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Social and Economic Dimensions of Ground Water Development in India

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Abstract : *This paper makes three propositions about the perspective of ground water development in India : (a) the yet unexploited ground water potential in India offers a major opportunity to reduce absolute and relative rural income disparities (b) the existing framework and instruments of policy by themselves are inadequate to either achieve equity or to contain the external diseconomies associated with unregulated private exploitation of this resource (c) the current thinking and policy on ground water development completely ignore the potency of locallised but pervasive ground water markets as instruments of equity as well as control.*

The paper goes on to summarise such empirical evidence as is available from various parts of the country in an attempt to understand how such markets work and how they can be used to achieve the goals of equity and control by managing a limited number of policy variables which are subject to public control.

1. The political economy of ground water development

Ground water is one of the most valuable natural resources in rural India today. The estimates of utilisable ground water potential have been substantially revised upwards from 17.7 m ha m in 1969 (Sinha 1983) to 42.3 m. ha.m in 1983 (NIRD 1985) due to a variety of reasons such as : refinements in estimation procedures, discovery of new reserves, increased recharge due to the development of surface irrigation projects, etc. Since the efficiency of ground water use in irrigation is considerably greater than canal irrigation projects under existing management regime, it may well be that ground water will, at full potential irrigate as much as 70-80 mha of farm lands.

Although the development of ground water potential has taken major strides in the last three decades, in overall terms, no more than 30% of India's known groundwater potential has been developed as yet (NIRD 1985). Barring isolated pockets (to be exact, in 5% of the blocks, [see RBI (1984) and Sanghal 1981)], there are large areas of the country, especially in parts of Orissa, West Bengal, Eastern and Central U.P., Madhya Pradesh, etc. where substantial reserves of ground water are yet to be developed. Thus while our literature abounds with the problems of over exploitation of the aquifer and the resultant externalities, which doubtless are real, the main question in ground water development at the national level is still of ensuring equity and efficiency; of deciding who gets this last resource - the haves or the have nots ? (ODI, 1980).

For, while canal irrigation in India is completely dominated by state action with water users having a passive role, in case of ground water, the initiative has always rested with private farmers. The direct participation of governments in ground water development has been limited to 40,000 odd state tubewells concentrated mostly in the Gangetic plains; in contrast, there are over 8 million private WLDs* which together irrigate over 30 m.ha of land (NIRD 1985). There is no doubt that this dominance of private initiative which has characterised India's groundwater development in the past will continue to do so in future as well, especially because the experience with state tubewells, the only distant alternative to private domination, is uniformly disappointing on grounds of both equity as well as efficiency (Pant 1984, Abby et. al. 1983).

Private ownership of WLDs has tended to be highly skewed; and this skewness tends to increase across regions as differences in aquifer characteristics increase the initial capital cost involved in establishing WLDs (Shah and Raju 1986). Thus, in Gangetic plains where water table is close to the ground surface and hydraulic conductivity high so that low cost shallow tubewells can produce reasonably good discharge, the skewness in WLD ownership is far less (Shankar 1986) than in hard rock areas of the southern penninsula or in areas like parts of Gujarat where economic discharge rate can be assured only by deep tubewells which require much higher initial investment (Shah and Raju 1986). Another reason for this skew ness is the skewness in the distribution of landholdings; to earn a decent return on investment in WLDs, a farmer must have a captive irrigable command area of a certain size; although there are possibilities of selling water, farmers with large land holdings have a natural advantage over small and marginal farmers in this respect.

2. Generation of irrigation surplus

Irrigation surplus may be defined as the incremental value of net output generated by access to irrigation less the cost of irrigation, or in other words. the maximum price that a user would be willing to pay for irrigation service. The size of the irrigation surplus generated by an irrigation system depends crucially on the degree of control that it provides to the user on the *timing* and *quantum* of water application. Thus, most canal irrigation projects in India have far less attractive features as an "on demand system" (Kolawalli 1986) and therefore generate smaller "Irrigation surplus" when compared to tubewells (Lowdermilk et. al quoted in Toulmin C and M Tiffen 1987). Empirical evidence supporting this hypothesis is vast; Dhawan (1985), after careful scrutiny, estimates the grain yield under three different irrigation systems as follows :

Table : 1

Source : Dhawan 1985 : 11 and 13

Output impact of groundwater, canals and tanks : (Tons of food grain per net irrigated hectares additional to rainfall yield)

	Ground water	Canal	Tanks
Punjab	4 4	2.1	–
Haryana	5.3	2 0	—
Andhra Pradesh	5.2	2.9	1.5
Tamilnadu	6.0	2.1	1.8

*Water Lifting Devices a term we shall use to denote open or dug wells mounted with electricity or diesel operated pumpsets.

Kolawalli (1986), Brahmbhatt (1986), Shah and Raju (1986), Asopa and Tripathi (1985), all of them working on the Mahi Kadana canal system found farmers paying 8-10 times more for purchased tubewell irrigation only for its vastly superior "on demand" properties. Tank irrigation, and state tubewell appear to have better performance as "on demand" systems in relation to large canal projects; however, own tubewell followed by purchased private tubewell water rank highest in terms of "on demand" quality and the size of the irrigation surplus generated. If we were to construct a profile showing the creation and appropriation of irrigation surplus by all these four irrigation systems, it would look somewhat like Figure-1.

The dimensions used in constructing Figure : 1 are intended to reflect the average or representative values of 'irrigation surplus' generated in various parts of the country and

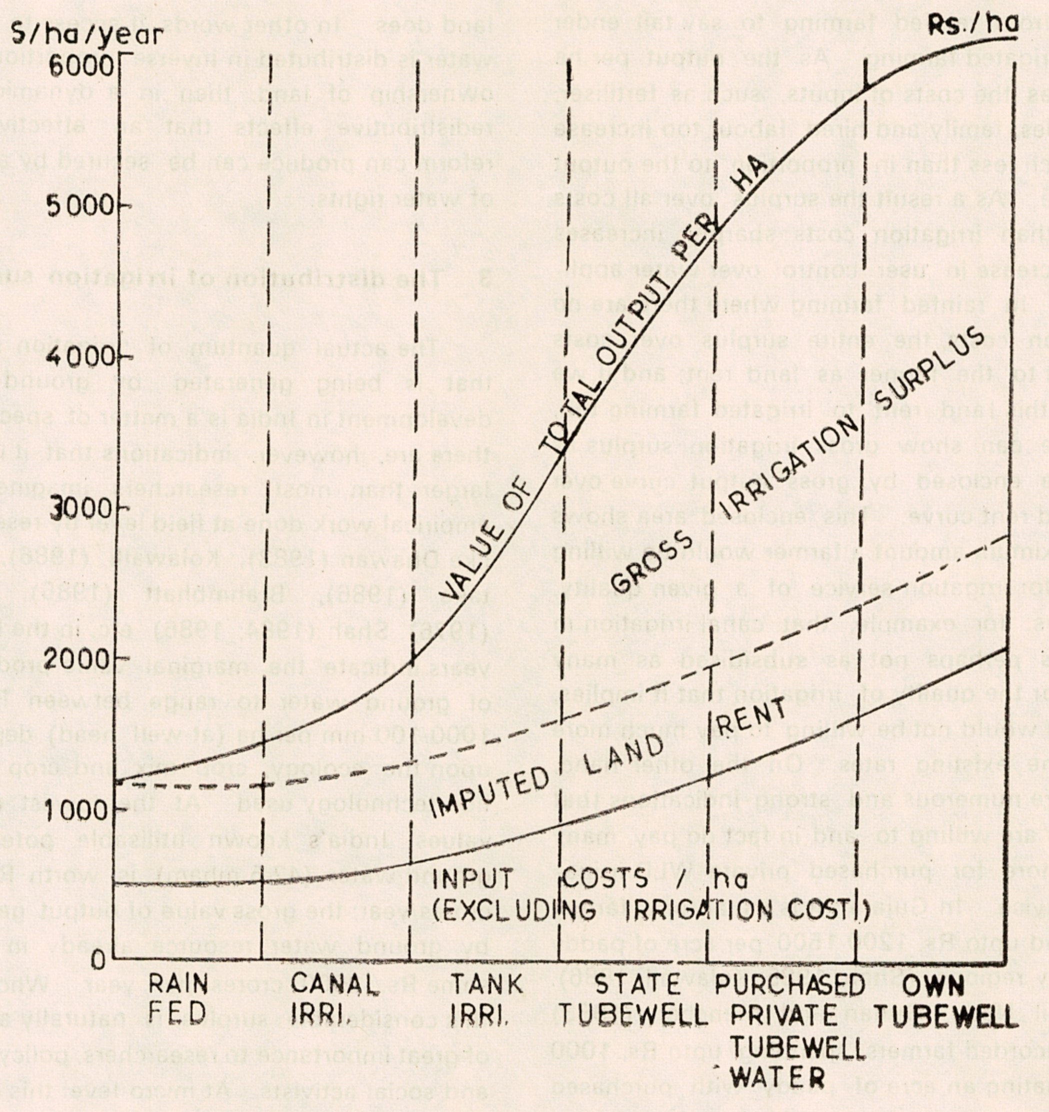

Fig. 1 : Creation and Approppration of Irrigation Surplus (Rs/ha)

derive empircal support from many studies, notably Kolawalli (1986), Brahmbhat (1986), Guhan and Mencher (1983), Lowdermilk et. al. quoted in Toulmin and Tiffen (1987), Dhawan (1983), Repetto (1986), Van Oppen and Subbarao (1985), etc. The main message that Figure : 1 is designed to deliver is that the increase in the value of output per ha (traced by the upper most thick line) caused by irrigation systems such as purchased or own WLD water affording greater control to the user is of a much higher order than that due to mere switch from rainfed farming to say tail ender canal irrigated farming. As the output per ha increases, the costs of inputs, such as fertiliser, pesticides, family and hired labour too increase but much less than in proportion to the output increase. As a result the surplus over all costs other than irrigation costs sharply increases with increase in user control over water application. In rainfed farming where there are no irrigation costs, the entire surplus over costs accrues to the farmer as land rent; and if we project this land rent to irrigated farming too, then we can show gross irrigation surplus as the area enclosed by gross output curve over the land rent curve. This enclosed area shows the maximum amount a farmer would be willing to pay for irrigation service of a given quality, It shows, for example, that canal irrigation in India is perhaps not as subsidised as many think for the quality of irrigation that it implies, farmers would not be willing to pay much more than the existing rates. On the other hand, there are numerous and strong indications that farmers are willing to and in fact do pay, many times more for purchased private WLD irrigation service. In Gujarat, it is usual for a farmer to spend upto Rs. 1200-1500 per acre of paddy in many regions (Shah 1985; Kolawalli 1986). In Tamil Nadu, Guhan and Mencher (1983) have recorded farmers spending upto Rs, 1000 for irrigating an acre of paddy with purchased private irrigation. Giving the well owner 1/3rd share in total output just for water is a standard water based share cropping in many regions (Chambers 1986; Shah (1986); and in many parts of Gujarat, the well owner shares half the fertiliser cost and claims 50%, and often 66%, share in output (Shah 1985). The share of timely and adequate irrigation service, in the perception of the farmer, is thus twice or often more than twice the rent enjoyed by unirrigated ha of land If the cost of lifting and distributing water is assumed to be 50% of the gross Irrigation surplus, then our analysis implies that one who controls enough ground water to irrigate 1 ha of land can, in effect, earn as much net income as the owner of a ha of unirrigated land does. In other words, if access to ground water is distributed in inverse proportion to the ownership of land, then in a dynamic sense, redistributive effects that an effective land reform can produce can be secured by a reform of water rights.

3. The distribution of irrigation surplus

The actual quantum of 'irrigation surplus' that is being generated by ground water development in India is a matter of speculation; there are, however, indications that it is much larger than most researchers imagine. The empirical work done at field level by researchers like Dhawan (1983), Kolawalli (1986), Copestake (1986), Brahmbhatt (1986), Moorty (1976), Shah (1984; 1986) etc. in the last few years indicate the marginal value productivity of ground water to range between Rs. 200-1000/100 mm per ha (at well head) depending upon the ecology, crop mix and crop production technology used. At the lowest of these values, India's known utilisable potential of ground water (42.5 mham) is worth Rs. 8400 crores/year; the gross value of output generated by ground water resource already in use is some Rs. 2500 crores per year. Who claims this considerable surplus is naturally a matter of great importance to researchers, policy makers and social activists. At micro-level this concern has spurred many innovative efforts by NGOs and voluntary organisations to achieve equitable distribution of the ground water irrigation surplus. Gram Gaurav Pratishthan, a voluntary organisation based in Maharashtra, for instance, has successfully tried allocation of water rights in cooperative lift irrigation schemes on a per capita basis (GGP 1983), this logic has been further extended by Aga Khan Rural Support Programme in Gujarat where water shares of members are fixed at 2.5 acres per each member of a co-operative lift irrigation scheme irrespective of the members' total land falling in the command area; but in loan repayment, a member's share is in proportion to his total land falling in the command. In Gonda district of Eastern, U.P. where water tables are high and aquifer recharge abundant, Deen Dayal Research Institute, a local NGO has promoted a policy of saturation whereby it has enabled about 10,000 small farmers to own low cost shallow tubewells so that every one has access to this common property resource (DDRI 1982, Chambers and Joshi 1983). And in Bangladesh, the government itself has enabled several hundred landless groups to own irrigation equipment so as to sell ground water to neighbouring farmers and derive livelihood through such sale (Mandal and Palmer Jones 1986; Wood 1983). While all these micro-experiment do undoubtedly have tremendous value as social live-labs of sorts, it is too much to expect them throw up a viable answer for the problems of the nation as a whole. Nor, for that matter, can we expect the state tubewells to make a major dent. Besides having a very small share in total ground water output, state tubewells have been uniformly notorious for inefficiency, long shutdown periods and dominance by local big wigs (Abby et. al. 1982). Clearly, the need is for a policy framework and instruments that can influence the behaviour of those 8 million private pumpers who hold the key to who gets what from the development of India's ground water resources. Recent empirical research on the behaviour of private pumpers indicates that while redistribution through a major reform ot water rights may be a politically unachievable dream, even so, it is possible to devise instruments of policy that would enhance benefits to rural poor from private exploitation of ground water resource (Shah 1987).

4. Private exploitation of ground water and benefits to the poor

In a well known work, Maass (1976) writes

"It is not surprising that economic rents from low water charges (for canal irrigation) are quickly capitalised back in to the value of land on which water is available... If the land is rented out, the terms of tenancy capture the full productive value of the irrigated land for the owner and do not pass on the subsidy embodied in low water charges to the tenant. Even if farmers trade (ground) water rights among themselves, as they do throughout India, Pakistan and Bangladesh when one farmer has a tubewell and his neighbour does not, the prices at which water rights are sold more nearly reflect irrigation's productive value to the buyer than its cost to the seller, which is often subsidised by the government......"

—A Maass (1976)

What is implied in this widely quoted passage is that private owners of WLDs usurp the entire, or the bulk of the gross irrigation surplus accruing to those to whom they sell water. If this were true, it would imply that ground water development in India must increase relative and absolute income disparities in the countryside.

Fortunately, Maass is wrong. Evidence is gradually building up to show that a sensitive and enlightened policy can create a buyers' market in water rights. In Bangladesh, for example, the share of water seller in water based tenancy agreements is recorded to have fallen from 50% first to 33% than to 25% between 1981-85 and more recently such contracts have been transacted even at 20% and 10% shares (Mandal and Palmer Jones 1986). Likewise, in many parts of India recent studies indicate that prices at which water rights are sold are closer to the cost of pumping to the seller than its productive value to the buyer even where water is a scarce resource (Copestake 1986; Shankar 1986; Shah and Raju 1986).

Though unequitable in a relative sense, private exploitation of ground water leaves the poor better off in an absolute sense. Benefits derived by the poor increase sharply as those who own WLDs experience greater *need* to sell water to others in order to spread their fixed costs over a larger command area (Shah 1987). The four major benefits of ground water development are (a) increased and stable net income through higher productivity and cropping intensity, proofing from draught (b) increased and year round labour demand and higher wage rates (c) opportunities to sell water at profit (d) appreciation in land value. Not all of these benefits accrue exclusively to those who invest in WLDs and the benefits to non-owners of WLDs tend to increase as localised markets of water become more 'efficient', as shown in Table 2. When private pumpers do not sell water to their neighbours, as in in parts of Karnataka (Prahladachar 1987), benefits of ground water development accrue only to WLD owners and, to some extent, to the landless through increased labour demand. However, even monopolistic markets, as those prevailing in Gujarat [Shah 1985, 1986 (a) 1986 (b)] expand the benefits of ground water development to other sections of the community. Efficient water markets, of course, maximise the benefits of private exploitation of ground water to poorer sections of the community.

Table 2 : Distribution of benefits from ground water irrigation

Benefits accruing to the owners of factors production when there is :	(a) Increased farm income	(b) Increased wage income	(c) increased land value	(d) Income from the sale of water
A. No market for water				
(a) Land + WLD	***		×××	
(b) Land alone				
(c) Labour		+++		
B. Monopoliaric market for ground water				
(a) Land + WLD	****		××××	$$$
(b) Land alone	**		××	
(c) Labour		++++		
C. Efficient market for ground water				
(a) Land + WLD	*****		×××××	$$$?
(b) Land alone	****		××××	
(c) Labour		+++++		

The performance of a water market from the buyers' viewpoint can be judged along the criteria of (a) dependability (b) adequacy and (c) the terms or the price at which water is sold. Since water markets are highly localised and fragmented, all these three reflect the balance between the bargaining power of buyers versus sellers whose need to sell water is often as great as the buyers' need to buy it. The size of the difference between the price and the incremental cost of lifting water is a very good indicator of the relative bargaining strength of the sellers. In a buyers' market, the difference would tend to be small; in a seller's water market it would be large. This would imply that maximum benefit from private exploitation of ground water to small and marginal farmers and to the landless would accrue if ground water markets become buyers' markets.

Field studies in different locations in India indicate enormous variations amongst states and regions - but surprising uniformity within a region - in the prices charged by private water sellers. The extent of sale is substantial and is likely to be 40-50% of the total water lifted by a typical WLD owner (Shah and Raju 1986, Shankar 1986; Patel and Patel 1987). Where markets are well developed, as in many parts of Gujarat and Andhra Pradesh, sellers themselves buy water to irrigate fragments far away from their own WLDs (Shah and Raju 1986).

There are clear and definite patterns to be seen in water prices charged in different regions These seem to indicate that water price formation can be explained in terms of the extent of monopoly power enjoyed by sellers and the incremental cost of lifting water. Factors that affect monopoly power are many and diverse as shown in Figure 2.

Where incremental costs of lifting water are high, over 85-90% of such costs are accounted for by power or diesel costs (Shah and Raju 1986). In the case of diesel WLDs, incremental fuel cost per hour of pumping would remain the same for WLDs of the same capacity across regions and therefore the prices charged by

Figure 2 : Determinants of the monopoly power enjoyed by water sellers

Low monopoly power	High monopoly power
(a) High and stable rainfall	(a) Low and erratic rainfall
(b) Abundant aquifer close to the surface	(b) High depth to the water table
(c) Low cost of WLD installation	(c) High capital cost of WLD installation
(d) High WLD density	(d) Low WLD density
(e) No spacing/licensing norms	(e) Stringent spacing/licensing norms
(f) Crops using large quantity of water	(f) Crops using small quantity of water
(g) Efficient state tubewells, access to canal water; access to electric power.	(g) No canal water; none or inefficiently managed state tubewells, no electricity.
(h) Private WLDs using lined channels or pipe lines for water distribution.	(h) Private WLDs using unlined field channels for conveying water to buyer's fields.

their owners should also remain comparable. However, in fact, they do not and vary across regions by a multiple of 2-3 (Table 3). The variations are expalined, in our view, by the differing degree of monopoly power enjoyed by water sellers in different regions.

In the cost of electric WLDs too, the same logic appears te be working. In Gujarat power supplied to agriculture used to be charged on *pro-rata basis* until June 1987 and therefore the water price charged by sellers is high (Shah 1985). In recent times, as pro-rata power charge has sharply increased, water price has increased by the same proportion (and, not just to cover the increased power cost). In Gujrat this has meant that every rupee extracted by the Electricity Board from WLD owners induces them to extract Rs. 3-4 from water buyers (Figure 3).

In most other states, where power is charged for on a flat rate linked to the hp of WLD, power cost does not enter the incremental cost of lifting water and therefore water prices are low even in areas with high monopoly power. Sellers are under great pressure to sell water since all costs are fixed and all revenue from sale of water, even at low prices, constitutes net profit. The overall results summarised in Table 4 thus indicate that flat power tariffs have the desirable result of creating buyers' water markets and even diesel WLD owners are affected in the same way though in a less intense manner.

The contention that by reducing the incremental cost of pumping water to near zero levels, flat power tariffs would reduce water prices in private ground water markets and produce enormous equity benefits by improving access of resource poor to ground water resource was strongly vindicated by the effects of a switch from pro-rata to flat power tariff system by Gujarat Electricity Board in July 1987. In accordance with our apriori expectations, private ground water prices fell by 25-60% in various regions of Gujarat even in a drought year when the bargaining power of WLD owners would be particularly high in relation to buyers. Sensibly, in face of great resistance by the powerful large farmer lobby, the Gujarat government has introduced a progressive flat power tariff system under which owners of WLDs with 7.5 or less hp pay Rs. 192/hp/year while those with WLDs of 30 hp or higher, pay over three times as much at Rs. 660/hp/year. Preliminary evidence indicates that areas like Mehsana district in north Gujarat where high depths to the water table necessitate large capacity motors, water prices have fallen marginally by 15-20%, in areas like Kheda district where water tables are high and aquifer substantial, water prices have declined by 40-60% In Anklav village for instance, where the competition among water sellers is intense (Shah and Raju 1986) WLD owners who charged Rs. 26-28/hour of pumping in May 1987 have now slashed their prices to Rs. 12-15/hour. However in Karamsad village where sellers are few and irrigable land large, sellers enjoy high monopoly power and as a result, water price has fallen due to flat rates but only to Rs. 20/hour where it has remained sticky. While the wider ramifications of this trend are yet to be investigated, the least that can be said is that it has redistributed irrigation surplus from WLD owners to water buyers.

5. Implication for public policy

The development of water markets provide the much needed scope to broaden the thrust of public policy and to devise new instruments with powerful productivity and equity results on ground water development. Three sets of instruments can be considered in which those currently used play a small and a somewhat different role. The main public policy goal is assumed to be to maximise productivity and equity in ground water development *without* undermining seriously the viability of existing institutions and promoting over-exploitation of ground water reserves.

Table 3 : Relationship between sale price of water, monopoly power and incremental cost : A hypothesis and evidence from field

Location	Monopoly power	Sale price of ground water in areas with: Low incremental cost of water extraction	High incremental cost of water extraction
1. Pandalaparru West Godavari Dt Andhra Pradesh (Shah & Raju 1986)	×	Rs. 2.9-3/hour Electric : 5-7.5 hp Flat tariff : Rs. 48/hp per year	Rs. 7.5/hour Diesel : 7.5
2. Meerut, Western U.P. and Punjab (Jairath 1983 D Prasad et al; 1985)	××	Rs. 4-6/hour Electric : 5 hp Flat tariff : Punjab : Rs. 180/hp/year U.P. : Rs. 260/hp/year	Rs. 8-10/hour Diesel : 5 hp
3. Parts of Eastern & Central U.P., Bihar (Kripashankar : 1987) Chambers & Joshi 1983)	××	Rs. 6-7/hour Electric : 5-7.5 hp Flat tariff : Punjab : Rs. 180/hp/year Bihar : Rs. 145/hp/year	Rs. 10-12 hour Diesel : 5 hp
4. Thasra taluka in Kheda district the head of MRBC (Shah & Raju)	××		Rs. 15/hour Diesel : 7.5 hp Rs. 15/hour Electric : 21 hp Prorata tariff : Rs. 0.70/KWH
5. Midnapur West Bengal (Shah, 1987)	×××		Rs. 14/hour Diesel : 5 hp
6. Charutar tract in Kheda district, Gujarat (Shah & Raju 1986).	×××		Rs. 25-28/hour Electric : 21-25 hp Prorata tariff : Rs. 0.70 KWH
7. Parts of Panchmahal Dt in Gujarat (Shah 1984)	××××		Rs. 16-18/hour Diesel : 5 hp
8. Mehsana, Sabarkantha, Banaskantha district of Gujarat (Shah 1984)	××××		Rs. 35-41/1 hour Electric : 30-35 hp Prorata tariff : Rs. 0.70/KWH
9. Madurai Dt Tamilnadu (Copestake 1986) Karimnagar Dt Andhra Pradssh (Shah 1985)	×××××	Rs. 4-5 hour Electric : 7.5 hp Flat tariff : Rs. 48/hp/yr	Rs. 18-21/year Diesel : 5 hp

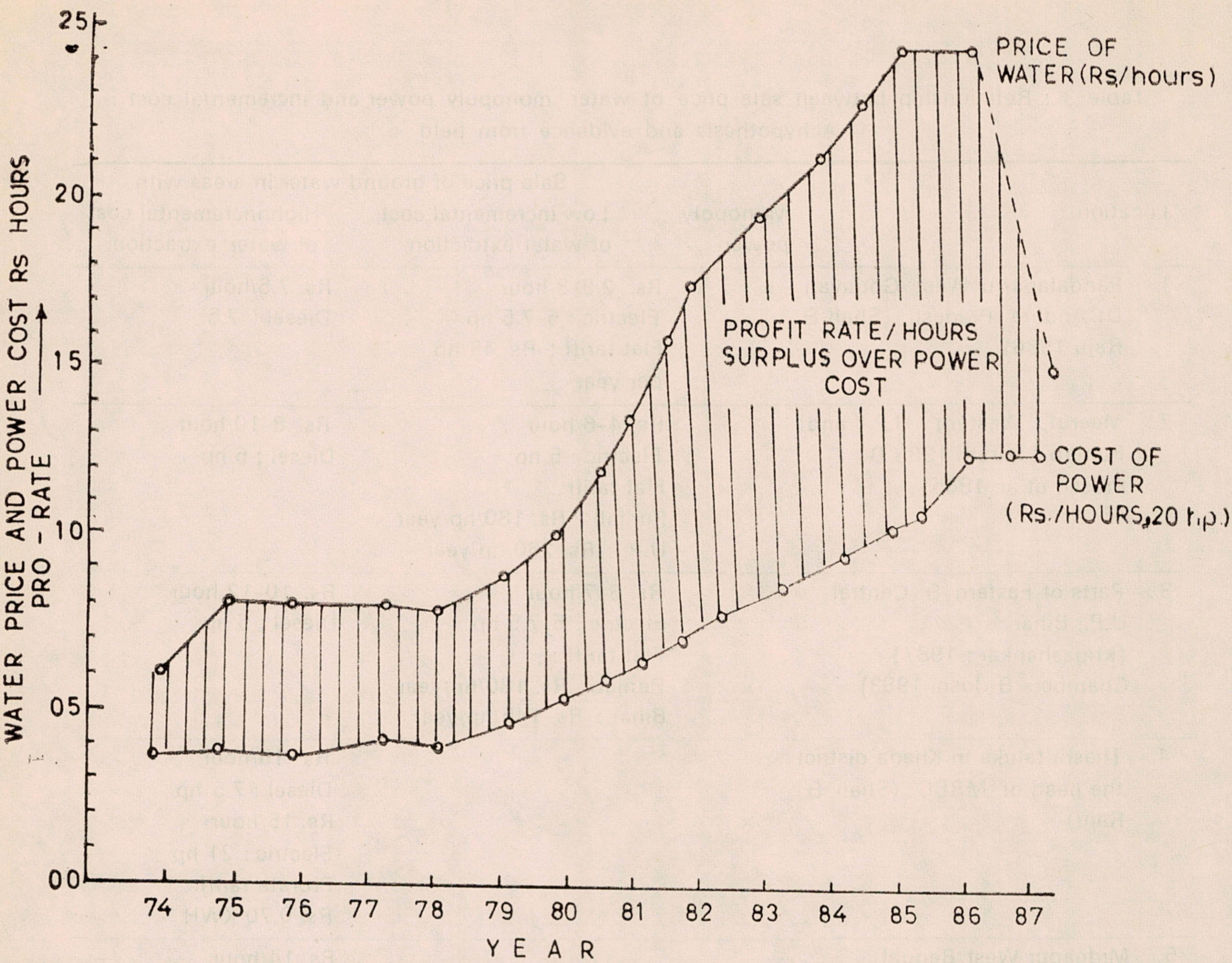

Fig. 3 : Relationship between prorata power cost/hour and market price of groundwater Anklav area

Table 4 : Determinants of water prices

Monopoly Power	Incremental cost Low	Incremental cost High
Low	Water price : very low Dependability : high Adequacy : High West Godawari (electric) Punjab, U.P., Haryana (electric)	Water price : high Dependability : high Adequacy : high West Godawari (diesel) Northern Kheda (electric) U.P., Punjab, Haryana (diesel)
High	Water price : moderately high Dependability : moderately high Adequacy : moderately high Madurai, Karimnagar (electric)	Water price : very high Dependability : low Adequacy : low Gujarat (electric) Madurai, Karimnagar (diesel)

(a) Flat versus pro-rata power tariff

Flat power tariff produces low water prices and reduces the monopoly power of sellers by by inducing them to sell more water. Pro-rata tariff produces high water prices and high monopoly power by removing the pressure to sell more. Increasing flat rates from very low level, as prevailing in Tamil Nadu and Andhra Pradesh, will have, if anything, salutory effects of making water markets more equitable although too high a flat rate may, in the long run, discourage private investment in WLDs. Every increase in pro-rata power tariff, on the other hand, results in *proportionate* increase in water prices and in the exploitation of buyers, Low water prices changed by owners of electric WLDs under flat tariff help to reduce the premia changed by diesel WLD owners too (Shah and Raju 1986).

Flat rates discourage investments and effort to minimise wasteful use of power and water *especially* when power supply is abundant. Pro-rata power tariff, on the contrary, *encourage such effort and investment.*

(b) Power supply

Low flat rates with abundant power supply as in Andhra Pradesh and high pro-rata tariff with low power use per WLD as in Gujarat-both may undermine the economic viability of power supply to agriculture. But the former may produce powerful equity effects; and the latter wiil make private ownership of WLDs instruments of profiteering Raising flat rates to moderately high levels - 4-5 times the present level in Andnra Pradesh and Tamil Nadu - may not have any significant adverse impact on productivity and equity in ground water use Shah 1987).

Restricted but regular, convenient and predictable power supply to agriculture may be an effective method of regulating overall withdrawal of ground water use in a given ecology and of promoting the viability of state electricity boards under flat tariff regime. Under abundant power supply and flat rates, WLD owners will face a lower opportunity cost of water to buyers and sellers, generate incentives to use water (but not power) economically and may promote investments in lined water conveyance systems (Shah 1987).

(c) Institutional support

In large parts of northern and eastern states with abundant aquifers but low levels of ground water development, rapid rural elecrrification holds the key to equitable ground water development. Hassle-free support to landless groups in terms of credit, subsidies and power connections may make water selling a livelihood-intensive occupation. Priority to small farmers in power connections, reduction in the 'hassle' factor in obtaining loans. subsidies, etc. through an integrated Ground Water Development Programme involving coordinated effort by electricity boards, banks and government officials would result in equitable saturation of groundwater potential. Improvement in the management and efficiency in state tubewell programmes could have substantial impact on the working of water markets.

The mix of instruments that may produce best results would vary across regions according to the availability of ground water and the extent to which it is already developed. In the water stress hard rock areas in the south. Efforts to increase equity in access have to be tampered by the need to prevent over exploitation and hence, a suitable policy mix in these regions may have to be different as shown in Table 5.

4. Conclusion

At macro level, national policy towards groundwater development needs to respond to two challenges; one, an opportunity and the other, a threat. The opportunity is the possibility of substantially reducing relative and

Table 5 : Mix of policies for different regions

Ground water potential	Extent of ground water devt	Macro policy intervention	Technological interventions	Institutional support
High	High	(a) High flat tariff (b) Restricted but predictable power supply	(a) Encourage small pumps (b) Encourage investments in power saving devices	(a) Landless group for Lift irrigation
High waterlogged areas in canal commands	Low	(a) Low or progressive flat tariff (b) Less restricted power supply (c) Well managed state tubewells	(a) Encourage small pumps & tubes	(a) Rapid rural electrification (b) Landless irrigation groups (c) Intensive Ground water development (d) Priority to SF MF in power connection
Low areas prove to salinity ingress	High	(a) High but progressive flat rates (b) Restricted power supply (c) Spacing and licensing norms ?	(a) Augment recharge (b) Subsidise pipelines (c) Encourage drip-irrigation (d) Develop surface water irrigation systems	(a) Ground water surveys (b) Priority SF/MF groups in power connections (c) Encourage NGO experiments in equitable allocation of water
Low	Low	(a) Steeply progressive flat rates (b) Less restricted power supply (c) Ban big pumps except by SF groups	(a) Encourage small pumps (b) Subsidise pipeline (c) Promote drip irrigation (d) Develop surface irrigation cum-aquifer recharge systems	(a) Groundwater surveys (b) Priority access to SF (c) SF/MF groups where big pumps are necessary (d) Encourage NGO action

absolute disparities in rural incomes through diffusion of access to and control of ground water resource; the threat is posed by indiscriminate exploitation by private exploiters of this common property resource which would, if unchecked, result in a series of ecological disasters and major external diseconomies for future generations.

Policy frameworks and instruments used so far to respond to these challenges have proved entirely inadequate. State tubewells and credit support to diffuse access to ground water have met with very limited success. On the other hand, administrative control over the rate of ground water exploitation through licensing, spacing norms, etc. are mostly ineffective and where effective, they are unequitous (Shah. 1986).

In this context. researchers and policy makers have completely missed the significance of localised but pervasive water markets that have sprung up all over the Indian sub-continent as a fall out of the rapid propagation of modern ground water extraction technology. Since these markets strongly respond to a limited number of variables amenable to public control, they can be used as effective instruments for meeting both the challenges described earlier.

A preliminary and tentative scheme of doing this has already been presented; this can be improved upon greatly by refining our under standing of the working of water markets through multi-disciplinary, empirical research.

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