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Groundwater Marketing in Nalanda District of Bihar State: A Socio-economic Appraisal

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Abstract

The cost and marketing of groundwater have been assessed in the Nalanda district, which is one of the most agriculturally advanced districts of the Bihar state. For the study, 60 farmers have been randomly selected from the district. It has been found that small and marginal farms use their tubewells mainly for hiring, whereas, large and medium farms use them mainly for their own purposes during the main crop seasons, i.e. *kharif* and *rabi*. The average installation cost on a tubewell has been found highest on large size of holdings (Rs 33,130), followed by medium (Rs 27,240), small (Rs 23,850), and marginal (Rs 19,610) holdings. The capital budgeting techniques, viz. net present value (NPV), benefit-cost ratio (B:C ratio) and internal rate of return (IRR) have been used for evaluating the investment on tubewells. The NPV has been found positive (Rs 1440) and B:C ratio more than one (1.05:1). The IRR has been estimated to be more than the capital cost (10.95%). But, the tubewells have failed to generate income flow equal to the investment by marginal farms. Farm size-wise analysis has revealed that the owner-seller farms category predominates in the water market in the study area. The participation in water market has been found to decline with increase in the size of farms. Financial analysis has revealed that the installation of tubewells is financially viable on large and medium farms but not on small and marginal farms. However, with the development of water market in the area, adoption of modern technologies in crop production and cultivation of cash crops would make the installation of tubewells on marginal and small size of farms financially viable.

Introduction

Lack of irrigation facilities and heavy reliance on monsoons are the major constraints to agricultural production and productivity in the Bihar

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state. Groundwater irrigation through tubewells is the most appropriate alternative source of irrigation that can harness the potential benefits of available resources at a reasonable cost and within a short period of time. It would be advisable to large landholders to install tubewells with higher water discharge capacity (Chaudhary, 1975). Informal markets of irrigation water extracted by the private tubewells provide an important means of increasing access to groundwater resources for the non-tubewell owners (Meinzen-Dick, 1994). The complete failure of state tubewells in the villages has paved the way for development of the groundwater market which does not seem to be competitive because of large variations in water charges and the presence of various discriminations, particularly to the small and marginal farmers in the supply of water to them (Prasad, 1993). An increased use of groundwater has been a major source of agricultural growth in many parts of the eastern India along with Bihar, with a plentiful reserve of groundwater.

Two types of tubewells common in the eastern India are electric-operated and diesel-operated. Water applied per cropped unit of area from diesel-operated tubewell is less and consequently, cost is more than that of electric tubewells (Koondhar *et al*., 1979). Due to the poor maintenance of canal irrigation system, increasing number of tubewell water markets have developed, particularly in Bihar. Marginal and small farmers sell less water and buy more water in comparison to other categories of farmers (Singh and Singh, 2003; Narayanamoorthy, 1995; Sankar, 1994). Groundwater markets provide the institutional mechanisms for increasing the poor farmers' access to groundwater irrigation resources (Meinzen-Dick, 1993).

During the early green revolution period, tubewells emerged as the most important source of irrigation in Bihar due to their low cost of installation (Prasad, 1993). It covers nearly 46 per cent of the net irrigated area of the state, but there is still scope to increase the area under tubewell irrigation. The cheaper shallow tubewells (STWs) have entered the groundwater market and the hitherto monopolistic deep tubewells have responded to the competition in the groundwater market (Akteruzzaman *et al*., 1998). Despite financial support from the state government in the form of subsidies, only a few large and medium farmers have installed their tubewells. On the whole, it is the small and medium farmers who are the sellers while the buyers are farmers who are very poor and own scattered bits of land (Narayanamoorthy, 1995). In recent years, due to inequality in the distribution of tubewells and non-availability of canal water during the *rabi* season, most of the non-tubewell owners are forced to purchase water from the tubewell owners. It is important to mention here that the south Bihar is considered as agriculturally well developed region endowed with assured irrigation system through private diesel-operated tubewells. In this region, Nalanda is one of the districts

where vegetables, paddy and wheat are intensively cultivated. Keeping in view the importance of groundwater in increasing the agricultural production, the present study was undertaken to examine the financial viability and cost of groundwater through tubewells in the Nalanda district of Bihar (India).

Data and Methodology

The study was based on the primary data obtained from two randomly selected villages, namely Ranipur and Vishnupur in Islampur block of the Nalanda district (Bihar). A sample of 60 farmers comprising 9 from marginal, 18 from small, 21 from medium and 12 from large farms were selected through the stratified random sampling technique. The probability proportionate to size (PPS) method was adopted for the allocation of sample size among different categories of farms. The survey method was used to collect the data and information from the respondents relating to the agricultural year 2001-02. The benefit cost ratio (B:C ratio), net present value (NPV) and internal rate of return (IRR) techniques were used to examine the financial viability of tubewells in the area.

For financial analysis cash inflow and cash outflow were prepared. Cash outflow connoted the investment made on oil engine, pumps, tubewell, construction of shed, installation cost and cost of delivery pipe. The net cash inflow was the difference between the receipts from shallow tubewells and their operating costs, including minor repairs and maintenance. In the present study, the receipt included the imputed value of irrigation charges for irrigating own farm and money received from the fellow villagers for irrigating their crop land on hire basis. The benefit-cost ratio, net present value and internal rate of return were calculated.

Factors Affecting Sale and Purchase of Irrigation Water

Several socio-economic and technological factors affect the sale and purchase of irrigation water. Some of these variables have been identified as measurable. However, some factors are plot-specific and others are socio-psychological, which may not be quantified easily. For the present analysis, we had prepared six statements for each buyer and seller and the farmers were asked to answer these dichotomous questions, i.e. in yes or no. The results were computed for all farm sizes separately.

Results and Discussion

The district of Nalanda being one of the agriculturally developed districts, the cropping intensity was worked out to be 143, marginally higher than that of the Bihar state (141).

Despite low average size of holdings (0.67 ha), a comparatively high per capita income (Rs 5425), as compared to the state average (Rs 4500), was reported (2003-04). The workers constituted 38.07 per cent of the population, whereas the literacy rate (53.64%) was higher than the state average (47.53%), which might have contributed to the higher per capita income in the district. About 78 per cent of the population earned their livelihood from agriculture, which was still the main occupation in the district.

Profiles of Sample Households

As is evident from Table 1, the average size of landholdings was 2.97 ha whereas, the average sizes of marginal, small, medium and large farms were 0.58 ha, 1.50 ha, 3.03 ha and 6.85 ha, respectively. In the total operated area of 178 ha on sample farms, 90.40 per cent was the irrigated area, which depicts the importance of irrigation in this district.

Use Pattern of Tubewells

The use pattern of tubewells was analysed on the basis of their working hours on different farm-sizes in the three agricultural seasons, viz. *kharif, rabi* and *summer*. An effort was also made to analyse the tubewell-use with respect to area irrigated on different farm-size groups in all the three agricultural seasons and the results have been presented in Table 2.

An area of 7.96 ha only was irrigated on marginal farms in comparison to as much as 12.39 ha on large farms in a year, whereas, medium and small farms irrigated 10.62 ha and 8.97, respectively during the same period, . It was also revealed that marginal farmers irrigated 84.67 per cent of the area

Table 1. Profile of sample households in the Nalanda district

Categories of farms	No. of respondents	Total operating area (ha)	Average size of holdings (ha)	Average irrigated area (ha)
Marginal	9	5.22	0.58	0.52
(< 1 ha)	(15.00)	(2.93)		(88.57)
Small	18	27.00	1.50	1.35
(1-2 ha)	(30.00)	(15.16)		(90.00)
Medium	21	63.63	3.03	2.89
(>2-4 ha)	(35.00)	(35.74)		(95.29)
Large	12	82.20	6.85	5.95
(>4 ha)	(20.00)	(46.17)		(86.86)
Total	40	178.05	2.97	2.68
	(100.00)	(100.00)		(90.40)

Note: Figures within the parentheses indicate percentage to respective totals

Table 2. Use pattern of tubewells on different farm sizes

Farm category	Average irrigated crop area in different seasons (ha)								
	Kharif		*Rabi*		Summer		Sub-total		Total
	Own	Hired-out	Own	Hired-out	Own	Hired-out	Own	Hired-out	
Marginal (< 1 ha)	0.55 (14.40)	3.27 (85.60)	0.55 (14.40)	3.27 (85.60)	0.12 (37.50)	0.20 (62.50)	1.22 (15.33)	6.74 (84.67)	7.96 (100.00)
Small (1-2 ha)	1.55 (38.65)	2.46 (61.35)	1.49 (33.48)	2.96 (66.52)	0.19 (37.25)	0.32 (62.75)	3.23 (36.01)	5.74 (63.94)	8.97 (100.00)
Medium (>2-4 ha)	2.72 (54.95)	2.23 (45.05)	2.72 (53.75)	2.34 (46.25)	0.23 (37.70)	0.38 (62.30)	5.67 (53.39)	4.95 (46.61)	10.62 (100.00)
Large (>4 ha)	4.31 (74.18)	1.50 (25.82)	4.31 (74.18)	1.50 (25.82)	0.25 (32.47)	0.52 (67.53)	8.87 (71.59)	3.52 (28.41)	12.39 (100.00)

Note : Figures within the parentheses indicate the percentage of respective totals.

through tubewells by hiring out. But, on large farms, the trend was reverse, i.e. only 28.41 per cent of the area was irrigated by hiring out. On the whole, the proportion of own-irrigated area by tubewells increased with the increase in the size of farms, while irrigation by hired tubewells revealed a declining trend with increase in the farm size.

Seasonwise use pattern of tubewells indicated that during both *kharif* and *rabi* seasons, the area irrigated through hiring of tubewells by marginal farms remained around 85.6 per cent and was lower (62.5%) during the summer season. By and large, a similar trend was observed on large, medium and small farms. During the *kharif* and *rabi* seasons, the irrigated area increased with increase in farm-size in the case of own tubewells, but in hired out tubewells, it declined with increase in farm-size. During the summer season, a reverse trend was observed. It was due to the fact that none of the groups could afford to cultivate crop in summer season mainly due to higher and frequent requirement of irrigation.

Installation Cost

Installation cost included costs on digging of pit, construction of shed, drilling charges, pipe, oil engine, pumpset and delivery of pipe. On an average, installation cost per tubewell worked out to be Rs 26,251. It was higher on the large and medium size holdings, and lower for small and marginal holdings than the average cost (Table 3). It was due to fact that the large and medium farmers were interested in installing high capacity tubewells which could extract water from the lower level.

Among different components of installation cost, pumpset emerged as the most important component, accounting for 49.75 per cent of the total cost of the tubewell system in the study area. The installation cost of tubewell was estimated to be almost double on the large size of holdings due to deep drilling.

Cost of Irrigation Water

The cost of irrigation water was estimated after considering the fixed costs of tubewell installation as well as variable costs in running the tubewell. On an average, per hour cost of irrigation water was estimated to be Rs 33.51, with Rs 7.99 as fixed expenses and Rs 25.52 as variable expenses (Table 4). The per hour irrigation costs were almost identical on all the farm-size groups. It was further observed that the per hour fixed irrigation cost was highest on small farms (Rs 8.43) and lowest on marginal farms (Rs 7.29). On an average, per hour variable irrigation cost worked out to be Rs 25.52.

Table 3. Installation cost of tubewells on different farm categories

(in Rs)

Cost on different components	Farm Size				
	Marginal	Small	Medium	Large	Average
Digging of pit and construction of wall	2150 (10.97)	2725 (11.43)	3225 (11.85)	3750 (11.32)	3019 (11.50)
Pipe	3100 (15.81)	3450 (14.47)	3520 (12.92)	3926 (11.85)	3517 (13.40)
Construction of shed	2150 (10.97)	3145 (13.19)	4514 (16.58)	6000 (18.11)	4046 (15.42)
Drilling	1150 (5.87)	1250 (5.24)	1223 (4.49)	1325 (3.99)	1240 (4.73)
Pumpset	11055 (56.38)	12550 (52.63)	13500 (49.57)	14555 (43.93)	13059 (49.75)
Irrigation pipe	-	725 (3.04)	1250 (4.59)	3575 (10.79)	1370 (5.29)
Total	**19605**	**23845**	**27232**	**33131**	**26251**

Note : Figures within the parentheses indicate the percentage of respective totals.

Table 4. Cost of irrigation water on different categories of farm sizes

Categories of farm- size	Average number of working hours in one year	Average fixed expenses in one year (Rs)	Cost of irrigation water per hour in terms of fixed expenses (Rs/h)	Average variable expenses in one year (Rs)	Cost of irrigation water per hour in terms of variable expenses (Rs/h)	Cost of irrigation water per hour (Rs/h)
A	B	C	D=C/B	E	F=E/B	G=D+F
Marginal	575	4193	7.29	14713	25.57	33.86
Small	622	5246	8.43	15900	25.53	33.96
Medium	771	5991	7.77	19685	25.52	33.29
Large	886	7288	8.22	22583	25.48	33.70
Average	720	5757	7.99	18383	25.52	33.51
F-value			1.256^{NS}		0.076^{NS}	0.245^{NS}
CV (%)			18.6		10.1	10.7

NS: Non-significant

Financial Analysis

The NPV, B-C ratio and IRR were worked out separately for marginal, small, medium and large farm-size categories as well as for the sample farms. It can be seen from Table 5 that the estimated NPV of tubewell was

Table 5. Net present value (NPV), benefit:cost ratio (B:C ratio) and internal rate of return (IRR) of tubewells

Items	Marginal	Small	Medium	Large	Average
Present value of cash inflow (Rs)	18443	22831	33744	35570	28540
Investment (Rs)	19577	22540	30772	31511	21700
NPV (1-2) (Rs)	-1134	291.26	2972.00	4058.89	1440
B:C ratio	0.94:1	1.01:1	1.10:1	1.29:1	1.05:1
IRR	9.00	10.00	11.85	12.38	10.95

@ 10% interest.

positive for all the categories of farms, except marginal farms, where NPV was negative, due to underutilization of the potential of tubewells by these farm owners. It indicated that the installation of tubewells was beneficial on large, medium and small farms. The B:C ratio was worked out to be 1.29:1 on large farms, which declined with decrease in the size of holdings. The estimated IRR was 12.38 per cent for large and 11.85 per cent for medium farms, indicating that installation of tubewells was financially viable on both these groups of farms in the study villages since the estimated IRRs, for these farms were higher than the capital cost, i.e. 10 per cent. On the other hand, the estimated IRR of tubewell installation was 10 per cent on small farms, which was equal to the capital cost (10%). Hence, income of small farmers through tubewells was equal to the investment and a minor reduction in tubewell use would adversely affect the financial viability of tubewells in this category of farms. The IRR was 9 per cent on marginal farms, which was less than the capital cost. Hence, there was no financial viability of tubewells on marginal farms, mainly due to their underutilization on this category of farms.

Factors Influencing Sale and Purchase of Irrigation Water

The availability of surplus water with the owners of tubewell (45%) was the most important factor for the sale of water, followed by the location of buyers' land (18.32%) near to tubewell. Profit motive (11.67%) and social relation (11.67%) were the next important factors for the sale of water. Other two factors, namely intensive cultivation (6.67%) and utilization of potential (6.67%) were not identified as important factors for the sale of water on farms under investigation (Table 6).

While analysing the factors responsible for the purchase of irrigation water, it was revealed that the non-ownership of tubewell was the most important factor (69.09%) for the purchase of water in the study villages. It was expected also because there was no other source of irrigation in these

Table 6. Factors influencing sale and purchase of irrigation water on different categories of farms

Items	Marginal	Small	Medium	Large	Total
Factors influencing sale of irrigation water					
(i) Surplus water	5(55.56)	12(66.67)	7(33.33)	3(25.00)	27(45.00)
(ii) Buyer's land located in vicinity of tubewell	3(33.33)	3(16.67)	3(14.28)	2(16.67)	11(11.32)
(iii) Profit in sale	1(11.11)	2(11.11)	4(19.05)	-	7(11.67)
(iv) Social relation with buyers	-	1(5.55)	3(14.28)	3(25.00)	7(11.67)
(v) Intensive cultivation	-	-	2(9.53)	2(16.66)	4(6.67)
(vi) To utilize full potential of tubewell	-	-	2(9.53)	2(16.66)	4(6.67)
Total	9 (100.00)	18 (100.00)	21 (100.00)	12 (100.00)	60 (100.00)
Factors influencing purchase of irrigation water					
(i) Non-owner of tubewell	45(75.00)	60(80.00)	8(34.78)	1(14.28)	114(69.09)
(ii) Fragmented holdings	6(10.00)	6(8.00)	8(34.78)	3(42.86)	23(13.94)
(iii) Small holdings	7(11.67)	5(6.67)	-	-	12(7.27)
(iv) Higher tubewell density	-	1(1.33)	3(13.04)	2(28.57)	6(3.64)
(v) Increased liquidity due to institutional credit	2(3.33)	3(4.00)	3(13.04)	-	8(4.85)
(vi) Longer dry spell	-	-	1(4.35)	1(14.28)	2(1.21)
Total	**60 (100.00)**	**75 (100.00)**	**23 (100.00)**	**7 (100.00)**	**165 (100.00)**

Note : Figures within the parentheses indicate the percentage of respective totals.

villages. Fragmented holdings (13.94%) was the second important factor, followed by small holdings (7.27%).

Water Marketing Process

The analysis of tubewell water marketing process was based on the information relating to 225 sample households comprising 165 water purchasers and 60 tubewell owners. All farms under study were categorized into five groups, namely buyers, owners-buyers, owners-buyers-sellers, owners-sellers and owners (Table 7). A perusal of Table 7 revealed that there were only 6 tubewell owners (10.0%) who did not participate in water marketing in the study villages. Out of these six tubewell owners, 4 belonged to large-size farms and 2 to medium-size farms. They installed tubewells for their own use. In the 54 tubewell owners (90.0%) who participated in the water marketing system, there were 24 owners-sellers (10.7%) who utilized tubewells for their own use as well as provided water to other farmers for irrigation on payment basis.

Table 7. Water marketing across different farm categories

Farm category	Buyers	Owners + Buyers	Owners + Buyers + Sellers	Owners + Sellers	Owners	Total
Marginal	60	2	2	6	-	70
	(85.71)	(2.86)	(2.86)	(8.57)		(100.00)
Small	75	4	4	9	-	92
	(81.52)	(4.35)	(4.35)	(9.78)		(100.00)
Medium	23	6	7	6	2	44
	(52.27)	(13.64)	(15.91)	(13.64)	(4.54)	(100.00)
Large	7	3	2	3	4	19
	(36.84)	(15.79)	(10.53)	(15.79)	(21.05)	(100.00)
Total	**165**	**15**	**15**	**24**	**6**	**225**
	(73.33)	**(6.66)**	**(6.66)**	**(10.66)**	**(2.66)**	**(100.00)**

Note : Figures within the parentheses indicate the percentage of respective totals.

The farm size-wise analysis revealed that the owners-sellers category of farms dominated in the water market in study villages. Six out of nine marginal farmers and twelve out of eighteen small farmers participated in water market. There were 15 tubewell owners who purchased water for irrigation purposes and utilized their own tubewells also for irrigating their own land but did not sell water to other farmers. A majority of owners-buyers farms (9 out of 15) belonged to either medium or large size group. In general, marginal and small farmers could not afford to be owners of tublewells and were buyers only. However, they were engaged in selling

the tubewell water to make their tubewell financially viable. The category of owners-buyers-sellers farms (15 farms) had water distribution pattern identical to that of owners-buyers category of farms.

Conclusions

It has been found in the study that a majority of tubewell owners fall in the area in the category of small and medium farms, who use their tubewells mainly for hiring out purposes .The large and medium farms use them for their own purposes. Among different categories of farms, the cost on installation of tubewells has been found higher by large farmers because of deep drilling. It has also been observed that only the marginal farms in the study area could not generate sufficient cash inflow so as to meet the installation and operation costs. Financial analysis like B:C ratio and IRR has confirmed the economic viability of the tubewell groundwater irrigation system in the study area, except in marginal farms. Water marketing analysis has revealed that the surplus water and vicinity of buyer's land to tubewells play an important role in influencing the sale of irrigation water. The study has revealed that the owners-sellers category of farms predominates the water market in the area. .

Since, it is the small and marginal farm category that participates in water market on a large scale, there is a need to provide cheaper and assured irrigation water supplies through either surface irrigation or assured electricity supply to these weaker sections of the rural society. Subsidy for tubewell installation to these farmers would further reduce their dependence on large farmers for irrigation of their crops. A serious effort is, therefore, needed at the policymaking level for reducing the irrigation cost through providing subsidized electricity/ diesel, subsidy for tubewell installation to small and marginal farmers or development of canal irrigation system. It will help in increasing agricultural production and securing livelihood for marginal and small households of farmers.

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