disastrous impact of the rural de-electrification of eastern UP; its role in ushering in eastern UP's ongoing agrarian transformation becomes all too clear when one compares today's eastern UP with regions like north Bengal, which have little rural electrification and where the diesel-pump subsidy scheme works pretty much like the way it did in eastern UP in the early 1980s. Eastern UP is already catching up with western UP, Punjab and Haryana, in terms of its agricultural productivity, land-use intensity and other parameters of agrarian growth; but the rest of eastern India, barring small pockets, is still stagnating in traditional technologies and methods, at least 20 years behind eastern UP.

Lessons for Eastern India

Eastern UP, a microcosm of eastern India and the GMB basin, has also served as the latter's leader and pathfinder. Our chief argument in this report is that there have been striking parallels between eastern UP and the rest of eastern Indian States in the public policies pursued to stimulate groundwater development and how they have failed to achieve their objectives. To be sure, the gulf between eastern and western UP is analogous to the gulf between eastern India and the rest of India. In illustrating this gulf, we have derived figure 13 based on NABARD (1995);[22] and from the analysis by Fan, Hazell and Thorat (1998) presented in

[22]Northern region: Haryana, Punjab, Himachal Pradesh, Jammu and Kashmir and Rajasthan; east and northeastern: Bihar, Orissa, west Bengal, Sikkim, Assam, Manipur and other northeastern States; western: Maharashtra, Gujarat and Goa; southern: Andhra Pradesh, Karnataka, Kerala and Tamilnadu; central: Madhya Pradesh and UP. It must be noted that eastern UP's 16 districts, which are an important part of eastern India are included in central India along with the rest of UP; this means that eastern India's poverty as well as groundwater resources are understated in these charts.

table 3. Figure 13 shows that eastern India contains over a fifth of India's blocks but it is home to nearly 88 million, or a third of India's rural poor. One department in which the eastern region has a great scope for poverty-focused development is groundwater; it has 25% of India's usable groundwater resources; and less than 20% of it is developed. And as we reviewed earlier, developing this resource further can not only create livelihoods and agricultural growth but also alleviate the chronic problems of waterlogging and flood-proneness that have bewitched the region. That there need be no worries on account of overexploitation of groundwater in the eastern region is also suggested by figure 12, which shows that only 4 of India's 600 "dark" blocks are in the eastern region.

Eastern UP's experience provides us many lessons for jump-starting eastern India's groundwater economy; but the most important is that public policies and programs—such as the public and community tube-well programs and rural electrification program—have not worked as planned. Based on our analysis, a strategy of stimulating poverty-focused groundwater development in eastern India needs to have at least five elements:

- first, eastern India needs to seriously reconsider its existing minor irrigation programs run by government bureaucracies, which gobble up funds but deliver little minor irrigation;

- second, while the electricity-supply environment is in total disarray, innovative ideas need to be piloted to test alternative approaches to efficient metering and

FIGURE 13.
Distribution of blocks, dark blocks, rural poor, groundwater resource and NABARD refinance for minor irrigation across five regions of India.

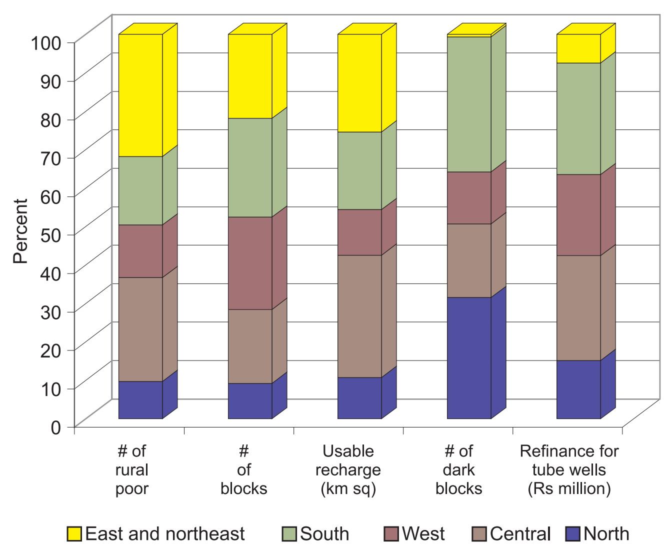


TABLE 3.
Eastern India versus the rest of India.

Region	# of rural poor	# of blocks	Usable recharge (km sq)	# of dark blocks	Refinance for tube wells (Rs million)
North	27,154	654	34.93	189	13,939
Central	75,030	1,354	103.3	115	24,979
West	38,094	1,698	38.6	81	19,345
South	49,470	1,814	65.5	210	26,657
East	88,429	1,543	82.57	4	6,810
Northeast India	278,177	7,063	324.9	599	91,730

Source: NABARD 1995; Fan, Hazzel and Thorat 1998.

collection of electricity dues from millions of small users;

- third, programs are needed to improve the efficiency of electric as well as diesel pumps;
- fourth, there is a need to promote smaller than 5-hp diesel pumps and improved manual irrigation technologies;
- finally, above all else, east Indian States need to reform their pump subsidy schemes in the style that UP has done so as to ameliorate the pump-capital scarcity, which lies at the heart of the problem. We deal with each of these at some depth in concluding this essay.

Public and Community Ownership and Management

With the plethora of studies and evaluations that testify to the resounding failure of PTW programs in eastern UP and elsewhere in India, cessation of support to such programs should be a forgone conclusion; however, this is far from the case. In many States, new programs—mostly donor-supported—are afoot to make new investments in group-owned and -managed minor irrigation assets, or to rehabilitate past investments. This steadfast devotion of donors and governments to the notion that the poor can access benefits of groundwater irrigation only through government- or community-managed tube wells seems particularly unfounded in eastern India where the conditions are best suited for small-scale owner-managed tube wells. In eastern UP, at least, the PTW program tried to harness scalar economies and new technologies—such as deep tube wells, piped distribution and dedicated power supply—to cover 100 ha or more of design command under each tube well. But in many other east Indian States, government departments are building small tube wells of the type that private farmers have and operate these through a bureaucracy at levels, which do not even cover their operators' salary. At the end of a spell of fieldwork in Puri district of Orissa, I found:

> "Of the 99 Lift Irrigation (LI) schemes that Orissa Lift Irrigation Corporation's (OLIC) Pipli office is responsible for in these three blocks, 61 were functional; last year

> (1997–98), according to OLIC records these irrigated 1,113 acres (average command area/LI is 18.2 acres) and collected an irrigation fee of Rs 216,600 (average fee collection/LI is Rs 3,550; average fee/acre is Rs 194.60). The economics of the LIs seems designed for unviability in perpetuity. Four new schemes were constructed in 1996–97 at a total cost of Rs 2.4 million; if this represents the general picture, the average 5-hp LI, which commands an average of 6–7 acres, costs Rs 600,000 apiece or Rs 90,000+/acre or over Rs 200,000/ha of net irrigated area commanded! Farmers build irrigation potential at 10% of this cost. This must be among the costliest irrigation potential created in a region, which abounds in groundwater and surface water. It is crazy that DRDAs and NABARD are throwing away good money after bad, but it is even crazier that a thoughtful donor like Kreditanstalt für Wiederaufbau (KfW) keeps supporting OLIC's new LI schemes" (Shah 1998b).

Similarly, in assessing the effectiveness of the Dutch-supported minor irrigation program in north Bengal, I found that:

> "...the critical challenge of minor irrigation development—and, indeed, of overall agrarian growth—in north Bengal is of dealing with the pump capital scarcity…of raising its pump density of around 1–3 pumps/100 ha of net sown area to 25–40. This requires programs designed to put the pump into the hands of the poor…north Bengal, instead, has been busy building minor irrigation miscellanies that gobble funds but make little net addition to minor irrigation. Most of India gave up building new PTWs and big community-managed river lift irrigation schemes 15 years ago; but north Bengal—which does not need deep tube wells in the first place—has continued building them. [Then, the] use of buried pipeline distribution systems in north Bengal—a flat terrain with the marginal value of groundwater at subzero levels—seems to be a doubtful strategy. True, large group tube wells with buried pipelines are doing well in north Gujarat and Maharashtra where farmers have money and enterprise but not groundwater. North Bengal's farmers have too much water but no pump capital; collective management of lift irrigation systems is neither necessary nor worthwhile for them. The correct minor irrigation strategy for Gujarat is clearly a wrong minor irrigation strategy for north Bengal; it should be the reverse of it" (Shah 1998a).

The first important initiative needed to stimulate groundwater development is to discontinue forthwith these costly programs of building public- and community-managed deep tube wells and large river lift irrigation schemes. Countless examples show that these are costlier to build and operate compared to small private tube wells, they are extremely difficult to manage, and use technologies for which there is no rationale in eastern India.

Electricity Supply and Pricing

During the 1980s, I showed that, in eastern India with abundant groundwater, a reasonably high flat electricity tariff, accompanied by a carefully rationed agricultural power supply, can be a powerful way of transforming groundwater markets into an effective instrument of small farmer development without subsidizing electricity (Chambers et al. 1987; Shah 1993). The argument had several propositions: a) a flat tariff reduces the real cost of supplying power to farmers by saving substantial costs of metering and revenue collection; b) it curtails the powerful incentive to pilfer under the metered tariff scheme; c) it forces ETW owners to sell more water by charging lower prices to buyers who are mostly the resource-poor; d) where diesel-pump owners compete with ETW owners in local water markets, the latter exercise a disciplining influence on the former and oblige them to sell water at a price lower than what they would have set; e) the Electricity Board can counter the propensity of ETW owners to expand their use of power under the flat tariff scheme either by raising the flat tariff to cover the average full cost and/or by carefully rationing high-quality power supply to agriculture. The veracity of these propositions has been proven by the experience of many Indian States, including eastern UP where, even today, ETW owners who remain sell water at a much lower price than that charged by diesel-pump owners and are a disciplining influence on local water markets. Many States have raised their flat tariff to reasonable levels. Haryana has raised its flat tariff to Rs 65/hp/month—at which its electricity subsidies have been maintained at manageable levels. Gujarat has a progressive flat tariff of Rs 195/hp/yr. for smaller than 7.5-hp tube wells going up to Rs 360/hp/yr. for tube wells bigger than 15-hp. However, this analysis presupposed fine-tuned management of electricity supply and pricing policies that eastern State governments and electricity boards have proven unequal to. As a result, the flat tariff has produced nearly opposite results in eastern India—of its rapid rural de-electrification. However, the critical role of rural electrification in eastern India's agricultural economy needs to be recognized. For one, in real terms, electricity is cheaper than diesel. Second, it is cleaner. Third, since over half of eastern UP's electricity is generated from hydroelectric projects, it makes good sense to promote its use for the region's agricultural development. Finally, as we reviewed earlier, east Indian agriculture, in effect, suffers from negative electricity subsidies; and if Central and State governments are willing to commit substantial public funds to subsidize canal irrigation and PTW programs, there is a strong case for removing the effective tax on agricultural power consumption by creating an opportune power-supply environment in the region.

No matter how urgent the need for improving eastern India's power-supply environment, may be for the region's agricultural development, it is unlikely that such improvement and the investments needed for them will come about without exploring radically new ways of pricing rural power supply, especially because dieselization of pump irrigation has provided an effective "safety valve" that will reduce the intensity of popular discontent. The existing literature offers no insights into how best to do this. The central issue is of reducing the SEB's metering and collection costs by drastically reducing the number of power-supply points that the SEB directly monitors. One idea worth experimenting is some variation of electricity cooperatives that became hugely successful in rural US in the early decades of the last century and that has also worked in Maharashtra and Andhra Pradesh though not very successfully. Basically, the Indian electricity cooperatives have been doing power distribution; they buy power in bulk and distribute it to their members; the Electricity Board finds it useful because they are in a better position to contain pilferage and collect electricity bills at lower costs. An alternative that uses the same principle is to invite *Gram Panchayats* (Village Councils) to undertake the distribution of power within the village and collect electricity dues. In such an arrangement, the SEB can maintain one central meter for the village as a whole and charge the Panchayat based on metered consumption by the village. The Panchayat can then monitor power consumption by both domestic and agricultural consumers and recover electricity dues from them. The arrangement can be attractive if the SEB can pass on to the Panchayats its own metering and collection costs, which are huge and were estimated to be nearly 45–50% of the actual cost of agricultural power supply. Efficient Panchayats can then transform electricity retailing into an income-generating proposition. An inferior alternative is to try private power-distribution contractors who will be charged on consumption recorded in a central SEB meter and who, in turn, retail power to individual users.

An important technological device that can make such decentralized retailing of electricity is the prepaid electricity cards that, for example, have been vigorously promoted by Eskom, the South African electricity utility to small, dispersed consumers. Eskom discovered the usefulness of the prepaid cards in meeting precisely the same challenge that Indian SEBs are facing, viz., of charging for power based on use by large numbers of tiny users scattered over a vast area. For the power supplier, this technology drastically reduces the cost of metering and charge-collection; for the users, it offers a transparent device to plan and monitor their electricity consumption. The prepaid card technology may be expensive for low volumes; but for the kind of large volumes that rural power consumers in India offer, the cost of the technology can be very affordable; and large-scale user acceptance can be ensured if the SEBs transfer part of the savings to users while improving the quality of power supply to adopters. Finally, when combined with prepaid cards, decentralized retailing and charging for power become a distinctly more feasible proposition.

Energy Efficiency

A critical issue in eastern India's groundwater irrigation is energy use in pumping and the measures to improve it; while its efficiency dimensions are well documented its equity dimensions are not. The subject has been studied since the early 1970s and a general empirical conclusion is that 30–35% of the energy actually used by irrigation pump sets can be saved through "rectification" of pump sets. It is suggested that against the maximum achievable "system efficiency" of 54% for electric pump sets and 20% for diesel pump sets, observed efficiencies are sometimes as low as 13% and 5%, respectively. Reasons? The subsidized flat electricity tariff and the ignorance of farmers about selection, operation and upkeep of the pump. S. M. Patel, an agricultural engineer based in Ahmedabad who pioneered thousands of pump rectification experiments throughout India, has asserted that replacing only the foot-valve and suction pipe increases the water output of diesel pumps by 30%. But as table 4 shows full-scale rectification—involving appropriately matched foot-valve, suction pipe, delivery pipe, pump and engine—can increase the discharge of a diesel pump by 85% and cut diesel consumption/hour by 17% (Patel and Pandey 1989; Reidhead 1999).

Independently of S. M. Patel's work, some Dutch-supported shallow tube-well projects using diesel engines in north Bengal also found energy efficiency of these pumping systems unacceptably low. Experiments on pump

TABLE 4
Impact of modifications on fuel efficiency of diesel pumps: Test results in north Bengal Terai Development Project (static suction head in shallow tube wells: 3.5 m).

Modification	Discharge (l/s)	Diesel consumption (l/h)	Cumulative Improvement (%)
Unmodified	8.6	0.8	-
Raising cooling water temp. from 35 ^{0}C to 75 ^{0}C	8.6	0.78	13
Removing check valve	10.5	0.76	31
Reducing engine speed from 1,470 to 1,100 rpm	10.3	0.55	51

Source: NBTDP 1996:4

rectification here showed that fuel efficiency can be improved significantly by removing the restrictor,[23] by attaching a thermo-syphon cooling system,[24] by reducing the engine speed,[25] and by removing the check-valve (or foot-valve in case of dug-wells) (NBTDP 1996; Bom and van Steenbergen nd). Tests on modified pumps showed that diesel consumption can be cut to half and discharge improved over 15% through rectification as shown in table 5. While the full rectification program recommended by S. M. Patel may cost nearly Rs 8,000 for diesel pumps (Reidhead 1999), the modifications piloted in the north Bengal project may cost Rs 350 (Bom and van Steenbergen nd).

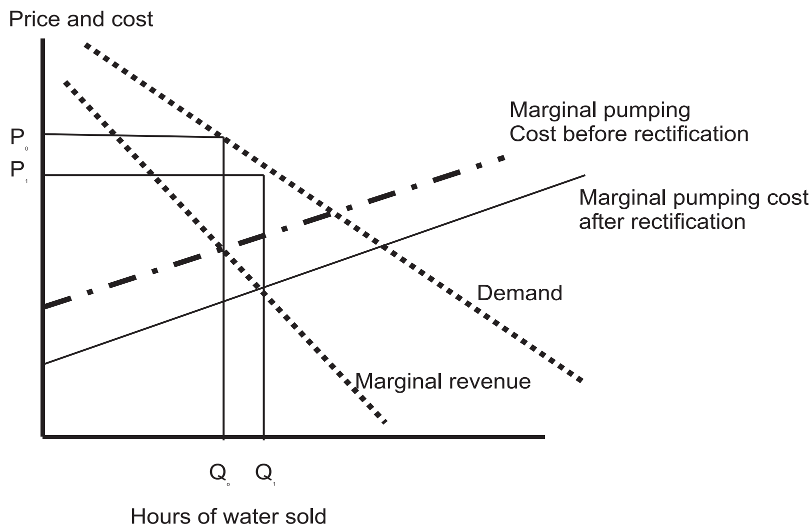
Following the pioneering work by S. M. Patel and his colleagues, many State electricity boards, Rural Electrification Corporations and NGOs like the Tata Energy Research Institute have promoted programs for pump rectification. The results have been mixed; and an important reason is that farmers are unable to meet the exacting conditions of maintenance, repair and spare-parts that high-fuel efficiency demands (Reidhead 1999). Nevertheless, the reasons for persisting with the pump-rectification programs are compelling. Existing programs are driven primarily by the energy efficiency goal and secondarily by the pollution-control goal. Reidhead (1999) estimates that rectification of all 5.4 million diesel pump sets in India can save 1 billion liters of diesel every year, or an annual economic gain of Rs 28 billion for a capital investment of Rs 48 billion. But an important additional reason, at least to push the diesel-pump rectification program, is equity. We examined the conceptual and empirical basis of the argument that asserts the price at which diesel pump owners sell water to resource-poor water buyers is linked directly with the cost of diesel consumed per hour by a multiple that tends to be "sticky." Because the sale of pump irrigation is transacted on the basis of hours of pumping rather than on the quantity of water, the cost of inefficiency of the pumps gets transferred to water buyers in two ways: for the same price/hour, buyers get less water than they would get from a rectified pump; second, rectified pump owners would be able to charge a lower price as a competitive strategy because they use less diesel per hour of operation. It is highly plausible then that a group of rectified diesel-pump owners competing with inefficient diesel-pump owners in a village would enjoy a powerful competitive advantage over the latter, create welfare gains for the water buyers in terms of doubly reduced cost per unit of water, and generate strong incentives for the rest of the diesel-pump owners to rectify their pump sets. Figure 14, which explores the profit-maximizing strategy of a water seller, suggests that after pump rectification, which lowers his marginal cost of water production, he would be induced to sell a Q_1 amount of water that is more than Q_0, which he sold earlier at a profit-maximizing price P_1, that is lower than P_0, which he charged before pump rectification.

[23]Pumps in north Bengal commonly use a 2-inch nozzle on a 2.5-inch delivery pipe to increase pressure for diverting the cooling water but causing unnecessary friction.

[24]Because farmers cool the engine by leading water directly from the pump to the engine, the engine operates at nonoptimal cooling temperatures of less than 35 ^{0}C, much lower than the temperature at which diesel engines are designed to operate. The NBTDP experiment attached a 25-liter water drum mounted on a bracket and welded to the delivery pipe. An inlet hose at the bottom of the drum leads the water into the engine; after circulating in the engine, the water is discharged back into the drum through an outlet at the top of the drum. The temperature of the circulating water stabilizes at 75 ^{0}C and is replenished every 2 hours.

[25]In north Bengal, as elsewhere in the Ganga basin—where suction heads range from 2 to 5 meters, a 5-hp engine proves oversized; here, pumps use only 2.3–2.5-hp and at 1,500 rpm, engines operate at part-load and therefore at low efficiency. Decreasing the engine speed to 1,100 rpm, the lowest possible speed, the power output is reduced to 3.7-hp, which is still too much. The speed (rpm) is reduced by counteracting the spring on the fuel pump with a rubber band.

FIGURE 14.
Impact of pump rectification on the economics of a water seller.



Manual and Small Diesel Pumps

The fourth element of the strategy for groundwater-led rural regeneration in the Ganga basin is the promotion of small pumps and improved manual irrigation technologies. In arguing for the pump-rectification programs, we noted that the shallow tube wells and dug-wells in the Ganga basin cannot use all the power of a 5-hp engine because the suction head is very low; and that, at full rpm, the pumps effectively use just around 2–2.5-hp. The ideal solution would be to offer 2- or 2.5-hp diesel engines in this region; however, after 50 years of groundwater development, the Indian diesel-pump manufacturers have not effectively promoted anything smaller than a 5-hp diesel engine that might drive an irrigation pump. Even today, only two manufacturers—Greves Cotton and Sriram Honda offer a 1.95-hp diesel/kerosene pump, which is popular in parts of the Chhotanagpur plateau; but it is difficult to find pumps of this size elsewhere in the basin. For a long time, the industry kept arguing that the market for small diesel pumps is very small. It was also suggested that the 5-hp diesel engine is versatile because it can be used to run a thresher or a generator set. The key reason, it seems, is that the small pumps marketed by the Indian manufacturers do not offer a significant price advantage compared to the 5-hp pumps nor are they particularly fuel-efficient in the field conditions as some of the Chinese small pumps are proving to be in Bangladesh. If the import of micro-diesel pumps had been allowed, small farmers, especially in the Indian side of the Ganga basin, would probably have taken to them in large numbers, as Bangladesh farmers have taken to Chinese micro-diesel pumps.

The availability of diesel pumps in a range of hp ratings would expand the choices available to the farmers to adopt a pump that fits his farm size. It would also help refine the pump-irrigation market; smaller pumps would be able to sell at a lower price because they are more fuel-efficient; this would also influence the competition within local water markets. Smaller pumps will also promote energy efficiency. Finally, since smaller pumps will also be correspondingly cheaper to acquire as well as to operate, they will be more appropriate and accessible to small and marginal farmers.

Indeed, the thumping response that improved manual technologies—such as treadle pumps—have received in Bangladesh and also in eastern India underscores the point that small farmers' capital investment decisions are highly price-sensitive. The hallmark of the treadle pump is that it costs in the neighborhood of Rs 750 to buy, it does not necessitate recurring cash outlays on diesel or kerosene, and it can be conveniently operated by men, women or children; and at a discharge of 0.9–1.1 l/s, it can easily irrigate half an acre of vegetables or even paddy. The treadle pump is an outstanding example of how access to groundwater irrigation can significantly improve the livelihoods of the ultra-poor. Many studies have tried to assess the impacts of the technology; the most recent one (Shah et al. 2000:1) concluded that:

> "a) the treadle pump technology does "self-select" the poor, although the first-generation adopters tend to be the less poor; b) it transforms smallholder farming systems in different ways in different subregions; in north Bengal and Bangladesh, adopters take to cultivation of HYV rice in the boro season; elsewhere, adopters turn to vegetable cultivation and marketing; c) it results in increased land-use intensity as well as "priority cultivation;" adopters provide crop-saving irrigation in a large part of their holdings but practice highly intensive farming in the "priority plot;" d) average crop yields on "priority plots" tend to be much higher than those obtained by farmers using diesel pumps or other irrigation devices; e) the income impact varies across households and regions; but US$100/yr. as an average increase in annual net income seems a conservative estimate. Less-enterprising adopters achieve fuller employment at an "implicit wage rate" that is 1.5–2.5 times the market rate. The more enterprising take to intelligent commercial farming and earn substantially more. For a marginal farmer with $12–15 to spare, there could hardly be a better investment than a treadle pump, which has a benefit/cost ratio of 5, an IRR of 100% and a payback period of a year. It thus ideally fills the need of the marginal farmers. The challenge lies in its marketing; exceptional ingenuity seems required to put the treadle pump in the hands of millions of the rural poor. In Bangladesh, where this has become possible, over a million pumps so far sold probably do not account for a large proportion of irrigated area but have certainly reached a significant proportion of Bangladesh's rural poor."

Reform of Pump-Subsidy Schemes

Finally, and above all, the eastern States need a drastic reform of their pump subsidy and credit schemes. As a region (including eastern UP) that is home to more than a third of India's rural poor and that commands a third of the country's groundwater resources, one would have imagined that eastern India would also get a corresponding share in minor irrigation credit. Yet, only 7% of NABARD's minor irrigation refinance—representing the total offtake of minor irrigation credit—goes to eastern India. It is important to recognize that this poor offtake does not reflect the absence of need or demand for subsidy support; nor does it reflect NABARD's unwillingness to push credit for tube wells in eastern India. Above all, it reflects the difficulty, hassle and transaction costs of accessing pump-subsidy and loan schemes as they are designed and operated by State governments. Indeed, the first-best solution is to remove pump subsidies altogether; in our analysis, pump prices in India would fall by 30–40% if pump subsidies were removed and free import of Chinese pumps was allowed. In Pakistan, which meets both these conditions, pump prices are 35–40% lower than in India, where pump subsidies and import restrictions have kept prices artificially inflated (see, e.g., Shah et al. 2000). However, if pump subsidies have to be maintained, their design and operation need to ensure smooth access and freedom from hassle and bribes in accessing these. This can be understood by the examples of north Bengal (Shah 1998b), where the pump subsidy scheme has become an instrument of political patronage and of Orissa where it has become a bureaucratic spoils system (Shah 1998a; 1998b).

In Coochbehar and Jalpaiguri districts of north Bengal—which are as flush with groundwater resources and equally bewitched by the problem of rural poverty as eastern UP—a scheme has existed for long to rapidly augment private stock of pump capital; however, a recent assessment of minor irrigation policy in north Bengal showed that the subsidy scheme of the latter has been systematically co-opted by the State's minor irrigation administration and the Panchayati Raj institutions; and the process of accessing the scheme has been made so lengthy, complex and laborious that small farmers, without backing in the political system, have completely given up hope of ever benefiting from it (Shah 1998a).[26]

The procedure for accessing the pump subsidy in north Bengal involves the following steps: 1) the aspirant, equipped with necessary documentation, gets his request registered with the Gram Panchayat; 2) once the Gram Panchayat clears his request, a Gram Panchayat member has to recommend his name to the Block Development Officer; 3) the application is discussed in periodic meetings of the Bank, Gram Panchayat Pradhan and *Panchayat Samiti* (Block Council) member concerned to assess the creditworthiness and eligibility of the aspirant; 4) if the aspirant clears this stage, his application is completed and forwarded to the bank with the recommendation of the Panchayat Samiti; 5) after this, the bank claims the subsidy from the DRDA; 6) the bank releases the loan but only after the DRDA reimburses the subsidy; 7) the bank issues the Delivery Order to the beneficiary who can go and claim his diesel pump. The procedure generally takes 1 year or more; in recent times, it has seldom got completed because banks, facing mass defaults in government-subsidy schemes, are dragging their feet.[27]

A major deterrent is the "quota" system. Each district, each Panchayat Samiti and each Gram Panchayat has a quota fixed by the government and Zilla Parishads. For a long time, the bulk of the quota got used up by Gram Panchayats buying subsidized diesel pumps and stocking them ostensibly for renting

[26]The pump-subsidy scheme in north Bengal is run under several schemes including the IRDP by the DRDA. Under this scheme, SC/ST and BPL families are entitled to a subsidy of Rs 6,000 on unit cost of the pump. The government departments involved in minor irrigation subsidy are the DRDA (IRDP), the Agriculture Department and the SC-ST Corporation. The unit price for an STW has recently been raised. The subsidy is 50% or Rs 6,000 whichever is less. The bank finances the whole investment for the diesel pump, but will not give cash; instead, it will issue a Delivery Order to the dealer; the dealer will issue the pump and the engine and will later get reimbursed by the bank.

[27]Banks do not proceed unless the Panchayat Samiti forwards an application; and the Panchayat Samiti does not forward it without the Gram Panchayat's recommendation. The Panchayat leadership thus *has* a tight grip over the process and uses it in a blatantly partisan manner. A senior bank manager suggested that Panchayat members and their protégés are naturally the first to access the subsidy; and ordinary folk cannot access it except through the goodwill of the Panchayat leadership.

out to small and marginal farmers.[28] We found all-round frustration with the pump-subsidy scheme, which was matched only by their frustration in accessing the Gram Panchayat diesel-pumps-for-renting. Even farmers who were Gram Panchayats or Panchayat Samiti members thought the procedure to access the loan-subsidy scheme to be very lengthy, complex and tiresome; so politically unconnected small farmers seldom tried it. A dealer in oil engines we met in Jalpaiguri lamented that a) the system of processing the loan-subsidy in west Bengal is extremely complex and takes enormous time; b) the dealer has no role in it; he comes into the picture only after all the loan-subsidy formalities are completed; and c) this affects the demand for pumps, which can be potentially large. Another prominent and experienced diesel-pump dealer of Coochbehar, however, went to the heart of the problem of why the subsidy-loan scheme here does not function quite like it does in eastern UP. He said that the pump dealer has a very limited marketing role in north Bengal; no buyer approaches the dealer until his application has been cleared at all the steps of the loan-subsidy process; so all that the dealer can do is to scout for farmers whose applications are already approved and try to sell his brand to him. The transaction cost of influencing the Panchayat decision-making process is very high; therefore, the diesel-pump dealer in north Bengal has not been very aggressive.[29]

In Orissa whose capital is Bhubaneshwar, a 50% subsidy is available on the cost of diesel as well as on electrified tube wells but the entire process of subsidy approval and supply of equipment is controlled by the Orissa Agro-Industries Corporation (OAIC) pretty much as the pump subsidy was administered in UP before it was reformed in the mid-1980s but the process is faster. The procedure here is: a) the farmer approaches the OAIC office with a completed form and required documentation; b) he gets the necessary clearance from the Agriculture Department; c) he deposits Rs 1,000 for test drilling; d) the OAIC makes an estimate of the total cost of the tube well; e) the farmer deposits 50% of the estimated cost with the OAIC; f) the pump and pipe are released immediately; and the bore-well gets commissioned in 7–8 days by any of the approved contractors of the OAIC. The OAIC people claimed that there is minimum hassle and delay; although the subsidy has to be approved by the Bhubaneshwar office, which often takes 4–5 months, the OAIC releases it to the farmer immediately; so the farmer does not have to wait. Several farmers we talked to agreed that hassle, running around from-this-government-office-to-that and delay are not the problems of availing of the OAIC subsidy; the problem is that there is little or no real subsidy left for the farmer; the bulk of it is swiped by the OAIC in the form of inflated cost estimates. The estimates made by the OAIC, based on which 50% subsidy is claimed, are so much higher than the market prices that effectively the farmer gets very little real subsidy. This is true about all the agro-equipment that the OAIC supplies on a 50% subsidy. In the course of fieldwork in the Puri district of Orissa in 1998, I found that the

[28]Various arrangements have been evolved in different villages for the custody, maintenance and repair, renting-out business and fee collection for panchayat-owned diesel pumps. Shah (1998a) however found that Panchayat-owned diesel pumps were commonly monopolized by the panchayat members and their kith and kin; and the marginal farmers who were really in need could seldom hire these pumps. Besides, the arrangement is proving unviable. A major problem was of maintenance; numerous Gram Panchayats have warehouses full of broken-down diesel engines and pumps; because they were common property, nobody paid attention to their maintenance; in many villages, we found that users bought diesel to run the machine but avoided buying Mobil leaving it to others to lubricate it.

[29]Jain, a large pump dealer I interviewed in 1998, told me, however, that the pump dealer is indeed a very aggressive player in agriculturally dynamic districts such as Burdwan and Hoogly. Perhaps, the large overall volume of business there has increased dealers' stake in an enlarged coordination role, and that at larger volumes, they can absorb the higher transaction costs of “managing” the Panchayat decision making in the minor irrigation field.

market price of the best brands of hand pumps ranged from Rs 290 to Rs 520; one dealer offered confidently to install any make of hand pump successfully for Rs 1,500; but at a local OAIC office, he was told that the unit cost of the hand pump (only the pump) is Rs 2,776 on which the farmer gets a subsidy of Rs 1,388, four times the market price of a hand pump (Shah 1998b). I also interviewed farmers who withdrew their applications for the subsidy scheme after they found that the cost estimates made by the OAIC were more than twice they would incur if they went direct to the market; in effect, thus there was a negative subsidy. In the case of hand pumps and diesel pumps, the farmer always has the option to go to the private dealers and not claim subsidy; but in the case of treadle pumps, the OAIC is a monopoly supplier. Manufacturers of treadle-pumps were willing to offer treadle pumps at Rs 785 each; but the OAIC brought the treadle pump under their subsidy list, priced it at Rs 1,400 and offered a subsidy of 50%. In Orissa, thus, the process of claiming the pump subsidy is smooth and fast, but there is effectively very little real subsidy to the claim. No wonder, then, that private investment in pump irrigation has not responded to the government's offer of the 50% subsidy.

Clearly, between them, eastern UP, north Bengal and Orissa offer us three models of "rent-seeking" from the monopoly that different groups of decision makers enjoy over the power to grant approval to loans/subsidy schemes. In north Bengal, the monopoly is enjoyed by members of the ruling political formation who use it as patronage to command and strengthen allegiance and political support; but since this objective is not consonant with the objectives of nationalized banks and NABARD, they have reduced their participation. In Orissa, the monopoly is vested in the Corporation, which has effectively skimmed the bulk of the subsidy by over-costing; as a result, the "demand pull" for the loan-subsidy scheme from the farmers itself has been weak. In eastern UP, the absolute monopoly power itself is diffused through the competitive dealer dynamic resulting in a win-win situation for all: dealers interested in increasing their sales and market share find in the FBS a powerful instrument; banks are happy because dealers take part-responsibility for recovering the loans; staff in relevant government and bank offices are happy because their total rents are large (though the piece rate is lower); and farmers are supremely happy because for a small sewa-shulk dealers roll the red carpet for them, and get their tube wells commissioned inside of 10 days.

There is a strong case for the rest of eastern India to redesign their pump-subsidy scheme à la eastern UP. Probably the most important first step to doing this is to recognize that the primary purpose of minor irrigation policy in east Indian States is to put the pumps in the hands of the small and marginal farmer. Second, the government should discontinue all allocations to government- and community-managed minor irrigation schemes since all available evidence shows that these fail to produce sustainable minor irrigation. Third, concentrating available financial resources for minor irrigation in the pump-subsidy scheme should create a general sense of resource sufficiency; similarly, NABARD too should help create the impression that all eligible loan applications will be processed and sanctioned. Creating this sense of sufficiency is important in breaking the monopoly rents that the power to approve loan and subsidy applications creates in bureaucracies. Fourth, the farmer should be given freedom to choose whatever brand of pump and engine he wants to buy; he should also have the freedom to choose his own contractor to make his bore-well. Fifth, the procedures to access the pump loan/subsidy scheme should be streamlined and rationalized as in UP. Finally, the dealer as well as the local administration should be vigorously involved in the recovery of loans.

Conclusions

It has to be concluded, then, that the story of groundwater-based livelihood creation in eastern India is one of failed public initiatives but one of successful adaptive responses by private agents. It has long been recognized that rapid development of groundwater irrigation in this region can create massive welfare for the poor by energizing the region's predominantly agrarian economy. Yet, the public and community tube-well program initiated by the government and supported by many donors has, in retrospect, been a resounding failure. The Rural Electrification Program, hugely funded by the World Bank, could also have stimulated much groundwater irrigation; however, the 1980s saw progressive "de-electrification" of eastern India's countryside, and a rapid decline in electricity use in the region's agriculture. Finally, while the public-sector financial institutions channelized massive resources to support groundwater development in western and southern India, where overexploitation of the resources has been reaching critical proportions, eastern India, which has much unutilized groundwater potential, has received a much smaller amount of institutional credit than its fair share.

In the face of such public-policy failures, it is not surprising that groundwater development in the Ganga basin has been far slower than elsewhere in the subcontinent. The redeeming aspect has been adaptive responses of private actors that, in eastern UP and north Bihar, have stimulated private groundwater development and catalyzed a belated Green Revolution. Here, the failure of the PTW program was overshadowed by the rise of pervasive pump-irrigation markets; and the impact of rural "de-electrification" was offset by the rapid dieselization of groundwater irrigation. An alternative to the high fuel cost of diesel-pump irrigation too was promoted—not by the government—but by the International Development Enterprises, a private NGO, which promoted treadle-pump irrigation as a technology for the poor. Finally, a hassle-ridden FBS was transformed into an instrument of small farmer development by spontaneous "dealer dynamic" in eastern UP and north Bihar. The moral of the story is clear: tube-well-induced agrarian dynamism that we find in eastern UP and north Bihar in recent years can spread to all of eastern India and Nepal terai if public policy makers learn correct lessons from the experience of these two subregions.

The object of this policy paper has been to understand these lessons. Our key conclusion is that much public policy effort aimed to stimulate groundwater-based livelihood creation has so far been misdirected and infructuous. In future, the best role for public policy lies in catalyzing and supporting private action. The strategy outlined to do this suggests five points of attack:

- Discontinue government minor irrigation programs; instead focus on private tube wells as the primary mode for groundwater development.
- Improve the electricity-supply environment for agriculture by reintroducing metered tariff, decentralized retailing of electricity, and the use of prepaid electricity cards.
- Initiate planned interventions to improve the energy efficiency of agricultural pumping sets.
- Introduce small diesel pumps and manual irrigation technologies for vegetable growers and marginal farmers.
- Remove the pump subsidies while also opening up the imports of Chinese pumps; if doing this is not feasible or practical, follow the next best alternative of redesigning the pump-subsidy schemes à la UP's FBS.

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