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Energy Use and its Efficiency in Tamil Nadu Agriculture: A Case Study of Different Groundwater Development Regions in Coimbatore District of Tamil Nadu

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Abstract

The study has revealed that over-exploitation of groundwater has effected drastic changes in energy input-use and energy output produced across the regions in Coimbatore district and the Tamil Nadu state. Energy equivalent values have been used for various direct sources of energy (human, animal and mechanical power), indirect sources (fertilizers, pesticides, manures), commercial, non-commercial, renewable and non-renewable energy sources to analyse the economics of energy usage in the agricultural production process in the two different groundwater development regions of the Coimbatore district. Energy inputs usage has been found very high in groundwater less-exploited area of Perur in paddy and cotton crops. For the coconut crop, Palladam block has shown consumption of more energy-inputs. Energy output-input ratios for paddy, coconut and cotton have been reported as 0.85, 29.35 and 0.09 in Perur region and 0.76, 13.20 and 0.09 in Palladam region. The energy efficiency has been observed higher in coconut crop among crops and in Perur among regions. Not much difference has been observed in gross value of output per MJ of energy input in paddy and cotton crops among groundwater severely-exploited and less exploited regions.

Introduction

When crop production was practised mostly under rain-fed conditions with more or less static technology, development of irrigation was mainly through exploitation of surface water, and irrigation was primarily protective and extensive. The increasing trend of well and borewell-irrigation has resulted a rise in net irrigated area, which ultimately has led to over-exploitation of groundwater (Janakarajan, 1993). Saini *et al*. (1998) have found that the cropping systems were more energy-efficient under irrigated than un-irrigated conditions. It was because of a higher yield under irrigated conditions as the irrigation does not involve substantial energy inputs other than human labour, implying thereby that energy efficiency of crops can be significantly improved through irrigation in Himachal Pradesh.

The increase in number of wells is inconsistent with the total investment and has resulted in a situation in which a large number of well-owners are competing to extract water from the limited available aquifers, with a concomitant secular lowering of the groundwater table. While the use of groundwater on a wider scale may provide scope for more extensive access to this resource, one should also be concerned with the economic implications and rising social costs of its exploitation. The over-exploitation of groundwater influences drastic

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changes in energy input-use and energy output-produced across the state. Birthal *et al*. (1998) have reported that the demand for commercial energy based inputs like fertilizers and diesel would increase with shift in cropping pattern from coarse cereals to fine cereals or commercial crops. Energy-use efficiency can be improved by practising good husbandry, as there is scope for increasing yield through higher input-use efficiency. Singh *et al*. (1998) and Subramaniyam *et al*. (1998) have reported that energy efficiency was low on large farms as they were using more irrigation energy, especially groundwater, because of the scale bias of this source of irrigation. They have also reported that the contribution of traditional inputs was higher than that of modern inputs due to the high energy intensity of groundwater irrigation

To understand this effect, a study was attempted in the Coimbatore district of Tamil Nadu to analyse and compare the economics of energy input-use and output produced in different groundwater potential areas of this region.

Methodology

The difference and the transition between the groundwater development among the three classified regions was much sharper and for the present study, both the extremes were taken as sample. The emphasis in this study was not on the official classification of groundwater development but on the degree of exploitation of groundwater in the region. For the study, the Perur and Palladam blocks were selected considering the stage of groundwater development in these blocks and probable number of feasible wells. The Perur block comes under the less-exploited area (region I) and the Palladam block comes under severely-exploited area (region III). Sixty farmers in each block growing paddy, coconut and cotton crops were selected randomly to make a total of 120 farmers who were surveyed for analysis.

Energy equivalent values were used for various sources of energy, viz. direct (human, animal and mechanical power), indirect (fertilizers, pesticides, manures), commercial, non-commercial, renewable and non-renewable to analyse the economics of energy usage in the agricultural production process in the two different groundwater development regions of the Coimbatore district. Standard values of energy equivalent units of various farm inputs and outputs were used.

Table 1. Irrigation details in the Perur and Palladam blocks (Tamil Nadu)

Particulars	Perur	Palladam
Average size of landholding (ha)	3.61	1.46
Average depth of well (m)	133.20	216.90
Water table in a normal year (m)	82.80	132.90
Water table in a dry year (m)	122.40	190.20
Duration of water supply per day in a normal year (hours)	9.2	4.9
Duration of water supply per day in a dry year (hours)	6.9	3.6
Average horse power, HP	6.7	7.8
Average output (hours/day)	9.2	4.9

Results and Discussion

Changes in Cropping Pattern

The average size of irrigated landholding was much smaller (1.46 ha) in the Palladam (over-exploited region) block; it was less than 50 per cent of the average landholding in the Perur (less-exploited area) block (3.61 ha) (Table 1). The average depth of well was higher in the Perur than Palladam block during a normal year and the duration of water supply was 9.2 h and 4.9 h, respectively (Table 2). This over-exploitation of groundwater has resulted in a situation in which certain portion of their lands is left un-irrigated. Ten years ago, almost 100 per cent of the landholdings were able to get sufficient irrigation in both the regions (Table 3). Certain crops have become obsolete during the ground-water depletion stages. Crops like, sugarcane and paddy in Perur, and groundnut and cotton in Palladam, grown 10 years ago have become obsolete (Table 3).

The average per day pumping hours in a normal year were 4.9 and 9.2 in the Palladam and Perur regions, respectively. The low water level and short-duration of water supply have compelled the farmers of Palladam region to limit the number and duration of their irrigations (Table 4).

Table 2. Month-wise water level and pumping hours in the Perur and Palladam blocks

Months	Perur		Palladam	
	Height (m)	Supply (hours)	Height (m)	Supply (hours)
January	81.90	9.2	114.00	5.5
Feb	99.90	7.8	117.00	4.1
March	98.70	7.7	122.10	4.2
April	125.40	6.7	165.60	4.3
May	122.10	4.8	174.00	3.4
June	124.20	4.5	197.10	2.5
July	105.90	7.7	195.30	2.5
August	87.00	10.7	174.00	3.4
September	75.00	12.1	92.10	6.0
October	72.60	12.3	93.60	6.1
November	90.00	13.6	80.40	7.5
December	87.60	13.6	71.70	8.5
Average	83.10	9.2	133.20	4.9

The limited availability of water resource had affected other inputs-use pattern in such a way that except paddy, fertilizer inputs were being used at a higher level in Palladam region, where water was excessively exploited with the anxiety of obtaining higher yields. In less-exploited area of Perur, labour consumption was more, implying that the labour force was being utilized for irrigation purposes (Table 5). Even though the fertilizer inputs-use was more in the groundwater over-exploited area, the less availability of irrigation, shorter duration of water supply and the lesser number of irrigations resulted in lower yields of paddy, coconut and cotton crops (Table 4).

Economics of Energy Inputs Used and Outputs Produced

The results of the study on the source-wise energy input-use on sample farms for paddy, coconut and cotton crops in the Perur and Palladam blocks have been presented in Table 6. The energy inputs usage was very high in groundwater less-exploited area of Perur in paddy and cotton crops. For the coconut crop, Palladam block consumed more energy input. Those two crops needed higher labour-inputs in animal, human and machine form, which led to high energy input consumption in the Perur area. Among crops, cotton was the most energy-intensive crop, consuming 489134 Mega Joules (MJ) per hectare. Cotton crop consumed more plant protection chemicals, which have a high-energy equivalent ratio of 120 MJ per kg of active ingredient. High labour inputs used in the groundwater less-exploited area (Perur block, region I) resulted in higher energy input

Table 3. Changing status of groundwater utilization in Perur and Palladam blocks

Periods	Area owned (ha)		Area irrigated (ha)		Types of crops	
	Perur	Palladam	Perur	Palladam	Perur	Palladam
Present	4.25	2.39	3.62	1.46	Coconut, banana	Maize, jowar, coconut
5 Years ago	4.25	3.40	4.25	2.23	Paddy, sugarcane, coconut, banana	Paddy maize, groundnut, coconut
10 Years ago	4.25	3.40	4.25	3.40	Paddy, sugarcane coconut, banana	Paddy, cotton, groundnut, maize, coconut

Table 4. Irrigation and yield of different crops in Perur and Palladam blocks

Crops	Irrigation				Returns			
	Perur		Palladam		Perur		Palladam	
	Number	Hours	Number	Hours	Yield	Gross income (Rs)	Yield	Gross income (Rs)
Paddy	90	319	58	184	7.35 tonnes	51,450	5.6 tonnes	39,375
Coconut	98	635	49	182	20608 nuts	82,433	10690 nuts	42,759
Cotton	18	145	10	83	1.82 tonnes	63,680	1.18 tonnes	35,301

Table 5. Crop-wise consumption of inputs in the Perur and Palladam blocks

(per ha)

Inputs	Perur				Palladam			
	Rice	Coconut	Cotton	Total	Rice	Coconut	Cotton	Total
Human labour (human-days)	3156	1221	1803	6180	2579	1213	1519	5311
	(51.07)	(19.76)	(29.17)	(100)	(48.56)	(22.84)	(28.60)	(100)
Animal labour (pair hours)	66	0	32	98	62	0	37	99
	(67.35)	(0.00)	(32.65)	(100)	(62.63)	(0.00)	(37.37)	(100)
Machine labour (hours)	13	3	151	167	14	3	148	165
	(7.78)	(1.18)	(90.42)	(100)	(8.48)	(1.82)	(37.37)	(100)
Seeds (kg)	63	175	36	274	70	168	32	270
	(22.99)	(63.87)	(13.14)	(100)	(25.93)	(62.22)	(1.85)	(100)
FYM (kg)	6313	358	2149	8850	3981	427	1822	6230
	(71.33)	(4.38)	(24.28)	(100)	(63.90)	(6.85)	(29.25)	(100)
N (kg)	250	264	125	639	262	336	125	723
	(39.12)	(41.31)	(19.56)	(100)	(36.24)	(46.47)	(17.29)	(100)
P (kg)	205	351	117	673	109	504	55	608
	(30.46)	(52.14)	(17.38)	(100)	(14.77)	(82.89)	(9.05)	(100)
K (kg)	71	351	39	461	49	504	55	608
	(15.40)	(76.14)	(8.46)	(100)	(8.06)	(82.89)	(9.05)	(100)
Plant protection chemicals (litres)	3	0	11	14	2	0	7	9
	(21.43)	(0.00)	(78.57)	(100)	(22.22)	(0.00)	(77.78)	(100)

Note: Figures within the parentheses denote percentages to total

Table 6. Level of inputs and pattern of energy sources in crop production

(MJ/ha)

Sources of energy	Perur			Palladam		
	Paddy	Coconut	Cotton	Paddy	Coconut	Cotton
Human labour (human-days)	6186	2394	3534	5055	2378	2978
Animal labour (pair-hours)	534	-	256	498	-	295
Machine labour (hours)	4373	1071	16717	4505	984	12286
Seeds (kg)	928	4385	909	1030	4201	805
FYM (kg)	1894	117	645	1194	128	547
Nitrogen (kg)	7078	7471	3539	7415	9515	3539
Phosphorous (kg)	412	705	236	220	1013	251
Potash (kg)	284	1410	155	196	2026	222
Pesticides (L)	124200	-	463143	81000	-	321517
Total energy input use (MJ)	145889	17553	489134	101113	20245	342440
Output energy (MJ)	123480	515208	45486	76781	267241	29526
Contribution of commercial energy sources to total energy use (%)	137275	15042	484699	94366	17739	338620
	(94.10)	(85.69)	(99.09)	(93.33)	(87.62)	(98.97)
Contribution of non-commercial energy sources to total energy use (%)	8614	2511	4435	6747	2506	3820
	(5.90)	(14.31)	(0.91)	(6.67)	(12.38)	(1.03)
Contribution of renewable energy sources to total energy use (%)	9542	6896	5344	7777	6707	4625
	(6.54)	(39.29)	(1.09)	(7.69)	(33.13)	(1.12)
Contribution of non-renewable energy sources to total energy use (%)	136347	10657	483790	93336	13538	337815
	(93.46)	(60.71)	(98.91)	(92.31)	(66.87)	(98.65)

Note: Figures within the parentheses are percentage values consumption besides number and duration of irrigations.

Table 6 also presents the contribution of different sources of energy classified on the basis of their renewability and economic value. Based on the comparative economic value, the energy sources were classified into commercial and non-commercial sources. Commercial energy sources, which include purchased seeds, fertilizers, machinery, etc. are generally capital-intensive and cannot be produced on the farm. Non-commercial sources of energy include home-produced seeds, FYM, human and animal labour, etc. In this study, seeds were classified under commercial sources because of lack of information on the source of procurement of seeds. The renewable energy sources included seeds, FYM, human labour and animal labour. The energy derived from fertilizer, pesticides and machinery was classified under non-renewable energy. For further details, *see* Singh and Mittal (1992).

In both the regions, the contribution of commercial energy sources to the total energy input-usage was 94 per cent in paddy and 99 per cent in cotton. Thus, there was not much difference in the commercial energy source utilization for paddy and cotton cultivation between these two regions. The trend was same in respect of renewable sources also for these crops in both the regions. The respective contribution of commercial and non-renewable energy sources was 85 per cent and 60 per cent in coconut crop in the Perur region and 88 per cent and 67 per cent in the Palladam region.

Efficiency of Energy Use

Agriculture not only consumes energy but produces also in the form of crop outputs. To compare how efficiently crops converted the input energy into output energy in two different production environments (different groundwater development regions), energy ratios were calculated (input energy used to produce 100 MJ of output energy) and have been presented in Table 9. Another technical indicator of energy efficiency (gross value of output per MJ of input energy) for the two regions has been presented in Table 8. The indicator of energy output-input ratio has been presented in Table 7.

From the data in Tables 7-9, it was observed that to produce 100 MJ of output, 118 MJ, 3 MJ and 1075 MJ of energy inputs were needed for paddy, coconut and cotton crops in the Perur region and 132 MJ, 8 MJ and 1160 MJ in the Palladam region. Energy output-input ratios for paddy, coconut and cotton were 0.85, 29.35 and 0.09 in the Perur region and 0.76, 13.20 and 0.09 in the Palladam region. This indicated that energy efficiency among crops was maximum in the coconut crop and in Perur among

Table 7. Input demand and energy output

(per ha)

Particulars	Perur			Palladam		
	Paddy	Coconut	Cotton	Paddy	Coconut	Cotton
Human labour (human-hours)	3156	1221	1803	2579	1213	1519
Animal labour (pair-hours)	66	0	32	62	0	37
Machine labour (hours)	13	3	157	14	3	148
Seeds (kg)	63	175	36	70	168	32
FYM (kg)	6313	388	2149	3981	427	1822
Urea (kg)	250	264	125	262	336	125
Super (kg)	205	351	117	109	504	125
Potash (kg)	71	351	39	49	504	55
Plant protection chemicals (L)	3	-	11	2	4	7
Total energy input use (MJ)	145889	17553	489134	101113	20245	342440
Total energy output (MJ)	123480	515208	45486	76781	267241	29526
Gross return (Rs)	56800	82433	63681	36563	42715	35431
Energy output-input ratio	0.85	20.35	0.09	0.76	13.20	0.09

Table 8. Relationship between commercial energy inputs and gross value of product

Particulars	Perur			Palladam		
	Paddy	Coconut	Cotton	Paddy	Coconut	Cotton
Energy input (MJ)	145889	17553	489134	101113	20245	342440
Gross value of output (Rs)	56800	82433	63681	36563	42715	35431
Gross value of output per MJ of input energy (Rs)	38.93	469.62	13.02	36.16	210.99	10.35

Table 9. Economics of energy-use in different crops in the Perur and Palladam blocks

Particulars	Perur			Palladam		
	Paddy	Coconut	Cotton	Paddy	Coconut	Cotton
Yield	7.35 tonnes	20608 nuts	1.8 tonnes	5.6 tonnes	10690 nuts	1.2 tonnes
Input energy (MJ/ha)	145889	17553	489134	101113	20245	342440
Economic output energy (MJ/ha)	123480	515208	45486	76781	267241	29526
Energy input needed to produce 100 MJ of economic output energy	118.15	3.41	1075.35	131.69	7.58	1159.79
Gross return (Rs/ha)	51450	82433	63681	39375	42715	35431

regions. There was not much difference in the gross value of output per MJ of energy input in paddy and cotton crops among groundwater severely-exploited and less-exploited regions. But, in the coconut, the ratio was twice in Perur (Rs 470) than Palladam (Rs 211). These results indicated that coconut was the most viable crop as for as the energy economics was concerned in both the regions.

Conclusions

The study has revealed that the scarcity of water resources influences the fertilizer inputs usage in the groundwater over-exploited region where water is excessively exploited under the anxiety of obtaining higher yields, whereas in the region of more water availability, labour force is used more for irrigation purposes. In the groundwater less-exploited area, usage of energy inputs has been found very high for paddy and cotton crops, as these two crops need higher labour inputs in animal, human and machine forms, which has led to high energy input consumption in these areas. Among the crops, cotton has been found the most energy-intensive due to usage of more plant protection chemicals, which have high-energy equivalent ratio of 120 MJ per kg of active ingredient. Energy efficiency has been observed higher in the coconut among crops and in the Perur block (over-exploited region) among the regions.

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