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RESEARCH PAPER

Energy use pattern in rice cultivation : An economic analysis

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ABSTRACT

The study examined the energy use pattern in rice cultivation in Cauvery Delta Zone (CDZ) of Tamil Nadu state. The study revealed that fertilizer was the dominant source of energy contributing 12,399.7 $MJha^{-1}$ which accounted for 51.1 per cent of the total energy utilized in rice cultivation. The total energy utilized for rice cultivation for mechanized small farms was 21,405.61 $MJha^{-1}$ while mechanized large farms contributed 25,467.97 $MJha^{-1}$. The operation wise energy use pattern in rice cultivation showed that among all the operations, manures and manuring consumed highest amount of energy (9,537.92 $MJha^{-1}$) for mechanized small farms and 11,073.56 $MJha^{-1}$ for mechanized large farms, followed by harvesting, threshing and cleaning activities.

KEY WORDS : Rice cultivation, Energy use efficiency, Cost of input – output energy

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Intensification of agriculture leads to increase in the use of different sources of energy in crop production. Agriculture is not only consumer of energy but also producer of energy in the form of crop output. Energy is invested in various forms like human, animal and mechanical energy. Sufficient availability of the right energy and its effective and efficient use are pre-requisites for improved agricultural production. The urgent need for securing the food security for India's teaming millions require high energy inputs and better management practices. Therefore, an attempt was made to examine the energy use pattern, source of energy and their profitability in the rice farms of the study area and the results are presented below.

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METHODOLOGY

The present study was carried out in Cauvery Delta Zone (CDZ) of Tamil Nadu state in 2013. A multi-stage random sampling procedure was adopted for the selection of talukas**,** villages and farmers.

In the first stage, six talukas were selected in the major three districts of CDZ, namely Thanjavur, Thiruvarur and Nagapattinam based on the highest area under rice cultivation. In the second stage, twelve villages (two villages per taluka) were selected and in the third stage twenty farmers per village were selected, based on the proportion of area under rice. The total sample size constituted 240 farmers, selected by a multistage stratified random sampling procedure. The sample was post stratified into small and large size group of farmers and partially and fully mechanized farms. Farmers owning upto two hactares were considered as small farmers and above two hactares as large farmers. The farms in which all operations except transplanting mechanized were treated as partially mechanized farms and the farms where all the operations were mechanized were treated as fully mechanized farms. Weeding operation was excluded from both the type of farms. Energy from inputs and outputs were calculated by converting the physical units of inputs and outputs into respective energy equivalent as standardized by

All India Co-ordinated Research Project (AICRP) on energy requirement in agricultural sector for calculation of energy requirement.

ANALYSIS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Source wise energy use:

The pattern of energy use in rice cultivation under different levels of mechanization and under different size of farms (Table 1 and 2) indicated that fertilizer was found to be the dominant out source of energy contributing an average of 21,284.5 MJ per ha for the fully mechanized and partially mechanized small farms and 25,812.2 MJ for the large farms. Percentage wise, 45.6 per cent of the total energy in small farms and 52.5 per cent of the total energy in large farms was contributed by fertilizer. The contribution of other major sources of energy were fuel and electricity 5,784.6 $MJha^{-1}$), machineries (2,286.2 $MJha^{-1}$) and human labour (1,775.7 $MJha^{-1}$) with a share of 29.6, 12.5 and 8.3 per cent, respectively. Fertilizer was the dominant source of energy in both the level of mechanization of small farms with almost equal percentage share of the total energy. It is evident from

Table 1: Source wise energy use pattern in rice cultivation ($MJha^{-1}$)

Sr. No	Source	Qty.	Partially mechanized small farms		Qty.	Fully mechanized small farms		All small farms	
			Energy MJ/ha)	(%)		Energy MJ/ha)	(%)	Energy MJ/ha)	(%)
1.	Human (h)	805.9	2,209.4	10.8	566.8	1,342.0	6.0	1,775.7	8.3
2.	Animals (h)	192.0	257.8	1.3	102.0	137.0	0.7	197.4	1.0
3.	Machineries (h)	80.6	2,089.6	11.4	87.5	2,482.8	13.4	2,286.2	12.5
4.	Seeds (kg)	32.0	423.9	2.2	21.0	305.9	1.5	364.9	1.9
5.	Fertilizers (kg)	284.3	9,699.1	45.0	332.6	11,604.5	46.1	10,651.8	45.6
6.	Chemicals (L)	1.1	199.1	1.0	1.2	248.7	1.3	223.9	1.1
7.	Fuel (L)/ Electricity (KWh)	124.4	5,439.9	28.3	139.5	6,129.3	31.0	5,784.6	29.6
8.	Micro nutrient (kg)	11.8	0.0	0.0	15.3	0.0	0.0	0.0	0.0
	Total input energy		20318.8	100.0		22,250.2	100.0	21,284.5	100.0
	Output energy								
	Grain (kg)	4,564	66,497.5	63.9	5,118	74,569.3	67.2	70,533.4	-
	Straw (kg)	2,840	35,500.0	36.1	2,915	36,437.5	32.8	35,968.5	-
	Total output energy	-	1,01,997.5	100.0	-	1,11,006.8	100.0	1,06,502.2	100.0

Table 2: Source wise energy use pattern in rice cultivation ($MJha^{-1}$)

Sr. No	Source	Qty	Partially mechanized large farms		Qty	Fully mechanized large farms		All large farms	
			Energy(MJ/ha)	(%)		Energy MJ/ha)	(%)	Energy (MJ/ha)	(%)
1.	Human (h)	904.9	3,047.5	12.5	602.8	1,917.8	7.0	2,482.6	4.8
2.	Animals (h)	91.2	122.5	0.8	72.0	96.7	0.4	109.6	0.4
3.	Machineries (h)	81.0	2,124.6	8.7	88.8	3,836.0	14.0	2,980.3	4.8
4.	Seeds (kg)	38	553.7	2.3	18.0	262.3	1.0	407.7	1.6
5.	Fertilizers(kg)	331	12,399.7	51.1	362.7	14,701.5	53.7	13,550.6	52.5
6.	Chemicals (L)	1.5	298.5	1.2	1.0	199.0	0.7	248.7	1.0
7.	Fuel (L)/ Electricity (KWh)	129.5	5,686.5	23.4	144.7	6,377.8	23.2	6,032.2	23.4
8.	Micro nutrient (kg)	13.5	0.0	0.0	15.5	0.0	0.0	0.0	0.0
	Total input energy		24,233.0	100.0		27391.3	100.0	25,812.2	100.0
	Output energy								
	Grain (kg)	4,821	70,241.9	63.7	5,336	77,745.5	63.9	73,993.7	-
	Straw (kg)	3,205	40,062.5	36.3	3,512	43,900.0	36.1	41,981.3	-
	Total output energy	-	1,10,304.4	100.0	-	121645.5	100.0	1,15,975.0	100.0

the table that the human energy use contribution has decreased from 2,209.4 MJha^{-1} to 1,775.7 MJha^{-1} as the level of mechanization increased. Similarly the contribution of machine energy had increased from 2,089.6 MJha^{-1} to 2,256.2 MJha^{-1} with the increased level of mechanization. In percentage terms, the human energy contribution declined to 6 per cent from 10.8 per cent and that of machine energy had increased to 13.4 pe rcent from 11.4 per cent as the level of mechanization increases. The average energy used for rice cultivation was 20,318.8 MJha^{-1} for partially mechanized small farms and 22,250.2 MJha^{-1} for fully mechanized small farms and 21,284.5 MJha^{-1} for mechanized small farms.

The energy use pattern for the large farms in the two different levels of mechanization is presented in Table 2. A similar trend in energy use was noticed in the two levels of mechanized large farms as that of small farms and it was also evident that the extent of energy use has increased as the farm size increased. While the partially mechanized small farms had used 20,318.8 MJha^{-1}, the partially mechanized large farms had used 24,233.0 MJha^{-1}. Similarly, the total input energy for the fully mechanized small farms was 22,250.2 MJha^{-1} while that for the fully mechanized large farms was 27,391.3 MJha^{-1}.

On an average, the small farms had used 21,284.5 MJha^{-1} and the large farms used 25,812.2 MJha^{-1} for both the levels of mechanization. Source wise, fertilizer was the major source of contribution with 12,399.7 MJha^{-1} for the partially mechanized large farms and 14,701.5 MJha^{-1} for the fully mechanized large farms, sharing 51.1 per cent and 53.7 per cent of the total energy, respectively for the two levels of large farms. The other major sources of energy use were 5,686.5 MJha^{-1} (23.4%) by fuel and electricity, 3,047.5 MJ/ha (12.5%) by human labour and 2,124.6 MJha^{-1} (8.7%) by machineries. And for the fully mechanized large farms, the next major source of energy use was 6,377.8 MJha^{-1} (23.2 %) by fuel and electricity, 3,836 MJha^{-1} (14.0%) by machineries and 1,971.8 MJha^{-1} (7.0%) by human labour. A significant fact was that the machine energy was increasing as the level of mechanization increases, the pattern very similar to that of small farms. The trend in the energy use pattern indicated that the use of human energy was decreasing and that of machine energy was increasing as the level of mechanization increases, similar to that of small farms.

Operation wise energy use:

The operation wise energy use pattern is furnished in Table 3 and 4. The operation wise energy use pattern was also studied for the two different size and level of farms as that of source wise energy use study. It is clear from the

Table 3: Operation wise energy use pattern in rice cultivation (MJha^{-1})

Sr. No.	Operation	Partially mechanized small farms		Fully mechanized small farms		All farms	
		Energy (MJ/ha)	%	Energy (MJ/ha)	%	Energy (MJ/ha)	%
1.	Ploughing	1,021.90	5.03	1,487.25	6.61	1,254.57	5.85
2.	Nursery preparation	149.20	0.78	92.24	0.41	241.44	1.12
3.	Manures and manuring	9,537.92	46.34	10,297.30	46.01	9,917.61	46.33
4.	Seeds and sowing	890.10	4.38	320.08	1.62	605.09	2.83
5.	Irrigation	3,840.40	18.89	4,412.27	18.64	4,126.33	19.27
6.	After cultivation	1,061.40	5.45	1,188.90	6.02	1,125.15	5.25
7.	Plant protection	1,088.50	5.63	1,179.58	5.96	1,134.04	2.29
8.	Harvesting, threshing and cleaning	2,446.38	12.04	2,965.50	13.18	2,705.94	12.63
9.	Transportation	283.80	1.46	307.08	1.55	295.44	1.43
	Total input energy	20,318.80	100.00	22250.20	100.00	21,405.61	100.0

Table 4: Operation wise energy use pattern in rice cultivation (MJha^{-1})

Sr. No.	Operation	Partially mechanized large farms		Fully mechanized large farms		All farms	
		Energy (MJ/ha)	%	Energy (MJ/ha)	%	Energy (MJ/ha)	%
1.	Ploughing	1,069.65	6.89	2,062.54	7.53	1,566.10	6.15
2.	Nursery preparation	175.24	0.72	88.40	0.37	87.62	0.34
3.	Manures and manuring	11,073.56	45.69	12,702.12	46.37	11,887.84	46.67
4.	Seeds and sowing	1,062.34	4.38	476.37	1.73	769.35	3.01
5.	Irrigation	3,856.92	15.91	5,115.27	18.67	4,486.10	17.61
6.	After cultivation	1,363.50	5.62	1,491.00	5.44	1427.25	5.60
7.	Plant protection	1,074.76	4.43	1,251.04	4.56	1,162.90	4.56
8.	Harvesting, threshing and cleaning	3,487.12	14.43	3,618.40	13.20	3552.76	13.94
9.	Transportation	469.91	1.93	586.20	2.13	528.05	2.12
	Total input energy	24233.0	100.00	27391.30	100.0	25,467.97	100.0

table that the application of manures had accounted for the major energy consumption of 46.34 per cent of the total energy use for rice cultivation followed by irrigation accounting for 18.89 per cent, for the partially mechanized small farms, which is in conformity to the source wise energy use *viz.*, fertilizers, fuel and electricity. The trend is also similar to the fully mechanized small farms. The application of manures had used 9,537.92 $MJha^{-1}$ for the partially mechanized small farms and 10,297.30 $MJha^{-1}$ for the fully mechanized small farms. The next major operation of irrigation had consumed 3,840.40 $MJha^{-1}$ for partially mechanized small farms and 4,412.27 $MJha^{-1}$ for fully mechanized small farms. The energy consumption of other operations were 2,730.18 $MJha^{-1}$ (13.50%) (operation 8 and 9) for harvesting, threshing and transportation, On an average, the large farms have consumed 25,467.97 $MJha^{-1}$ of energy while the small farms used 21,405.61 $MJha^{-1}$ indicating that higher the output energy (11,597.50 $MJha^{-1}$) higher the level of input energy use (25467.97 $MJha^{-1}$). Among the different operations, while the proportionate use of energy was almost similar between the operations of small and large farms, it was significantly different for the harvesting, threshing and transportation. While the small farms have used 3,001.38 $MJha^{-1}$ (14.06%) for the above operation, the large farms have used 4,080.81 $MJha^{-1}$ (16.06%) revealing, higher the output higher the input use energy towards harvest and transport.

Costs and input use energy:

The costs of different sources of input energy use in rice cultivation were analyzed (Table 5 and 6) to understand the nature of inputs in relation to their energy content. Among the sources of input energy, the cost incurred per unit of input energy in human labour was found to be the highest in partially mechanized small farms (Rs.17.49 / MJ), fully mechanized small farms (Rs.14.90 /MJ), and partially mechanized large farms (Rs.13.28/MJ) while the cost of machinery input use was the maximum in fully mechanized large farms (Rs.14.52/MJ).This is evident from the fact that the fully mechanized large farms were using the machineries at a higher scale with the minimum component of human labour. Overall, the cost of input energy was found to be higher either for human labour or machine labour.

Non-availability of human labour and inaccessibility towards the machineries during peak seasons might be the causes for the higher cost of these inputs, in both physical and energy terms.

The cost per unit of other major sources of input energy

Table 5: Costs of different sources of input dnergy use

Sr. No	Source	Partially mechanized small farms			Fully mechanized small farms		
		Energy use (MJ/ha)	Cost of input (Rs/ha)	Cost /energy (Rs/MJ)	Energy use (MJ/ha)	Cost of input (Rs/ha)	Cost /energy (Rs/MJ)
1.	Human	1,337	23,395	17.49	969	14,430	14.90
2.	Animals	258	1,582	6.13	137	845	6.16
3.	Machines	1,090	9,240	8.48	1,283	16,342	12.73
4.	Seeds	424	1,482	3.49	306	1,235	4.04
5.	Manures and fertilizers	11,571	5,182	0.44	13,177	5,361	0.41
6.	Chemicals	199	932	4.68	249	1,394	5.60
7.	Fuel and electricity	5,440	1,645	0.30	6,129	1,431	0.23
	Total	20319	43458	2.13	22250	40,738	1.83

Table 6: Costs of different sources of input energy use

Sr. No	Source	Partially mechanized large farms			Fully mechanized large farms		
		Energy use (MJ/ha)	Cost of input (Rs/ha)	Cost /energy (Rs/MJ)	Energy use (MJ/ha)	Cost of input (Rs/ha)	Cost /energy (Rs/MJ)
1.	Human	1,498	19,894	13.28	1,028	7,565	7.36
2.	Animals	123	769	6.27	97	534	5.52
3.	Machines	1,125	10,432	9.27	1,336	19,396	14.52
4.	Seeds	554	1,876	3.38	262	1,185	0.71
5.	Manures and fertilizers	14,949	4,335	0.28	18,091	5,963	0.32
6.	Chemicals	298	1,235	4.13	199	1,365	6.85
7.	Fuel and electricity	5,686	1,782	0.31	6,378	1,666	0.26
	Total	24233	40323	1.66	27391	37674	1.38

was plant protection chemicals, animal power, seeds, manures and fertilizers and fuel and electricity in that order. The cost per unit of fuel and electricity worked out to be neglible, the reason being the availability of free electricity and also the study period was a very normal year with canal water flowing throughout the year and hence, the farmers might have used the diesel engines minimally. The per unit cost of energy of all inputs put together worked out to Rs.1.38/MJ, Rs.1.66/ MJ, Rs.1.83/MJ and 2.13/MJ for the fully mechanized large farms, partially mechanized large farms and fully mechanized small farms and partially mechanized small farms, respectively.

The output - input energy ratio worked out for the partially mechanized small farms, fully mechanized small farms, partially mechanized large farms and fully mechanized large farms were 4.0, 4.25, 4.2 and 4.75, respectively indicating that the fully mechanized large farms were the most efficient among the different types of farms interms of energy use. Islam *et al.* (2009) studied the energy investigation in unpuddled transplanting of wet season rice in Dhaka Bangladesh. Similarly Abubakar and Ahmad (2010) and Prasanna Kumar *et al.* (2013) studied the energy use pattern in millet production and cotton cultivation from Nigeria and India, respectively.

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