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Terms of Transactions in Groundwater Markets: A Study in Anantapur District of Andhra Pradesh

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INTRODUCTION

Groundwater markets, widespread across different parts of the country (Pant, 1991; Shah and Raju, 1987; Shah, 1993; Janakarajan, 1993; Shankar, 1989, 1992; Kolavalli, 1989), can (i) offer opportunities to the poor owning tubewells to share the operational costs with the buyers (Shankar, 1989), (ii) to augment command area for wells to break even, (iii) to enable the resource poor to get access to groundwater which they can not have otherwise. In general, small farmers tended to depend on the groundwater markets (Meinzen-Dick, 1994). And, possibly the performance of the buyers is better than farmers using other sources of irrigation (Shankar, 1989, Satyasai, 1987). Thus groundwater markets have a tendency to improve the equity in sharing the groundwater as well as the income generated thereof.

The terms of groundwater transactions, however, may tend to be rather exploitative (Janakarajan, 1993). Still, in the wake of failure of traditional irrigation systems like tanks (Janakarajan, 1993; Reddy *et al.*, 1993), the farmers may opt for purchase of water at any cost rather than going without it.

There were two basic modes of payment for water transactions in vogue in the study area. The first mode was the hourly mode where the water was charged at hourly rate. The other mode was sharing the crop output where the buyers of water have to surrender a part of their crop output to the seller of water. Other arrangements for payment for water observed in this area included exchange of water and offer of labour for farm work. Sometimes water was given even free of cost. Crop sharing, *prima facie,* may be more expensive than hourly mode. Then the question is how the cost of obtaining water under these two modes of transactions to the buyer of groundwater compare with each other and what are the factors determining the choice of the mode.

In this paper, this question is addressed to, besides examining the role of groundwater markets in improving the access of small farmers to water in a typical water scarce area.

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DATA AND THE MODEL

Data collected from a random sample of 90 irrigators from Hindupur taluk of Anantapur district in Andhra Pradesh form the data base for this paper. Anantapur is the second lowest rainfall receiving district in the country and as such represents a typical water-scarce district. Wells and tanks constitute the main sources of irrigation in the district. The reference year of the study is 1991-92.

When an irrigator faces choice between two modes of payment, i.e., crop sharing and hourly rate for groundwater exchange, several factors may influence his choice of one of them. The influence of such factors on the probability of choice of the mode of payment can be studied using logit model (for details of the model, see Maddala, 1983).

If dependent variable, Y, takes a value of '1' if a farmer chooses crop sharing mode and '0' otherwise, the probability that Y=1 can be given by

Prob (Y=1) = exp {w}/(1+exp{w})

where w is linear function in x_i , independent variables, i.e., $w = \beta' x_i$

The parameters are estimated using Newton's method of obtaining maximum likelihood estimates.

The choice of mode of payment may be determined by availability of water in the village, nature of crop, level of education, farm size category, preference of the sellers for leisure or farm work and so on. The sellers may prefer crop sharing in view of their command over water. However, in the event of better water situation in the village in terms of presence of good number of borewells or other wells and large tanks, the monopoly power of the sellers diminishes and the bargaining power of the buyers improves. Hence, hourly mode may become more prevalent. Large farmers, because of their superiority in terms of ownership of borewells and better socio-economic position in the village, may prevail in entering into crop sharing contract with the buyers. Education is one of the important socio-economic parameters influencing the awareness, decision-making ability, behavioural patterns, etc., of the farmers. So an educated buyer may not prefer crop sharing. Similarly, an educated seller may not like to exploit the buyer by tying the latter into crop sharing contract. If the water is transacted for water intensive but the main food crop like paddy, both the sellers and buyers may prefer crop sharing.

With the foregoing *a priori* reasoning, logit model with the following specification is estimated.

$$\ln \{P_i/(1-P_i)\} = \beta_0 + \beta_1 SP + \beta_2 FG + \beta_3 FGSP + \beta_4 VSITU + \beta_5 ED + \beta_6 EDSP + \beta_7 RPD + \beta_8 RPDSP + u$$

where
- P_i = probability of a seller/buyer preferring crop sharing mode,
- SP = intercept dummy variable taking value '1' for seller and '0' for buyer,
- FG = dummy variable taking value '1' for large farmer and '0' for small farmer,
- FGSP = slope dummy for category of farmer,
- VSITU = dummy for water availability situation in the village taking '1' for better availability and '0' for scarcity situation,
- ED = number of years of schooling,
- EDSP = slope dummy for education (ED) variable,
- RPD = dummy for *rabi* paddy taking '1' for transacting water for *rabi* paddy,
- RPDSP = slope dummy for selling/buying for *rabi* paddy.

β'_s are coefficients denoting the marginal impact of the variables on the logarithms of odds of choice. Intercept and slope dummies are included in the model to take care of the differential impact of the independent variables on the choice of sellers and buyers.

RESULTS AND DISCUSSION

1. *Access to Groundwater Irrigation*

Small farmers in the sample had limited access to groundwater as shown by the details given in Table 1.

TABLE 1. DISTRIBUTION OF GROUNDWATER STRUCTURES OWNED ACCORDING TO FARM SIZE

(per cent)

Type of groundwater structure (1)	Small farmers (2)	Large farmers (3)	Total (4)
Dugwells	17	83	100
Inwells	26	74	100
Borewells	8	92	100
Average	17	83	100

The data showed that large farmers accounted for about 83, 74 and 92 per cent of dugwells, inwells and borewells respectively. On the other hand, small farmers as a group, in general, owned lesser proportion (17 per cent) of all types of groundwater structures, let alone the dependable source, i.e., borewells.

The disparity in ownership of groundwater structures may be due to high cost of borewell technology. As can be seen from Table 2, in 1990-91 prices, the unit cost of borewells was the highest at Rs. 33,750 (including Rs. 11,950 towards cost of boring), followed by inwells (Rs. 27,400) and dugwells with pumpsets (Rs. 19,400). Lumpy initial investment for borewells bars small farmers from going for borewells. Thus they are deprived of the benefits of cost-effectiveness of borewells as reflected by the low capital cost in drawing one unit of water compared to dugwells and inwells.

TABLE 2. UNIT COST AND DRAFT OF GROUNDWATER STRUCTURES

Type of groundwater structure (1)	Unit cost (Rs.) (2)	Unit draft (ha-m/year) (3)	Cost per ha-m(Rs.) (4)
Dugwells	19,400	0.93	20,860
Inwells	27,400	1.05	26,095
Borewells	33,750*	2.48	13,609

Source: Unit costs were taken from Circular dated May 7, 1991 issued by District Rural Development Agency, Anantapur district, Andhra Pradesh and unit draft was taken from Government of India (1984).

*Includes Rs. 11,950 towards cost of boring (sample average) which is not being financed by the banks.

Since borewells which represented the state-of-the-art technology were capable of withdrawing large quantities of groundwater from greater depths, in effect large farmers enjoyed access to large quantities of groundwater.

2. *Groundwater Markets and Access to Water*

Small farmers, however, could offset their limited access to groundwater through groundwater markets where they purchased water from fellow farmers who had better source of water. Table 3 shows the details of the extent of groundwater markets in the study area.

TABLE 3. EXTENT OF GROUNDWATER MARKETS IN THE SAMPLE

Particulars (1)	Sellers (2)	Buyers (3)	Overall (4)
1. Number of farmers	17	27	44
2. Number of transactions	26	37	65*
3. Average area supported (ha)	1.83	0.45	0.99
4. (3) as per cent of irrigated area on own farm	51	47	49
5. Number of irrigation hours transacted by seller/buyer on an average during the year	440	136	N.A.
6. (5) as per cent of total number of irrigation hours on the farm of seller/buyer	35	47	38

*Includes two transactions on exchange and free of cost basis.
N.A. = Not available.

In the sample as a whole, there were 17 sellers and 27 buyers. That is, about half of the sample farmers participated in groundwater markets. The total number of transactions, taking selling/purchasing for one crop activity as one transaction, was 65 covering about 20 per cent of the total area under groundwater irrigation in the sample as a whole. Out of the total number of transactions, selling accounted for 40 per cent and buying for 60 per cent. Each seller in the sample supported about 1.83 ha of irrigated area on an average which amounted to 51 per cent of the irrigated area on their own farms. They could extend as many as 440 irrigation hours, forming about 35 per cent of those used on their own farms, to neighbouring farmers. On the other hand, the buyers of water could support about 47 per cent of their irrigated area through purchased water. Further, about 47 per cent of the irrigation hours applied on their farms were obtained from the market. Thus both in terms of area and the number of irrigation hours the extent of groundwater markets seems to be considerable.

Data in Table 4 give an idea of the potential of the groundwater markets to augment irrigated area and irrigation input (measured in hours) of the buyers of water, thus improving the equity in access to water. When this augmentation was translated into additional gross irrigated area that would be possible due to purchased water, it can be seen that there was about 23 per cent increase in the gross irrigated area of small farmers and a little above 3 per cent increase in the case of large farmers. The ratio of gross irrigated area of large farmers to that of small farmers declined from 5.30 without considering the area under purchased water to 4.40 when the area under purchased water was included, thus signifying the reduced distance between large and small farmers in respect of gross irrigated area per holding.

TABLE 4. IMPACT OF GROUNDWATER MARKETS ON THE ACCESS TO WATER

Particulars (per holding) (1)	Small farmers (2)	Large farmers (3)	Col. (3) ÷ col. (2) (4)
1. Gross irrigated area (ha)	0.87	3.83	4.40
2. Irrigated area under purchased water (ha)	0.17	0.12	*
3. Gross irrigated area from sources other than purchased water (ha) [=(1) minus (2)]	0.70	3.71	5.30
4. (2) as per cent of (3)	24.28	3.23	*

* Ratio not relevant.

The distribution of number of sellers/buyers and area covered by water transactions (Table 5) indicated that as high as 71 per cent of the sellers owned borewells in single or in combination with other sources like inwells, filter points, dugwells and tanks covering the same proportion of the total area. The remaining 29 per cent of the sellers were tapping inwells alone or a combination of inwells, dugwells and tanks which covered an equal proportion of area. This points to the positive impact of borewell expansion on the spread of groundwater markets.

TABLE 5. DISTRIBUTION OF NUMBER AND AREA OF SELLERS AND BUYERS ACCORDING TO SOURCE OF IRRIGATION

(per cent)

Source of irrigation	Sellers		Buyers	
	Number	Area	Number	Area
(1)	(2)	(3)	(4)	(5)
No source	(-)	(-)	22	19
Tanks	(-)	(-)	63	56
Combination of tanks inwells, dugwells and filter points	29	29	15	25
Borewells	29	14	(-)	(-)
Borewell combination	42	57	(-)	(-)
Total	100	100	100	100

(-) Nil.

3. *Terms of Transactions in Groundwater Markets*

On an average, hourly payment was more frequent among both the sellers and buyers. About 69 per cent of the transactions covering 78 per cent of the area supported by water markets were conducted through hourly mode (Table 6). This mode was relatively more common among the buyers, though it covered a smaller proportion of area, compared to the sellers. Crop sharing was adopted by a relatively higher proportion of sellers than buyers. The buyers showed relative tendency to cover a larger area under crop sharing mode.

TABLE 6. DISTRIBUTION OF NUMBER AND AREA OF GROUNDWATER TRANSACTIONS ACCORDING TO MODE OF PAYMENT

(per cent)

Mode of payment	Sellers		Buyers		Overall	
	Number	Area	Number	Area	Number	Area
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Hourly	62	80	74	71	69	78
Crop sharing	27	14	21	25	23	17
Others	11	6	5	4	8	5

As shown in Table 7, out of the total area covered by the sellers under crop sharing, *rabi* paddy, chillies and mulberry occupied 58, 37 and 5 per cent respectively. Out of the area under hourly mode, mulberry occupied 26 per cent of the area, followed by *rabi* paddy (11 per cent). Water was sold to 50 per cent of the area under this mode without any crop specificity. On the other hand, the buyers raised *rabi* paddy in 50 per cent of the area under crop sharing mode, followed by mulberry (43 per cent) and chillies (7 per cent). In the case of area under hourly mode the cropping pattern was comparatively diverse with mulberry occupying the largest area (36 per cent), followed by chillies (28 per cent), *rabi* paddy (17 per cent) and other crops (19 per cent). On the whole, both the sellers and buyers showed preference for crop sharing in the case of *rabi* paddy.

TABLE 7. CROPWISE DISTRIBUTION OF TOTAL AREA UNDER HOURLY AND CROP SHARING MODES

(per cent)

Crop	Selling		Buying	
	Hourly	Crop sharing	Hourly	Crop sharing
(1)	(2)	(3)	(4)	(5)
Mulberry	26	5	36	43
Rabi paddy	11	58	17	50
Chillies	(-)	37	28	7
Other crops	13	(-)	19	(-)
No crop specified	50	(-)	(-)	(-)
Total	100	100	100	100

(-) Nil.

Among other arrangements for payment of water, in case of water sales on exchange basis (observed in one case), one farmer used other farmer's irrigation source for irrigating his far off piece of land and supplied irrigation to other farmer's plots located nearer to his source. In one instance, water was supplied on offer of labour by the buyer. This sort of tie-up was made by the seller to ensure labour for his farm work. In three cases water was supplied free of cost. However, it was not absolutely free of cost, as such transactions involved obligations from the buyers to help the seller in the latter's farm operations 'free of charge' or any other service on demand. Even in case of payment on hourly basis or crop sharing basis, these types of obligations were prevalent to some extent, even after paying for the water. This may be basically because of the monopoly power of the sellers in the

water markets where too many buyers were demanding water which was obviously short in supply.

In hourly mode the rate per hour varied from village to village and the type of source of irrigation supply. The hourly rate varied from Rs. 8 to Rs. 10 in the case of borewells to Rs. 3 to Rs. 10 in the case of other wells. In the crop sharing mode the terms of sharing crop output varied from crop to crop. In the case of mulberry the gross income from the sale of silk worm cocoons after netting out seed (Disease Free Layings, i.e., DFLs) cost, labour charges for rearing and rental charges for *chandrikas* (bamboo trays on which the silkworms are allowed to form cocoons) was shared equally. In the case of paddy, both costs (seed, manures, fertilisers and harvesting labour) and income were shared equally. In villages where tanks were very small and water scarcity was acute, for example, Guravanahalli village, even more exploitative terms of sharing were observed wherein gross income was shared equally without sharing the costs at all.

Table 8 shows the cost of purchased water under different modes of sharing.

TABLE 8. COST OF PURCHASED WATER PER HOUR UNDER HOURLY AND CROP SHARING MODES OF PAYMENT

Particulars	Mode of payment	
	Hourly	Crop sharing
(1)	(2)	(3)
Number of irrigation hours (hours)	109	140
Total amount to be paid to seller of water (Rs.)	837	7,000
Cost of water to the buyer (Rs./hour)	7.70	50
Operation and maintenance cost to the seller (Rs./hour)	0.55	0.55

The average amount paid to the seller by the buyer in the sample was Rs. 837 and Rs. 7,000 under hourly and crop sharing modes respectively. Considering the 109 and 140 irrigation hours received by the buyers under these two modes, in the same order, the average cost paid by the buyer for each hour of irrigation worked out to Rs. 7.70 and Rs. 50 respectively. These rates were 14 and 91 times higher than the operation and maintenance cost of running a well for an hour incurred by the seller, which worked out to about Rs. 0.55 respectively. Thus the actual rate to be paid for one hour of irrigation seems to be rather exploitative. Out of hourly and crop sharing modes, the latter was too expensive and exploitative. This result shows that the buyers of water were willing to pay even as much as Rs. 50 per hour of irrigation rather than going without it. The reason offered by buyers is that crop sharing agreement would bind the seller of water over releasing water as he can maximise his share in the crop produce which comes without any labour on his part.

An attempt is made to ascertain the factors affecting the probability of preferring crop sharing by the sellers as well as the buyers using logit model and the results are given in Table 9.

TABLE 9. ESTIMATED PARAMETERS OF LOGIT MODEL

Variable (1)	Coefficient (2)	Standard error (3)	Level of significance (4)
SP	2.1649	1.652	19.0
FG	1.4852	1.007	14.0
FGSP	1.1332	1.927	55.6
VSITU	-1.4239	0.880	10.5
ED	0.07453	0.098	44.5
EDSP	-0.6062	0.269	2.4
RPD	2.1446	1.052	4.2
RPDSP	0.2586	2.314	91.1
Constant	-2.4931	1.051	1.8

Percentage of correct predictions = 75.0
Value of χ^2 (significant at 1 per cent) = 20.06
Number of observations (hourly and crop sharing modes only) = 60
Estimated probability (P_i) of choosing crop sharing mode
Sellers = 0.419
Buyers = 0.162

Of the eight independent variables included in the final model, two variables are highly significant. Three more variables are significant at different levels upto 20 per cent. However, the model seems to have given a satisfactory fit with a significant Chi-square value of 20.06 and predicting 75 per cent of the cases correctly. Thus the model helps us in qualitative understanding of the factors influencing the choice of the mode of transaction. The results of the model reveal that the sellers and large farmers tend to prefer crop sharing. The sign of VSITU is negative, signifying that if the water situation in the village is better, the probability of preference for crop sharing declines. Interestingly, longer years of schooling among sellers tend to reduce their preference for crop sharing as reflected in the sign and significance of coefficient for EDSP. Transacting water for growing *rabi* paddy (variable RPD) has significant positive impact on the probability of preference for crop sharing. There does not seem to be any difference between the buyers and sellers in this respect as RPDSP variable is not significant. In other words, this result implies that both the sellers and buyers preferred crop sharing for *rabi* paddy. This may be because of the fact that paddy is the main cereal in the consumption basket of the farmers and is grown in this area only for own consumption. The farmers of this area grow paddy to a large extent in the years of good rainfall and store the grains for the next few years as an insurance against possible drought.

The coefficients of the model give the marginal impact of the variables on the logarithm of the odds of choice and hence their interpretation is not straight forward (Bagi, 1984). Hence, following Pindyck and Rubenfeld (1981), the marginal impact[1] of each variable included in the model on direct probability (P_i) is computed for the sellers and buyers (Table 10).

TABLE 10. MARGINAL IMPACT OF FACTORS ON THE PROBABILITY OF CHOICE OF CROP SHARING

Variable (1)	Sellers (2)	Buyers (3)
FG	0.637	0.202
VSITU	-0.347	-0.193
ED	-0.129	0.010
RPD	0.585	0.291

The above estimates show that being a large farmer and growing paddy among sellers increases the probability of preferring crop sharing mode by 0.637 and 0.585 respectively. The marginal impact of farm size category is three-fold and the marginal impact of RPD is twice as much in the case of sellers compared to the buyers. The results show that the large farmers among both the sellers and buyers tended to prefer crop sharing though the rationale is different. Among the sellers, the large farmers in view of their superior bargaining power can manage contract on crop sharing basis. Further, in view of labour problems reported in the area by the large farmers, crop sharing may be their preferred choice to obtain returns without cultivation. On the other hand, the large farmers among buyers seem to prefer crop sharing so as to obtain assured water from the sellers. The number of years of schooling has a socially desirable influence on the sellers as they with longer schooling tended to prefer hourly mode. In the case of buyers the marginal impact, though positive, is very low at 0.01, possibly implying that education is not a strong determinant of their choice of the mode of payment. The water situation in the village has negative influence on both the sellers and buyers. That is, as the water availability situation in the village improves, hourly mode becomes prevalent both among the sellers and buyers. In other words, in the face of difficult water situation the sellers may prefer crop sharing thus exploiting the situation. The buyers also showed preference for crop sharing in such situation. The motive, as corroborated by the opinions expressed by some of the buyers, is to ensure water supply by giving incentive to the sellers. The relatively larger marginal impact in the case of sellers implies that as the village water situation deteriorates the sellers are faster in contracting on crop sharing basis compared to the buyers. In other words, the buyers tend to stick to hourly mode as far as possible. The positive marginal impact for RPD variable indicates that the sellers and buyers tend to transact irrigation water for *rabi* paddy on crop sharing basis. The preference is because of the importance of paddy as the highly preferred staple food. Besides, the buyers prefer crop sharing to get assured supply of water for *rabi* paddy which is sensitive to water shortage. The sellers also may go for crop sharing as it ensures supply of paddy without the hassles of cultivation.

SUMMARY AND CONCLUSIONS

Small farmers had limited access to groundwater compared to large farmers. The groundwater markets prevalent in the area helped improve the access of small farmers to water. However, there was a cost to improving the equity as water was purchased at the rate of Rs. 7.70 and Rs. 50 per hour under hourly and crop sharing modes of payment respectively. These rates were 14 and 91 times higher than the operation and maintenance cost of running a well for an hour incurred by the seller (Rs. 0.55) in the same order. Thus the actual rate to be paid for one hour of irrigation seems to be rather exploitative, more so in the case of crop sharing mode. Crop sharing mode was, however, preferred by sellers for obvious reason that it maximises their returns without any effort; and by buyers for the purpose of giving incentive to seller for supplying water. It further appears that crop sharing is preferred for a staple food crop like paddy. As the water availability situation in the village improves the buyers are faster in changing to hourly mode compared to the sellers. Education seems to have motivated the sellers to opt for hourly mode.

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NOTE

1. Marginal impact $(\delta P_i/\delta X) = \beta_x\{P_i(1-P_i)\}$, where β_x = coefficient of independent variable, X; and P_i = probability of preferring crop sharing evaluated at the mean values of independent variables.

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