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Water Markets and Irrigation Development in India*

Tushaar Shah†

I

BACKDROP

Of the 47.5 million hectare-metres (mham) of India's known groundwater potential (Padmanabhan, 1988), very likely some 18 odd mham is currently used to irrigate about 28 million hectares (mha) of land. At a rate of 0.60-0.65 metre per ha, the ultimate irrigation potential with groundwater may well be around 70-80 mha. Considering the current rate of expansion of groundwater use, much of the remaining potential will get developed in the coming two decades. Four decades after Independence during which our hopes of achieving more egalitarian rural income distribution through land reforms have been dashed, a crucial question that has concerned many social researchers concerned with groundwater is: who gets this last resource: the haves or the have-nots?

There has been some sensitivity to this concern which is reflected in state tubewell programmes, support to NGO-sponsored group tubewells, and various subsidy programmes - all of which aim at enhancing poor people's access to this precious resource. There are many legitimate concerns about the efficacy of these measures in reaching the poor; but the most important worry is about their ability to check and make more equitable the massive scale and speed with which the resource is already being pre-empted by the rural elite who have been putting up groundwater structures at an inexorable rate of over a million a year. As a result, in states like Uttar Pradesh, the presence of public tubewells which dominated the groundwater scenario until the early sixties has long since been reduced to insignificance. At the national level, of the over 12 million groundwater structures currently in use, less than 50,000 are state tubewells and much fewer are NGO-induced group tubewells. Over 95 per cent of the area served by groundwater in India is commanded by privately owned wells; and this proportion is unlikely to change drastically in coming decades. Considering the substantial skewness in the ownership of private tubewells, the stage seems set for the usurpation, by the elite, of one more - and, final - productive resource.

II

REGRESSIVE IMPACT OF PUBLIC POLICIES

Existing public policy instruments do not do much to check this trend; in point of fact, they often exacerbate it. Unlike privately owned land, groundwater is a common property resource; in view of its fungibility, it is privatised as soon as it is captured and therefore, generally ends up being appropriated and used as an open access resource. As the demand for irrigation has increased with the spread of modern crop production technology, existing owners of tubewells have enjoyed unchallenged *de facto* ownership right on the community's groundwater resource. In effect, thus ownership rights on water are given or denied through the rights to establish modern Water Extraction Mechanisms (WEMs). A pumper may sell

* Keynote paper.
† Director, Institute of Rural Management, Anand (Gujarat).

to his neighbour water underlying the latter's land itself and still extract a monopoly premium from the transaction.

Siting and licensing norms adopted by groundwater departments, banks and electricity boards to contain well interference and excessive withdrawals from the aquifers determine who is denied the right to establish modern WEMs. Since these norms *(a)* have been established only in the last two decades, *(b)* have begun to be enforced seriously only recently and *(c)* do not affect existing modern WEM owners, they impose a 'virtual' allocation of ownership rights on groundwater which favours early exploiters and penalises the late ones a majority of whom are likely to be resource poor. Moreover, while siting norms seek to protect an existing modern WEM from a potential one, they do not provide any protection to existing traditional WEM owners from new modern WEMs which, in many cases, have wiped out the former (see, *e.g.*, Dhawan, 1985). Spacing and licensing norms are difficult to enforce through the regular policing system; therefore, in most states, credit support by public sector banks and the issuance of electricity connections are made contingent upon compliance with these norms. Those, usually the resource rich, who can self-finance WEM investment and/or use diesel engines (or of course, bribe their way to an electricity connection) are thus unaffected by the norms. Moreover, preventing the establishment of new WEMs in the neighbourhood of an existing one usually strengthens the monopoly power of the latter in his water transactions with his neighbours; such monopoly power often takes the form of exploitative prices and arbitrary behaviour on the seller's part. The redeeming feature in this otherwise gloomy scenario is the emergence of water markets and the opportunities they offer for ensuring equitable access. Even in a community in which few rich members own WEMs with technical capacity to irrigate the bulk of all the members' land, everyone, notably the poor, would be substantially better off (in absolute terms) with the emergence of water markets than without the market; more so with an efficient water market than an inefficient one. In particular terms, four major beneficial effects of water markets can be noted: *(a)* higher and more risk-free income flows from farming for non-WEM owners who, with a water market, have access to modern farming technologies; *(b)* appreciation of market value of non-WEM owners' land; *(c)* opportunities offered by water market to small holder WEM owners to increase WEM utilisation beyond what their own land would permit and thereby to spread its overhead on a larger command area; and *(d)* improved wages, more and seasonally balanced employment opportunities for the landless (Shah, 1988). All these four benefits will be larger and more widely distributed with efficient water markets than with inefficient ones.

III

WATER MARKETS: EVOLUTION AND DEVELOPMENT

In much recent literature, the term 'water market' has been used to describe a localised, village-level informal arrangement through which owners of water extraction mechanisms (WEMs) sells irrigation service to other members of the community. Water may be lifted from open wells or tubewells, deep or shallow wells, or from canals, tanks, rivers, drains or such other surface sources. It may be transported to the buyers' field either through unlined field channels or through lined field channels (as in some parts of Uttar Pradesh) or through underground pipeline networks as in many parts of Gujarat. Where land holdings are fragmented, most sellers of water are also buyers themselves; for, most farmers sink wells in one or two of their largest and best fragments and often use purchased water for irrigating others.

Studies in Gujarat indicate that well-developed water markets have existed in many parts of the state for 70 to 80 years. During the sixties and the following period, water markets have become more pervasive and important. Evidence available from recent studies indicates that upto half or more of the gross area irrigated by private modern WEMs in many parts of India belongs to the buyers of water. In water scarce areas, this proportion tends to be small or, in several areas, zero; in many other areas, water abundant as also water scarce, as in parts of Gujarat, however, it may go up to 80 per cent or more. Since the area irrigated by purchased water is not fully included in the gross area irrigated by WEMs, official estimates are likely to seriously under-state the actual total area irrigated by privately owned and operated minor irrigation sources.

In areas irrigated through water markets, the intensity of irrigation may vary greatly. However, since the buyers can get water *when* they need, the productivity of water is high. Where opportunity to buy small quantities of water at crucial periods of moisture stress enables small holders to take an additional crop, water selling by private WEM owners can have dramatic beneficial impacts on the incomes of water buyers and the economy of the community as a whole. Evidence on these lines has been recorded in the last five years for Midnapur district in West Bengal, West Godavari and Karimnagar districts in Andhra Pradesh, Panchmahal, Kheda, Sabarkantha and Mehsana districts of Gujarat by Shah (1985, 1989*a*), Shah and Raju (1987); in Bankura and Purulia districts of West Bengal, eastern Uttar Pradesh and Kheda district in Gujarat by Kolavalli and Chicoine (1987) and Kolavalli *et al.* (1989), Madurai district in Tamil Nadu by Copestake (1986), Allahabad district of Uttar Pradesh by Kripa Shankar (1989); and for Bihar, Assam, West Bengal, eastern Uttar Pradesh and Orissa by Pant (1988, pp. 33-37).

As a social institution, the development of water markets has been highly variable across regions. Some of the salient differences are summarised in Table I. In the early stages of water market development, three types of water-based tenancy contracts predominate: *(a)* labour contract, in which the buyer will provide labour and draft power to the seller in return for water; *(b)* crop-sharing contract in which the seller provides only water while the buyer provides land, labour, manure and other inputs and both share the crop; *(c)* crop- and input-sharing contract in which the buyer provides land and labour, the seller provides water, both share other input cost and output. The terms of sharing output may vary across transactions depending primarily upon the nature of relationship between the buyer and the seller. In the second type of contract, for instance, the sellers' share in output ranged from 33 to 55 per cent and in the third contract, between 50 per cent and 66 per cent. As the water transactions increase, apparently, the multiplicity of 'kind' contracts gives way to one or two standard and widely used contracts; and outright cash payment for water gains precedence over crop-sharing contracts.

Depending upon the intensity of competition and the economics of WEMs, the share of water may change substantially across space and time. In many parts of India, for example, one-third crop-share for water is quite common. In Bangladesh, the share of water dropped from 50 per cent first to 33 per cent and, more recently, to 20-25 per cent in some areas as local competition intensified (Palmer-Jones and Mandal, 1987). In Gujarat, in contrast, water sellers are claiming 50 per cent, in some cases upto 66 per cent. of the crop-share (Asopa and Dholakia, 1983, p. 23; Shah, 1985).

TABLE I. MORE DEVELOPED VERSUS LESS DEVELOPED WATER MARKETS

	Features (1)	More developed (2)	Less developed (3)
1.	Transactions	Cash transactions and sale of water per hour of pumping more common; lease contracts standardised to a few types	Kind transactions dominate a wide variety of lease contracts used; absence of standardisation
2.	Proportion of water output sold by LIS owners	Quite high ranging from 40-90 per cent	Small 10-25 per cent
3.	Differences in cropping pattern, input use, technology, between WEM owners and others	Small	Large
4.	Per cent of non-WEM owners and their land using purchased water	Large	Small
5.	Objective function of WEM owners	To meet own irrigation needs *plus* maximise returns from sale of water	To meet own irrigation needs

When water is sold for cash, it may be priced on the basis of acres irrigated of a particular crop or on the basis of hours of pumping. Price per acre of a crop is more common in some southern regions, especially with electrified WEMs although price per watering too is often encountered. In Gujarat, price per hour of pumping is more widely practised; here, owners of electrified WEMs often charge per unit (kWh) of actual power used by taking meter readings. In the case of diesel WEMs, either a full price per hour may be charged in which case the seller procures diesel; or the seller may just charge a fixed sum per acre as 'rent' for the use of the WEM. In this latter practice, widely used in many parts of southern India and Bangladesh, the buyer has to arrange for diesel/oil.

Availability of water resources, scale and quality of adoption of irrigated farming technologies, progress of rural electrification, quality of power supply, extent of land fragmentation are among the factors that seem to influence the pace of development of water markets. In many hardrock areas, where well yields are low, a variety of inhibitions and taboos prevent WEM owners from sharing it with others. However, even in those low potential areas where modern crop production technologies have been widely practised and the full economic potential of irrigated farming recognised, water markets tend to develop rapidly, in some cases, into highly mature institutions. Mehsana, Sabarkantha, Banaskantha and several water scarce areas of Saurashtra region of Gujarat and the Madurai district in Tamil Nadu, for instance, are such areas. Here, water markets may accentuate the over-exploitation of groundwater resources, but they also diffuse access to the benefits from this precious and declining resource.

Orissa, Bihar and West Bengal, in contrast, have large and easily accessible groundwater reserves, and yet highly under-developed groundwater markets. The constraints here are from supply as well as demand sides. The resource itself has not been adequately developed; the pace of rural electrification is slow. The slow spread of high-yielding variety (HYV) fertiliser technology and protective as distinct from production use of irrigation has meant less opportunities to sell water to neighbouring farmers. Eastern India offers a major opportunity where development of water markets can produce vast benefits for the poor. The question here is how to speed up the development of water markets and saturate the available potential.

Water markets tend to be more developed as one moves towards the west in the Punjab, Haryana and Western Uttar Pradesh, Gujarat, Maharashtra. Also, cash sale of water is most common in the Punjab (Jairath, 1985), Haryana, Western Uttar Pradesh and Gujarat (Shah, 1985); prices tend to be uniform, close to incremental pumping costs, and are normally charged per hour of pumping rather than per acre of a crop. Not owning a WEM is not a great disadvantage in these areas due to ample opportunities to purchase water.

The nature and scale of the social effects of water markets depend on *(a)* the extent to which water markets have developed, *(b)* the efficiency of market transactions and *(c)* the fit between the groundwater endowment of a region and systèm of appropriation implied by water markets. In terms of the typology used in the last section, the social role of water markets can be viewed as in Table II.

TABLE II. ROLE OF WATER MARKETS IN EQUITABLE DEVELOPMENT OF GROUNDWATER RESOURCE

Area category (1)	Key problem (2)	Potential role of water markets (3)	Key goal of public policy (4)
Low potential Low utilisation	Equitable development of unused potential	Positive. Can diffuse access	Stimulate water markets
Low potential High utilisation	Equitable control of with-drawal of water	Potentially harmful as in Meh-sana and Saurashtra but still broaden access	Establish equitable mecha-nisms to control over-exploitation
High potential Low utilisation	Saturation of potential and access to all at low cost: Eastern India	Powerful and positive: can ensure poor peoples' access regardless of who owns LISs; large employment increases	Stimulate rapid development of water markets by removing supply side constraints
High potential High utilisation	Market may become instrument of exploitation of poor by LIS owners	Very positive provided it is efficient; can delink access to water from ownership of LISs	Make water market efficient

In areas where water markets have already flourished, ensuring their economic efficiency is a major issue. Where water sellers enjoy high degree of monopoly power, they can skim the bulk of the marginal value product generated by irrigation service on the buyer's field. In contrast, a seller operating in an efficient water market will be under pressure to sell more water to more buyers and, in the process, to cut the price to the level close to his average economic cost of pumping. The latter will generate a larger irrigation surplus and more livelihoods for the resource poor and the landless; and still sellers as a class may not necessarily earn less total profit than in the former situation.[1] The key problem in realising this dream is that localised, fragmented water markets almost everywhere operate like natural oligopolies.

IV

WATER MARKETS AS NATURAL OLIGOPOLIES

Recent research on water markets suggests that whereas there is considerable uniformity in terms of water sales in a given region, there are wide variations in prices charged by water sellers across regions for comparable service. For example, Shah (1989 *c*) compiled, from several sources, water prices charged by 5 HP diesel WEM owners in 15 districts around 1985-86; he found prices ranging from Rs. 6 to Rs. 21/hour; and price per HP/hour, from Re. 1.20 to Rs. 3.40. In oligopolistic water markets price variations across regions would reflect differences in incremental pumping costs as well as differing degrees of monopoly power enjoyed by sellers. Since the average pumping costs per HP/hour showed remarkable uniformity, it could be inferred that the differences in prices charged by water sellers in different regions reveal the variations in monopoly power enjoyed by water sellers in different regions. Indeed, the ratio of price charged to incremental pumping costs is a good indicator of the monopoly power of water sellers in different regions.[2] A number of factors seem to affect the degree of monopoly power enjoyed by water sellers in a given regional setting (Table III). All these factors operate through their impact on the intensity and criticality of the dependence of those without own irrigation sources on private water sellers. Making water markets more competitive, unfortunately, is difficult since groundwater markets operate as natural oligopolies. The density of WEMs (measured, for instance, as installed HP/100 ha) tends never to be so high as to make individual water seller completely powerless especially due to topographical barriers and high seepage losses through unlined field channels. High capital intensity of modern water extraction technology, stringent enforcement of spacing norms through financial institutions and electricity boards contribute to oligopolistic interaction amongst sellers, and between buyers and sellers. The main question thus is: is it possible to create a situation where oligopolists behave as if they operate under competitive conditions? In the case of water markets, it seems it is.

TABLE III. DETERMINANTS OF MONOPOLY POWER ENJOYED BY WATER SELLERS

Factors (1)	Low monopoly power (2)	High monopoly power (3)
Physical and climatic factors	High and stable rainfall	Low and erratic rainfall
	Abundant aquifer close to the surface	High depth to the water table
	Cropping patterns dominated by crops using small quantity of water. Flat topography	Cropping patterns dominated by crops using large quantities of water. Undulating topography
Institutional economic factors	Low cost of LIS installation	High cost of LIS installation
	No spacing or licensing norms	Stringent spacing and/or licensing norms
	High LIS density (installed HP/100 ha of cultivated land)	Low LIS density
	High degree of rural electrification	Poor progress in rural electrification
Factors enhancing competition	Use of lined conveyance to supply water	Use of unlined field channels by water sellers
	Operation of efficient state tubewells charging low water prices	Inefficient state tubewells charging high water prices
	Access to canal or other irrigation sources	No canal or other irrigation sources

V

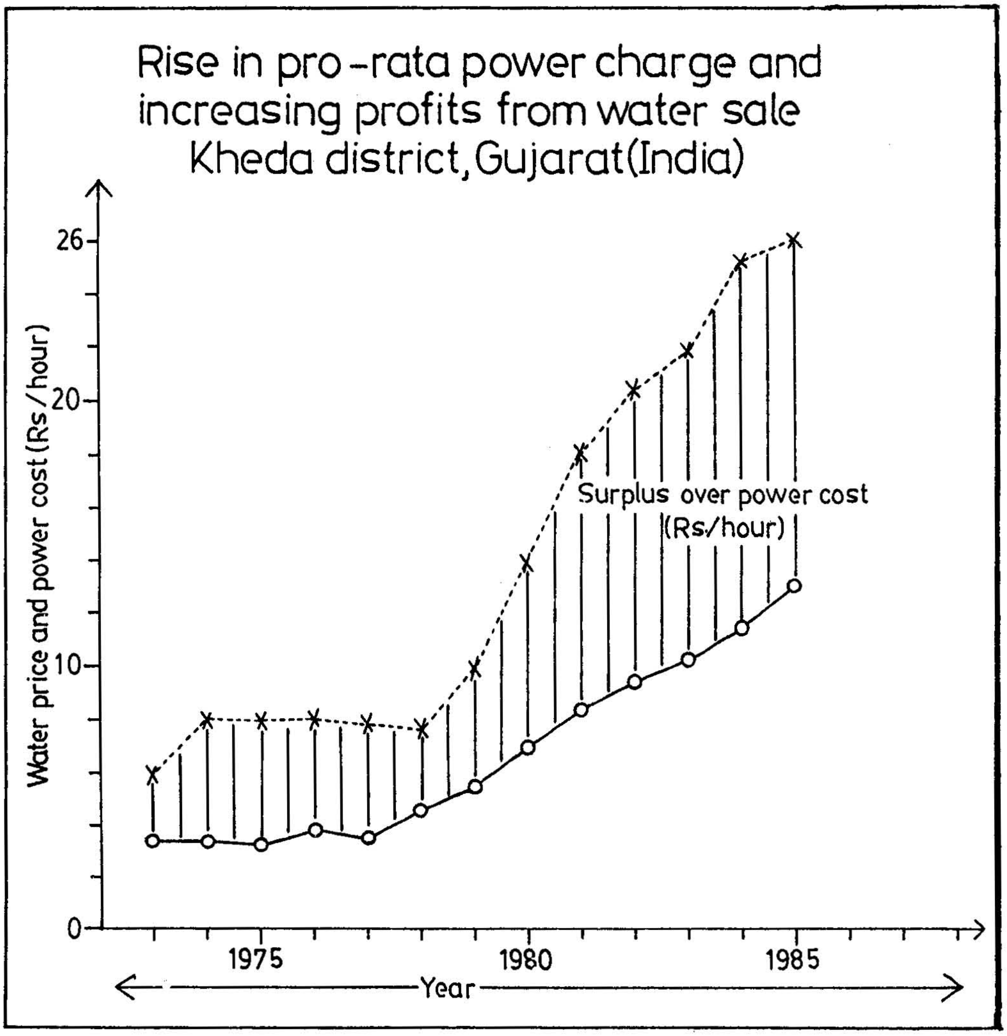
PRICING OF ELECTRICITY AND EFFICIENCY OF WATER MARKETS

The choice of a power pricing method has dramatic impact on water prices charged by the owners of electric water extraction mechanisms (WEMs) in different regions. Basically, there are three methods of charging for electricity used by pumpers: pro-rata tariff (PR) based on meter readings where each farmer pays for the power actually used; flat, horse power linked tariff (FR) where a farmer pays a flat rate regardless of actual power used; and a mix of the two - which we call FR-PR - in which each farmer pays a part of the power bill as a fixed charge and the rest as metered charge.[3]

The imposition of FR affects the behaviour of water sellers in two ways: first, it reduces incremental pumping costs to virtually zero; second, it has the immediate effect of reducing the monopoly power enjoyed by the sellers. Both these effects occur because under FR, sellers experience natural and powerful stimulus to expand the utilisation of their WEM by selling more water since the bulk of the additional revenue so earned constitutes their net profit. This stimulus intensifies competition among oligopolistic sellers and forces a lowering of the water price. As for diesel WEMs, Shah (1989 *c*) also compiled evidence from different states on water prices charged by owners of electric WEM owners; his comparisons amply vindicated the thesis that while in several states such as Uttar Pradesh, Haryana, Andhra Pradesh, Bihar and Tamil Nadu, water prices charged by electric WEM owners (ranging between Rs. 2.50 and 7.50/hour for different motor capacities and Re. 0.35 to Rs. 60/HP hour) were close to average pumping costs and increased moderately as monopoly power increased across locations, in states like Gujarat, extremely high water prices charged by electric WEM owners (ranging between Rs. 15 and 45 per hour for 15-25 HP motors and from Re. 1.05 to 1.45 per HP hour) were explained by PR electricity tariff. In Gujarat, I also found that every time the Electricity Board increased the PR tariff, water prices increased by comparable percentage; and thus the seller's profits increased too as depicted in Figure 1.

To be sure, low water prices in electric WEMs are produced by *flat tariff* and not by *subsidised power tariff* as is generally believed. The level at which FR is pegged has little effect on water prices; thus field research clearly shows that water prices recorded in Uttar Pradesh are comparable to Andhra Pradesh and Tamil Nadu although the FR in the former is five times higher. Many politicians and civil servants in Andhra Pradesh and Tamil Nadu believe that the government is helping poor people through power subsidies. It is perhaps not the case. For, many more poor depend on purchased water than use their own WEMs. The bulk of the power subsidies probably go to the well-off WEM owners. To enable poor people to gain access to groundwater, it is enough to switch to FR; keeping the FR as low as in Andhra Pradesh and Tamil Nadu is neither necessary nor desirable. In point of fact, raising the FR to 3-4 times higher than their current levels, at least in areas with abundant groundwater and reliable power supply, will have salutary effects on water prices and on water buyers; it will also help the electricity boards to mop up some of the profits made by the water sellers and become that much less unviable. The best pricing system seems to be of progressive FR such as that introduced by Gujarat recently; in this, rate per HP rises as the capacity of the WEMs increases. Progressive FR not only encourages small holders to own WEMs but also enables small WEMs to assume leadership role in the market since they have distinct cost advantage; in addition, in water scarce areas, they discourage large

FIGURE 1



capacity motors.[4] In Gujarat, as the Gujarat Electricity Board switched from PR to progressive FR in June 1987, 25 to 60 per cent decline in water prices was observed in different parts of the state and it was estimated that through the price decline alone, a transfer of some Rs. 100 crores would occur every year from WEM owners to water buyers (Shah, 1989 *a*).

VI

SOCIAL COSTS AND BENEFITS OF FR

To most economists, recommending FR is a blasphemy because it violates the marginal cost pricing rule; FR makes WEM owners behave as if the marginal social cost of generating electric power is zero and thus leads them to a somewhat profligate use of power and water; indeed, its salutary effects on water markets are a direct outcome of this changed attitude of WEM owners. Ideally, optimal pricing of power requires that WEM owners as well as buyers expand the use of water or power (whichever is costlier to the society on the margin) to the level where its marginal value productivity equals its marginal social costs. This can be only achieved in limited conditions either through setting PR power price at the marginal cost of power or water (whichever is higher) or through FR with rationing of power (see Shah, 1989 *c*).

Compared to PR, FR has three other advantages: *(a)* under PR, water buyers will end up paying a higher irrigation cost compared to actual cost to the society; and thus, water sellers will be able to earn monopoly premia from water sale; under FR, this will be contained. Concomittantly, the bargaining power of water sellers subject to FR will be lower than those subject to PR; and of those subject to high FR will be lower than those subject to low FR; *(b)* by eliminating the need for metering, FR saves real resources used up in metering power use; these can be substantial and include the cost of maintaining an army of meter readers, of installing and maintaining meters and of the power used up by meters themselves; *(c)* finally, PR produces strong incentive to pilfer power; this incentive strengthens as PR rises; to the extent that pilfered power is wastefully used, FR reduces such social waste by eliminating the incentive to pilfer. For the Electricity Boards, FR may become attractive for its administrative simplicity, elimination of metering costs and hassles, and reduction in the incentive to pilfer power.[5] An REC study of the switch from PR to FR in Uttar Pradesh and Maharashtra showed that in spite of the 40 to 60 per cent increase in power consumption per WEM consequent to the switch to FR, the Boards could break even on agricultural operations by reducing power subsidies marginally (REC, 1985). All in all, thus choosing between FR and PR systems may not be as clear-cut as the Rajadhyaksha Committee thought. This is suggested by the balance sheet in Table IV.

Moderately high FR, high quality power supply (implying uninterrupted, reliable power supplied on schedules announced well in advance and targetted to periods of peak irrigation needs) and judicious rationing of such power supply may offer the most equitable method of containing over-exploitation in many ecologically fragile areas. On the contrary, too high an FR not accompanied by improvements in the quality of power supply will, for sure, have disastrous impacts. If FR is pegged so high as to result in average pumping costs higher than the value of irrigation on margin or water price, then disinvestment in electric WEMs will cause reduction in WEM density, and in the long run, to increased water price. The recent trend in many parts of Uttar Pradesh and Bihar towards massive replacement of electric WEMs by diesel engines in the face of increased FR and extremely unreliable and inadequate power supply is suggestive of this (Sharma, 1988; Pant, 1988).

TABLE IV. MERITS AND DEMERITS: PR VERSUS FR POWER PRICING SYSTEMS

	Particulars	Flat tariff	Pro-rata tariff
A.	Water Market		
1.	Water price	Low	High
2.	Premia charged by diesel LISs	Low	High
3.	Dependability	High	Low
4.	Adequacy	High*	Low
5.	Overall productivity and equity effects	Very positive	Negative
B.	Viability of Electricity Boards		
1.	Power demand	Sharp increase+0	Decrease
2.	Metering cost	Zero	Substantial
3.	Collection cost	Very low	Very high
4.	Incentive to pilfer power	Disappears	Very strong
C.	Efficiency of Power Use		
1.	Incentive for power saving investment	Low or nil	High
2.	Use of over capacity motors	Strongly discouraged0	Encouraged
D.	Efficiency of Water Use		
1.	Danger of over-exploitation	High+0	Low
2.	Incentive to invest in pipelines	Low+	High
3.	Difference in water use efficiency of buyers and sellers	High+	High

* Subject, of course, to the availability of water.
0 Progressive flat tariff will have further positive impact on these.
\+ All the four major undesirable effects of flat rates - such as B1, D1, D2 and D3 can be minimised through judicious restrictions on 'high quality' power supply to irrigation. C1 will however remain a drawback of flat tariff just as C2 will remain as a drawback of pro-rata tariff.

VII

PUBLIC POLICY FOR GROUNDWATER DEVELOPMENT

Appropriate targeting of resources and improving the management of public systems are two key areas for maximising beneficial effects of water markets. In most eastern states it can be argued that water market performance can be substantially improved not by subsidising power but by improving the quality of power supplied to WEMs. Improving the quality of power supply would mean providing more power in summer and *rabi*; targetting it to peak irrigation periods; supplying more power during the day; improving the maintenance of power distribution infrastructure; and announcing and sticking to schedules of power supply.

Similar logic applies to public tubewells. Selling water cheap, as most tubewell programmes in the eastern states are trying to do, seems less important to farmers than selling more dependable and adequate irrigation service. Running state tubewell programmes better would, for example, make water markets more competitive even if subsidies are reduced. The experience with World Bank tubewells in Uttar Pradesh, though meagre, provides some evidence on the power of well-run state tubewell programmes to bring discipline and order in fragmented water markets. In contrast, Gujarat state tubewell programme has itself become a victim of fierce competition from private water sellers; it has therefore initiated an innovative programme to hand over state tubewells to co-operatives of water users located in their commands.

How best to target subsidies in groundwater development so that they generate maximum gain for the poor? At present, public resources are used to subsidise the losses of public tubewell programmes; to subsidise low FR; and to provide direct assistance to the resource poor as subsidy towards the full or partial costs of WEM investments. Direct subsidies to farmers to invest in WEMs can increase the density of WEM population in a village, and thereby make the water market more competitive. This, for example, is what happened in the Gonda district of eastern Uttar Pradesh where, between 1978 and 1980, through two graduate workers posted by the Deen Dayal Research Institute in each block of Gonda district, some 30,000 inexpensive bamboo tubewells and 16,000 pumpsets, mostly diesel, were installed in the region; as a result of the high WEM density achieved, a highly competitive water market emerged. Chambers and Joshi (1983) noted *(a)* sharp increase in the land productivity and total output, *(b)* better access to irrigation for small and marginal farmers and *(c)* rise in real wages especially where all or part of the wages were paid in kind and set as a proportion of yield.

In Gujarat, a different option has emerged to make water markets more competitive by making conveyance of water easier and more cost-effective. Where water is charged for on an hourly basis, seepage losses get translated into higher effective water price for the buyers; the greater the distance between the WEM and the buyers' field, the higher the 'effective' water price that the buyer pays. The buyers thus have strong incentive to deal with the WEM owner closest to them who, as a consequence, enjoys considerable degree of monopoly power over the buyers located in his immediate neighbourhood (Shah, 1989 *a*). For the seller, unlined field channels mean a market limited to his immediate neighbourhood. In undulating topography, unlined field channels imply high degree of fragmentation of the water market since all WEM owners, depending upon gravity flow, can serve only the segments lower than their own fields and are thus insulated from each other.

The water markets operating in Gujarat differ from those in the country in that *(a)* farmers invest in modern WEMs not so much to meet own irrigation needs as for selling water which has become a specialised subsidiary occupation; and *(b)* substantial private investments made in underground pipeline networks generate high degree of competition in an otherwise oligopolistic market. While the main beneficiaries from the pipelines have been the buyers of water, early sellers were motivated mainly by the desire to establish monopoly position in the emerging new business by overcoming topographical constraints in supplying water to a large command. As it turned out, once one seller in a village established a pipeline network, he drove out of business several others who used unlined field channels to convey water to the buyers' fields. In course of time, many sellers were obliged to invest in pipeline systems or to quit as sellers and turn buyers. In Navli village of Kheda district in Gujarat that I surveyed in 1988, 24 private WEMs had put up 65 km of pipeline networks with a total of nearly 600 outlets; almost every parcel of land has 3 to 7 outlets of different WEMs opening into it thus offering buyers greater degrees of freedom for choosing between WEM owners.

The evolution of such 'irrigation grids' is by no means uniform in different parts of Gujarat. It is obvious however that areas which are agriculturally advanced have better developed 'grids'; and that once one or two WEM owners begin using pipeline networks, others seem to follow suit. If this indeed is the case then subsidising such investments, perhaps for a few WEM owners in a new area to start with, may have large multiplier effects especially in water scarce areas. In addition to making the water markets more competitive, investments in underground pipelines would also increase the efficiency in water and power use.

VIII

WATER MARKETS AND CONJUNCTIVE WATER USE

In the command areas of canal and tank irrigation projects securing optimal use of surface and groundwater resources poses a peculiar set of management and policy problems. Since the presence of active water markets strongly affects the extent of pumping activity in an area, in principle, it is possible to identify a set of policies that would effectively integrate water markets into a scheme of conjunctive water use using private tubewells as vertical drains.

In our study of the conjunctive water use possibilities in the command of the Mahi Right Bank system (Shah, 1989 *b*), statistical analysis of time-series data over the 1967-85 period and cross-section data over 71 villages selected to represent different locations within the command suggested a strong tendency for water tables to build up over years in the *core command* - areas near the head and along the main and branch canals; at the same time, I found that in the *peripheral command* - areas away from the core and served by distributaries, minors and sub-minors - groundwater pumping costs can be substantially reduced by raising water tables through more even spread of canal water over the entire command. In core command, farmers have taken to water intensive crops and, over time, dismantled old wells to benefit from cheap canal water, especially as canal irrigation has become more reliable. In contrast, in the periphery, booming water markets have raised the rate of depletion of the aquifer which any way has no source of recharge besides the rainfall since canal water seldom reaches most areas in the periphery.

All existing policies - of licensing private wells, location of state tubewells, canal irrigation, etc., which I considered as default option - accentuate this disequilibrium. Optimal land-water management would require a reversal of this spatial pattern. Groundwater markets can play a major role in establishing 'water resource equilibrium' in such a situation if groundwater irrigation is encouraged in core command in favour of canal irrigation and more canal water is made available to recharge the aquifers as also to reduce the pressure on groundwater irrigation in the peripheral command areas.

TABLE V. DEFAULT TENDENCY AND EQUILIBRIUM POLICIES

Variable	Core command		Peripheral command	
	Default	Policy goal	Default	Policy goal
(1)	(2)	(3)	(4)	(5)
Canal water: Availability Reliability	High	Reduce, make it costilier	Low	Improve
Seepage from canals and field irrigation	High	Reduce	Low	Strengthen
Private incentive for LI	Low	Strengthen	Strong	Monitor, discourage
Density of public tubewells	Very low	Increase	High	Decrease

Source: Shah (1989 *b*).

Table V summarises the effect of the 'default' option in the core and peripheral commands and also suggests the policy goals that emerge. Direct policy implications derived are: *(a)* the need to stimulate drain irrigation by pricing it at zero rather than at half the canal irrigation rates; *(b)* the need to rationalise siting and licensing norms for WEMs so that it becomes easier and more attractive for farmers to put up WEMs in core command; *(c)* the need to stimulate pumping in the core command by appropirate subsidies especially in the form of low FR of power charge and also subsidies towards capital costs of WEMs (such as, for example, provided under the free boring scheme in Uttar Pradesh) and on pipelines; and *(d)* the need to locate state tubewells in core areas and sell efficient irrigation service at subsidised rate with a view to increasing the rate of groundwater use in the core command and saving surface water for the tail ends.

NOTES

1. Inefficient water markets redistribute irrigation surplus from buyers to sellers. If resource poor farmers are given monopoly rights to lift and sell groundwater to the resource rich, as with the landless irrigation groups of Bangladesh, substantial transfers of wealth in the form of monopoly profit from water sale can be secured from the resource rich to poor water sellers through inefficient water markets. However, even in this situation, resource poor families as a class may be worse off than with efficient water markets when the elasticity of labour demand and wage rate with respect to irrigation use is high, as many field studies show. High water prices will constrain irrigation expansion to sub-optimal levels especially in water abundant areas. It is therefore certain that from output as well as distributional viewpoints, ensuring efficient water market should be an important goal of public policy for irrigation development (Shah, 1988).

2. A standard result from the theory of imperfect competition applied to our fragmented water markets would explain the relationship between water price charged by the sellers per hour of pumping (w), incremental pumping costs per hour (c) and the monopoly power enjoyed by water sellers (reflected in e, the elasticity of water demand function facing each) as:

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

When e is small, as in an oligopoly, e/(e-1) will take a large value, and the price charged will be a large multiple of the incremental pumping cost; the markets will be highly inefficient and also inequitable when most buyers are resource poor. Only in competitive water markets with large number of water sellers competing with each other, will the value of e increase and of e/(e-1) decline to make water markets efficient.

3. The FR-PR system was widely used by northern states and in states like Gujarat, until the early seventies. For administrative simplicity, many states in the north, notably, Uttar Pradesh, Punjab, Haryana, etc., switched to FR system since the mid-seventies. Some southern states followed suit in the early eighties, Andhra Pradesh in 1982, Tamil Nadu in 1983, and so on. By 1986, all but a few states - Gujarat, Assam, West Bengal and one or two others - had switched to FR. Gujarat and West Bengal had also abandoned FR-PR but in favour of PR.

4. For large tubewell groups of the resource poor, such as those established by the Sadguru Sewa Sangh in Dahod and the Aga Khan Rural Support Programme in Bharuch, using large motors to irrigate their land, the new progressive FR proved highly inequitable since it treated them at par with large farmers. In a recent modification, a separate policy has been announced by Government of Gujarat for such irrigation co-operatives; under this, the total installed HP of the tubewell would be divided by the number of members and the rate levied would be that applicable to twice the installed HP per member. In short, all such co-operatives would be subject to the minimum charge per HP. Interestingly, there is a major move now for the water companies of Kheda and Mehsana to register as co-operatives to take advantage of this concessional policy.

5. Tentative estimates by the Gujarat Electricity Board also suggest a major decrease in transmission losses in rural feeders since the introduction of FR. The transmission losses which used to be of the order of 30 per cent in recent years are now estimated at around 21-22 per cent. The basis of this estimate is, however, not clear.

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