EXTERNALITY AND EQUITY IMPLICATIONS OF PRIVATE EXPLOITATION OF GROUND WATER RESOURCES

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ABSTRACT

Private exploitation of ground water resources has several externality and equity effects. Four of these which have become particularly important in India are: a) inequities caused by unequal access b) diseconomies caused by clustering of modern Water Extraction Mechanisms (WEMs) and permanent decline in water table due to excessive pumpage c) ingress of saline water into coastal aquifers due to lowering of ground water table and d) the potential that private WEMs offer to mitigate diseconomies in the form of water logging and build up of soil salinity in command areas of canals.

Existing instruments of policy and the manner of their implementation are unlikely to be effective in managing these diverse effects. Public control of ground water resource may, in theory, provide an alternative; however, existing evidence abour management capacities available in the third world irrigation systems raises serious doubts about its viability. A third alternative aiming at managing these effects by influencing private returns to irrigation has been explored and developed.

1 INTRODUCTION

Private exploitation of ground water involves powerful and extensive externality effects. Some of these directly hit the poor; some affect all owners of land in certain regions by reducing the productivity of land. Further, if equitable development of a valuable common property resource is an important goal of public policy, it becomes relevant to ask "who gains from this last frontier?" (IDS, 1980). This paper attempts an analysis of four situations in which such externality and equity effects of ground water exploitation have become important in the Indian context. We shall also attempt to indentify areas where significant welfare gains can be achieved either by modifying the institutional arrangement or by a judicious mix of suitable tax-subsidy-type public interventions. Towards the end, we examine major implications of our analysis for the formulation of a more comprehensive policy for the equitable development of ground water resources.

2 SITUATION 1: SURPLUSES ACCRUING TO OWNERS OF MODERN WEMs THROUGH A SUPERIOR ACCESS TO THE GROUND WATER RESOURCE

When the amount of ground water actually tapped and used by a community is very small proportion of the potential available to ir, the real value of water itself is close to zero at the margin and a higher than average rate of use by some members of the community is not perceived as an infringement of others' rights. Such situation is representative of the conditions that prevailed in most parts of India until the beginning of widespread adoption of modern Water Extraction (WE) technologies (using either diesel or electric power to lift large quantities of water) in the 1960's. Under traditional technology, the value of water was close to zero at the margin because the rolo of irrigation in traditional farming was more "risk reducing" rather than "output augmenting"; traditional crop varieties did not respond strongly to irriation, and because traditionl lifts such as charas, mhot, rant or Persian Wheel, using animal and human energy could produce very small quantities of water per unit of time.

The simultaneous emergence of the Green Revolution technology in farming and the tubewell tecnology in water extraction during the 1960's produced several changes in the situation described above:

a) since water had a very high marginal productivity when used in conjunction with HYVs (high yield varieties) and chemical fertilisers, the use of irrigation in augmenting labour and land productivity became widespread

b) the use of diesel and electric motive power increased the water extraction capacity of individual pumper manifold

c) the new water extraction technology reduced the human and animal labour cost bur increased the cash cost (of diesel and power) of water extraction, and

d) it increased the gulf between the resource poor and resource rich farmers since the latter could make the large and chunky investments in modern WEMs (Water Extraction Means) far more easily than the former.

As the rate of use of water approaches the potential, the marginal value of water as perceived by the members tends to rise to approximate its marginal value product ner of extraction cost. Therefore, unequal rate of use of water by owners of modern WEMs coupled by the lack of properly specified property rights on ground water enables them to earn a surplus for which they are not obliged to compensate the community. It may be noted that this external economy would not arise without the coexistence of both the HYV and the modern extraction technology as explained in figure 1, below. We assume, for the time being, that all of the members of the community have equal land holding and each enjoys an equal share W/n in the community's total ground water potential W. The area abc, enclosed by the incremental gain (IG) and water extraction cost (IC) curves under traditional technology represents modest gains from ground water irrigation in early 1950's.

HYV crop production technology (represented by IG') with traditional lifts (IC) leads to a small increase in gain to ced; likewise, access to modern water extraction technology (IC') used in conjunction with the traditional farming technology raises the gain from irrigation marginally to afg. Simultaneous introduction of HYV and modern water extraction technologies has, however, increased the gain from ground water irrigation substantially from abc to ghd but, in the process, induced each WEM owners to expand water use to w', which is greater than W/n, his share of W. If, attracted by these profits, all members begin to pump w' amount of water, each may, over time, experience steeply rising cost IC" as total withdrawals exceed W and water table begin to get lowered.

If effective checks are enforced to restrict total wirhdrawals to W, then each member will be obliged to use only W/n amount of water and forgo hij amount of profit. Alternatively, if some members are not able to use their share of the resource, they can extract a payment of upto hij from each modern WEM owner by theatening to claim their share. This could, however, happen only if equal rights of all members on the community's ground water resource are effectively enforced. Since, in reality, this does not happen, owners of modern WEMs are able to usurp others' share without having to compensate the community. This

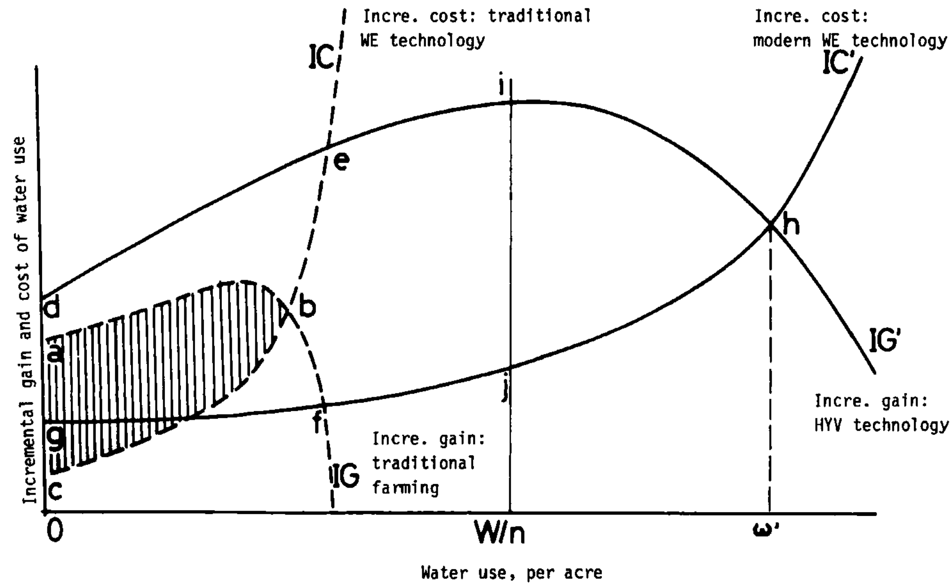

Figure 1.- External economy realised by private owners of modern WEMs.

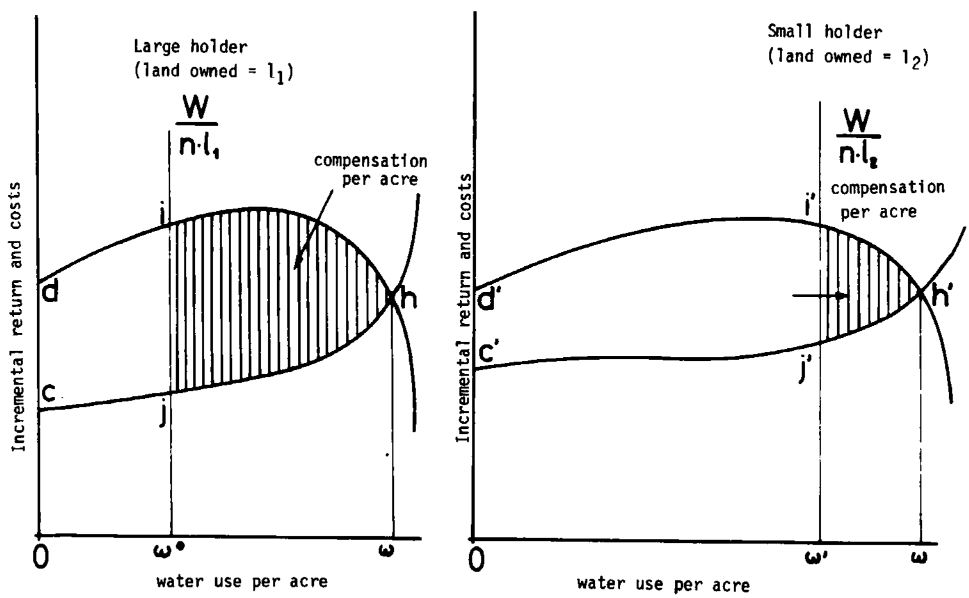

Figure 2.- Compensation payable by large and small owners under equal rights on ground water resource.

inequality in the appropriation of irrigation surplus is further reinforced by the fact that: a) land holdings are not equal as we initially assumed and available evidence indicates strong positive correlation between land holding size and ownership of modern WEMs (Shah 1985a) access to modern WE technology opens up new, more attractive enterprise mix possibilities to ehich the access of the resource poor is resticted and c) WEM owners can extract monopoly premia by selling water to other members at prices higher than marginal pumping costs since the demand for water in fragmented, village level water markets is less then perfectly elastic (Shah 1985, 1987a).

That such economies arising out of unequal access to a common property resource are important to gainers as well as losers is evident in spontaneous efforts to evolve a variety of contractual relationships. The owners of grape orchards in Karnataka and Andhra Pradesh, for instance, are known to buy up neighbouring plots at premium prices so that the neighbours will not pump their wells (Haldipur, pers. comm, 1985). In many parts of Gujarat, where water markets have assumed highly sophisticated form, it is common for a well owner to lay under ground pipelines through neighbours' fields at his own cost and dissuade them from establishing their own WEMs by informal long term contracts for the supply of water at mutually agreed prices (Shah 1987d).

As figure 2 shows, if available potential is distributed equally rather than in proportion to land holding size, then larger farmers will have less water per acre and will therefore have to compensate the comunity by a greater proportion of their gains than small holders do; equal shares could thus produce distributive effects similar to a powerful land reform (Shah 1987b). This premise has formed the vasis of several local level developmental efforts in India in recent times. Gram Gaurav Pratishthan, an NGO in Maharashtra, for example, allocates water on a per capita basis (1/2 acre per person) amongst the members of its cooperative lift irrigation schemes (GGP 1984). Likewise, the Sukhomajari project in Haryana distributes water equally among member families including those who have no land of their own (Seckler and Joshi 1983). In Gujarat, Aga-Khan Rural Support Programme too enlists the landless as members in cooperative lift irrigation groups and provides them equal water share with which, hopefully, they will be able to lease in land at better terms from large farmers whose water share falls short of their total holding.

3 SITUATION 2: COSTS IMPOSED BY WELL INTERFERENCE AND THE MINING OF GROUND WATER

The relationship between water output of a well and its area of influence is governed by established hydraulic principles. The yield of a well is determined by the ease and speed with which water can move through the aquifer, the drawdown available in the well as a result of pumpage, etc. In the traditional water extraction technology regime, water output per well was low because of stringent constraints on the quantity of water that could be lifted per unit of time with human and animal power; as a result, well interfernce was nomexistent and only a fraction of the potential was used. Modern WEMs can extract substantially more water per unit of time; further, because of their very high fixed costs, their owners have a compulsion to operate at hifh levels of capacity utilisation (Patel and Patel 1971). As a result, modern WEMs often tend to interfere with other modern or traditional WEMs in their neighbour hood, reduce their water yields and increase their extraction costs; such interference tends to increase as the population of modern WEMs in an area increases. Further, for the same discharge rate and extent of pumping, a tubewell which affords a deep drawdown will have a greater area of influence than an open well which acts as a storage reservoir especially when pumping is not constant. The drawdown caused by the same rate of pumping will be less in an open well which continues to get recharged slowly during the nights when pumping is discontinued. Similarly, wells located in the centres of land holdings tend to have less overlapping of areas of influence than wells are affected by interference will depend upon the depth and the number of aquifers they themselves tap. A shallow open well will be hit hard; but if several tuvewells interfere with each other, each will impose a counterveiling diseconomy on others. Well interference is normally a temporary problem and assumes serious form mainly because most members of the community tend to lift water during the same period. The impact may, however, be serious on owners of traditional wells when monsoon fails.

The clustering of modern WEMs in a small area and rapid increase in the cultivation of water intensive crops such as sugarcane, banana, etc often lead to a rate of water use higher than the rate of aquifer recharge; in such cases, the water table declines permanently and many shallow wells either suffer major decline in water yield or become permanently dry. Dhawan (1982) has examined several cases where mining of ground water led to permanent decline in water table. In parts of Mehsana district in Gujarat, over exploitation of the aquifer pushes the water table down by 5-7 m every year. Dhawan argues that the disapperence of traditional wells in the Punjab can be partly explained by the lowering of ground water tables far beyond the technically feasible limit for traditional water lifts. In the hard rock areas of the southern India where most wells exploit limited aquifers which are hydraulically unlinked with each other, digging a well faces a high risk of failure and, therefore, it is customary for neighbouring farmers to dig wells very close to a successful well (as in many parts of Telangana region, Andhra Pradesh). This usually proves a very expensive method of sharing the limited potential offered by a small aquifer. Well interference as well as permanent lowering of the water table have evoked serious concern among researchers and policy makers. Official response has usually taken three forms: a) norms of spacing to be maintained between existing and new wells b) categorisation of areas into white (under exploited), grey (close to fully exploited) and dark (over exploited) by the state ground water departments and c) a licensing system of sorts operated with the help of public sector banks and state electricity boards. In Gujarat, for example, a proposed new tubewell will not be allowed within the command area of a state tubewell or if it falls within a radius of 680 meters of an existing tubewells over 50 m deep. The applicant is required to secure consent of neighbouring WEM owners before an electricity connection or bank finance is provided.

The actual effect of such norms and the manner of their enforcement are often quite unequitable and regressive:

a) Since the spacing norms do not apply to a modern WEM being located close to a traditional WEM, they merely seek to protect resource rich early exploiters from late exploiters; but do not offer any protection to existing owners of traditional WEMs who are usually the poor.

b) Because of their large investment requirements and because of their obvious appeal to farmers with large holdings, most early adopters of modern tubewell technology were large and medium farmers. Spacing regulations which came in more recently thus serve to exclude the poor who are coming late into the game. In other words, spacing regulations tend to single out the poor to bear the cost of maintaining the ecological balance.

In the 14 villages of Karimnagar district served by a highly successful multipurpose coop, the resource poor late comers vehemently fought against the spacing norms until the coop gave in and provided large number of loans to small other taluks too. But in the 14 Mulkanoor villages, the poorshared the prosperity and are now sharing the costs; but in the neighbouring taluks, the poor only shared the costs (Shah 1986)

c) Since the norms are enforced through banks and electricity boards, the well off farmers who can finance their own investment and afford the somewhat costlier diesel engines remain completely untouched by them. Unofficial premia on electricity connections are common and often quite high. In Pandalparru village, in a grey taluk of West Godavari district, such premia could be up to Rs 10000 per connection; but in parts of Gujarat, they were lower at Rs 2000.

d) Most importantly, spacing and licensing norms create and strengthen monopoly power of existing owners of modern WEMs who often can and do use this power to extract exorbitant prices for water sold to others (Shah 1985a; Guhan and Mencher 1984). In many parts of Gujarat, for instance, highly oligopolistic water markets have placed such water lords in commanding position of the village economy. Prices usually charged by them exceed incremental costs by a multiple of 3 to 4.

4 SITUATION 3: DISECONOMIES IMPOSED BY SALINE INGRESS IN COASTAL AREAS

Coastal areas have a very fragile ground water balance. In coastal aquifers, fresh water with its lower specific gravity float on a layer of saline water. Lowering of water table beyond a certain depth caused by excesive pumping causes a difference in head which leads to the intrusion of sea water into the aquifer thereby rendering large areas of land unirrigable with ground water and often unfit for cultivation.

This form of diseconomy has assumed serious form in coastal areas of Tamilnadu (Minjur aquifer) and Gujarat. Until 1970, the coastal areas of Saurashtra (Gujarat) were agriculturally prosperous, ful of mango orchards and known as "Lili Nagher" (Green Creeper). In the mid 1960's, in its enthusiasm to promote Green Revolution in the region, the government granted liberal loans for installation of tubewells until a substantial proportion of farms had their own tubewells. The withdrawal of ground water increased fivefold; where a traditional "rant" used to draw 2 to 4 m^3/h, a tubewell began to lift 20 to 40 m^3/h. Food crops were replaced on a large scale by sugarcane encouraging rapid growth of sugar facroties in the area. As a result, water tables along the coastal belt fell by 3 to 10 m over a 7 to 8 year period; in 1970, most farmers in the area suffered reduced crop yields, and found well water brackish; some farmers continued to irrigate with the saline water thereby ruining their top soils. Succesive draughts during 1972)74 led to further decline in the water table and more saline ingress. In some parts of the area, well water contained 10000 ppm salt content, much beyond the safe limit for drinking purposes (600 ppm) and for irrigation purposes (2000 ppm). Over 12000 wells became saline in the small strip between Madhavpur and Una. By 1977, the yield of mango fell from 40 mt to 2 mt per ha; of coconut, from 22000 units per ha to 8160 units per ha; of banana to less than a third and of bajra and sugarcane to half of their 1970 level. The market value of this prime agricultural land plummeted from Rs 60000 to Rs 15-18000 per ha (US$ 5000 to 1100-1500/ha). In several villages, half or more families, including those of some large land owners, migrated in search of work and gave away their animals to relatives or sold them. In balance, unfettered exploitation of ground water in the coastal strip stretching from Bhavnagar to Lakhpat imposed largely un)repairable damage on 1.2m ha of land affecting some 1.3 families in over 800 villages (Shukla 1985; Menon 1986).

A recent study of the process of salinity ingress in the Minjur aquifer near Madras has come up as a repeatition of the same story (Hindu 1985). A 350 km strip of coastal farm land has been rendered largely unproductive due to saline intrusion caused by large scale pumping of ground water over the last 15 year period. Most farmers of this once prime paddy land have had tos witch to rain fed crops; many have sold off their lands at discount. As in Saurashtra, land prices here too have crashed. Drinking water has emerged as a major problem and even tender coconut water has turned saline.

5 SITUATION 4: CONJUNCTIVE USE OF GROUND AND SURFACE WATER RESOURCES

In the command areas of many of India's canal irrigation projects, rising water tables and the build up of salts in the top soils have emerged as major social problems. Excessive canal water use and rapid rise in the cultivation of water loving crops by canal irrigators encouraged by low per hectare (rather than volumetric) water charges; seepage from unlined distributaries and field channels; and inadequate provision for drainage facilities are identified as key contributary factors. Investments in drainage and canal lining supported by organisational reforms involving greater participation by users in maintenance and management of the systems have been widely discussed as a feasible solution. In this context, the potential value of tubewells as irrigation cum drainage and pure lateral drainage mechanisms in canal commands has also been recognised by researchers and technologists (O'Mara 1984; Carruthers and Stoner 1981). As a matter of fact, a series of tubewells along the banks of the Satlej Jamuna canal in Haryana has been used effectively to contain potential tise in the water table and to pump ground water in to the canal to augment supplies to the tail enders (Michael, 1983). Likewise, the Khairpur Irrigation Project i n Pakistan also uses public tubewells as pure drainage and drainage cum irrigation systems (O'Mara, 1984). Such a strategy of conjuntive water use depending on public tubewells, however, has inherent limitations. Public tubewell extraction capacities in a given region would tend to be insignificant when compared to those available with private pumpers. Then, there are problems of maintenence and proper management of public tubewells which severely impair their performance. The Khairpur project worked well for the first ten years but later suffered from lack of maintenance. For large scale and long term impact on conjunctive use therefore it is important to find ways to induce private pumpers to operate their pumping plants as irrigation cum drainage systems. The main difficulty here is that their private returns from pumping in high water table areas are lower than the long term returns to the community as a whole; a structure of incentives has to be devised that would match private incentive with the needs of the community. Figure 3 is divided in to two parts: the upper half, which concentrates on the economic aspects, describes the relationship between ground and canal water use and the incremental private and social costs and returns attendant to such use. To the extent that private costs imply allocation of real resources, they are costs to the society as well; but social costs exceed private costs when private action imposes diseconomies on others or on future generations. They are less than private costs if private action saves real resources needed to mitigate undesirable outcomes. In the lower half we examine the relationship between ground and canal water use and the movements in the depth to the water table. To simplify the analysis, wede fine d1 d2 as the safe range within which the society desires to contain the movement of the ground water table; a fall in the water table below d2 implies dangers of aquifer minig; a rise in it above d1 indicates dangers of water logging and soil salinity; under traditional WE technology, water table keeps moving within a narrow range about d0. To start with, we concentrate on the figure which shows that the opening up of modern WA technology creates posibilities of highly profitable irrigated agriculture as reflected in the large area r c1 e1 enclosed by the privatere turn (g) and private cost (c) curves. Private users will expand ground water withdrawals to gw1 which, however, will force water table down below d2 to d4 and impose social costs along the incremental social cost (c') curve. A marginal tax on water users which discounts adverse future outcomes at a finite interest rate will rduce water use to gw2 and force up the water table to d3 which is still below d2 and will result in progressive depletion of the aquifer over a long time period. The diseconomy can be completely eliminated only by containing the ground water use to gw5 either by quantity restrictions or by a unit tax that increases the marginal cost to c or by a prohibitive penalty on withdrawals beyomd gw3. Alternatively, the society would be willing to spend anything up to c1 e1 e2 e3c on aquifer recharge mechanisms to keep the water table at the safe level of d2.

Now we consider similar relationships for canal irrigation in the left half of figure 3: we assume, for the time being, complete absence of modern WE technology and that the canal system, which has no provision for drainage and minimum of puccalining, provides through a network of distributaries and channels newly found surface water for irrigation. To illustrate the logic, we assume that conveying canal water through unlined canal network itself raises the water table to d5, above the safe limit of d1. Hectare based pricing of canal water renders the incremental cost of water use zero and profit maximising water users expand canal water use to cw1 at which level ground water table rises to d7, very close to the surface and imposes a sicaial cost on the community which, in the long run, may even exceed the total private gain from canal irrigation; in such a case, the society may even be better off without a canal system. Alternatively, volumetric pricing of canal water at P will contain water use at cw2, restrict the rise in the water table to d6. We note that even completely abolishing canal irrigation will not eliminate the social cost of water logging under our assumptions.

We now consider the question of conjunctive use by analysing the entire construction of figure 3. We note that if the canal system is used only as an aquifer recharge mechanism and not for irrigation with modern WE technology become zero until groundwater use expands to between gw4 to gw5 but the social cost imposed by the canal system in terms of water logging too becomes zero. It

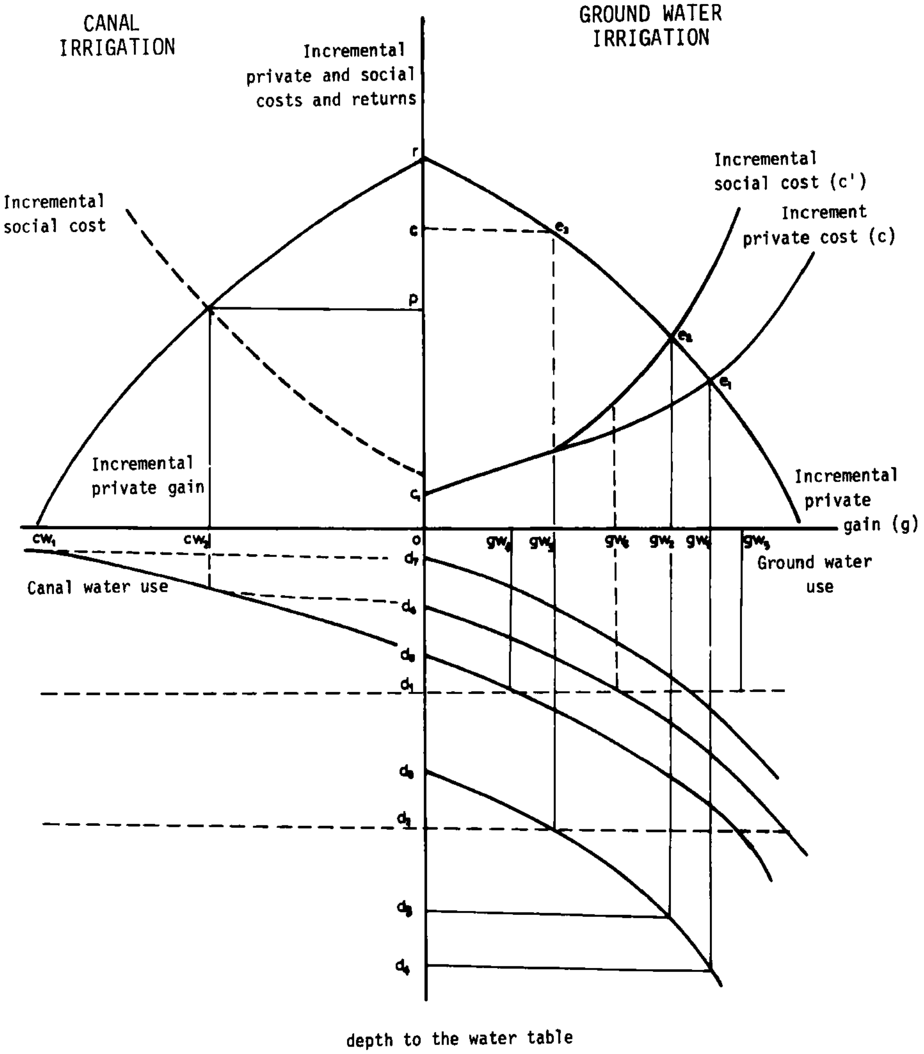

Figure 3.- The logic of conjunctive use of ground and surface water.

is also evident that as canal water use increases, there would be a countervei-ling *need to increase ground water withdrawals. In sum, then an optimal* conjunctive water use strategy in canal commands implies encouraging ground water irrigation in precisely those areas (near the head and along unlined branches and distributaries) where incentives for it are likely to be minimum; where cheap canal water is available aplenty. It would also imply using the canl network more as an aquifer recharge mechanism in such areas and as a long distance water transport system so that tail enders get more canal water and are discouraged from excessive exploitation of the aquifers away from the canal head where the rate of recharge is lower.

Empirical evidence, though limited, indicates that the actual build up of private water extraction capacity in canal commands follows a pattern opposite to what is required to ensure a stable equilibrium in the water table movements. An econometric investigation of 20 years' data of monsoonal and inter monsoon changes in water table over some 100 locations in the command area of the Mahi Right Bank Canal system in Gujarat carried out by the present author (Shah 1987c) indicated that while rainfall precipitation and canal water releases for kharif crops were the main determinants of the monsoonal rise in water tables in different areas, differential rates of build up of water extraction capacity caused varying rates at which water tables fell in different locations during winter and summer months. Thus while the capacity of private pumping to lower water tables in water logged areas is clearly demonstrated, in actuality, it does not help to stabilise water tables because the build of private WE capacity tends to be low in areas with very high and very low water tables. In figure 4, we have plotted the curve of the quadratic equation estimated using data on private WEMs and the depth to the water table over the 1968-84 period for seven talukas covered by the project.

A more detailed form of the MRBC command showed that the totals in the water table in a given village over the 1967-84 period (R) was explained by the proportion of its farm land receiving canal irrigation (CI), the total installed WE capacity measured as the ratio of horse power and cultivable area (H) and the

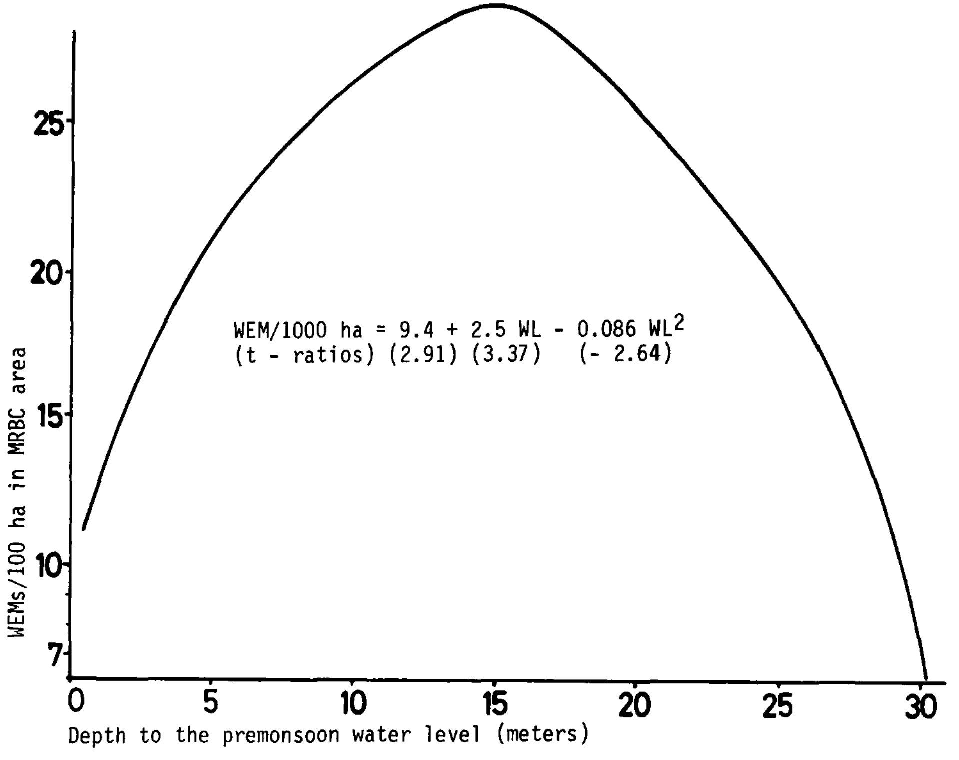

Figure 4.- The relationship between private WE capacity and the depth to the water table.

1967 depth to the water table (WL 67) through the relationship:

$$R = 0.915 + 0.0211\ CI - 0.843H = 0.582WL\ 67$$

(0.58) (1.83) (2.16) (6.84) H does thus act as an antidote to the effect of raising water table.

However, for a stable ground water equilibrium, H must be related inversely to CI; in fact, it was found to be positively related. CI was found to decrease, and H was found to increase as the distance of the village from the head along distributaries and minors (but not along the main and branch canals) increased. Optimal conjunctive water use requires a reversal of this pattern (Shah 1987c).

6 INADEQUACY OF THE EXISTING PUBLIC POLICY REGIME

A variety of instruments used by public policy makers in various states for regulation and control in this field have failed to produce viable solutions in any of these four situations. Each instrument has been used in a piecemeal and adhoc manner; while some have produced limited results, other shave either failed or run counter to what should be important public policy goals (table 1). Licensing and spacing norms, as we saw, have been difficult to enforce when they defy immediate private interests. Likewise, in water logged areas of canal commands, the command area administrations have found it impossible to contain over irrigation and wasteful use of canal water in the face of acre based water pricing policy. In the coastal areas of Saurashtra, even as the irrigation department has begun to spend large amounts on check dams and tidal regulators to prevent salinity ingress, private farmers continue to pump their wells while at the same time using subsidised gypsum which is beginning to have progressively declining leaching effect.

A comprehensive land water policy framework which may effectively respond to these complex problems would recognise all such questions of balncing the various externality and equity effects discussed earlier as special cases of the larger task of achieveng optimaluty in spatial, interpersonal and intertemporal use of water resource. Among other things, such framework would aim at: a) exploiting to safe limits all water resources available in a given region and ensuring, to the estent possible, equitable access to it for all b) minimise inter farmer and intergenerational diseconomies in exploiting and using water c) devise workable ways of minimising ground water withdrawals in coastal areas and d) promote conjunctive water use where both canal and ground water are available aplenty.

Past experience in dealing with this task in many countries indecates that legal, quasi legal and organisational instruments of public policy will not, on their own, succeed in securing the compliance of farmers unless they are also accompanied by measures aimed at affecting private returns to irrigation indifferent regions or unless the structure of property rights on water resource itself is drastically reformed.

7 PUBLIC CONTROL OF WATER RESOURCE: AN UTOPIAN ALTERNATIVE

In theory, effective public control over all water resources could neutrallise all the effects discussed earlier. In such as cenario, all private WEMs, traditional and modern, would be delicensed; a public authority, assuming the role of a monopoly extractor of ground water would locate a small number of modern WEMs in each farming community and provide water to all users at a price equal to the long run marginal cost of extraction. Where there exists danger of over exploitation, the authority would charge an additional premium to contain the rate of water use to the rate of recharge and use a proportion of surpluses so generated to explore feasible ways of improving the rate of recharge. From the viewpoint of equity, an ideal state could be established if the profits earned by the monopoly are distributed equally among all the members of the community including the landless. The questions of optimal use and equity will thus get resolved simultaneously (Shah 1987d). Since all the externalitites associated with private exploitation arise primarily because losers find it impossible to extract suitable compensation from the emitters of the externalities under the existing structure of property rights, public control over water resources by a well informed and just authority will result in their effective

Table 1
The effectiveness of existing policy instruments in neurallising the externalities: Gujarat

Policy instruments	Situation:1 Equity in the access to ground water	2 Well interference and over exploitation	3 saline ingress diseconomies	4 conjunctive water use externalities
1 Well licensing policy	strong	?	weak	-
2 Spacing regulations	—	?	weak	-
3 Public tubewell water supplied at cost or subsidised rates	+ strong	+	_	+
4 Cheap finance to the resource poor for WEMS	+	+	strong	+
5 Power pricing system				
a) pro rata	_	?	+	_
b) flat rate per hp	+	+	_	+ strong
6 Canal water supplies at low cost	+	+	+strong	_ strong

Notes: + indicates that the given policy can further public policy goals under the corresponding situation; _ indicates that the given policy does or can act against public policy goals; ? indicates the lack of evidence to make a judgement either way

Table 2
The pricing of electric power and the nature of ground water markets

Typologies of areas for which evidence is available	Price of water (electricWEM)	Price of water (dieselWEM)	The size of the water market	Dominence of of lease vs cash transactions
A.AREAS WITH SUBSTANTIAL AQUIFERS				
a) subsidised flat rates (Rs 5 per hp) WEST GODAVARI;ANDHRA PRADESH)	very low (Rs 4 to 5|hour)	low (Rs 5 to7 per hour	very large	mostly cash
b) high flat rates (Rs 18 to 21 per hp) U.P;HARYANA; BIHAR	low (Rs 4 to 6 per hour)	quite low (Rs 6 to 8 per hour)	very large	cash
c) high pro rata power charge (Rs 0.60 per kWH) KHEDA;BARODA;BULSAR DISTRICTS IN GUJARAT	high (Rs 18 to 23 per hour)	very high (Rs 15 to 20 per hour)	large	cash
B AREAS WITH LIMITED AQUIFERS				
a) subsidised flat rates (Rs 5 per hp) KARIMNAGAR DIST;A·P MADURAI DIST IN TAMILNADU	low (Rs 4 to 5 per hour)	high (Rs 18 to 20 per hour)	limited	lease and cash
b) high flat rates (Rs 16 per hp) MAHARASHTRA	low (Rs 5 to 6 per hour	moderately high (Rs 12 to 14 per hour	limited	lease and cash
c) high pro rata power charge (Rs 0.60 per kWH) MEHSANA,SABARKANTHA DISTRICTS IN GUJARAT	very high (Rs 30 to 35 per hour)	very high (Rs 22 to 25 per hour)	small	cash

elimination. When private WEMs do not exist, well interference will not be a problem any longer. Likewise, in areas of water use to safe levels through pricing policy and, if necessary, through quantity restrictions. In canal commands, similarly it would ban all together or restrict canal water use near the head and along the canals where water tables are likely to rise due to seepage. By maintaining parity between canal and well water, it could, in theory, eliminate the existing preference for cheap canal water over ground water. Thus, in addition to neutrallising all the harmful effects discussed earlier and harnessing the beneficial effects, effective public control of all water resources could substantially reduce society's investments in WEMs and drainage systems.

In spite of all these highly desirable features, few researchers pay serious attention to the alternative of public ownership and control of water resources. For one, there is no guarantee that the local level bureaucracy under public control will either be effective or demonstrate the sensitivity needed to appreciate the complex questions of equity involved. Worldwide experience with public systems managing major and even small irrigation systems has been so uniformly disappointing that most reasonable viewpoints now increasingly favour decentrallisation of management and control of water resources to farmers and farmer groups. The review of a relatively rare example of such an effort in Pakistan showed that the entire public programme suffered from a variety of technical and administrative problems; but above all, the review concluded that "the programme pre-supposed the existence of a management structure and skills that did not exist in the irrigation bureaucracy at that time" (O'Mara 1984). Likewise, while small farmer groups are known to have achieved considerable success in neutrallising locallised externalities and inequities by reducing transaction and bargaining costs, it can not be safely supposed that such groups will be any more considerate than individual water users to other groups with whom they can not directly relate but who might be affected by their actions.

8 RATIONALISING THE STRUCTURE OF PRIVATE RETURNS FROM IRRIGATION: A SECOND BEST ALTERNATIVE

Thus even with decentrallisation, an imaginative and effective regulatory and coordinating mechanism is needed to influence the actions of millions of decidion makers involved. Some observers have considered an elaborate legal framewor, detailing the structure of water rights as a possible alternative to work detailing the structure of water rights as a possible alternative to public control of water resource. In a country the size of India, with millions of pumpers scattered throughout the hinterland, to what extent would it be feasible to enforce a set of laws which challange powerful private interests is not certain. More importantly, in our view, the existence of a well designed legal framework can make maximum impact only if the structure of private returns to irrigation in different regions is so regulated as to be consistent with public policy goals (Shah and Raju 1986).

An alternative strategy aiming at rationalising the structure of private returns in irrigation could be based on the following premises: a) the rate of increase in the population of private WEMs in a region can be regulated by a licensing policy supported by an annual license fee b) the rate of pumping by a cluster of WEMs in a region can be regulated by influencing the incremental cost of pumping mainly through the pricing of electric power c) a structure of incentives can be created to influence farmer preference towards ground versus canal water d) it might even be feasible to create a structure of incentives to induce private pumpers to use their spare pumping capacity as pure drainage device to pump ground water in to the canals.

In areas where aquifers are substantial and water tables high, recent evidence indicates rapid increases in private investments in modern WEMs (Dhawan 1982). In such areas, as the Gangetic plains of northern India, experience has established policy regimes which induce private pumpers to use their spare capacity to sell water to others. Where conditions are opportune, highly competitive water markets have emerged in which large quantity of water is sold at prices close to incremental pumping costs (mainly of power or diesel). Such

Table 3

A summary statement of policy instruments relevant for different areas and their likely effects

Area characteristics	licensing policy	annual license fee	power taiff policy	power supply policy	expected effects and implications
1 abundant ground water reserves which are largely unexploited in high water table areas such as Eastern U.P, Bihar West Bengal, parts of Madhya Pradesh, coastal Andhra Pradesh,etc	liberal	very low	flat rates high enough to cover power supply costs	unrestricted power supply	Competitive water markets emerge;low private water prices ensure equitable access for all increased irrigated area and higher cropping intensity lead increased labour demand
2.areas in canal commands, especially near the head where water tables are rising rapidly	very liberal	zero or negative	heavily subsidised flat tariffs to encourage private pumping on large scale	pririty allocation of power especially during Kharif	In order to stimulate ground water use, canal water supplies in such areas should be restric- ed; such a policy would arrest the rise in water table and augment canal water supplies to tail enders
3. areas with limited ground water potential such as the hard rock areas of the southern peninsula	stringent	moderately high and progressive	high and progressive flat rates	judiciously restricted power supply	Flat power tariffs will tend to keep water prices low and access to buyers equitable though limited. Restricted but predictable power supply may effectively check total withdrawals
4. areas where over exploitation has already assumed accute form (eg. Mehsana dist. in Gujarat or Coimbtore dist.in Tamilnadu) and coastal areas in danger of saline ingress.	very stringent	prohibitive and steeply progressive	high flat rates which are steeply progressive	restricted to permit only safe withdrawal of groundwater	Monitoring and licensing of diesel WEMs is absolutely essential to check overall rate of withdrawal. Augmenting surface water resources for irrigation and aquifer recharge essential as a long term solution.

competitive water markets reduce greatly the inequity of private pumpers' oligopolistic access to ground water resource because they have a powerful economic incentive to share this access with the resource poor (Shah 1985a, 1987b; Shah and Raju 1986). Recent evidence indicates that the behaviour of private water sellers is determined in the main by: a) the method used by the state electricity boards for pricing electric power for lift irrigation b) the role played by public tubewells as a check on the oligopolistic behaviour of private pumpers and c) artificial barriers on the establishment of new WEMs. Table 2, presenting evidence from several states of India, shows that flat power tariff, even when high, and in water stress areas produce low water prices and equitable access; on the other hand pro-rata power tarif produces high water prices acontaining monopoly premia even where water resource is abundant as in Kheda district of Gujarat. Indeed, in all parts of Gujarat, 25 to 60% decreases in private water prices were recorded soon after the electricity board replaced prorata power tariff by progressive flat rates in mid 1987 in response to a major agitation by farmers (Shah 1987c). In a similar manner, low, subsidised prices charged by state tubewells in UP, Haryana and the Punjab have helped to contain somewhat the oligopolistic premia that private sellers would otherwise be tempted to charge. In Gujarat, state tubewells charge very high water prices; in the process most of them have been rendered unviable; besides, the state tubewells in Gujarat have had no effect on the behaviour of private water sellers.

Table 3 presents a framework that could be used as a regulatory mechanism in areas with differing water resource profiles. The underlying objective is to maximise equity in acces to the resource where it is plentiful; and to minimise adverse ecological effecrs in areas under stress with minimum damage to the interests of the resource poor. In areas with water stress or those prone to saline ingress, competitive water markets induced by flat power tariff are likely to encourage mining; in such areas, the most equitable method of restricting withdrawals is by judicious restrictions on power supply since high prorata power tariff would impose a very high cost on the resource poor who are normally the water buyers. The most equitable long term solution in these areas, of course, would be to increase aquifer recharge rate and surface water resources through long distance water transport.

Implementation of such a policy may face three major problems: a 4) since the policy is not "Pareto safe" those who get hurt will oppose the policy. Such opposition may be particularly accute where different power tariff or water pricing policies need to be followed in regions of the same state b)the existing dychotomy between agencies dealing with irrigation and those dealing with the supply and pricing of power for lift irrigation may need to be removed by establishing a unified water resource authority in command of all water resources c) a uniform licensing system should effectively cover electric as well as diesel WEMs. It needs to be stressed that the present licensing and spacing policies are ineffective, mainly because they can not keep any check on diesel WEMs. Further, with a more effective monitoring of diesel WEMs, changes in power tariff can become a powerful instrument of regulating the behaviour of private WEM owners.

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