# GROUND WATER MARKETS AND SMALL FARMER DEVELOPMENT: AN ARGUMENT AND EVIDENCE FROM INDIA

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## ABSTRACT

Localised, fragmented, village based ground water markets, the off-shoot of wide spread diffusion of modern water extraction technology in India, are far more pervasive and important than most researchers and policy makers imagine. Due to their responsiveness to certain public policy interventions, such water markets have the potential to become powerful instruments for efficient and equitable ground water development.

This paper presents an argument about how the working of such markets could be influenced and examines empirical evidence in two markedly similar villages selected from the West Godavari district of Andhra Pradesh and the Kheda district of Gujarat. The paper highlights the differential impact of puvlic policies followed by the two states on the terms of business; and the output and livelihood intensities of ground water markets of these two villages.

## 1. INTRODUCTION

Localised, some what fragmented, village based markets for ground water in India are far more pervasive and important in terms of size, role and implications than most researchers and policy makers concerned with irrigation imagine. In Gujarat alone, for example, the value of ground water extracted and used for irrigation every year is around Rs 5-6000 million (1) and between 40-60% of ground water extracted is sold mostly to the resource poor farmers without their own means to gain direct access to this precious resource. Influencing the terms at which ground water business is conducted can prove to be an important area of public policy. In contrast, existing thinking about ground water development is excessively concerned with promoting and regulating investment in modern Water Extraction Mechanisms (WEMs) as the sole instrument of achieving equity and efficiency in the use of a resource which is to command increasing importance in the years to come.

A major policy issue that has concerned those dealing with ground water development has arisen from the highly skewed distribution of private ownership of $WEM_s$ and the unequal access to this precious common property resource. It is unlikely that the scale bias observed in private ownership of $WEM_s$ will, in future, decline except throught a radical reform in the structure of water rights. However, due to the operation of locallised water markets, substantial proportion of the total benefits generated by private investment in $WEM_s$ accrue to the resource poor non-WEM owning farmers and even the landless; this proportion tends to increase as the water markets become more "efficient" and the gap between the incremental pumping costs and water prices declines (Shah 1985). From economic theory, we can infer that each of a group of profit maximisinf water sellers will sell water a price w such that

$$w = (e/e-1)c \text{ --------------- } (1)$$

where e and c denote respectively the price elasticity of demand and incremental pumping cost facing the seller. (e/e-1) is a measure of the monopoly power enjoyed by a seller. Empirical studies reveal a number of factors that may influence the extent of monopoly power enjoyed by water sellers in different regions as shown in Table 0.

These inferences imply that the economic behaviour of the 9 million private pumpers in India can be influenced by using a mix of several public policy instruments aimed at affecting either the monopoly power of water sellers (e/e-1) or the incremental pumping costs facing them (c) or both. They also imply that many of the policies in force have powerful efficiency and equity effects operating through the markets which the policy makers have not recognised (Shah 1987).

## 2 PROFILE OF THE VILLAGES STUDIED

The field work results described in this paper attempt to explore some of these hypotheses on the basis of intensive field study of two villages and also by drawing upon the work done by other researchers. The villages from Andhra Pradesh and Gujarat selected for this purpose are comparable in that a) both have abundant continuous aquifers located at a depth of 14-18 meters and constantly recharged by canals and/or rivers b) both have canal irrigation available to a few of the farmers c) both have highly developed ground water markets with powerful impact on their agricultural economies d) both have irrigation induced

Table 0

Key determinants of monopoly power in ground water markets

| 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 WEM installation | c) High capital cost of WEM installation |
| d) High WEM density | d) Low WEM 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) Use of lined water conveyence system to irrigate distant farms | h) Use of unlined field channels for transporting water to distant farms |

cash-crop orientation in farming facilitated, in both cases, by the proximity to well-developed market centres, and e) both are located in districts which are among the more prosperous ones of their respective states. The major differences between the two village are two: a) Anklav in Kheda district of Gujarat is nearly five times as large as Pandalaparru (Dist: West Godavari, state: Andhra Pradesh) in terms of population, number of households and farm lands and b) the Anklav farmers have preferred to establish 150-180 feet deep tube wells to secure a high discharge rate of 75-100000 litres/hour where as the Pandalaparru farmers get modest discharge rates at 50-60 feet using a somewhat inexpensive device called "filter point".

Pandalaparru has 85 filterpoints (or shallow tubewells); each consists of 40-45 feet long pipe inserted in to the ground and covered by 18 feet long screens which prevent the sandy soil from clogging the pipe. Although the recharge to the aquifer from river Godavari and the Pandyala canal has been substantial, water table has fallen by about 10-15 feet over the past 20 years. Over the past three years the Ground Water Department has declared the area "grey" and issuance of further electricity connections has been considerably slowed down except reportedly to those who can offer substantial unofficial premium (of upto Rs. 10000 per connection) 2 . In Anklav, the installing of a deep tubewell, bigger motor, construction of a pacca shed and laying of underground pipelines to convey water typically result in substantially higher investment per WEM than in Pandalaparru. Here, too, siting regulations make it somewhat difficult for potential WEM owners to install electric WEMs. However, Anklav has two state tube wells and three panchayat tubewells with fairly large potential commands to supplement ground water irrigation provided by private WEM owners.

Both the villages have 30 year old history of ground water irrigation as also of water transactions amongst farmers. In Pandalaparru the choice of motive power for lifting ground water has been dictated largely by the comparative economics of using diesel v/s electricity for pumping. In 1975, for example, when the prorata price of power was raised to Rs. 0.16 per unit, many farmers switched to diesel engines; later in 1982, as the Telugu Desam Government switched from the prorata power charge of Rs 50 per hp per year, many owners of diesel WEMs decommissioned their diesel engines and began to buy water from those with electric WEMs. In Anklav, on the other hand, the total absence of diesel WEMs is explained mainly in terms of the high discharge rates obtained

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2. Areas where less than 65% of known ground water potential is developed are catergorised as "white" areas; those where 65-80% is developed are called "grey"; and those with over 80% developed are called "dark".

through greater draw-down and long hours of operation per year, for both of which electric submersible turbine motors are believed to be more suitable and efficient (2).

In Pandalaparru, introduction of irrigation during the 60s and 70s brought about major changes and diversification in the cropping pattern from rainfed paddy and maize in favour of lucrative water loving perennial crops like banana and sugarcane and to double cropping of land on a major scale. In Anklav, on the other hand, tobacco-cotton which have always been a preferred crop mix gave way to sugarcane-banana-paddy combination during the 1970s; but the primacy of tobacco-cotton came to be reestablished in more recent years mainly in response to, we believe, the changing economics of ground water irrigation.

Table 1 shows the enormous difference in the investmentes involved in ground water irrigation for a sample of WEM owners drawn from the two villages. The substantial investments made by Anklav farmers in pipelines indicates a strong economic incentive to a) reduce seepage losses and power cost and b) be able to sell water to more and distant farmers. The private rate of return on

Table 1

Investments in WEMs: Pandalaparru and Anklav

| Average Investment (Rs/WEM) in | Pandalaparru electric | Pandalaparru diesel | Anklav electric |
|---|---|---|---|
| 1. Well construction | 847 | 2253 | 34104 |
| 2. Pumping plants | 3742 | 3057 | 28098 |
| 3. Pipelines | 2769 | - | 16400 |
| 4. Total | 7358 | 5310 | 88602 |
| 5. Average depth of well | 60 feet | 60 feet | 160 feet |
| 6. Average hp/WEM | 7.54 | 6.0 | 21.5 |
| 7. Sample size | 13 | 7 | 26 |

investments in pipelines here is very high because of a high prorata power price of around Rs 0.80 (December 1986) per kWh in Pandalaparru; on the other hand, electric WEM owners pay a flat rate for power linked to the hp and, therefore, charge for water on the basis of crop acre irrigation rather than on the basis of actual power or water used. As a result, investments in pipelines are uneconomic and, therefore, less are made.

Table 2

Land holding profile of WEM owners and water buyers

| Land holding categories (acres) | Pandalaparru | | | | Anklav | | | |
|---|---|---|---|---|---|---|---|---|
| | Well owners | | Water buyers | | Well owners | | Water buyers | |
| | **No in sample** | Average own land | **No in sample** | Average own land | **No in sample** | Average own land | **No in sample** | Average own land |
| 0-2.5 | **7** | 1.1<br>(1.29)* | **56** | 1.47<br>(1.2) | | | **61** | 1.31<br>(1.02) |
| 2.5-5.0 | **11** | 3.15<br>(1.85) | **11** | 1.62<br>(2.0) | **4** | 3.36<br>(2.9) | **45** | 3.88<br>(1.6) |
| 5.0-10.0 | **11** | 6.32<br>(1.86) | **6** | 3.91<br>(3.17) | **10** | 3.91<br>(4.7) | **9** | 5.94<br>(1.87) |
| 10+ | **5** | 25.2<br>(3.2) | **-** | - | **12** | 18<br>(7.4) | **-** | - |
| Total | **34** | 6.99 | **72** | 1.72 | **26** | 11.67 | **115** | 2.64 |

* Figures in parentheses indicate average number of parcels per land holding.

The relatively high investment required in WEM establishment explains the strong scale bias in WEM ownership in Anklav (Table 2); 22 out of 26 WEM owners in Anklav are medium and large holders. In Pandalaparru, in contrast, where capital requirements are low, half of the WEM owners are small and marginal farmers. The profile of the water buyers is, however, quite comparable dominated as it is, by marginal and small farmers in both the villages.

The figures in parantheses in Table 2 also show that the holdings of the sellers are, in general, far more fragmented in Anklav than in Pandalaparru; as a result many sellers of water in Anklav are also buyers in those of their parcels where they do not have WEMs. A few large farmers in Pandalaparru, on the other hand, have put up WEMs in 2 or 3 parcels because the cost of doing so are nowhere as high as in Anklav.

Out of 85 owners of WEMs in Pandalaparru, a few did not have surplus pumping capacity; however, there were many who wanted to sell but could not do so for the want of buyers. On an average, a seller supplied water to 2.6 buyers in addition to irrigating his own land; a large farmer seller served more buyers but small and marginal farmer sellers irrigated more of the buyers' land. In Anklav, all owners of WEMs sell water; each seller serves an average of 16 buyers most of whom are marginal and small farmers. However, the number of buyers served and acres of buyers' land irrigated per every Rs 10,000 of original investment in WEMs are not very different in the two villages. Because of the high initial capital requirement, several WEMs in Anklav are owned jointly by groups ("water companies") who issue printed receipts and manage their operations quite professionally. Accounts are kept of all the transactions (which must be quite complicated because one such company sells water to over 150 buyers). Some companies provide free water to partners; some others charge them full price and share the profits among partners at the year end.

Anklav has a truely massive ground water business. The 26 private sellers provide nearly 1100 acre seasons of irrigation to some 5th of the farm lands of the village through the enormous and complex network of privately laid underground pipelines. The 34 Pandalaparru sellers too irrigate roughly a fifth of the village's farm land. However, the differences between the two situations are great as shown in Table 3. The most important difference between the two villages is that the average cost of irrigation per acre season for the buyers of Anklav (Rs 681) is over four times as high as it is Pandalaparru (Rs 169); the average price per hour of water supplied in Anklav (Rs 25.2/hour) is nearly 8 times as high as it is in Pandalaparru (Rs 3.04); the average price per hp hour in Anklav (Rs. 0.34/hp hour). Naturally, an average Anklav seller earns a gross revenue of nearly Rs 30000 per year just from sale of water enough to pay back the original investment in a little over 3 years.

In comparison, in Pandalaparru an average seller grosses a modest Rs 1370 with a pay back of some 5-6 years.

Table 3

Summary indicators of the working of ground water markets

| | Pandalaparru | Anklav |
|---|---|---|
| 1. No, of sellers sampled | 34 | 26 |
| 2. Average number of buyers per seller | 2.6 | 15.6 |
| 3. Average season acres of buyers land irrigated per seller (acres) | 7.8 | 43.6 |
| 4. Average hours of water used by buyers per acre | 56 | 27 |
| 5. Weighted average cost of irrigation to buyers: | | |
| (a) Rs/acre | 169 | 681 |
| (b) Rs/hour of pumping | 3.04 | 25.2 |
| (c) Rs/hp hour | 0.34 | 1.28 |
| 6. Cost to the buyer of irrigating: | | |
| (a) Sugarcane and banana (Rs/acre) | 446 | 3714 |
| (b) Kharif paddy (Rs/acre) | 221 | 509 |
| (c) Rabi/summer paddy (Rs/acre) | 285 | 772 |

The extraordinarily high water sales - in terms acres seasons, hours and value - by Anklav WEM owners in relation to Pandalaparru sellers are explained by the smaller population of WEMs in relation to irrigable land, by substantial investments in pipelines made by WEM owners and by the pressure on them to generate surpluses to cover their relatively high overheads with such a heavy average pumping cost of Rs 20.2/h.

Table 4

Relationship between average pumping cost and capacity utilisation

(Rs/hour of pumping)

| | 0-1000 hours/year | 1000-2000 hours/year | 2000-3000 hours/year | 3000 + hours/year |
|---|---|---|---|---|
| 1) Pandalaparru (electric) | | | | |
| a) Average cost | 4.13 | 2.30 | 1.87 | - |
| b) Price charged | 4.53 | 3.66 | 2.55 | - |
| 2) Pandalaparru (diesel) | | | | |
| a) Average cost | 6.76 | 5.79 | 6.24 | - |
| b) Price charged | 7.84 | 8.11 | 7.53 | - |
| 3) Anklav (electric) | | | | |
| a) Average cost | 27.03 | 22.2 | 14.5 | 14.9 |
| b) Price charged | 24.95 | 26.3 | 25.6 | 24.6 |

On the other hand, evidence collected by Copestake (1986) from the water scarce Madurai district in Talminadu showed water sellers enjoying high monopoly power charging a price 2.8-3.4 times the incremental pumping costs. Table 5 presents an array of prices charged by sellers in water markets in different regions of India. Notably, sellers using 5-7.5 hp diesel engines for pumping charge enormously different prices in different regions but their costs can not differ all that much. The only factor that can explain such price differences thus are the incremental (not average) costs facing them.

Thus owners of electrified tubewells in Gujarat charge so much higher prices than those in other states primarily because the Gujarat sellers pay for power on a prorata basis awhile, in all other states, water sellers pay for power an annual flat rate which reduces incremental power cost to zero.

Significantly, in case of both the groups - the diesel WEM owners in Pandalaparru and electric WEM owners of Anklav who incur positive incremental power/fuel cost - profit rate (profit/hour) is higher than for all other groups with zero incremental power cost. This is what should be expected since if we substitute w = (e/e-1)c in to a seller's profit function.

Table 5

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) | very low | Rs 2.9-3/hour<br>Electric: 5-7.5 hp<br>Flat tariff: Rs 48/hp/yr | Rs 7.5/hour<br>Diesel: 7.5 |
| 2. Meerut, Western Punjab. (Jairath 1983). D Prasad et al.; 1985 | UP and low | Rs 4-6/hour<br>Electric 5 hp<br>Flat tariff: Punjab Rs 180/hp/year<br>UP: Rs 260/hp/year | Rs 8-10/hour<br>Diesel 5 hp |
| 3. Parts of Eastern & Central UP, Bihar (Krispashankar: 1987) Chambers & Joshi 1983 | low | Rs 6-7/hour<br>Electric: 5 hp<br>Flat tariff: Punjab Rs 180/hp/yr Bihar Rs 145/hp/yr | Rs 10-12/hour<br>Diesel: 5 hp |
| 4. Thasra taluka in Kheda district the head of the MRBC (Shah & Raju 1986) | low | | Rs 15/hour<br>Diesel 7.5 hp<br>Electric: 21 hp<br>Prorata tariff Rs 0.7 |
| 5. Midnapur West Bengal (Shah, 1987) | moderate | | Rs 14/hour<br>Diesel 5hp |
| 6. Charutar tract in Kheda district, Gujarat (Shah and Raju 1986) | moderate | | Rs 25-28/hour<br>Electric: 21-25 hp<br>Prorata tariff: Rs 0.70/KWH |
| 7. Parts of Panchmahal, Dt. in Gujarat (Shah 1985) | high | | Rs 16-18/hour<br>Diesel 5 hp |
| 8. Mehsana, Sabarkantha, Benaskantha district of Gujarat (Shah 1985) | high | | Rs 35-41/hour<br>Electric: 30-35 hp<br>Prorata tariff: Rs 0.70/KWH |
| 9. Madurai dt. Tamilnadu (Copestake 1986) Karimnagar, dt. Andhra Pradesh (Shah 1985) | very high | Rs 4-5 hour<br>Electric: 7.5 hp<br>Flat tariff: Rs 48/hp/yr | Rs 18021/year<br>Diesel 5 hp |

Table 6

Determinants of water prices

| Monopoly power | Incremental cost LOW | Incremental cost HIGH |
|---|---|---|
| LOW | Water price: very low<br>Dependability: high<br>Adequacy: high<br>West Godawari (electric)<br>Punjab, UP, Haryana (electric) | Water price: high<br>Dependability: high<br>Adequacy: high<br>West Godawari (diesel)<br>Northern Kheda (electric)<br>UP, Punjab, Haryana (diesel) |
| HIGH | Water price: moderately high<br>Dependability: moderately high<br>Adequacy: moderately high<br>Madurai, Karimnagar (electric) | Water price: very high<br>Dependability: low<br>Adequacy: low<br>Gujarat (electric), Madurai, Karimnagar (diesel) |

c = w.H-cH-F (2)

with c and H denoting total profit and hours of operation per year respectively and F denoting fiwed costs, then we can write profit rate

c/H = c/(e-1)-F/H (3)

Differentiating this profit rate function with respecto to c, we get

d (c/H)/dc = 1/(e-1) (4)

which implies that for every rupee increase in the cost of diesel or prorata power tariff per hour, sellers' profit per hour would increase by 1/e-1. Only in the unlikely conitions of e = 1 will the increase in peice be equal to increase in cost. In Anklav, for example, where we estimated e to be 1.86, every one rupee increase in the prorata power price per hour would increase profit rate by Rs 2.14; in Madurai, where e is closer to unity, a rupee increase in diesel cost/hour would induce the seller to increase water price by Rs 2.70 per hour. Further, even if diesel and electric WEMs faced the same demand conditions and average costs, the latter would thys always sell at a lower price than the former if electricity was charged for on flat rates. By the same token, if flat power charges are increased moderately, they would serve to reduce sellers' monopoly power by pressuring them to sell more to cover higher fixed costs. In contrast, when prorata power tariffs are increased by a given proportion, sellers tend to put up sale prices by the same proportion and, in effect, expand their monopoly surplus considerably. From equation (1), by differentiation we can write

dw/dc = e/e-1 (5)

and the elasticity of w with respect to c as

dw/dc . c/w = e/(e-1) . w/c = 1 (6)

Since w/c = (e-1)/e. Empirical implications of this relationship is evident from the rapidly increasing profit rate in Anklav area over the past decade as shown in Figure 1.

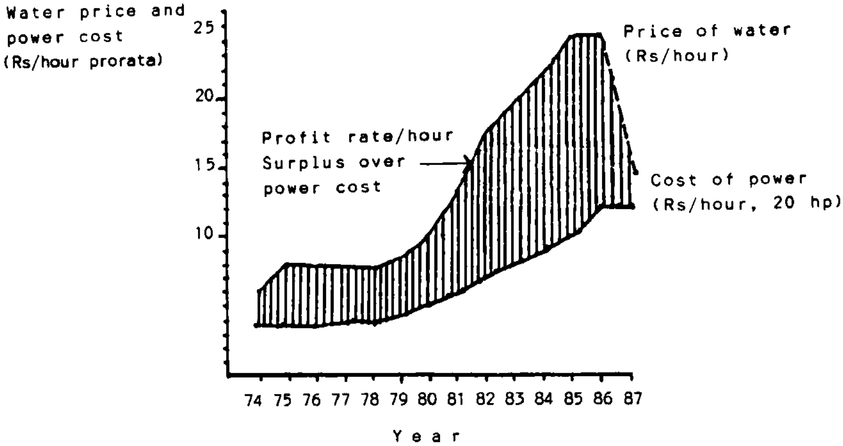


Figure 1.- Relationship between prorata power cost/hour and market price of ground water Anklav area.

## 3 IMPACT OF WATER MARKETS

The effects of the water markets on the well owners in both the villages have been entirely beneficial; the Pandalaparru and Anklav well owners could pump 1.5 and 4.5 times more water respectively than they would have in the absence of the market; as a result, capacity ytilisation of the wells has been better and the economics of investment in wells more favourable. From the social point of view too, water markets have created substantial social benefits by reducing the society's investments in water lifting capacity.

Buyers of water are, however, more important beneficialies; their gain has significant equity dimension since most of them would not afford their own wells. Buyers of Pandalaparru have benefitted much more than those of Anklav. In Pandalaparru, low water prices and intense competition among sellers have ensured that resource poor buyers have the access to the same enterprisetechnology option as well owners have; the differences between the two groups in cropping pattern, input use and yield levels were found to be insignificant and the overall cropping intensity in the village was as high as 280%.

According to the buyers of Pandalaparru, these benefits have increased greatly since the Telugu Desam government changed the method of power pricing from a prorata rate of Rs 0.16/kwh to a flat rate of Rs 5/hp/month in october 1982. Table 7 shows, in the basis of the buyers' recall, the change in the crop pattern and increase in area supplied with purchased irrigation since 1981-82. The maximum increase has been recorded in annual crops like sugarcane and banana considered very lucrative by the farmers, summer crops of groundnut and maize seem to have gained at the expense of some rabi crops.

The switch to flat power tariff in Andhra Pradesh also led to considerably increased demand for farm labour in Pandalaparru. Off season wage rates are beleived to have increased from Rs 8-10 in 1982 to Rs 15-20 and peak season wage rates have increased from Rs 17-20/day in 1982 to as high as Rs 25-30/day.

Table 7

Increase in area irrigated with purchased water after the introduction of flat power tariff in October 1982: Pandalaparru

| | 1981-82 (acres) | 1984-85 (acres) | %change |
|---|---|---|---|
| 1. Area under Annual crops (Sugarcane, banana, etc.) | 24.54 | 58.34 | 137.7 |
| 2. Area under Kharif crops | 82.80 | 98.21 | 18.6 |
| 3. Area under Rabi crops | 51.30 | 37.85 | -26.2 |
| 4. Area under Summer crops | 2.50 | 11.75 | 370 |
| 5. Season acres irrigated | 210.2 | 322.83 | 53.6 |

The 200 landless families of the village dependant solely on farm labour have found it difficult to cope up with the expanded work opportunities and as a result, in the last two years, outside labour has been coming to the village for 4-6 months every year. The increases in cropping intensity have rendered farm work loads more continous and thus reduced greatly the seasonal decline in work opportunities for the landless. In overall terms, thus the low cost ground water economy of Pandalaparru has been intensive in both farm output as well as livelihoods of the poor.

In Anklav, in contrast, the differences between buyers and sellers in enterprise choices, input use, yield rates, etc are of a much higher order. Here, the average fertiliser use by the buyers is less than a fifth of the very high amounts that sellers use; their use of water (in Kharif and annual crops) is 30% lower than selles; and the average crop yields that buyers obtain, are only 50-60% of the yields that the sellers obtain. If we use our earlier definition of acre season, then the cropping intensity works out to 208% for sellers and 193% for buyers. These figures conceal the greater differences in the role that purchased irrigation playes in the economics of farming as shown in Table 8. Anklav buyers' main disadvantage is low gross value of output per acre explained, in the main, by the choice of less lucrative crops and low fertiliser use both induced, at least in part, by high incremental cost of irrigation with purchased groundwater.

Table 8

Economics of irrigation with purchased ground water: Pandalaparru and Anklav*

| | Pandalaparru | | Anklav | |
|---|---|---|---|---|
| | Sellers | Buyers | Sellers | Buyers |
| 1. Average value of output/acre (Rs) | 7986 | 7302 | 5428 | 2620 |
| 2. Average cost of irrigation (Rs) | 195<br>(326)+ | 340 | 380<br>(619) | 723 |
| 3. Cost of irrigation as % of value of output | 2.44<br>(4.1) | 4.7 | 7.0<br>(11.4) | 27.6 |

* These figures represent the entire year.

+ Figures in brackets refer to opportunity costs of water used on ownfarm as defined by sellers.

As we noted earlier, ground water prices in Anklav have shot up some 2.5 times in the past 10-12 years in response to succesive increase in pro-rata power charge. As a result, although the total area irrigated has marginally increased, the composition of crops irrigated by ground water has undergone major changes since 1981 when water prices began to soar rapidly. Water intensive and high return cash crops such as banana and vegetables have given way to cash crops like tobacco and cotton which need less water but have uncertain returns; likewise, in food crops, paddy and wheat have lost ground to bajri. The crops which have reduced in importance were also more labour intensive; all those which have gained in land seem to use much less labour. Also, bajri, which has gained substantially, offers far less income per acre; and so do cotton and tobacco in comparison to banana, papaya, potato and other fruits and vegetables which they have replaced. In all these senses, thus the rapidly rising prorata power price has reduced the livelihood intensity of the ground water markets in Anklav, especially when one notes that over 95% of water buyers who have borne the burnt of this rise are small and marginal farmers. From a broader social point of view, this decline is unnecessary and avoidable since Anklav, as indeed most of the villages surrounding it, has plentiful groundwater that can support the kind of output and equity intensive ground water development that Pandalaparru has secured.

Broader implications for policy

At macro-level too, available evidence vindicates our thesis abour a strong negative relationship between incremental power cost and the average level of tubewell operation. In Andhra Pradesh as a whole, average annual power consumption per tubewell stagnated between 1969/75 period (2186 KWH) and 1975/82 period (2232 KWH) but shot up to 3294 subsequently after flat rates were introduced in the end of 1982; in Gujarat, on the other hand, average power use per tubewell declined from 6664 KWH per year during 1974-78 period to 5790 KWH during 1979-81 period and then to 5205 KWH during 1981-86 period. As a matter of fact, regression analysis of power use per tubewell (K) on incremental power price (P in Rs/KWH) and rainfall (R) using 1974-86 data produced following results:

Andhra Pradesh

1. $K = 3500 - 6924\,P - 0.31\,R$ $\quad R_2 = 0.68$
$\qquad (-5.21) \quad (-0.84)$

2. $K = 3025 - 134.7\,P - 0.8\,R + 1009\,D$ $\quad R_2 = 0.74$
$\qquad (-1.013) \quad (-1.08) \quad (3.6)$

Gujarat

1. $K = 9201 - 456\,P - 2.2\,R$ $\quad R_2 = 0.68$

In case of Andhra Pradesh, a dummy variable introduced in the second regression for the period during which flat rate was in force, rendered both rainfall and earlier prorata price statistically insignificant, and showed that the switch to the flat rate increased K by 1008 units per WEM (by nearly 50%) over an average value of 2200 KWH per WEM. In Gujarat, on the other hand, every 10 paise increase in power price per KWH has reduced average power consumption per well by 456 KWH area ittigated per electric WEM by 1.4 acres (assuming 400 hp hours needed to irrigate an acre); and reduced total area irrigated by the 3.2 lakh electrified wells of Gujarat by some 4.5 lakh acres and results in the loss of farm output worth some Rs 90 crores. Since the bulk of the farm outpur lost is what might have been produced by the resource poor water buyers, it become all the more important to stress that the pricing of power for lift can have enormous output and equity effects.

An important policy implication of out analysis thus relates to the pricing of electric power. In Andhra Pradesh, Tamilnadu, etc where flat power rates are heavily subsidised, the viability of electricity boards can be improved without hurting the welfare of resource poor farmers by moderate increases in flat rates. Comparison across several states indicates that in Uttar Pradesh where flat rates charged are over four times as high as in Andhra Pradesh, private water prices are only 1.5-1.8 times higher. Contrary to the general perception among political leaders, subsidised flat rates can achieve less equity than moderately high flat rates which, in addition, will improve the viability of electricity boards. Progressive levy of flat charges would be ideal from equity view point since small holder WEM owners, normaly using low hp pumps, will be directly benefitted.

In Guajrat, our analysis meant that private water prices would decline substantially if pro-rata tariff was replaced by flat rates and, thereby, many of the inequities observed in Anklav could be eliminated. Events subsequent to this analysis confirmed our expectations. In June 1987, Gujarat government adopted progressive flat power rates in lace of pro-rata tariff. Although, the full effects of this change will need time to work out, private water prices all over the state have fallen by 25-60% and this has made it somewhat easier for the resource poor buyers to survive the 1987 drought (Shah 1987b for more details).

Several objections can be raised to the policy of charging flat tariff for power. Flat tariff is blamed for unviability of electricity boards; in our view, subsidies on power rather than flat tariffs are the culprit. Flat tariffs can infact improve their viability by eliminating the substantial metering and policing costs incurred by most electricity boards and by removing the incentive to pilifer power (REC 1981). A more valid apprehencion is that flat tariffs would result in overexploitation of ground water resources in water-stress areas. In our view, using progressive flat tariffs to keep water prices low and promote equity and judicious controls on the supply of power to contain total ground water withdrawal may be for more effective than using high pro-rata tariff to control withdrawals. Current experience in many parts of Gujarat indicates that the latter may not be possible; even if it is, it shifts almost the entire cost of maintaining the ecological balance on the resource poor water buyers.

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