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
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:

\[
C = \sum_{j=1}^{n} r_j k_j + \sum_{k=1}^{n} O_k \quad \ldots(1)
\]

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

\[
r_j = \frac{i(1+i)^n}{(1+i)^n-1} \quad \ldots(2)
\]

where,

- \( i = \text{Rate of interest (8.5 %)} \)
- \( n = \text{Estimated life of capital asset (20 years)} \)
- \( k_j = \text{Present value of cost components like pipes, motor, pumps, pumpshed, etc., and} \)
- \( O_k = \text{The} k^{th} \text{ component of operating cost of electricity, annual repairs, maintenance, etc.} \)

(Imputed electricity charges were Rs 0.50 per kwh).

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

\[
\text{Electricity consumption} = \frac{\text{Horse Power} \times \text{Duration of Pumping (hours)}}{0.75} \quad \ldots(3)
\]

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.

\[
\text{Annual running hours} = \sum_{j=1}^{n} \left[ \frac{\text{Time taken to irrigate one ha of the} n^{th} \text{ crop}}{\text{Total No. of irrigations of the} n^{th} \text{ crop}} \times \frac{\text{Area in ha under the} n^{th} \text{ crop}}{\text{Area in ha under the} n^{th} \text{ crop}} \right]
\]
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):

\[
Q = \frac{HP \times E \times 75}{H} \quad \text{(4)}
\]

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 =

\[
\left( \text{Annual running hours} \right) \times \left[ \frac{\text{Discharge Capacity in litres/second}}{3600} \right]
\]

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 2. Cropping sequence in sand mining and non-sand mining blocks (in number)

<table>
<thead>
<tr>
<th>Cropping pattern</th>
<th>Sand mining block</th>
<th>Non-sand mining block</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Marginal and small</td>
<td>Medium</td>
</tr>
<tr>
<td>Paddy-paddy-black gram</td>
<td>6 (54.54)</td>
<td>2 (18.18)</td>
</tr>
<tr>
<td>Paddy-paddy-paddy</td>
<td>14 (46.66)</td>
<td>13 (43.33)</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>9 (31.03)</td>
<td>14 (48.27)</td>
</tr>
<tr>
<td>All farms</td>
<td>25 (53.19)</td>
<td>16 (34.04)</td>
</tr>
</tbody>
</table>

Notes: Figures within the parentheses are percentages to total.

Table 3. Cropping intensity of sample farms (in percentage)

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Sand mining block</th>
<th>Non-sand mining block</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marginal and small farmers</td>
<td>214.0</td>
<td>255.0</td>
</tr>
<tr>
<td>Medium farmers</td>
<td>129.1</td>
<td>160.0</td>
</tr>
<tr>
<td>Large farmers</td>
<td>146.5</td>
<td>167.0</td>
</tr>
<tr>
<td>Average</td>
<td>176.5</td>
<td>239.4</td>
</tr>
</tbody>
</table>

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 DCBW 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, the 12.5 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
In general, farmers with higher HP motors were more prevalent in the non-sand mining block. The electric accessories and pump shed 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.

**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...
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-sand mining block. The escalation in the cost was much higher in the case of large farmers than other farmers. The escalation 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 magnitude 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

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Water pumped out per farm (ha-cm)</th>
<th>Hours of pumping per farm</th>
<th>Water output per hour (ha-cm)</th>
<th>Without electricity cost Annual Rs per ha-cm</th>
<th>Rs per hour</th>
<th>With electricity cost Annual Rs per ha-cm</th>
<th>Rs per hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Panruti (Sand mining) block</td>
<td>Marginal &amp; small farmers</td>
<td>353</td>
<td>1464</td>
<td>0.24</td>
<td>17505</td>
<td>51.20</td>
<td>12.36</td>
</tr>
<tr>
<td></td>
<td>Medium farmers</td>
<td>475</td>
<td>1876</td>
<td>0.25</td>
<td>18132</td>
<td>38.13</td>
<td>9.66</td>
</tr>
<tr>
<td></td>
<td>Large farmers</td>
<td>1002</td>
<td>4350</td>
<td>0.23</td>
<td>18418</td>
<td>17.98</td>
<td>4.23</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>480</td>
<td>1973</td>
<td>0.24</td>
<td>18154</td>
<td>42.50</td>
<td>10.40</td>
</tr>
<tr>
<td>B. Annagaramam (non-Sand mining) block</td>
<td>Marginal &amp; small farmers</td>
<td>277</td>
<td>811</td>
<td>0.34</td>
<td>14941</td>
<td>53.86</td>
<td>18.42</td>
</tr>
<tr>
<td></td>
<td>Medium farmers</td>
<td>699</td>
<td>1066</td>
<td>0.65</td>
<td>15584</td>
<td>22.27</td>
<td>14.61</td>
</tr>
<tr>
<td></td>
<td>Large farmers</td>
<td>3066</td>
<td>1614</td>
<td>1.89</td>
<td>16650</td>
<td>5.43</td>
<td>10.32</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>730</td>
<td>977</td>
<td>0.74</td>
<td>15321</td>
<td>39.55</td>
<td>16.42</td>
</tr>
</tbody>
</table>

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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References


