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Effect of Sand Mining on Economic Performance of Groundwater Irrigation in Cuddalore District of Tamil Nadu

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Abstract

The effect of sand mining on the economic performance of groundwater irrigation has been studied in the Panruti taluk of Cuddalore district in Tamil Nadu. A comparison of water productivity for different farms-size categories has been done in sand mining and non-sand mining blocks. The cropping sequence, cropping intensity, irrigation particulars, investment pattern on tubewells, use of different HP-motors, etc. have been studied in sand mining and non-sand mining blocks. The study has revealed that due to sand mining externality, the watertable has gone down and to offset this effect, the farmers have been increasing the horse-power of their motors. Thus, investment has been increasing in the sand mining block in all farm-size categories. Its repercussions have been reflected in the economic performance of sand mining block in terms of higher annual cost and unit cost of irrigation. The study has suggested to take necessary steps to augment the groundwater recharge on one hand and imposing restrictions on indiscriminate sand mining on the other hand. The regulation of sand quarrying has also been suggested to streamline the flow of river Malattar.

Introduction

In Tamil Nadu, 70 per cent of the population depends on agriculture for its livelihood and irrigation plays a major role in ensuring agricultural productivity. Among the sources of irrigation, groundwater dominates with around 60 per cent share in the gross irrigated area of the state. Along the riparian areas, sand beds serve as a recharge-augmenting source of groundwater. Sand is accumulated in layers along the river path, due to natural flow of surface water during monsoons. These layers form a spongy surface, which enhances groundwater recharge. The sustainable management of groundwater resource lies in matching and manoeuvring the recharge and the extraction factors. The primary source of groundwater recharge is rainwater which depends on the soil type, its physical properties, topography, nature of vegetation, etc. Thus, a proper harvesting of rainfall assumes significance in recharging the groundwater. The surface irrigation sources like rivers, canals and tanks serve as the major secondary sources of groundwater recharge. On the other side, the extraction factors constitute different types of wells and groundwater lifting devices, which cater to the intersectoral water demand. The disturbances in either the recharge facilitating factors or abstraction factors dislocate the groundwater balance, which leads to externalities. Thus, the human-induced problems affect the performance of agriculture and its prospects will be gloom unless timely and prudent rescue measures are not taken.

The tail end of the Malattar command area in Cuddalore district of Tamil Nadu faces the sand mining problems. This area is characterized by sandy loam soil where paddy is the predominant crop. The

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topography slopes downwards, which facilitates its natural flow towards the Bay of Bengal, from the west to east. However, indiscriminate sand mining in the Malattar river has obstructed the natural flow, leading to interrupted water flow. This problem has led to poor groundwater recharge, which in turn, has affected the agricultural performance of this area.

In this study, a comparison of water productivity for various sizes of holdings in the two sand mining regimes has been made. The cropping sequence, cropping intensity, irrigation particulars, distribution of motor HP investment pattern on tubewells and their performance in terms of unit cost of irrigation water in sand mining and non-sand mining blocks have been studied.

Sampling Design

This study was conducted in the Malattar command area of Panruti taluk in Cuddalore district of Tamil Nadu. Two blocks, viz. Panruti and Annagramam, were purposively selected for the study, since they were experiencing the externalities of irregular and interrupted river flow at varying levels due to indiscriminate sand mining. Between the two blocks, the problem of sand mining was acute in the Panruti block and therefore, it was termed as 'sand mining block'. The problem was sporadic in the Annagramam block and hence, it was denoted as 'non-sand mining block'. A quota of 60 respondents was allotted to each block and they were distributed as 30 each between the two randomly selected villages (Veerparumanallur and Siruvathur in the Panruti block and Thropadi and Oriayur in the Annagram block). In each village, a sample of 30 households was selected randomly. Thus, the total sample size constituted 120 farm households. The field investigations were carried out during September 2006 to February 2007.

Tools of Analysis

Different valuation methods and simple percentage analysis were used to analyze the primary and secondary data and to interpret the observed results.

Cost of Irrigation Water

In this analysis, the marginal cost of water was calculated by the volumetric pricing method (Johnsson, 2000). The investment on tubewell installation was arrived at by assessing the cost of various components (Michael and Khepar, 1989), from which the annual cost of irrigation was computed, both for the existing condition of free electricity and with inclusion of imputed charges for electricity by taking into account fixed and variable costs of irrigation. The annual cost (C) was worked out by formula. (1) as:

$$C = \sum_{j=1}^{n} r_j k_j + \sum_{k=1}^{n} O_k \qquad \ldots(1)$$

where, r_j is the capital recovery factor (CRF) for the j^{th} component of capital cost, and is given by Equation (2):

$$r_j = \frac{i(1+i)^n}{(1+i)^n - 1} \qquad \ldots(2)$$

where,

i = Rate of interest (8.5 %),

n = Estimated life of capital asset (20 years),

k_j = Present value of cost components like pipes, motor, pumps, pumpshed, etc., and

O_k = The k^{th} component of operating cost of electricity, annual repairs, maintenance, etc. (Imputed electricity charges were Rs 0.50 per kwh).

The electricity consumption was calculated by the formula (3):

$$\text{Electricity consumption} = \frac{\text{Horst Power} \times \text{Duration of Pumping (hours)}}{0.75} \qquad \ldots(3)$$

The average cost of water was calculated by dividing the annual cost of irrigation with the quantity of water pumped out in a year. The total quantity of water pumped out in a year was calculated by multiplying the annual running hours with the quantity of water discharged in an hour, i.e.

Annual running hours =

$$\sum_{j=1}^{n} \begin{bmatrix} \text{Time taken to} \\ \text{irrigate one ha} \\ \text{of the } n^{th} \text{ crop} \end{bmatrix} \times \begin{bmatrix} \text{Total No. of} \\ \text{irrigations} \\ \text{of the } n^{th} \text{ crop} \end{bmatrix} \times \begin{bmatrix} \text{Area in ha} \\ \text{under the} \\ n^{th} \text{ crop} \end{bmatrix}$$

where, n denotes the number of crops grown in a year.

For calculating the quantity of water pumped out, discharge capacity (Q) was assessed by formula (4):

$$Q = \frac{HP \times E \times 75}{H} \qquad \ldots(4)$$

where,

Q = Discharge rate of pumping in litres / second
H = Total head in metres, and
E = Overall efficiency of the pumping plant (75%)

Annual quantity of water pumped out =

$$\begin{bmatrix}\text{Annual}\\ \text{running}\\ \text{hours}\end{bmatrix} \times \begin{bmatrix}\text{Disch arg e}\\ \text{Capacity in}\\ \text{litres / sec ond}\end{bmatrix} \times 3600$$

Results and Discussion

Size of Holding and Irrigation Endowments

A perusal of Table 1 revealed that 13 farmers purchased water in the sand mining block, and 11 farmers purchased water in the non-sand mining block. The water purchasing was prevalent only among the small and marginal farm categories in both the blocks. Hence, for further analysis in this study, the sample size of 47 in sand mining and 49 in non-sand mining was considered by excluding the water purchasers.

Cropping Sequence

The cropping sequence followed in the sample farms has been reported in Table 2. A perusal of Table 2 revealed that in both the blocks the percentage of farmers following the cropping sequence of paddy-paddy-black gram was lower as compared to other cropping schemes. The number of farmers following the monoculture of paddy, i.e. paddy–paddy–paddy, was higher in the sand mining block than non-sand mining block. The percentage of farmers growing sugarcane was higher (61.7%) in the sand mining block than non-sand mining block (55.1%). Hence, it could be inferred that the more water-extracting crops were in higher proportion in the sand mining block, that aggravated the problem of groundwater depletion in the area, which was already prone to deprivation in groundwater replenishment due to the sand mining problems.

Among the size categories, more than 50 per cent of the small and marginal farms in both the blocks practised monoculture of paddy throughout the year. The paddy-paddy-black gram sequence was followed in a higher proportion by large farmers in both the blocks. Sugarcane cultivation was not in higher order among the small and marginal farmers of both the blocks and it was in higher order with medium farms. The share of large farms in sugarcane cultivation was very low.

Cropping Intensity

The cropping intensity of the sample farms, presented in Table 3, revealed that the average cropping intensity was higher in the non-sand mining block than sand mining block. In both the blocks, the highest cropping intensity was recorded by the marginal and small farms. This might be due to the

Table 1. Size of holding and irrigation endowments of the sample farms

Farm-size category	Sand mining block						Non-sand mining block					
	Farmers purchasing water			Own borewell			Farmers purchasing water			Own bore well		
	No.	Area ha	Average area, ha	No.	Area ha	Average area, ha	No.	Area ha	Average area, ha	No.	Area ha	Average area, ha
Marginal farmers <1 ha	10	3	0.30	8	6	0.85	7	4	0.57	9	7	0.77
Small farmers 1-2 ha	3	6.0	2.0	17	30.5	1.79	4	5.5	1.37	21	36	1.71
Medium farmers 2.1-4 ha	0	0	0	16	54.5	3.40	0	0	0	13	43	3.30
Large farmers > 5 ha	0	0	0	6	39	6.50	0	0	0	6	39	6.50
Total	13	9.0	0.69	47	130	12.54	11	9.5	0.86	49	125	12.28

Table 2. Cropping sequence in sand mining and non-sand mining blocks

(in number)

Cropping pattern	Sand mining block				Non-sand mining block			
	Marginal and small	Medium	Large	Total	Marginal and small	Medium	Large	Total
Paddy-paddy-black gram	6	2	3	11	8	4	5	17
	(54.54)	(18.18)	(27.27)	(100.00)	(47.05)	(23.52)	(29.41)	(100.00)
Paddy-paddy- paddy	14	13	3	30	13	5	1	18
	(46.66)	(43.33)	(10.00)	(100.00)	(66.66)	(27.77)	(5.57)	(100.00)
Sugarcane	9	14	6	29	9	12	6	27
	(31.03)	(48.27)	(20.68)	(100.00)	(33.33)	(44.44)	(22.22)	(100.00)
All farms	25	16	6	47	30	13	6	49
	(53.19)	(34.04)	(12.76)	(100.00)	(61.22)	(26.53)	(12.24)	(100.00)

Notes: Figures within the parentheses are percentages to total

Table 3. Cropping intensity of sample farms

(in percentage)

Particulars	Sand mining block	Non-sand mining block
Marginal and small farmers	214.0	255.0
Medium farmers	129.1	160.0
Large farmers	146.5	167.0
Average	176.5	239.4

availability of adequate irrigation water for the marginal and small farm-size groups in all the seasons.

Groundwater Irrigation

The general particulars of groundwater irrigation have been presented in Table 4. A perusal of Table 4 reveals that two types of wells, dug-cum-bore well (DCBW) and tubewell (TW), existed in the study area, wherein tubewells had replaced dug-cum-bore wells with a high share of around 80 per cent in both sand mining and non-sand mining blocks. The average age of wells revealed that the dug-cum-bore well was an age-old technology and most of the DCBWs were operating beyond their economic life-period, whereas the tubewell technology was of recent origin introduced within a span of 15 years. However, for the investment and performance analysis, the dug-cum-borewell and tubewell were treated alike. The seasonal watertable fluctuations had a wider range in the sand mining than non-sand mining block.

A comparison of depth of wells between the blocks showed that both the initial and present depths were higher in the sand mining than non-sand mining block. The number of deepenings and depths of deepening led to infer that the problem of decline in watertable was more acute in the sand mining than non-sand mining block.

Distribution of Motor HP among Farm-size Categories

The HP distribution among the sample farms, presented in Table 5, shows that in the sand mining block the 15 HP motor constituted a higher share, while in the non-sand mining block, 12.5 HP occupied a major share among various HP categories. Among the marginal and small farm categories, the12.5 HP and 15 HP motors were evenly spread and the 10 HP motors had a marginally lower share. In the medium farm category, the major share was of 15 HP (50%) in the sand mining block and of 12.5 HP (54%) in the non-sand mining block. In the case of large farms, 15 HP motors were in higher share in both the blocks, as 50 per cent of farmers in the sand mining block and more than 60 per cent of farmers

Table 4. Groundwater irrigation particulars in sand mining and non-sand mining blocks

Particulars	Sand mining block	Non-sand mining block
Type of wells (in numbers)		
Dug-cum bore wells (DCBW)	8 (17.0)	11 (22.5)
Tubewells	39 (83.0)	38 (77.5)
Total	47 (100.0)	49 (100.0)
Average age of wells (years)		
Dug-cum bore wells (DCBW)	31.0	31.1
Tubewells	7.9	5.4
Total	47 (100.0)	49(100.0)
Total depth deepened (in metres)		
Initial depth	28.5	27.3
Present depth	38.1	33.3
Total depth deepened	9.6	6.0
Number of deepenings	3.6	2.9
Depth in season (in metres)		
Sampa season	34.8	31.8
Karuvai season	40.0	34.8
Seasonal difference	17	10

Notes: Figures within the parentheses are percentages to total

Table 5. Distribution of horse power of motors among different farm–size categories

(in No.)

Particulars	Sand mining block				Non-sand mining block			
	10 HP	12.5 HP	15 HP	Total	10 HP	12.5 HP	15 HP	Total
Marginal and small farmers	7	9	9	25	4	16	10	30
	(28.0)	(36.0)	(36.0)	(100.0)	(13.3)	(53.3)	(33.3)	(100.0)
Medium farmers	4	4	8	16	2	7	4	13
	(25.0)	(25.0)	(50.0)	(100.0)	(15.4)	(53.8)	(30.8)	(100.0)
Large farmers	1	2	3	6	0	2	4	6
	(16.7)	(33.3)	(50.0)	(100.0)	(0.0)	(33.3)	(66.7)	(100.0)
Total	12	15	20	47	6	25	18	49
	(25.5)	(31.9)	(42.6)	(100.0)	(12.2)	(51.0)	(36.7)	(100.0)

Note: Figures within the parentheses indicate percentage to total values

in the non-sand mining block owned 15 HP motors. In general, farmers with higher HP motors were more in the sand mining block.

Investment Pattern on Tubewells

The investment pattern on tubewells in the sample farms has been presented in Table 6. Among different cost components of tubewell irrigation, the costs on boring accounted for the highest share in both the blocks, followed by pipe cost and motor + pump cost. Between the blocks, a wide difference in the average cost component was noticed in the case of electric accessories and pump shed. The electric accessories accounted for around 13 per cent share in the sand mining block which was double of that in the non-sand mining block (6 %). In absolute terms, the average total investment was higher in the sand mining than non-sand mining block .

Performance of Tubewells and Unit Cost of Irrigation Water

Economic performance of tubewell irrigation in terms of water pumped out per farm, hours of

Table 6. Investment pattern on tubewells in sand mining and non-sand mining blocks

(in Rs)

Particulars	Sand mining block				Non-sand mining block			
	Marginal and small	Medium	Large	Weighted average	Marginal and small	Med	Large	Weighted average
Motor + Pump	21172	23057	21918	21762	18751	20615	20469	19456
	(22.58)	(21.93)	(21.17)	(22.03)	(13.35)	(24.00)	(21.14)	(23.06)
Pipe	22990	28494	28841	25377	21562	24636	29905	23399
	(24.51)	(27.11)	(27.86)	(25.69)	(15.35)	(28.70)	(31.28)	(27.74)
Boring	32160	31625	33000	32108	29166	32384	31833	30346
	(34.29)	(30.08)	(31.87)	(32.50)	(20.77)	(37.73)	(33.29)	(35.98)
Electricaccessories	13085	14435	14044	13589	12981	4791	5777	5127
	(13.95)	(13.53)	(13.58)	(13.75)	(9.25)	(5.58)	(6.14)	(6.07)
Miscellaneous accessories	313	277	300	326	281	300	233	208
(transport + repair and maintenance)	(0.33)	(0.30)	(0.28)	(0.33)	(0.24)	(0.38)	(0.34)	(0.34)
Pump shed	3300	5712	3782	4148	56770	2276	6801	4912
	(3.55)	(5.53)	(3.65)	(4.19)	(40.43)	(2.65)	(7.20)	(5.85)
Pebble, etc.	752	1500	1666	1495	870	807	583	817
	(0.80)	(1.52)	(1.60)	(1.51)	(0.61)	(0.94)	(0.61)	(0.96)
Total	93774	105101	103520	98780	140383	85813	95605	84342
No. of samples	25	16	6	47	30	13	6	49

Notes: Figures within the parentheses are percentages to total

pumping and unit cost of irrigation with and without imputed electricity cost in the sand mining block have been presented in Table 7 for both sand mining and non-sand mining blocks. A perusal of Table 7 revealed that the total quantity of water lifted per farm and hours of pumping increased with increase in the farm-size in both the blocks. The water output per hour was almost the same in all farm-size categories in the sand mining block, but it increased with increase in farm-size in the non-sand mining block. The annual cost of irrigation also increased with increase in the farm-size in both the blocks. The units of irrigation, viz., Rs/ha-cm and Rs /hour had inverse relationship with the farm-size in both the blocks. The average increase in irrigation cost with imputed electricity charges over the free electricity was 78 per cent in sand mining block and about 40 per cent in non-san mining block. The escalation in the cost was much higher in the case of large farmers than other farmers.

The percentage increase in the costs with electricity charges was much higher in the sand mining than non-sand mining block in all farm-sizes. This could be due to the higher electricity consumption in the sand mining block because of its deeper watertable and consequently, higher HP of motors.

Conclusions

The study has revealed that cropping intensity is in higher magnititude in the non-sand mining than sand mining block. However, highest cropping intensity has been recorded by the marginal and small farms in both the blocks. In general, the farmers with higher HP motors are in higher proportion in the sand mining block. The seasonal watertable fluctuations have a wider range in the sand mining than non-sand mining block. The investment pattern on tubewells in the sample farms has exhibited that in absolute terms the total investment cost is higher in the sand mining than non-sand mining block in all farm-size categories.

The groundwater irrigation performance has shown that the water output per hour is almost the same in all farm-size categories in the sand mining

Table 7. Performance of tubewells and unit cost of irrigation water in sand mining and non- sand mining blocks

Particulars	Water pumped out per farm (ha-cm)	Hours of pumping per farm	Water output per hour (ha-cm)	Without electricity cost			With electricity cost		
				Annual cost (Rs)	Rs per ha-cm	Rs per hour	Annual cost (Rs)	Rs per ha-cm	Rs per hour
A. Panruti (Sand mining) block									
Marginal & small farmers	353	1464	0.24	17505	51.20	12.36	27210	78.65	18.99
Medium farmers	475	1876	0.25	18132	38.13	9.66	30157	63.42	16.07
Large farmers	1002	4350	0.23	18418	17.98	4.23	47438	46.32	10.90
Average	480	1973	0.24	18154	42.50	10.40	31115	69.34	16.96
B. Annagramam (non-Sand mining) block									
Marginal & small farmers	277	811	0.34	14941	53.86	18.42	20062	82.32	24.73
Medium farmers	699	1066	0.65	15584	22.27	14.61	22559	32.24	21.14
Large farmers	3066	1614	1.89	16650	5.43	10.32	27979	9.11	17.32
Average	730	977	0.74	15321	39.55	16.42	21690	53.95	22.87

Source: Figures within parentheses are increase in the percentages of cost on irrigation with electricity over without electricity

block, but the annual cost of irrigation increases with increase in the farm-size. The annual cost has exhibited a marginal difference without electricity cost, but it has accounted for a substantial difference with imputed value of electricity cost. The escalation in the cost due to imputed electricity charges has been found much profound in the case of large farms.

In the non-sand mining block, the average water output is substantially higher with reduced pumping hours, despite the fact that the pumping hours are only half of those in the sand mining block in all farm-size categories. The percentage increase in the cost with electricity charges has been higher in the sand mining than non-sand mining block in all farm-sizes. This could be due to higher electricity consumption in the sand mining block because of its higher depth of watertable and consequently use of higher HP motor. Thus, it could be inferred that small and marginal farmers are not taxed much compared to medium and large farmers, if electricity charge is levied.

The study has concluded that due to sand mining externality the watertable has gone down and to offset this effect, the HP of motor is being increased. Its repercussions have been reflected in the economic performance of this block in terms of increased annual cost and unit cost of irrigation. Hence, necessary steps should be taken by the officials to augment the groundwater recharge, and by imposing restrictions on indiscriminate sand mining. The regulated sand quarrying needs to be implemented to streamline the flow of river in this area.

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