WELLS AND WELFARE IN THE GANGA BASIN:
ESSAY ON PUBLIC POLICY AND PRIVATE INITIATIVE

Tushaar Shah

International Water Management Institute, Colombo

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Tushaar Shah
Policy Institutions and Management Program
International Water Management Institute, Colombo

Eastern India is home to nearly 88m. or a third of India's rural poor; but it has over 1/4th of India's usable groundwater resource; and less than 1/5th of it is developed. Stimulating groundwater development is not only central to kick-starting the region's Green Revolution, and creating livelihoods for its poor but also to addressing its syndrome of extensive water-logging and flood-proneness. This essay analyses 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 deliver the development the region needs so direly. The essay outlines a strategy with five components: first, Eastern India needs to scrap its existing minor irrigation programs run by government bureaucracies which guzzle 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 collection of electricity dues from millions of small users; third, programs are needed to improve the unacceptably efficiency of electric as well as diesel pumps; fourth, there is need to promote smaller than 5 hp diesel pumps and improved manual irrigation technologies such as the treadle pumps; finally, above all else, East Indian states need to reform their pump subsidy schemes on the lines that Uttar Pradesh has done so as to ameliorate the pump capital scarcity which lies at the heart of the problem.

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

1. Backdrop.

Eastern India, especially the 15 eastern districts of Uttar Pradesh and the entire states of Bihar, West Bengal and parts of Orissa comprise 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 paper deals with—and the strategy outlined to respond to it—in the East India context applies with equal force to the terai areas of Nepal as also 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 of the world's poorest people.[1]The region is marked by high dependence of its predominantly rural population on smallholder agriculture and wage labour. 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 Uttar Pradesh, Haryana and the two Punjabs (Indian and Pakistan) underwent massive agrarian transformation during the 1960's, agrarian growth in the Eastern areas of India remained stagnant. District-wise analysis of agricultural growth in India by Bhalla and Singh shows that during 1963-93, the productivity/male agricultural worker crossed the Rs 10000 barrier in much of India; but most of Eastern India was not a part of it. The only region of Eastern India, which seems to be crossing the barrier is Eastern Uttar Pradesh (UP).

Eastern UP, the western-most part of Eastern India and the GBM basin, is an interesting study because it has just managed to break out of its agrarian stagnation. It is interesting also because, its transformation over the past 15 years is 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 Uttar Pradesh--is quintessentially a study in political economy and practical policy. It is about how major public policy initiatives have actually impeded groundwater development rather than expediting it, and how the agrarian transformation in Eastern UP has come about largely through spontaneous techno-institutional responses of a multitude of private economic agents aimed at countering or coping with the powerful propensity of well-intentioned public policy initiatives to degenerate over time and become counter-productive. The overarching argument is that the seeds of an effective strategy for groundwater-led agricultural development for all of Eastern India—and the GBM basin—lie in the lessons offered by the experience of Eastern Uttar Pradesh. In sections 2,3,4 and 5, our focus then is on learning lessons from Eastern Uttar Pradesh. In section 6 and 7, we explore their implications for Eastern India as a whole.

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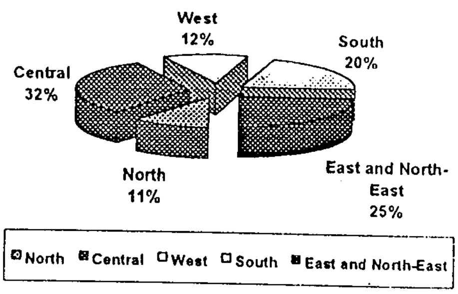
[1] These estimates seem plausible; Eastern India's 3.48 lakh square km is 10.6% of India's total area but its 260 m people are over a 4[th] of the Indian population. Add to this Bangladesh's 280 m, and we already have over 500 m.

2. *Groundwater Resources of Eastern India*

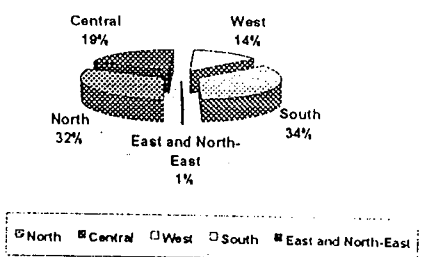
Eastern and North Eastern India has abundant surface as well as groundwater resources. Figure 1, based on estimates prepared by India's Central Groundwater Board (which have recently been revised upward), suggests that of the total usable recharge of 325 cubic km for India as a whole, 25%, or over 80 km^3 is available to Eastern and North Eastern India. These figures exclude 16 districts of eastern Uttar Pradesh. If these were included, eastern India's groundwater resource would increase further to 92 km^3. Less than 1/4th of this resource is in use at present.

Figure: 1 Regional Distribution of India's Usable Groundwater Recharge of 325 km. sq



Uttar Pradesh (UP)'s own groundwater resources are abundant; its surface irrigation potential is estimated at some 13-14 m ha; but groundwater irrigation potential is estimated at over 20 m ha, taking the total irrigation potential to 33-34 m ha.[2], [3] All of UP falls in the piedmont zone of the Himalayas skirted 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 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 GBM basin ranging from 50-75 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 4000 m^2/d and hydraulic conductivity from 10 to 800 m/d. The well yields range up to 100 liters/second and more but yields of 40-100 lps are common...' (GOI 1996:3).

Figure: 2 Regional Distribution of India's 599 'Dark' Blocks with over 85% Groundwater Development



Overall, then, while peninsular India is crying out for effective control of groundwater over-exploitation, the need of Eastern UP, as indeed of the rest of the Eastern India, is to step up the utilisation of abundant groundwater resource for wealth creation and poverty alleviation. Of India's 7063 blocks, 599 are dark. Figure 2 shows that only 1% of these are in Eastern and North Eastern India. Similarly, figure 3 sets out the distribution of

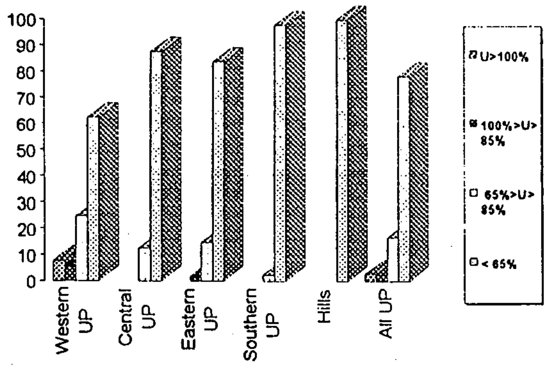
[2] The state's annual average precipitation is 33 mham; after making allowances for evaporation losses, the share of other states, requirements of industry, commercial and domestic users and others, it has a surface irrigation resource potential of 14-15 mham and total groundwater resource estimated at 8.5 m ham which is nearly 1/5th of the all-India potential estimated at 43.18 m ham (GOI 1996:9). After allowing 15% of the gross recharge for non-agricultural uses, the net recharge available for irrigation is 7.74 mham. Because of its inefficiency, surface water is estimated to be capable of irrigating 13.7 m ha (with a delta of well over 1 meter). In contrast, UP's groundwater resource can irrigate around 20.3 m ha (with a delta of 0.38 m), taking the ultimate irrigation potential of the state to 34 mha.

[3] The UP state groundwater department monitors groundwater levels through a network of 4000 hydrograph stations including 500 shallow piezometers located through out the state except the hill areas (GoUP 1996b).

white, gray and dark blocks in different sub-regions of Uttar Pradesh. For UP as a whole, less than 2.5% of the blocks are designated dark; and nearly 4/5th are denoted as white, offering much scope for tapping unutilised 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 over-development is more acute in Western UP where groundwater irrigation has developed more rapidly 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 point of fact, nearly 1/4th-- of Uttar Pradesh's groundwater recharge is contributed by canal irrigation according to the estimates by the State Groundwater Department; however, this proportion is probably even higher for, water losses through seepage are estimated to be 75% in many systems with unlined canal distributary network. In this flood-prone region, flood waters too contribute to recharge as do the shallow water tables to which recharge gets added.

Figure 3: Uttar Pradesh: % Distribution of Blocks according to Level of Groundwater Utilisation in relation to available net recharge



All in all, the available irrigation potential-estimated using generous delta values, is 1.33 times the state's 1991 gross cropped area of 25.5 mha, 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 unutilised potential is in groundwater. Already, 6 out of the 13.7 mha potential of surface irrigation is utilised; but only 6 mha of the 20.3 mha (gross) of available groundwater potential is used, leaving room to bring over 14 m 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 or greater but its utlisation is far lower than in Eastern UP.

3. 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 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 groundwater accentuates its flood-proneness and water-logging.

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 Uttar Pradesh, too. While Western UP forged ahead in Green Revolution in the 1960s and '70s, eastern UP lagged behind in most respects (see table 1). The region needs a strong push in its agricultural sector to promote wider spread of the HYV technology, more crops under irrigated conditions, cropping pattern diversification in favour of high value crops, and a large summer crop which is by and large non-existent.

A major hypothesis—which has survived three decades and several failures to clear macro-level empirical tests—is that the rise of Green Revolution in Punjab, Haryana and Western Uttar Pradesh was fueled by the tubewell revolution that preceded it in these states; and that its refusal progress east-ward from Lucknow, which divides Western from Eastern India in the north is explained by the inadequacy 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 tubewell irrigation(see, e.g., GOI 1985) ; [b] numerous 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[4]; (see, e.g., Dhawan 1985) and [c] by common observation, this difference is obviously explained by the superior *quality* –in terms of reliability, timeliness, adequacy -- of irrigation that tubewells offer compared to other sources (Chambers, Saxena and Shah 1987; Shah 1993). As far back as in 1985, a study group constituted by India's Planning Commission to explore agricultural strategies in Eastern India noted that 'one major

*Table: 1 East and West: Regional Disparities in Agrarian Performance in Uttar Pradesh, India**

	Eastern UP	Wester UP
Population/sq. km 1991	614	602
GW potential as % of Gross Recharge (1990)	75	67
Gross Irrigated Area as % of GCA	46.9	76.7
% of total irrigated area served by canals(89-90)	29.3	23.4
% of irrigated area served by tubewells (89-90)	63.2	68.8
% of all farm-holdings in <1 ha (marginal)	81.3	65
Average size of the marginal holding (ha)	0.32	0.4
Fertiliser 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 88-89	8872	11612

* Source: GoUP (1996)

[4] Regression equations on survey data typically have low coefficients of determination and large values for the intercept --representing the weight of the omitted variables-- and 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 the Shah, Indu and Paleja (1997) showed following results:.

Paddy: $q_p = 4.840 \, . \, F_p^{0.269} \, . L_p^{0.128} \, . \, H_p^{0.050}$ $\quad R^2 = 0.204$
$[15.3]^{**} \quad [4.29]^{**} \quad [2.68]^{**} \quad [1.203]$

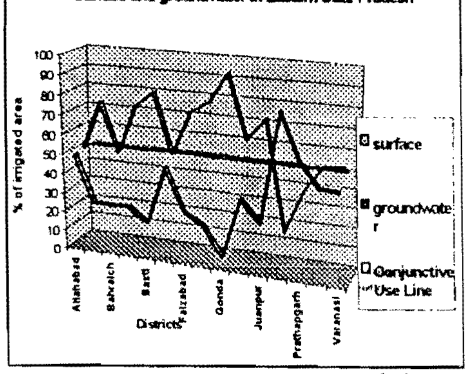
Wheat: $q_w = 4.873 \, . H_w^{0.155} \, . \, L_w^{0.124} \, . \, H_w^{0.137}$ $\quad R^2 = 0.325$
$[9.059]^{**} \quad [2.877]^{**} \quad [2.972]^{**} \quad [3.292]^{**}$

Where, subscripts p and w refer to kharif paddy and rabi wheat, q refers to output/acre (kg); F refers to fertilizer use/acre (kg). L is hired labour/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 foe wheat, that for kharif paddy was small and insignificant, presumably because kharif paddy in Eastern UP is predominantly rainfed. The sum of the elasticities for fertiliser, labour and pump irrigation hours is much less than unity-- 0.416 for wheat and 0.447 for paddy, suggesting steeply increasing returns to the scale and scope for beneficial intensification of the use of all the inputs.

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 monsoon conditions affected by floods as well as draughts' (GOI 1985:1).

Finally, increased density of wells can increase welfare of the people in the eastern region through the powerful positive externality they produce by acting as an *anti-dote to water logging and flood-proneness*. Much of eastern India, particularly Eastern Uttar Pradesh, 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 m ham of the total of 8.42 m ha m of groundwater recharge that Uttar Pradesh gets annually occurs from canal irrigation (1.24 m ham), surface irrigation reflows (0.69 m ham), and recharge from tanks, and lateral recharge from flood prone areas and from shallow water table areas (GoUP1996b). This surfeit of groundwater recharge increases as one moves from west to east. In Eastern UP, vast areas remain inundated by flood waters for better part of the year, and acute water logging characterizes the Saryu-par areas in the middle of the Ganga basin--lined 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 acute problem of sub-soil water drainage and consequently, 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 mite in flooding the region (Vajih and Kumar nd). Rapti alone inundates 3,50,000 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 water logging in Eastern UP (within latitudes $26^0 0^1$ and $30^0 0^{1\,N}$ and longitudes $78^0 15^1$ and $84^0 30^1$ E) during September 2-6, 1988 showed that 1.089 m ha-- including crop lands-- was 'completely/partially inundated' and 0.678 m ha had surface water logging (Kolavalli et al 1989: 81). Over 15% of Eastern UP's crop land is hit by floods every year; and over half of the region has groundwater tables less than 5 m *pre-monsoon* (ibid.). According to a study undertaken by the Gorakhpur Environmental Action Group, some 0.398 m ham of water is added to the groundwater table every year; of this, only 0.064 m ham (around 16%) is abstracted through various irrigation structures. Water logging and flood-proneness are aggravated by large-scale erection of embankments in Gorakhpur and Deoria districts, which further impede drainage and accentuate water logging.[5]

Figure 4: % of irrigated area served by surface and groundwater in Eastern Uttar Pradesh



[5] In Deoria and Gorakhpur districts, water table has risen over the 1971-91 period by 0.63 and 0. 36 m. In Padrauna, Salempur, Hata and Deoria tehsils of the undivided Deoria district, water logged areas increased by 60-90% over the 1971-91 period due to Gandak canal system; in Gorakhpur Sadar, Bansgaon, Pharendra and Maharjganj tehsils of the undivided Gorakhpur district, water logged areas increased by 65-95% over the same period. 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 sq km (Vajih and Kumar 1994). Nearly 0.45 m ha in Sharda Sahayak command and 0.25 m ha in the Gandak command are water logged (RBI 1984) Nearly 2/3rd of the area irrigated by Sharda Sahayak was water logged in 1987; and in 50,000 ha in the Gandak command, the water table depth was just around 1 meter (Yadav and Lal nd).

Flood proneness and water logging hit the lives and livelihoods of people in myriad ways. Between 1951-1981, the area cultivated in kharif in the Gandak River Project command *fell* from 214 thousand ha to 68 thousand ha due to annual flooding and surface water logging (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 minimised 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, large bovines have declined in population. Marginal farmers and landless have increasingly taken to piggery.[6] Flooding and water logging have also brought in their wake a variety of health-related disbenefits: incidence of diseases like malaria, Japanese encephalitis, filaria is rampant. Moreover, due to flooding and water logging, soluble iodine is washed away or removed by seepage, causing severe iodine deficiency (Vajih and Kumar, *opp.cit.).* Over a third of the *usar* (sodic) lands of Uttar Pradesh are largely an outcome of the rapidly rising water tables causing water logging conditions in extensive areas of the state. In saline lands, vegetation exists only in kharif and pH is lower than 8.5; in saline-alkaline lands, the most common variety of *usar* lands, the presence of a kankar pan 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 that the best approach to achieving seasonal water balance is better and more integrated management of the basin as a whole (see, e.g., Ramaswamy 1999:2296). The centerpiece of such a strategy has to be increased sub-surface retention and storage of peak-flows for use in lean season; and the most practical and cost-effective way of doing this is through rapid groundwater development.

A major reason for Eastern India's water logging and flood proneness is insufficient conjunctive use of ground 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 4 shows, in Eastern UP districts, ground and surface water development have lacked this balance. As far back as in 1948, a commission appointed by the Government of Uttar Pradesh 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, resulted in rapid and persistent rise in groundwater tables resulting in large areas water-logged for 5-6 months after the last of the monsoon rains. This problem—which has bewitched the entire Eastern India, got enormously 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 farm lands from flash-floods but have been producing exactly the opposite impact (Mishra 1999a and 1999b). As in Eastern UP, Bihar's flood-prone area too tripled from 2.5 m ha in 1954 to6.8 m ha in 1994—which means that 70% of the population in North Bihar, some 30 m people, are at risk from floods every year (ibid.).

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[6] 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 light-weight ones, have got caught in infructuous crossfire between 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 sugar cane supply rights (in the form of *ganne-ki-parchi*).

Many strategies have been recommended and tried out to deal with the intensification of the flood-proneness and water logging of Eastern UP as a consequence of canal irrigation growth. But there has been growing consensus that the most important long term strategy to flight flood-proneness is of 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 made by several experts, the Delhi-based Center for Science and Environment 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 50% reduction in the monsoon flow of the river. Thus groundwater utilisation can not only contribute to full realisation of the agricultural potential of the region but would also be effective in reducing and preventing water-logging 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 can not afford the investment required in installation of tubewells... (CSE 1991: 121-122).

Public Policy: State and Community Tubewell Program

Preponderance of marginal farmers and their lack of capacity to make tubewell investments has then been the central challenge in stimulating poverty-focused groundwater development in Eastern India. And all government and NGO initiatives since the 1950 have been designed to respond to this challenge. Early thinking aimed at organizing the poor for collectively managing an irrigation asset or through an extensive and vigorous public tubewell program. Eastern UP offers examples of both these institutional options, although there is only one significant case of tubewells owned and managed by farmer groups. This experiment was promoted in Deoria district of UP and 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 tubewells over a period spanning more than a decade, wrote in early 1980's, '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 tubewell 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 tubewells were subsumed by the World Bank tubewells.. the World Bank tubewell water was available at a much cheaper rate.. (Pant 1989: 97-98).

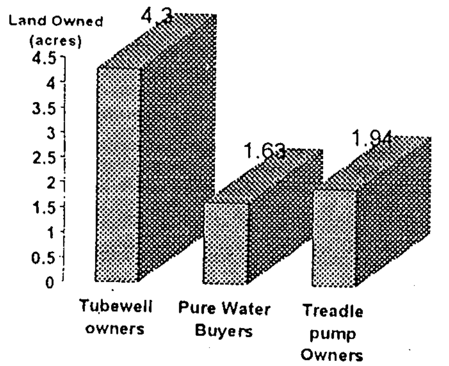
The Public Tubewell program, which cannibalized the Deoria tubewell groups itself, fell, a few years later, to the predatory onslaught of booming local pump irrigation markets besides its own short-comings. By 1990, there were nearly 30,000 large public tubewells strewn all over UP's countryside, constructed with financial support of the Dutch and the World Bank. Its failings however soon began to come to the fore. In mid-1980s, the Public Tubewell Program was losing around Rs 65-70 crores/ year (Kolavalli and Shah 1989); in the 1990's, the annual losses exceeded Rs 100 crore. A new program launched in late-1970 with World Bank support promoted several new design features such as: dedicated power supply to a cluster of 25 PTW's linked to an independent 11 kV line, buried pipelines, automatic operation of wells, tamper-proof outlets, and the system of *osrabandhi* 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 public tubewells. They did better than conventional PTWs while they were new. However, as they advanced in age, the performance of the World Bank tubewells declined too. For instance, the average number of hours and area irrigated per tubewell fell from 2304 hours and 77 ha in 1976-77 to 780 hours and 35 ha in 1983-84 (Kolavalli and Shah 1989); the downward spin continued thereafter. A study of the 'new design' PTWs (i.e., Public Tube Wells) 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 non-functioning meters; 30% of PTWs did not have farmer committees and in the rest, the committees had seldom met; the performance of tubewells themselves was quite poor compared to what was planned; the highest realizable revenue by PTWs was less than needed to meet the operator salary (Pant 1989).

Different researchers have found marginally different clusters of reasons explaining the failure of the UP Public Tubewell Program. Kolavalli and Shah (1989) blamed insufficient and erratic power supply, inadequate conveyance systems, operator-absenteeism, failure of *osrabandi* system, and poor maintenance as the main reasons. In addition to all these, Pant (1989) also found organization-design failure to be an important factor: ' [operators] thought they were accountable to irrigation officials rather than to command farmers or to the Tubewell 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) 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.."(p:iv)

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 tubewells increased rapidly once an area got covered by a World Bank PTW command, in Faizabad, by 54% and in, Deoria by 33%. Over 2/3rd of the PTW command farmers used other private tubewell irrigation; and of these, only 1/4th owned tubewells, the rest purchased irrigation from private tubewell owners (Pant 1989:90). When the first generation public tubewells came up in UP in the 1940s and 50's, private tubewell development was all but non-existent. In fact, even in the 1970's, when the community tubewell experiment was carried out, eastern UP had very little private tubewell development. During the 1980's, however, the growth of private tubewells was truly rapid; and in their wake came the practice of water selling. Indeed, both the community tubewells as well as public tubewells faced growing farmer apathy and disinterest because private water sellers rapidly made deep inroads into their command, established themselves as market leaders and reduced public tubewells to the status of suppliers of supplemental irrigation.

Figure 5: Scale bias in Tubewell Ownership: Survey of 380 farmers in Eastern UP (Shah et al 1998)



Rise of Pump Irrigation Markets:1960-90

Even without its failings, the Public Tubewell Program would not have played more than a marginal role in

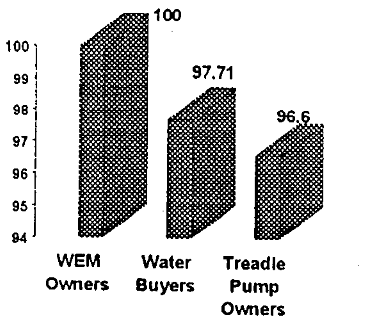
UP's Green Revolution. At full strength of 30000 tubewells all working to their full capacity, the Program would have developed no more than 1 percent of UP's groundwater potential. And a program much bigger than this would prove unmanageable in the best of conditions. Growing private investment in tubewell irrigation was thus a Godsend for UP agriculture. One reason why interest in public and community tubewell persisted long after it was 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 tubewell installation. Studies in the 1980's and 90's (Kolavalli, Kalro and Asopa 1989; Kolavalli, Naik and Kalro 1992; Lall and Pachauri 1994; Pant 1992; Pant 1989; Shankar nd; Shankar 1992; Shah 1993, Shah, Indu and Paleja 1997), however, showed that a fitting response to this important equity issue came not from public tubewell programs but from private water markets.

As far back as in the 1960's, purchased pump irrigation from private tubewell 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 was beginning to get recognised only during the late 1980s as the South Asian water market debate opened up. Most of these researchers found that compared to the lackadaisical public tubewell operators, private pump owners were surprisingly eager irrigation service providers, taking on their competition by lowering price and improving 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 access for the poor, ironically, it was the poor water buyers who disowned public and community tubewells to turn to private water markets because of their superior and more reliable—even if apparently costlier—irrigation service.

Table:2 Key Results of Pant (1992) on Water Markets in Faizabad and Bahraich Districts of Eastern Uttar Pradesh

	Faizabad		Bahraich	
	Owner	Buyer	Owner	Buyer
1. % of pump owners selling water	90.6		75.7	
2. % of water buyers owning tubewells		33.3		17.2
3. average # of buyers per tubewells	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

Figure 6: % of Operated Area Irrigated: Eastern UP Sample Survey of 380 farmers (Shah etal 1998)

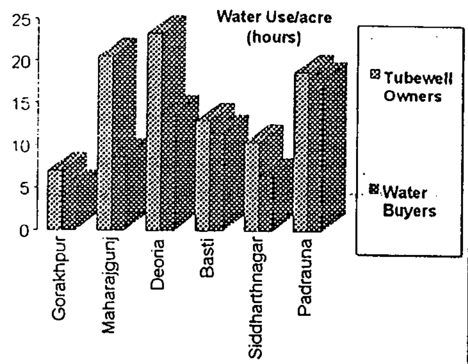


In late 1980's, Niranjan Pant reanalysed his 1981 survey of 280 farmers in Deoria, Barabanki and Meerut districts and concluded that whereas only 27.7% of the farmers owned bore wells, *all* the remaining 63.3% purchased irrigation from pump owners. He found water trade deeper and broader in Barabanki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

In 1990, Pant explored water markets in course of extensive fieldwork through out 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 8-25/hour from a 5 hp pump/ tubewell..'[Pant 1989:89]. Still later, exploring the comparative reach amongst the poor of water markets, World Bank tubewells and canal irrigation in Faizabad and Bahraich, amongst India's poorest districts,[7] 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].'[8] In contrast, Pant found that both World Bank Public tubewells as well as the canal system benefited primarily the well off. '...the World Bank assisted tubewells in Faizabad at least cater to the needs of the poor to some extent, while in Bahraich, such tubewells cater to the needs of the relatively well off..". And then '..canal as a public source of irrigation is worse than public tubewells and among the two districts, it is much worse in Faizabad.."

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. In manual technologies, the most notable has been the introduction of treadle pump, which is particularly suited to farmers with less than a ha 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 point of fact, a 1996 survey (Shah, Indu and Paleja 1998) 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 us to find farmers pure rain-fed farmers in Eastern UP; almost every farmer who does not have own means of irrigation buys irrigation service from private tubewell owners. Figure:6 , based on a survey of 134 tubewell owners, 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 tubewell is not all that much of a disadvantage because over 95% of the operated area in case of all the three categories is irrigated. Another interesting finding of this survey was the surprisingly small contribution of surface water to

Figure 7: Water Use/acre by Tubewell Owners and Water Buyers in Eastern UP: Results from a Survey of 380 Farmers (Shah et al 1998)



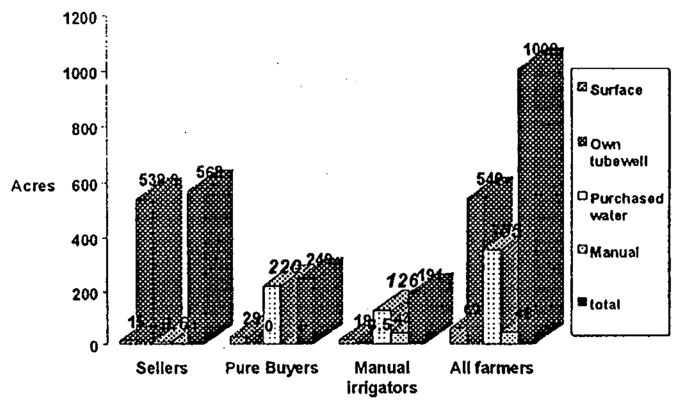
[7] Pant selected 14 villages for his study, 7 from each district of which 4 each had World Bank Tubewells; two each were outside the command of any public irrigation source; and one each had a canal. Farmers with and without pumps were chosen from each of the 14 villages. Of the total sample of 247 farmers, roughly half owned private tubewells; 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.

[8] Further 'Amongst the category <0.4 ha farmers, 64 percent in Faizabad and 53 percent 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 percent of them depend on purchased water which is the largest single category. In Faizabad, even a great chunk (28%) of the Category 1ha< III<2 ha farmers depend on purchased water for their wheat irrigation..' (ibid.)

smallholder irrigation. Considering that the sample of 280 was chosen from 25 villages in the districts of Deoria and Maharajganj which have a large canal network, we had expected that canal irrigation would be an important presence for the farmers surveyed. Yet, it emerged that, after own tubewells, purchased pump irrigation was the largest provider of small-holder irrigation: of the 1000 odd acres operated by the 380 sample farmers, 35% was served by the water market (figure 8).

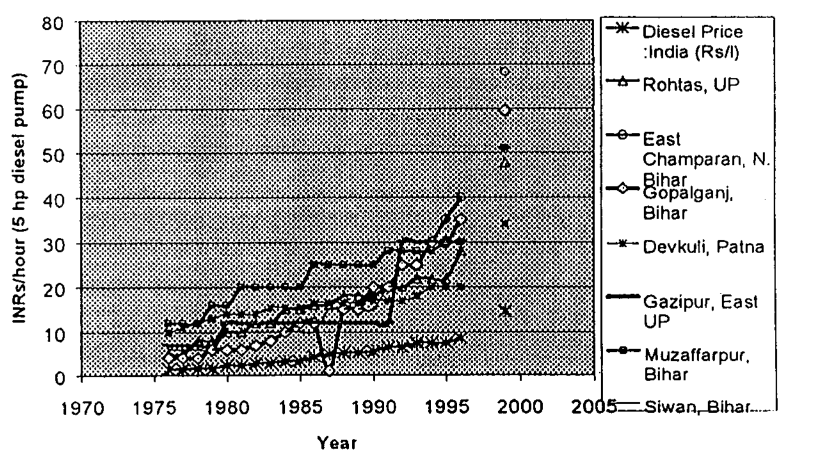
The downside of water markets is the high cost of irrigation to the buyers, and the pressure on them to economize on groundwater use especially in a region like Eastern India, where as we reviewed earlier, groundwater withdrawal creates a powerful positive externality. Many studies indicate that where as water markets have a wide reach, water buyers invariably use less water compared to tubewell owners themselves. Figure: 7, for example, shows the relative frugality of water use by water buyers in the five districts of Eastern UP from which Shah, Indu and Paleja (1998) drew their sample of 380 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/ha by tubewell owners 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, Naik and Kalro (1992) found that where as 90% of tubewell owners in Azamgadh and Sultanpur gave more than 2 irrigations to paddy, more than 75% of water buyers gave less than two irrigations. Then authors 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..' (p 46).

Figure 8: Contribution of Water Markets in Eastern UP Agriculture: Survey of 380 Farmers (Shah et al 1998)



In 1996, water buyers in Eastern Uttar Pradesh 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 ha of wheat in rabi would need 100 hours costing Rs 1960/ha and Rs 2800/ha respectively. Canal irrigation rates for paddy and wheat in UP for years have been Rs 180/ha and Rs 70/ha. Thus irrigating wheat and paddy with purchased tubewell water is nearly 20 times costlier than canal irrigation.

Figure 9: The Impact of 35% Diesel Price Hike on Pump Irrigation Prices (INR/hour: 5 hp diesel pump)



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 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

$$w = e/(e-1).c$$

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/litre since a 5 hp diesel engine consumes on average1 liter/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 NGO's, we constructed time series of diesel pump irrigation prices in a selection of 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 diesel price increase. Figure:9 which presents these data 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 irrigation sold in Eastern India contained a 'monopoly rent' of Rs 10 in 1996; assuming that the 22 lakh diesel pump owners in Eastern India sell 100 hours each per year, we can surmise that water buyers subsidize pump owners to the tune of Rs 2200 m every year. With the 1999 hike in diesel prices by 35%, we believe this 'rent' has more than doubled.

Progressive Rural De-electrification of Eastern UP

UP government's policy on rural electrification did to catalyze pump irrigation markets what its public tubewell program did to initiate private tubewell revolution. During the 1960's, 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 tubewell irrigation. As a result of this intensive effort, the population of electric tubewells rose rapidly, particularly in Western UP; but 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 tubewell owners. Diesel pumps were cheaper to buy but were less preferred because they were substantially costlier to operate. The high investment costs of electric tubewells encouraged their owners to operate their pumps at a high level of capacity utilisation by supplying irrigation service to other farmers. Thus arose the new institution of pump irrigation markets; and private electric tubewells began playing pretty much the same role as public tubewells were envisaged to do--*viz.*, providing tubewell irrigation service to small and marginal farmers--but in a more service-oriented and economically profitable manner.

However, by the early 1970's, the logistics of metering electricity supply and collecting the tariff was beginning to prove too much for the UP electricity board which had hired an army of meter readers to take readings on the rapidly growing numbers of household and tubewell connections in UP's vast country-side. [9]The meter readers who were initially appointed on contract during the early 1960's soon unionized and eventually forced a populist chief minister to regularize them as government employees with manifold increase in wages and benefits. Soon thereafter, the quality of metering declined, and so did the collection of electricity charges. Meter readers were easy to bribe or to brow-beat into under-reporting 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 manifold 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 the cost of metering electricity consumption by farmers and rural households was over 40% of the cost of power itself! UP was not the only state that was facing these problems; all states did. So in 1975, when the UP 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 five years, most other Indian SEB's followed suit and changed from metered to flat electricity tariff, especially for agricultural users.

The change to flat tariff gave a powerful stimulus to pump irrigation markets; it raised the fixed cost but reduced the incremental pumping cost to zero, almost. This meant that the electric tubewell owner was under powerful compulsion to sell more; and competition amongst electric pump owners forced the pump irrigation price down, improved the quality of service, and in general, created a buyers' market for pump irrigation. Comparative surveys across states during the 1980's showed that a 5 hp electric pump owner in Meerut (Western UP) and Basti (Eastern UP) sold pump irrigation at Rs 5-6/hour where as 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 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 in order to survive in the competition. All

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[9] UP has 1.10 lakh 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 UP State Electricity Board (UPSEB) 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 two years after this arrangement was created, SEB inspections revealed that many meter readers sub-contracted the work to school boys 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 all, the resource poor farmers—who were mostly pump irrigation buyers—had the best possible deal they could hope for in the early years after the change to flat electricity tariff[10].

However, this state of happiness proved short-lived. While changing from metered to flat tariff, the UP State Electricity Board (SEB) was governed by the economics of power supply as well as the politics of power. Compared to many other states especially in South India, where political leaders used the change to 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 break-even point for pre-change level of average electricity consumption, particularly since the flat tariff eliminated substantial cost 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 flat tariff. The very process that transformed pump irrigation markets into a boon for resource poor farmers—and heralded a new promise for Eastern UP's belated Green Revolution-- was also playing havoc with the UP SEB's balance sheet. Ideally, the SEB should have put up the flat tariff as the average power consumption per tubewell rose; and it did manage to raise it to Rs 25/hp/month in early-1980s to Rs 30 in late-1980's and further to Rs 50/hp/month in early 1990's[11]. This was creditable compared to many southern Indian states which used 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 electric tubewells, were getting organised 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 UP SEB had control over either the price or the quantity supplied of the product it supplies 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 18 hours/day. Something had to give; 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.

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[10] According to Pant's analysis, some 91% of the tubewell owners in Faizabad and 76% in Bahraich sold pump irrigation; an average seller served 4 buyers in both the 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 tubewell owners--who had to pay a flat electricity tariff of Rs 25/hp/month-- sold water at Rs 3-5/hour. Generally, 3 hp tubewell owners charged Rs 3/hour and 5 hp tubewell owners charged Rs 5/ hour. Electrified tubewell owners 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 irrigations as needed when electricity was available. Diesel tubewell owners sold only on per hour basis; at Rs 12/hour for 3" delivery pipe and Rs 14/hour for 4" delivery pipe, purchased pump irrigation from diesel pump owners was substantially costlier. The terms of pump irrigation sale also included offer of credit. Part payment was made in cash; this was typically half of the cost of diesel; the rest was paid at the time of harvest.

[11] Which was later slashed to Rs 40/hp/month by Prime Minister Devegauda in a pre-election 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 organised and militant compared to *Jats* in western UP. This process of omission was slow; cessation of investment in maintenance and repair—and the resulting erosion of the element-- take time to take effect; but slowly and surely it did and began to translate in declining quality and reliability of power supply. At the close of the 1980's, only 1-1.5% of transformers in Eastern UP used to be 'down'; in early 1990's 20% were found to be non-functional 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; 24 hours/day were supplied during peak-monsoon and 3 hours/day in peak-irrigation seasons to make up the required annual average. Flat tariff has many advantages for tubewell owners 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 all of Eastern India—during the 1980's was that agricultural power supply got concentrated during monsoons and, that too, during nights. In such inopportune power supply environment[12], electric tubewell owners began to find it increasingly difficult to operate their tubewells at a level of capacity utilisation 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 1980's and the 90's, all indications from the field show that these have actually declined rapidly. During late 1970's, one could find at least a dozen electric tubewells in a village in Deoria district; in course of our 1995 fieldwork, we had to visit a dozen villages before we could interview the owner of an electric tubewell. As early as in 1989, Indra Deo Sharma (Sharma 1989) had presented a paper lamenting the 'diesalisation of Eastern UP's groundwater sector' at a workshop in Faizabad. In course of his 1990 survey in Faizabad and Bahraich, Niranjan Pant's stratified random sample of 50 tubewell owners in Faizabad (just east of Lucknow in Central UP) captured 22 electric tubewells; but his sample of 70 tubewell owners in Bahraich (deep in Eastern UP) captured only 2 electric tubewells[13] In trying to explain why Eastern UP does not use its groundwater potential fully, Kolavalli et al randomly selected 193 tubewell owners for their survey in Gorakhpur, Sultanpur, Azamgarh and Mirzapur districts of Eastern UP and found only 10 electric tubewells to survey (Kolavalli et al 1992). For our own survey of 380 farmers in five districts of Gorakhpur Mandal, we tried to include an equal number of electric, diesel and treadle pump owners, water buyers and non-irrigators; however, we found no 'pure' non-irrigators and only 4 electric tubewell owners in 25 villages (Shah et al 1998). This trend is not evident in SEB's published figures on electrified tubewells because these do not deduct the disconnected tubewells, which are treated as provisional disconnections. But in

[12] The term *inopportune* is used to contain a combination of circumstances that disable tubewell owners from making their tubewells 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, power not available for long periods (often running into several weeks) because of poor maintenance of power distribution infrastructure.

[13] 'In fact, in majority of the villages in Bahraich electricity was not available for tubewell irrigation and was available only for worship places like mosques.. Low use of electricity in Bahraich compared to Faizabad is manifested in the fact that on 31.3.86, there were 2936 energized private tubewells in Bahraich compared to 16600 in Faizabad..' (Pant 1992:20)

private discussions SEB managers readily conceded that 80% of the pump electrification targets got 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 tubewells 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 significantly higher electric tubewell density compared to the rest of the UP. Even within these districts, electric tubewell 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, electric tubewell density rapidly declines even in these *electrically* privileged districts.

Officially, the UP SEB has spun an unbelievable story that militates against commonsense as well as the ground reality of Eastern UP. According UP SEB figures, since 1972-73, the total number of private electric tubewells in UP increased from 1.83 lakh to over 7 lakh in 1993-94 at a compound rate of around 10%/year. The power supplied to these has increased at an even faster pace than their number, from 794 m units/year in 1972-73 to 9500 m units in 1994-95, at a compound growth rate of 11.9% per year. As a result, the average power consumption per electric tubewell has gone up over three times, from 4072 units/year in 1972-73 to 11800 units in 1994-95. The official UPSEB estimate of its losses from agricultural power supply shot up from Rs 163 cr in 1993-94 to just under Rs 1300 crore in 1994-95. For every hour of pumping of an electric tubewell, the UP SEB has been losing over Rs 6.[14] 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. 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 concluded similarly.

But several inconvenient facts remain unexplained. First, why should farmers reject electric tubewells 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 on the hours of pumpage by electric tubewells imply a level of actual power consumption, which is a small fraction of the average claimed by the UP SEB. Third, accepting the UP SEB's estimates raise important questions about what are 2.2 million diesel pumps doing in UP's countryside and why are diesel tubewells growing at such a phenomenal rate[15]. Finally, much evidence suggests that, if any, rural power subsidies are concentrated in electrically privileged areas of Western Uttar Pradesh[16]; in Eastern UP, far from being subsidized, electric power is, in effect, heavily taxed.

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[14] 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 electric tubewell 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 UP SEB.

[15] Over 1968-69/93-94 period, diesel pumps increased twice as fast as electric tubewells; the former have increased from 85,000 to 2051,000 by 24 times, whereas the latter have gone up from 56,000 to 6,90,000, by 12 times (Tyagi 1995).

[16] Pant notes this dichotomy in his study of Faizabad and Behraich: 'In fact, in majority of the villages in Bahraich electricity was not available for tubewell irrigation and was available only for worship places like mosques.. Low use of electricity in Bahraich compared to Faizabad is manifested in the fact that on 31.3.86, there were 2936 energized private tubewells in Bahraich compared to 16600 in Faizabad..' (Pant 1992:20)

Consider the following. At the UP SEB's figure of 11800 kWh as the average power consumption per electric tubewell/year, assuming the connected load to be 6 hp on average, the average private electric tubewell should be operating over 2500 hours/year. But except in small pockets of electrically privileged districts of Western UP where studies show average of 1300-1500 hours of annual operation, nowhere do electric tubewells in Eastern UP—nay, Eastern India--operate for more than 600-700 hours/year. The Faizabad sample of 18 electric tubewell owners in Pant's 1992 study reported an average operating hours of 665/year. In Kripa Shankar's study (1992:58) of a sample of 140 households in Allahabad, electric tubewell owners reported the average hours of operation to be 663/year (Kripa Shankar 1992:58). A survey of 478 tubewells owners from Muradabad, Barabanki and Agra districts by the Operations Research Group in 1990 indicated that 70% of sampled electric tubewells operated for less than 500 hours/year; only 8% operated for more than 1000 hours. Far from 11,800 kWh, on an average, electric tubewells consumed 1870 kWh/year in their Muradabad sample, 924 kWh/year in Barabanki sample and 1990 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 UP SEB. A 1981 survey by NABARD (1988) in Allahabad district in Eastern UP showed that electric tubewell owners operated their tubewells for an average of 636 hours and the average electricity cost/hour to them was Rs 0.77/kWh when the UP SEB claimed it realised only Rs 0.18/kWh from agricultural consumers (UP SEB 1996: p 97). But a similar evaluation in electrically privileged Muzaffarnagar district in Meerut division, a sample of 42 electric tubewells operated for 1034 hours Rs 0.36/unit (NABARD 1987). Tyagi (1995) found the average power consumption by a sample of 229 electric tubewells from all over UP at 2566 kWh/year, less than 1/4th of the SEB estimate of 11800. At a flat tariff of Rs 50/hp/month, the average electricity cost thus is Rs 1.43/kWh, over 3.5 times Rs 0.43/kWH claimed by SEB. Tyagi showed that for the bottom 10% tubewells that operated for an average of 280 hours/year, the effective power cost rises to Rs 2.87/unit or Rs 13.08/hour. In electrically privileged Kanpur district of Western UP, where because of more opportune power supply environment, an average tubewell operated for 774 hours, the cost declined sharply to 1.04/kWh or Rs 4.74/hour of operation. With this economics, it is not surprising why farmers in Eastern UP switch to diesel engines. A 6.5 hp diesel pump would cost between Rs 9.50-10/hour in fuel; thus an electric tubewell operating over 750 hours/year is half as cheap to run as a diesel pump; but one operating at less than 300 hours costs much higher to run. In early 1990's this made electricity sold to Eastern UP's agriculture amongst the most expensive in all consumer categories: domestic users paid Rs 0.77/k WH; commercial users paid Rs 1.16/kWh; industries paid Rs 1.36; and Eastern UP's agriculture paid an effective price of Rs 1.43.

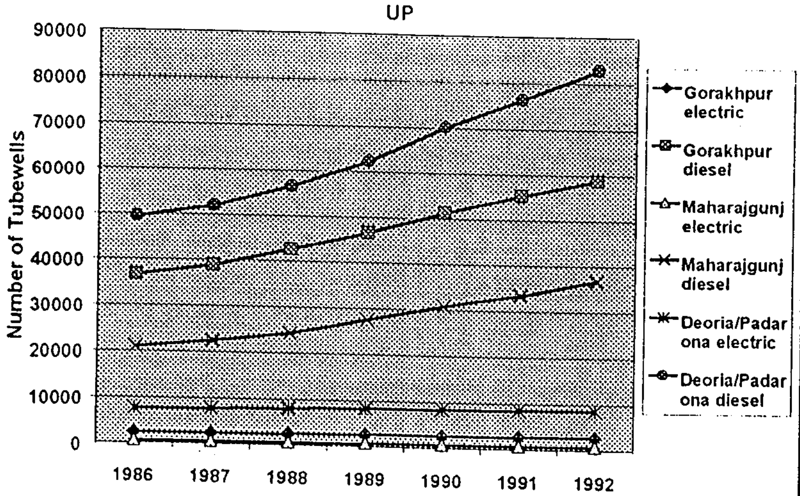
Dieselisation of Eastern UP's Groundwater Irrigation

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, North Bihar, North Bengal and coastal Orissa—which combine large volumes of undeveloped groundwater potential with massive concentration of rural poverty. If UP tried a public tubewell program, so did West Bengal, Bihar and Orissa. If UP's public tubewells failed in their promise to the poor, they failed even more resoundingly in Bihar and Orissa.[17] The rest of the East Indian states mounted their

[17] Though West Bengal designed a moderately successful program of turn over of small-scale government irrigation schemes—including tubewells and river lift irrigation schemes—to beneficiary groups. In Orissa, the Lift Irrigation Corporation—which established and managed public tubewells and river lift irrigation schemes piled up huge losses and was obliged to design a turn-over program which has not been as successful as West Bengal's was, especially in Southern West Bengal.

rural electrification programs much the same way as UP did, but with a lag of 3-5 years. Elsewhere in Eastern India too, private electrified tubewells grew in numbers but except in SouthWest Bengal, through not as rapidly as in UP, especially Western UP. UP changed from metered to flat tariff in 1975; Bihar and Orissa followed suit. Finally, as in Eastern UP, few years after the introduction of flat tariff, the power supply environment throughout Eastern region began deteriorating. Within each state, there were 'electrically privileged' areas where rural electricity infrastructure remained relatively better maintained and power supply environment, in reasonable good condition. In West Bengal, southern districts had better power supply environment and developed dynamic agrarian economies; North Bengal, with poor power supply environment failed to develop its extraordinary groundwater potential and stagnated. Bihar remained electrically under-privileged throughout; still, the central region became less electrically under-privileged than north Bihar with its massive underdeveloped groundwater resource. In Orissa, Puri and Cuttak districts became electrically privileged; western Orissa ended up with poor power supply environment. In most respects, then, Eastern UP became a forerunner to the rest of Eastern India.

Figure 10: Growth of Electric and Diesel Tubewells in Gorakhpur, Maharajgunj and Deoria-Padrona districts, Eastern UP



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, tubewell irrigation continued to be a boom sector. Eastern UP dealt with the crisis of deteriorating power supply by dieselizing its groundwater irrigation. Here, the population of private diesel pumps increased at a faster rate than the electric pumps declined. Some evidence of this trend is available in data collected from district level; however, these too only add new electric tubewells connected every year without deducting those which are disconnected. Even so, as figure 10 shows, the pace of dieselisation of Eastern UP's groundwater irrigation sector is unmistakable. Equally unmistakable was the fact that *inopportune* power supply environment has been behind the strong preference for diesel pumps. A report of the Indo-Dutch UP Tubewell Project MAC-IDTP (1989), citing Government of Uttar Pradesh, Draft Annual Plan 1988-89, Volume I, stated:

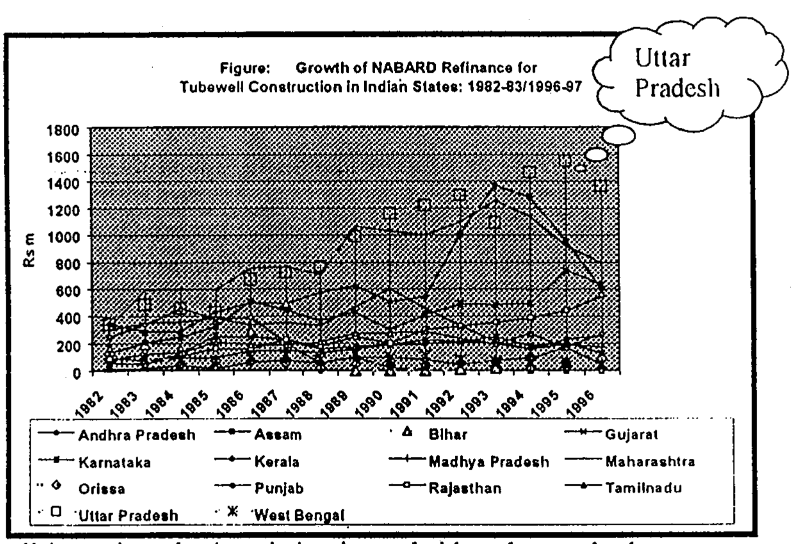
> 'The overall shortfall in realisation of the Seventh Plan target of energization of private electrical tubewells is mainly due to cultivators' preference for diesel driven sets. This preference derives from erratic and inadequate power supply in most areas and lower initial cost to cultivators for diesel sets.'[18]

[18] The Working Paper further stated: 'Public tubewells and private tubewells have to compete for relatively scarce power supply. Public tubewells constructed under the World Bank Program are connected with dedicated feeder lines while private tubewells are connected with rural feeder lines.

There are many problems with the dieselisation of groundwater irrigation. Diesel is 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 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 Uttar Pradesh as diesel-pump driven shallow tubewells. The central issue of interest is: why was the rest of Eastern India unable to dieselize its groundwater irrigation as rapidly as Eastern UP did during the 1985-95 period.

The Diesel Pump Dealer Dynamic

Inopportune power supply environment was certainly a key reason behind the rapid increase in the population of diesel pumps in Eastern UP during the 1980's. 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 UP government decided to switch to 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. The 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 Uttar Pradesh launched a poverty-targeted 'Free-Boring Scheme' (FBS) under which the minor irrigation department was to undertake the preparation of borewells (shallow tubewell) 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 a 'Million Well Scheme' with precisely the same objective, and targeting socially and economically backward farmers.



Until mid-80's, 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

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.)

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 hassle of getting an electricity connection. Electric tubewell ownership during the 1970's was therefore highly scale-biased compared to the ownership of diesel pumpsets during the 1980s and 90's. So, although the subsidy schemes covered electric as well as diesel pumps, the funds allocated to them remained grossly under-utilised. Now that electric tubewells 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 Free Boring Scheme prohibitive and intimidating. A study in 1984 by the Delhi-based Society for Prevention of Wastelands Development concluded that even if all his paper-work were perfect, the decision on the application of a small farmer under the Free Boring Scheme 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 valve issued from the Minor Irrigation Office, diesel pump issued from the stipulated dealers, and bank loan released from the Lead Bank designated for each district. Several other restrictions were in force: for example, only field staff of the minor irrigation department were allowed to make the bore using the department's rig; only one or two pre-designated 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 tubewell was commissioned, 35-40% of the subsidy was 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 small holder irrigation. During mid-1980's, a series of changes occurred in the design and implementation of the Free Boring Scheme (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 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 tubewell under the Free Boring Scheme. In course of unstructured interviews with nearly 200 small farmers in Gorakhpur, Maharajganj and Deoria districts of Eastern UP, we found that the diesel pump dealer had been one of the best things to happen to small farmers in the region; and that he had been instrumental in transforming the much-berated Free Boring Scheme 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 tubewell 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 'service fee' (*sewa-shulk)* for the red carpet the dealer laid out for them. By a rough estimate, over 800,000 small diesel-pump operated tubewells have been installed in the Eastern UP under the Free Boring Scheme after 1985, which probably irrigate a gross area of 2.4-3.2 m ha of their owners and water buyers' land 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' is 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 over 3 or 5 years in installments.

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 electric tubewells; and each district and taluka town of Eastern UP saw the rise of an uncommonly large community of (20-60) 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 'service charge' (*sewa-shulk*)[19]. Large dealers with reputed brands of pumps had a head start over smaller ones; some of these sold 3-4000 pumps/year 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 'service charge'. Smaller dealers are not as 'efficient' as larger ones in cutting the transaction costs of FBS access but are restrained from levying high 'service charges' because of the price leadership role of large dealers in setting reference service charge. It also seems that dealers, whom pump manufacturers offer pretty high retail margins varying from 18-30% of the sale price, gun for maximising 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 clear 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 late 1980's or early 1990's. Another indicative evidence is provided by the data on the off-take of institutional credit for minor irrigation (read pumps and tubewells).

[19] A good estimate of the service charge is provided by the 'discount' of Rs 700-1800 that off-the-shelf buyer gets compared to a farmer applying for loan-subsidy scheme. This 'discount' on direct purchase without subsidy includes: [a] the unofficial payments-bribes—that pump dealers have to pay in agencies authorised 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 large 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 lower 'service charge' to attract customers and increase their market share.

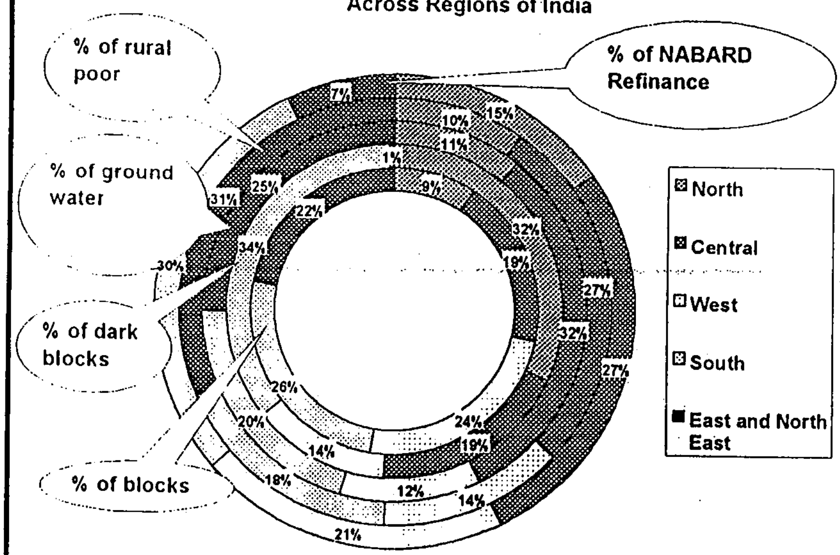
Figure: 11 shows the state-wise refinance provided for minor irrigation by the National Bank for Agriculture and Rural Development which is a very good proxy for the off take of pumps under loan-subsidy scheme. It clearly shows that while the rest of Eastern India has been lukewarm in using NABARD's refinance facility, UP has beaten even states like Andhra Pradesh and Maharashtra where private small-holder 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 down-side, the pump dealer has been widely discredited as the shady operator on the scene precisely because he is at the centre-stage of the entire scheme and lay-observers see him as the recipient of the bribe that is the 'service charge' (*sewa-shulk*); even some pump manufacturers we interviewed considered them with disdain in the 'wheeling-dealing' class; it is also likely that the reformed Free Boring Scheme(FBS) is a trifle more prone to mis-targetting. 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 farm lands) from less than 10 in mid-1970's to 40-50 in early 1990's; despite room for mis-targeting, FBS has probably single-handedly done far more to put a pump in the hands of the poor compared to any other policy initiative ever. The overall impact of high pump density is further leveraged by the increased intensity of competition among pump irrigation sellers, and its beneficial results 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 diesel pump subsidy scheme works pretty much like the way it did in Eastern UP in early 1980's. 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 Uttar Pradesh, a microcosm of Eastern India and the GBM basin, has also served as its leader and pathfinder. Our chief argument in this essay 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

Figure: 12 Distribution of Blocks, Dark Blocks, Groundwater Recharge, Rural Poverty and NABARD's Minor Irrigation Refinance Across Regions of India



Western UP is analogous to the gulf between Eastern and the rest of India. In illustrating this gulf, we have derived figure 11 based on NABARD (1996)[20]; and from the analysis by Fan, Hazell and Thorat (1998) presented in table 6. Figure 11 shows that Eastern India contains over a fifth of India's blocks, but it is home to nearly 88m, or a third of India's rural poor. One department in which Eastern region has a great scope for poverty-focused development is groundwater; it has 25% of India's usable groundwater resource; and less than 1/5th 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 water logging and floodproneness that have bewitched the region. That there need be no worries on account of over-exploitation of groundwater in the Eastern region is also suggested by figure 11 which shows that only 4 of India's 600 'dark' blocks are in the Eastern region.

Table 3: Eastern India versus the Rest of India

Region	# of Rural Poor	Number of Blocks	Usable Recharge (km sq)	# of Dark Blocks	Refinance for Tubewells (Rs m)
North	27154	654	34.93	189	13939
Central	75030	1354	103.3	115	24979
West	38094	1698	38.6	81	19345
South	49470	1814	65.5	210	26657
East and North East	88429	1543	82.57	4	6810
India	278177	7063	324.9	599	91730

Source: NABARD 1996; Hazzel and Thorat 1998

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 tubewell 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 guzzle 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 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 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 on the lines that Uttar Pradesh 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.

a. Public and Community Ownership and Management

With the deluge of studies and evaluations that testify to the resounding failure of public tubewell 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

[20] Northern Region: Haryana, Punjab, Himachal Pradesh, Jammu and Kashmir and Rajasthan; East and North Eastern: Bihar, Orissa, West Bengal, Sikkim, Assam, Manipur and other North Eastern States; Western: Maharashtra, Gujarat and Goa; Southern: Andhra Pradesh, Karnataka, Kerala and Tamilnadu; Central: Madhya Pradesh and Uttar Pradesh. 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.

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 tubewells seems particularly unfounded in Eastern India where the conditions are best suited for small-scale owner managed tubewells. In Eastern UP, at least, the public tubewell program tried to harness scalar economies and new technologies—such as deep tubewells, piped distribution and dedicated power supply—to cover 100 ha or more of design command under each tubewell. But in many other East Indian states, government departments are building small tubewells 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 in these three blocks, 61 are functional: last year (1997-98), according to OLIC records, these irrigated 1113 acres (average/LI: 18.2 acres) and collected irrigation fee of Rs 2,16,600 (average/LI: Rs 3550; average/acre: Rs 194.6). The economics of the LI's seem designed for unviability in perpetuity. Four new schemes were constructed in 1996-97 at a total cost of Rs 24 lakh; if this represents the general picture, the average 5 hp LI which commands an average of 6-7 acres costs Rs 6 lakh apiece or Rs 90,000+/acre or over Rs 200000/ha of net irrigated area commanded! Farmers build irrigation potential at 1/10[th] of this cost. This must be among the costliest irrigation potential created in a region, which abounds in ground 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 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 guzzle funds but make little net addition to minor irrigation. Most of India gave up building new public TWs and big community-managed river lift irrigation schemes 15 years ago; but North Bengal—which does not need deep tubewells 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 sub-zero levels—seems to be a doubtful strategy. True, large group tubewells 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 obverse 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 tubewells and large river lift irrigation schemes. Countless examples show that these are costlier to build and operate compared to private small tubewells, they are extremely difficult to manage, and use technologies for which there is no rationale in Eastern India.

b. Electricity Supply and Pricing

During 1980's, I had shown that, in Eastern India with abundant groundwater, reasonably high flat electricity tariff accompanied by carefully rationed agricultural power supply can be a powerful way of transforming groundwater markets in effective instrument of small farmer development without subsidizing electricity (Shah 1985; Chamber, Saxena and Shah 1987; Shah

1993). The argument had several propositions: (i) flat tariff reduces the real cost of supplying power to farmers by saving substantial cost of metering and revenue collection; (b) it curtails the powerful incentive under metered tariff to pilfer power; (c) it forces electric tubewell owners to sell more water by charging lower prices to buyers who are mostly the resource poor; (d) where diesel pump owners compete with electric tubewell owners in local water markets, the latter exercise a disciplining influence on the former and oblige them to sell water at lower price than they would have; (e) the Electricity Board can counter the propensity of electric tubewell owners to expand their use of power under flat tariff either by raising the flat tariff to cover the average full cost and/or by careful rationing of high quality power supply to agriculture. The veracity of these propositions has been proved by the experience of many Indian states, including Eastern UP where even today, electric tubewell owners that remain sell water at much lower price than that charged by diesel pump owners and are a disciplining influence in local water markets. Many states have raised 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/year for smaller than 7.5 hp tubewells going up to Rs 360/hp/year for tubewells 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 proved unequal to. As a result, 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 public tubewell 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 dieselisation 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 co-operatives that became hugely successful in rural US in the early decades of the century and have also worked in Maharashtra and Andhra Pradesh through not very successfully. Basically, the Indian electricity co-operatives have been power distribution co-ops; they buy power in bulk and distribute them to their members; the Electricity Board finds them 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 to undertake 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 hole and charge the Panchayat based on metered consumption by the village. The Panchayat can then monitor power consumption by both domestic as well as 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.

c. *Energy Efficiency*

A critical issue in Eastern India's groundwater irrigation is of energy use in pumping and the measures to improve it; its efficiency dimensions are well documented but equity dimensions are not. The subject has been studied since early 1970's; and a general empirical conclusion is that 30-35% of the energy actually used by irrigation pumpsets can be saved through 'rectification' of pumpsets. It is suggested that against the maximum achievable 'system efficiency' of 54% for electric pumpsets and 20% for diesel pumpsets, observed efficiencies are sometimes as low as 13% and 5% respectively. Reasons? Subsidized flat electricity tariff and farmer ignorance about selection, operation and up-keep of the pump. SM Patel, an agricultural engineer based in Ahmedabad who pioneered thousands of pump rectification experiments throughout India, has asserted that merely replacing the foot valve and suction pipe increases water output of diesel pumps by 30%. But 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 by17%/hour (Patel and Pandey 1989; Reidhead 1999).

Independently of SM Patel's work, some Dutch-supported shallow tubewell projects using diesel engines in North Bengal also found energy efficiency of these pumping system unacceptably low. Pump rectification experiments here showed that fuel efficiency can be improved significantly by removing the restrictor[21], by attaching a thermo-syphon cooling system[22], by reducing the engine speed[23], and by removing the check valve (or foot valve in case of dug wells) (NBTDP1996; 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: --. More, while the full rectification program recommended by S M Patel may cost nearly 8000 for

Table:4
Impact of Modifications on Fuel Efficiency of Diesel Pumps: Test Results in North Bengal Terai Development Project
(Static Suction head in Shallow tubewells: 3.5 m)

Modification	Discharge (l/s)	Diesel consumption (l/h)	Cumulative Improvemen (%)
Unmodified	8.6	0.8	-
Raising cooling water temp. from 35 to 75^{0}c	8.6	0.78	13
Removing check valve	10.5	0.76	31
Reducing engine speed from 1470 to 1100 rpm	10.3	0.55	51

Source: NBTDP 1996:4

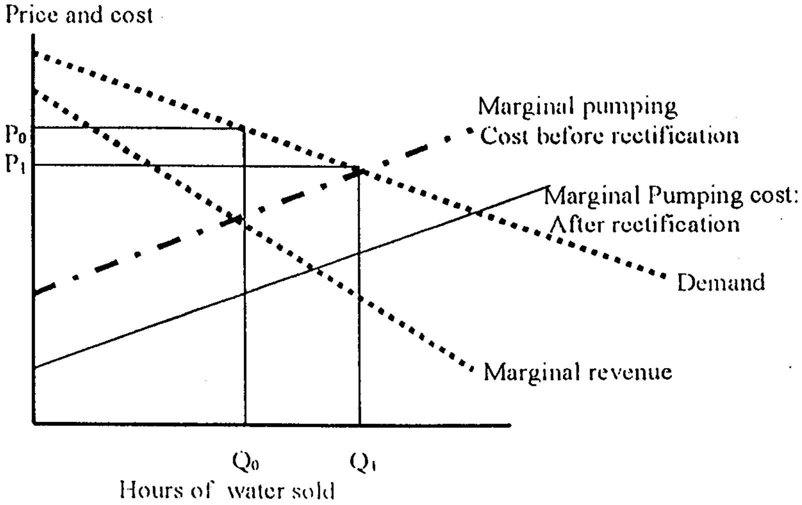
[21] Pumps in North Bengal commonly use a 2" nozzle on 2.5 " delivery pipe to increase pressure for diverting the cooling water but causing unnecessary friction.

[22] Because farmers cool the engine by leading water directly from the pump to the engine, the engine operates at non-optimal cooling temperature 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-litre 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 two hours.

[23] In North Bengal, as elsewhere in the Ganga basin—where suction heads range from 2-5 m, 5 hp engine proves over-sized; here, pumps use only 2.3-2.5 hp and at rpm of 1500, engines operate at part load and therefore at low efficiency. Decreasing the engine speed to 1100 rpm, the lowest possible speed, the power output is reduced to 3.7 hp, which is still too much. Rpm is reduced by counteracting the spring on the fuel pump with a rubber band.

diesel pumps (Reidhead 1999), the modifications piloted in the North Bengal project may cost all of Rs 350 (Bom and van Steenbergen nd).

Figure: 12
Impact of Pump Rectification on the Economics of a Water Seller



Following the pioneering work by SM Patel and his colleagues, many state electricity boards, Rural Electrification Corporation/s 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 demand (Reidhead 1999). Nevertheless, the reasons to persist with the pump rectification programs are compelling. Existing programs are driven primarily by energy efficiency goal and secondarily by the pollution-control goal. Reidhead (1999) estimates that rectification of all 5.4 m diesel pumpsets in India can save 1 billion litres of diesel every year, or an annual economic gain of Rs 28 b for a capital investment of Rs 48 b. But an important additional reason, at least to push diesel pump rectification program, is equity. We examined the conceptual and empirical basis of the argument that asserts that 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 pump irrigation sale is transacted on the basis of hours of pumping rather than the quantity of water, the cost of inefficiency of the pumps get 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

Table: 5
Impact of Rectification on Energy Efficiency of Irrigation Pumps: Institute of Co-operative Management's Test Results from Gujarat

Rectification	Change in Water Output (%)		Change in Energy Use (%)	
	Electric	Diesel	Electric	Diesel
R1 Foot valve+suction pipe	31.5	30.1	3.0	0.6
R2= R1 + delivery pipe	68.1	43.1	-7.9	-1.5
R3= R2+ pump	na	60.4	na	-5.2
R4 = R3+ engine	20.6	85.2	-36.9	-16.9

Source: Patel and Pandey 1989

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. In figure 12, which explores the profit maximising strategy of a water seller suggests that after pump rectification which lowers his marginal cost of water production, he would be induced to sell Q_1 amount of water which is more than Q_0 that he sold earlier at a profit maximizing price P_1 which is lower than P_0 which he charged before pump rectification.

d. 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 pump rectification programs, we noted that the shallow tubewells and dug wells in the Ganga basin can not 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 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 Indian manufacturers neither 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 but also in Eastern India underscore the point that small farmers' capital investment decisions are highly price sensitive. The hallmark of the treadle pump is that it costs in the neighbourhood of Rs 750 to buy, it does not necessitate recurring cash outlays on diesel or kerosene, 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 acre of vegetables or even paddy. 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) 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 small-holder farming systems in different ways in different sub-regions; in North Bengal and Bangladesh, adopters take to cultivation of HYV rice in 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 holding but practice highly intensive farming in the 'priority plot';[d], average crop yields on 'priority plots' tend to be much higher than obtained by farmers using diesel pumps or other irrigation devices;[e] the income impact varies across households and regions; but $100/year as average increase in annual net income seems a conservative estimate. Less enterprising adopters achieve fuller employment at '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, IRR of 100% and pay-back period of an 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 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. " (Shah et al 2000:1)

e. 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 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 off-take of minor irrigation credit—goes to Eastern India. It is important to recognize that this poor off-take does not reflect the absence of need or demand for subsidy support; nor does it reflect NABARD's unwillingness to push credit for tubewells 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. This can be understood by the examples of North Bengal (Shah 1998), where the pump subsidy scheme has become an instrument of political patronage and Orissa where it has become a bureaucratic spoils-system (Shah 1998 a; 1999b).

In Coochbehar and Jalpaiguri districts of North Bengal—which are as flush with groundwater resource 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 North Bengal's subsidy scheme 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)[24]

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 BDO; [3] the application is discussed in periodic meetings of the Bank, Gram Panchayat Pradhan and *Panchayat Samiti* member concerned to assess the 'credit

[24] 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 6000 on unit cost of the pump. The government departments involved in Minor Irrigation subsidy are DRDA (IRDP), Agriculture department, SC-ST Corporation. The unit price for STW has recently been raised. The subsidy is 50% or Rs 6000 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 later get reimbursed by the bank.

worthiness' 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 seldom gets completed because banks, facing mass defaults in government subsidy schemes, are dragging their feet.[25]

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 it ostensibly for renting out to small and marginal farmers.[26] 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 Panchayat 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. An oil engine dealer we met in Jalpaiguri lamented that [a] the system of processing 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 cleared 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.[27]

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[25] Banks do not proceed unless the Panchayat Samiti forwards an application; and the Panchayat Samiti does not forward unless the Gram Panchayat recommends. 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 protégé-- are naturally the first to access the subsidy; and ordinary folk can not access it except through the goodwill of the Panchayat leadership.

[26] A variety of 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.

[27] 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 co-ordination role, and that at larger volumes, they can absorb the higher transaction costs of 'managing' the Panchayat decision making in the minor irrigation field.

In Orissa, a 50% subsidy is available on the cost of diesel as well as electrified tubewells 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 mid-1980's but the process is faster. The procedure here is: [a] the farmer approaches OAIC office with completed form and required documentation; [b] he gets the necessary clearance from Agriculture Department; [c] he deposits Rs 1000 for test drilling; [d] OAIC makes an estimate of the total cost of the tubewell; [e] the farmer deposits 50% of the estimated cost with the OAIC; [f] the pump and pipe are released immediately; and the borewell 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 Bhubaneshwar, 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 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 market prices that effectively the farmer gets very little real subsidy. This is true about all the agro-equipment that OAIC supplies on 50% subsidy. In course of fieldwork in Puri district of Orissa in 1998, I found that the market price of the best brands of hand pumps ranged from Rs 290-520; one dealer offered confidently to install any make of hand pump successfully for Rs 1500; but at a local OAIC office, he was told that the unit cost of the Hand pump (only the pump) is Rs 2776 on which the farmer gets a subsidy of Rs 1388, 4 times the market price of a handpump (Shah 1998b). I also interviewed farmers who withdrew their applications for subsidy scheme after they found that the cost estimates made by 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 pump and diesel pumps, the farmer always has the option to go to the private dealers and not claim subsidy; but in treadle pumps, OAIC is a monopoly supplier. Treadle pump manufacturers were willing to offer treadle pumps at Rs 785; but OAIC brought the treadle pump under their subsidy list, priced it at Rs 1400 and offered a subsidy of 50%. In Orissa, thus, the process of claiming pump subsidy is smooth and fast, but there is effectively very little real subsidy to claim. No wonder, then, that private investment in pump irrigation has not responded to the government's offer of 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 nationalised 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 Free Boring Scheme a powerful instrument; Banks are happy because dealers take part responsibility of recovering the loans; staff in relevant government and bank offices are happy because their total rents are large (though piece rate is lower); and farmers are supremely happy because for a small *sewa-shulk* dealers lay red-carpet for them, and get their tubewells commissioned inside of 10 days.

There is a strong case for the rest of Eastern India to redesign their pump-subsidy scheme along the lines of Eastern UP. Probably the most important first step to doing this is to recognise that the primary purpose of minor irrigation policy in East Indian states is to put the pump in the hands of the small and marginal farmer. Second, the government should discontinue all allocations to government-managed and community managed minor irrigation schemes since all available evidence shows that these fail to produce sustainable minor irrigation. Third, a general sense of resource sufficiency should be created by concentrating available financial resources for minor irrigation in pump subsidy scheme; 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 Fourthly, 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 borewell. Fifth, the procedures to access the pump loan/subsidy scheme should be streamlined and rationalised as in UP. Finally, the dealer as well local administration should be involved in rigorous recovery of loans.

Overall, then, while long-terms strategies of improving power supply environment are a must for the overall development of the region, more urgent interventions are needed to stimulate the region's groundwater development for it socio-ecological advancement. In our analysis, the quickest way of jump-starting the region's groundwater economy is the reform of the pump subsidy schemes; but along side, efforts are also needed to promote a wider variety manual and diesel pumps, to improve the fuel efficiency of pumps and experiment with innovative approaches to cost-effective approaches to metering and tariff collection for rural electricity supply.

References:

CADR (1995) *Electric Power Consumption and Transmission Losses in Rural Areas (Phase I)*, Lucknow: Centre for Advanced Development Research.

CSE (1991) *Floods, Flood Plains and Environmental Myths*, New Delhi: Center for Science and Environment, State of India's Environment: A Citizens' Report # 3.

Chambers, Robert, N C Saxena and Tushaar Shah (1987) *To the Hands of the Poor: Water and Trees*, Delhi: Oxford and IBH Publishing Company.

Dhawan, B D (1992) *The Development of Tubewell Irrigation in India*, New Delhi: Agricole Publishing Academy.

Dhawan, B D (1985) Output Impact according to Main Irrigation Sources: Empirical Evidence from Four Selected States, presented at the INSA National Seminar on 'Water Management: Key to Development of Agriculture', at New Delhi, 28-30 April 1986.

Fan, Shenggen, Peter Hazell and Sukhadeo Thorat (1998) *Government Spending, Growth and Poverty: An Analysis of Linkages in Rural India*. Washington: International Food Policy Research Institute (unpublished draft report)

Government of India (1996) *Groundwater Resources of India*, New Delhi: Central Groundwater Board.

Government of Uttar Pradesh (1992) *Uttar Pradesh Ki Arthik Sthiti Ke Abhigyan Hetu Jilewar Vikas Sanketak: 1991*, Lucknow: Bureau of Economics and Statistics, State Planning Institute.

Government of Uttar Pradesh (nd) 'Rural Electrification Losses of UPSEB', Lucknow: State Planning Department's internal memo.

Government of Uttar Pradesh (nd) 'Losses Incurred by Uttar Pradesh State Electricity Board on the Operation of Rural Electrification Program'. Lucknow: State Planning Department's internal memo.

Government of Uttar Pradesh (986) *District-wise Indicators of Development*, Lucknow: Planning Division, State Planning Institute.

Government of Uttar Pradesh (1996b) 'Groundwater Resources of Uttar Pradesh', Lucknow: Groundwater Department.

Government of Uttar Pradesh (1996c) *UP Electricity Board: 1994-95: Statistics at a Glance*, Lucknow: UP State Electricity Board.

Government of India (1985) *Report of Study Group on Agricultural Strategies for Eastern Region of India*, New Delhi: The planning Commission.

Kolavalli, Shashi and Nitin Shah (1989) 'Management of Public Tubewells in Uttar Pradesh', Ahmedabad: Indian Institute of Management.

Kolavalli, S, A H Kalro and V N Asopa (1989) *Issues in Development and Management of Groundwater Resources in East Uttar Pradesh*, Ahmedabad: Indian Institute of Management.

Kolavalli, S, Gopal Naik and A H Kalro (1992) *Utilisation of Groundwater in East Uttar Pradesh*, Ahmedabad: Indian Institute of Management.

Lall, Preeta and Shonali Pachauri (1994) *Agriculture, Irrigation and Water Markets: A Community Perspective- Cast Studies from Three Villages in Lalitpur District of Uttar Pradesh*, New Delhi: Ecotech Services (India) Pvt. Ltd.

Mishra, Dinesh Kumar (1999a) 'Above the Danger Mark', *Himal, The South Asian Magazine*, January, vol 13, no.1

Mishra, Dinesh Kumar (1999b) 'Flood Protection That Never Was: Case of Mahananda Basin of North Bihar', *Economic and Political Weekly*, July 17-23; vol XXXIV, No 29.

Indo-Dutch Uttar Pradesh Tubewell Project (1989) *Working Paper-1: Power Demand and Supply Projections*, Lucknow: Monitoring and Appraisal Cell.

NABARD (1987) *Minor Irrigation in Muzaffarnagar District, UP: An Ex-post Evaluation Study*, Bombay: National Bank for Agriculture and Rural Development.

NABARD (1988) *Minor Irrigation in Allahabad District, UP: An Ex-post Evaluation Study*, Bombay: National Bank for Agriculture and Rural Development.

NABARD (nd) *Minor Irrigation: Potentials and Policy Issues*, Mumbai: National Bank for Agriculture and Rural Development (internal document).

NABARD (1995) *Status Papers on Minor Irrigation: XI Annual Development Meet of Technical Officers*, Mumbai: National Bank for Agriculture and Rural Development, papers for a meeting during 19-22 December, 1995.

Bom, Gert Jan and Frank van Steenbergen (nd) *Fuel Efficiency and Inefficiency in Private Tubewell Development*, Arcadis: Euroconsult (unpublished report)

NBTDP (1996) *Improving Fuel Efficiency of Diesel Pumpsets*, Jalpaiguri: North Bengal Terai Development Project (unpublished).

ORG (1991) *Improving Efficiency of Agricultural Pumping Systems for Energy Conservation*, Baroda: Operations Research Group.

Palmer-Jones, R (1995) Deep Tubewell Technology in South Asia. Norwich: Center for Development Studies (unpublished draft for the Ford Foundation).

Pant, Niranjan (1984) *Organisation, Technology and Performance of Irrigation Systems in Uttar Pradesh,* Lucknow: Giri Institute of Development Studies.

Pant, Niranjan (1989) *Water Distribution and Management in New Design Public Tubewells in Eastern Uttar Pradesh,* Lucknow: Centre for Development Studies.

Pant, Niranjan (1992) *New Trends in Indian Irrigation: Commercialization of Groundwater,* New Delhi: Ashish Publishing House.

Patel, S M and M K Pandey (1989) *Conservation of Diesel through Rectification of Agricultural Pumping Systems,* Ahmedabad: Institute of Co-operative Management (unpublished)

Ramaswamy, R Iyer (1999), 'The Fallacy of Augmentation: Demands on Ganga Waters', *Economic and Political Weekly,* August 14, vol XXXIV, No 33.

Reidhead, Paris W (1999) 'Efficient pumpsets and efficient policy: Towards sustainable agricultural energy use in India', Delhi: International Development Research Center (IDRC), unpublished.

Shankar, Kripa (nd) ' Water Market in East UP Village', Allahabad: Unpublished Paper.

Shankar, Kripa (1992) *Dynamics of Groundwater Irrigation,* New Delhi: Segment Books.

Shah, Tushaar (1993) *Water Markets and Irrigation Development: Political Economy and Practical Policy,* Bombay: Oxford University Press.

Shah, Tushaar (1998a) *Elixir or Opiate: An Assessment of Minor Irrigation Policy in North Bengal,* Anand: Policy School Working Paper

Shah, Tushaar (1998b) Treadle pump Social Impact: Field-notes from Orissa, Anand: Policy School, unpublished paper.

Shah, Tushaar, Rajnarayan Indu and Shams Paleja (1997) *Muscle, Diesel, Electrical: The Pump Irrigation Political Economy of Eastern Uttar Pradesh,* Anand: Policy School (unpublished report).

Shankar, Kripa (nd) ' Water Market in East UP Village', Allahabad: Unpublished Paper.
TERI (nd) *Demand Side Management in Agricultural Sector of Uttar Pradesh: Investment Strategies and Pilot Design,* New Delhi: Tata Energy Research Institute.

Tyagi, B N (1995) *Requirement of Electric Power for Agriculture in Uttar Pradesh,* Lucknow: Centre for Advanced Development Research.
UPSEB (1993) *Statistics at a Glance: 1992-93,* Lucknow: Uttar Pradesh State Electricity Board.

Wajih. Shiraz and Varesh Kumar (nd) *Impact of Floods on Ecohealth: A Case Study of Two Districts in Uttar Pradesh,* Gorakhpur: Gorakhpur Environmental Action Group, Cast Study#3, (mimeo).

Yadav, R and Pandey B B Lal (1994) 'Management of Flood, Drainage and Water Logging: Problems of Rapti-Gurra and Ami-Rapti Doabs in Gorakhpur District', paper presented in the 'Regional Workshop on Environmental Aspects of Groundwater Development' at Kurukshetra during October 17-19, 1994

Yadav, R, Pande, B. B Lal (nd) *Project Report on Management of Submerged Land Area near Kauriram (Gorakhpur) and Hydrological Study of Rapti and Ami Rivers,* Gorakhpur: Madan Mohan Malaviya Engineering College.

reasonable to suppose that Bangladesh has sold more than a million treadle pumps although probably no more than 700-800 thousand are in operation after making allowance for asset retirement.

[7] South Asian pump irrigation most likely uses up some 18-22 b liters annually of diesel-equivalent of non-renewable energy. In areas with deep water tables, there is no alternative to diesel/electric pumps; but in Eastern parts of South Asia, gainful opportunities for efficient substitution of muscle power for fossil fuels can create a positive 'externality' which might be an important beneficial impact of Treadle Pump technology. But a small farmer is unlikely to buy a treadle pump because it will save diesel for his country or spare the world a bit of global warming.

[8] The main source of evidence used in this report is a Foundation Study of treadle pump impacts that was carried out by the authors in 6 locations. Each location study is available as a stand-alone report with IDE, Delhi. The reports are as follows:

M Alam and K M Hussain assisted by M Salimullah *Socio-Economic Impact of Treadle Pump Irrigation in Bangladesh.*

M Dinesh Kumar: *Small Farmer Irrigation and Rural Economy: Socioeconomic Impact of Treadle Pump Technology in Rural Orissa*

R K Nagar *IDE-SDC Foundation Study on Socio-economic Impact of Treadle Pump Technology in Cooch Behar, North Bengal*

R K Nagar *IDE-SDC Foundation Study on Socio-economic Impact of Treadle Pump in Nepal*

Mahendra Singh *Irrigation by Pedal Pump: A Study in Uttar Pradesh*

Mahendra Singh: *Socio-economic Impact of Pedal Pump in North Bihar*

[9] In this particular context, α-error would mean the exclusion of poor in a poverty-alleviation program and β—error would mean inclusion of the non-poor. The sum of the two reflects the cost of mistargeting which is known to be high in most poverty-alleviation programs.

[10] Take for example the hand pump technology which has guzzled up huge subsidies but whose targeting has always been problematic. The Orr et al (1991) study of treadle pump in Bangladesh concluded that treadle pump targeted the poorest better than No 6 Hand tubewell because of the latter's much higher capital cost; the HTW adopters' average land holding in 1975-76 survey turned out to be 3.81 acres while it was targeted to those with 1.5 acres or less. They found the average treadle pump adopter to have 0.25 ha.

[11] An important aspect is also that there is little pure rainfed farming; therefore, our comparison mostly is of treadle pump farmers with farmers using other forms/sources of irrigation. In Nepal terai, the comparison is between treadle pump adopters and farmers using artesian springs or *karin's,* a traditional water lifting device for irrigation. In North Bengal, the comparison is between adopters and the pump-less dependent either on rainfed farming or purchased pump irrigation. In Orissa, there was an important group of pumpless who used *tenda* for manual irrigation; they performed as well as treadle pump adopters in vegetable cultivation. A major advantage of adopters and *tenda* users in the Orissa village was that they were close to important retail vegetable markets; as a result, their incomes from vegetables were higher than estimated here using average prices. In Eastern UP, the comparison is between adopters and the pump-less who depend mostly on purchased diesel pump irrigation. Income from vegetables is somewhat overstated because upper caste treadle pump owners do not sell vegetables but distribute their surplus among friends and relatives. *Koiri's*, the main adopter group, however, are specialist vegetable sellers. Treadle pump owners commonly use their pump for supplementary irrigation to paddy or wheat in periods of moisture-stress. Finally, in North Bihar, the comparison is essentially between adopters and the pump-less most of who have and use hand pumps for irrigating vegetables but also buy diesel pump irrigation. In both the Bangladesh

villages, purchased diesel pump irrigation was the mainstay of the pump-less. More, the average pump-less household in the sample had a significantly larger land-holding and gross cropped area. Although adopters obtained significantly higher yield of all treadle pump irrigated crops, their output/household was pulled down by smaller average area under crops compared to the pump-less.

[12] M Alam, who carried out our Bangladesh study, however, suggested that given free choice to farmers, there would probably be more treadle pump irrigated china boro in Sreepur than he found in course of his survey. Most treadle pumps in Sreepur were supplied by an NGO which got an undertaking from the adopters that they would use it only for growing vegetable crops!

[14] The HURDEC (N.D.) study, which compared the results of a survey of 100 treadle pump adopters in Nepal terai on a *before* and *after* basis found that nearly half of the adopters they surveyed were earlier using hand-pumps; and a quarter used pumps, canals, rower pumps, buckets and springs; only a quarter pursued rainfed farming; however, it concludes differently on treadle pump impact. It found: 'Crop production after the installation of TP has dramatically increased. Varieties of vegetables cultivated in winter and summer has increased in number and quantity; the number of farmers practicing vegetable cultivation has also gone up to 85%. (these grow) three to forty vegetables in winter. The farmers have been attracted towards cultivation of vegetables even during the summer, which brings them immediate returns in monetary terms.' Since the HURDEC study does not look at non-adopters at all, it is somewhat hard to be sure if the increased spread of vegetable cultivation is *because of* TP adoption or whether it is a more generalised phenomenon.

[15] The Orr et al (1991) study found new crops grown—much more on up-lands than medium lands—included cabbage, wheat, tomato, spinach, potato, onion and several others.

[16] The HURDEC (N.D.: 5) study concluded similarly: '[treadle pump adopters] used the treadle pump to irrigate a small area of their land. [For] the cultivation of something different from the usual traditional practice of rice and cereal production.' Elsewhere, it notes ' the cultivation practice of farmers has changed. Earlier, it was confined to summer cultivation and paddy production. [Now] cash crops have been the prime attraction. Cultivation is carried out in. summer and winter. Many farmers have been cultivating even three times focusing on crops like chilies. The use of fertiliser and higher-yield seeds has increased. The most remarkable benefit.. is increase in vegetable selling..'

[17] The study did not seek information on farm gate prices, marketed surplus and income from sale of farm products. The value figures presented here are estimated using average farm gate prices for all locations. There are huge variations in farm-gate prices of agricultural products across space and time. The prices used to compute the value of increased output were those collected in course of fieldwork. The farmer prices used are: *China boro* : US $11/qtl of paddy; *aman* paddy: US $ 13.5/qtl; potato- US$ 12/qtl; onion-US$14.5/qtl; green vegetables- US $ 9/ qtl; tobacco—US $ 23/qtl; Jute—US $ 19/qtl.

[18] Interestingly, 14-37% of the total treadling labour was provided by hired hands (as part of general farm work). Total labour requirement on treadle pump irrigated boro HYV was estimated at 214 man/days equivalent per acre of HYV paddy in *boro* season.

[19] Other studies too faced the same constraint despite using other methods of sample selection. Of the 400 adopters that the AIMS study (1997:204) study covered, 97% in Orissa, 44% in North Bengal, 79% in North Bihar and 38% in Eastern UP had used it for two years or less.

[20] To be exact, CES (1997) estimated the benefit cost ratio (BCR) of treadle pump investment to be 5.02; Net Present Value (NPV) of Net Cash flow to be INRs 21557 (over US $400), IRR to be 95.78% and payback period to be 1 year. In comparison, the hand pump was less attractive an investment with a BCR of 3.52, IRR of 29.54% and payback period of 2 years. The Orr et al (1991) study estimated treadle pump net benefits/ crop/hectare to range from US $ 120-440; it also estimated the benefit:cost ratio at 3.4 and IRR at

50.9%; pay-back period, one season (ibid.: p58). 93% of the 151 farmers surveyed recovered their capital investment in one season.

[21] For example, a 1995 'Mission on Pump Technology' fielded by the North Bengal Terai Development Project found poor quality an endemic problem. 'About 40% of the installed test foot pumps were inspected and the result was not as good as was expected. Out of 9 pumps visited (on one location) only one was operational and that one too was not in good shape. Washers have shrunk. Check valves don't work well which reduces discharge and causes fast loss of prime. [In Nandanpur cluster,] out of five pumps, three were removed by IDE. [In the other two] there is a clearance of 4 mm between piston washer and cylinder barrel [causing] significant leakage. In Kachua cluster, out of five [3.5" bamboo] pumps, only one was in working order. The other four pumps [suffered from] excessive piston washer clearance.' (NBTDP 1995: 1).

[22] One of the numerous brands—such as Nahar, KPK, Mostafa-- under which treadle pumps are sold in the 'informal' sector in Bangladesh.

[23] This relates to another crucial issue of whether the unruly organization of treadle pump marketing that obtains in Bangladesh today was a result of a deliberate and careful strategy or the default outcome of autonomous market pressure. The MRC-Mode (1993) study met a sample of manufacturers and found that nearly 70% of them got in to treadle pump manufacture without any external support merely because they found the demand upbeat, technology simple and marketing not a problem. In all three countries, it does not look as if IDE has actively prevented the mushroom growth of local manufacturers although it would--and should—control the use of *Krishak Bandhu* brand name by anyone except those meeting its quality standards. But in Eastern India and Nepal terai, there is apparently no interest in getting in to treadle pump manufacture presumably because of the weak demand.

[24] In oligopolistic pump irrigation markets of the type found in eastern India, the pump irrigation price is directly linked to diesel price by a factor whose value is determined by the monopoly power enjoyed by sellers (Shah 1993). In Eastern India, the value of this factor is estimated to be in the neighbourhood of 3.5. The recent hike in India diesel prices by 40 % will mean corresponding increase in pump irrigation prices from Rs 25-40/hour to Rs 40-65/hour. No matter how well justified on macro-economic grounds; this diesel price hike will put marginal farmers in East India to great misery. Dependent upon private pump irrigation markets, they will end up irrigating their crops with the costliest water probably anywhere in the world at US $ 1-1.2 for 15-18 m^3.