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Efficiency and Productivity - The Case of Sericulture Farms in Tamil Nadu*

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SETTING

The role and significance of agriculture in the Indian economy hardly need any emphasis. Agriculture is a major source of livelihood and employment for 70 per cent of the country's labour force, besides providing raw materials for half of its industrial output. In the absence of more lands to be brought under cultivation and increased pressure on land for maximising output, employment and income, 'integrated agriculture' with animal husbandry, sericulture, poultry and forestry is given nationwide importance. To accelerate agricultural development process and to make it more dynamic and vibrant, as part of integrated farming system, broad-based agricultural extension approach is followed in Tamil Nadu State. Concerted efforts are made by the state to improve productivity and efficiency in farming with emphasis on economics and equity.

PROBLEM FOCUS

Sericulture is an agro-based industry with short gestation period, low investment, continuous cash flow and high-pay off. A noteworthy feature of sericulture is that the mulberry crop could be raised under wide ranging production environs and by small and marginal farmers. Being labour intensive, sericulture is ideally suited to India for creating gainful employment to the ever increasing labour force, particularly women.

India is the second largest silk producer in the world. During the past four decades, the mulberry area expanded, on an average, at the rate of 4 per cent, while the increase in cocoon and raw silk production was 5.6 per cent and 6.6 per cent per annum respectively. Tamil Nadu ranks third among the states producing mulberry silk in the country. Sericulture in the state was traditionally concentrated in the districts of Dharmapuri, Salem, Coimbatore, Periyar and North Arcot. With concerted efforts in research and extension programmes, sericulture has spread to non-traditional areas as well. Sericulture in the state has been promoted by a number of region-specific and target group oriented programmes such as National Sericulture Project (NSP), Integrated Sericulture Development Programme (ISDP), Drought Prone Area Programme (DPAP), Hill Area Development Programme (HADP) and the programmes funded by International Labour Organisation (ILO) and International Fund for Agricultural Development (IFAD). At this stage of development, one is interested to know the nature of technical and allocative efficiency among regions and across farms practising sericulture. The findings of such a study could help in setting the pace and pattern for reorienting sericulture development in Tamil Nadu and in the country as well.

RESEARCH DESIGN

Multi-stage sampling design was adopted. Taking into consideration the natural endow-

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ment and concentration of area under mulberry, two agro-climatic zones, namely, north region and the central region were purposively selected. To get better perspectives of the problems and prospects, Dharmapuri district in the north region and Dindigul Anna district in the central region were chosen, the former represents traditional area and the latter, non-traditional one. Two taluks, having largest area under mulberry were purposively chosen from each district. Similarly, one block in each taluk and three villages in each block were purposively selected based on the concentration of mulberry area. Finally, from each village 10 sericulture farmers were randomly chosen. In total, 120 farmers were chosen, spread over 12 villages in the two districts. The cross-section primary data collected from the two districts formed the primary source material for efficiency and productivity analysis.

THE MODEL

To capture the ability of the farmers in achieving the maximum realisable crop output with minimum level of inputs under the existing resource environment and given technologies, careful examination of farm-specific technical efficiency and input-specific allocative efficiency of the individual farmers is necessary. Technical efficiency evaluates the firm's ability to obtain the maximum possible output from a given set of resources, while allocative efficiency explores the needed adjustments in equating the marginal revenue with marginal cost for maximising profitability. Variations in the pattern of input combinations across farms result in variability in the level of crop output. Hence, allocative efficiency tends to differ from farm to farm under the same level of technology and the inputs. Technical and allocative efficiency of the farms measure the productive contribution of tangible and intangible factors.

Farrell (1957) pioneered the work on deterministic approach to measuring technical efficiency. Aigner and Chu (1968) used mathematical programming to construct deterministic production frontiers. The stochastic frontier production functions developed by Aigner *et al.* (1977), Schmidt (1986), Bauer (1990) and Battese (1992) give excellent review on efficiency measures. Time-invariant models were used by Battese and Coelli (1988) for balanced panel data, and Battese *et al.* (1989) estimated unbalanced panel data models. Kalirajan (1991) examined farm-specific application of new rice technology by using micro level panel data from a South Indian district adopting stochastic frontier model. Battese and Coelli (1992) applied panel data model incorporating time varying firm effects in the analysis of data for paddy farmers in an Indian village.

In the present study, frontier production function was derived from Cobb-Douglas production function and estimated by corrected ordinary least squares (COLS) method. From the estimated equation, Timmer's measure of technical efficiency and Kopp's measure of allocative efficiency of various resources utilised in sericulture farms were examined.

The specified Cobb-Douglas function is:

$$C_p = \beta_0 NL^{\beta_1} LCR^{\beta_2} FYM^{\beta_3} FER^{\beta_4} HLD^{\beta_5} ID^{\beta_6} e^{\mu_i}$$

where C_p = cocoon production in kg,

NL = number of layings in 100 disease free layings (DFLS)

LCR = leaf-cocoon ratio,

FYM = farmyard manure in tonnes,
 FER = fertiliser in kg,
 HLD = human labour in man-days,
 ID = irrigation dummy,
 '1' if irrigated; '0' if rainfed,
 $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ and β_6 are elasticities to be estimated.
 β_0 = intercept, μ_i = error term.

The frontier production function is given by

$$C_p^* = \beta_0^* NL^{\beta_1} LCR^{\beta_2} FYM^{\beta_3} FER^{\beta_4} HLD^{\beta_5} ID^{\beta_6} e^{\mu_i}$$

where C_p^* gives the frontier level of cocoon production,

β_0^* is corrected constant term of OLS estimates.

Technical Efficiency (TE) = $C_p/C_p^* \leq 1$

C_p = annual cocoon production,

C_p^* = potential cocoon production.

Kopp's measure of allocative efficiency was derived for all resources. For illustration, a case with reference to frontier value of number of layings (NL) is given.

$$\beta_1 \log NL = \log C_p^* - \log \beta_0^* - \beta_2 \log LCR - \beta_3 \log FYM - \beta_4 \log FER - \beta_5 \log HLD - \beta_6 \log ID$$

Adding

$$\beta_2 \log NL + \beta_3 \log NL + \beta_4 \log NL + \beta_5 \log NL + \beta_6 \log NL$$

on both sides, and rearranging the equation,

$$\log NL^* = \frac{\log C_p^* - \log \beta_0^* - \beta_2 \log R_2 - \beta_3 \log R_3 - \beta_4 \log R_4 - \beta_5 \log R_5 - \beta_6 \log R_6}{\sum \beta_i}$$

where $R_2 = LCR/NL$; $R_3 = FYM/NL$; $R_4 = FER/NL$; $R_5 = HLD/NL$; $R_6 = ID/NL$

Similarly, for other inputs.

SALIENT FINDINGS

The details of descriptive statistics and results of resource use efficiency function are given in Tables 1 and 2 respectively for Dharmapuri and Dindigul Anna districts.

TABLE 1. DESCRIPTIVE STATISTICS OF VARIABLES CONSIDERED IN THE RESOURCE USE EFFICIENCY FUNCTION

Sr. No.	Variable	Dharmapuri		Dindigul Anna	
		Mean	Standard deviation	Mean	Standard deviation
(1)	(2)	(3)	(4)	(5)	(6)
1.	Cocoon production (kg)	348.22	185.90	287.26	162.51
2.	Number of layings (100 DFSL)	8.58	5.95	7.91	4.34
3.	Leaf-cocoon ratio	30.00	2.92	30.49	2.69
4.	Farmyard manure (tonnes)	4.58	0.91	5.22	2.15
5.	Fertiliser (kg)	158.18	33.24	293.42	202.16
6.	Human labour (man-days)	381.24	205.62	343.22	199.32
7.	Irrigation	0.72	4.22	-	-

TABLE 2. RESULTS OF RESOURCE USE EFFICIENCY FUNCTION: COBB-DOUGLAS TYPE

Sr. No.	Variable	Dharmapuri			Dindigul Anna		
		Co-efficient	't' ratio	Significance level	Co-efficient	't' ratio	Significance level
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.	Egg laying (100 DFSL)	0.58	10.87	**	0.53	8.08	**
2.	Leaf-cocoon ratio	-0.43	-3.23	**	-0.06	0.34	NS
3.	Farmyard manure (tonnes)	0.03	0.35	NS	0.04	0.80	NS
4.	Fertiliser (kg)	0.22	2.04	*	0.15	3.34	**
5.	Human labour (man-days)	0.19	3.61	**	0.35	4.26	**
6.	Irrigation (dummy)	0.02	2.55	**			
		$\beta_0 = 0.82^{**}$ $R^2 = 0.98^{**}$ $\bar{R}^2 = 0.98^{**}$ N = 60 * P < 0.05 ** P < 0.01 NS = Non-significant			$\beta_0 = 1.79^{**}$ $R^2 = 0.95^{**}$ $\bar{R}^2 = 0.95^{**}$ N = 60 ** P < 0.01 NS = Non-significant		

The technical efficiency and allocative efficiency along with related details are given in Tables 3 and 4 respectively. The allocative efficiency worked out for different levels of technical efficiency are given in Appendix I and Appendix II for Dharmapuri and Dindigul Anna districts respectively.

(a) Dharmapuri District (Traditional area)

The production function of sericulture enterprise in Dharmapuri district revealed diminishing returns to scale. The coefficient of multiple determination (\bar{R}^2) worked out to 0.98. The mean cocoon production was 348.22 kg/ha. The elasticity of cocoon output with respect to egg layings (0.58), human labour (0.19) and irrigation (dummy) was found positive

and significant at 1 per cent level; in the case of fertiliser, it was positive and significant at 5 per cent level of probability. The ratio of marginal value product (MVP) to price derived revealed that utilisation of these resource inputs could be further increased to maximise the cocoon production.

TABLE 3. TECHNICAL EFFICIENCY AND YIELD GAP OF SERICULTURE IN DHARMAPURI AND DINDIGUL ANNA DISTRICTS

Sr. No.	Technical efficiency level (per cent)	Number of farms	Average actual output (kg/ha)	Average potential output (kg/ha)	Average technical efficiency (per cent)	Yield gap (kg)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dharmapuri district						
1.	75-80	15	793.32	999.48	79.37	206.16
2.	81-85	25	834.41	996.53	83.73	162.12
3.	86-90	15	857.98	976.88	87.83	118.90
4.	Above 90	5	870.25	924.16	94.17	53.90
Dindigul Anna district						
1.	50-60	1	617.67	1,096.69	56.32	479.02
2.	61-70	23	706.37	1,023.05	69.05	316.68
3.	71-80	24	758.58	1,005.77	75.42	247.19
4.	81-90	9	817.37	968.56	84.39	151.19
5.	Above 90	3	859.32	876.18	98.08	16.86

TABLE 4. LEVELS OF ALLOCATIVE EFFICIENCY IN SERICULTURE UNITS

Sr. No.	Technical efficiency level (per cent)	Excess use of				
		Number of layings	Leaf-cocoon ratio	Farmyard manure	Fertiliser	Human labour days
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dharmapuri district						
1.	75-80	11.03	14.41	2.56	18.48	21.71
2.	81-85	12.24	13.01	7.07	19.78	25.93
3.	86-90	8.49	9.34	6.94	19.26	19.86
4.	>90	12.38	14.78	4.61	19.03	25.66
Dindigul Anna district						
1.	50-60	29.47	28.89	14.83	74.01	83.84
2.	61-70	27.41	3.17	24.86	92.56	96.32
3.	71-80	28.50	3.93	17.65	68.96	85.05
4.	81-90	8.91	3.17	14.94	78.04	44.52
5.	>90	19.30	3.55	14.21	61.70	68.10

The results of frontier production revealed that the overall technical efficiency (TE) and allocative efficiency (AE) of sericulture enterprise in Dharmapuri district worked out to 86.28 per cent and 87.77 per cent respectively. Potential cocoon production in the district was 1,228 kg/ha. However, the highest cocoon production actually realised by the sample farmers was 992 kg/ha, while the lowest cocoon production observed in the sample was 716.67 kg/ha. The technical efficiency of sericulture farmers ranged between 76.63 per cent

and 100 per cent. Table 3 presents four categories of farmers with different levels of technical efficiency. Of the total 60 sample farmers, 15 were between 75 and 80 per cent TE; 25 farmers were between 81 and 90 per cent TE; 15 farmers were between 86 and 96 per cent TE and 5 farmers were found near the frontier recording above 90 per cent TE.

It could be seen that inefficiency was the highest in the case of human labour followed by fertiliser, leaf-cocoon ratio and number of layings, irrespective of various levels of technical efficiency. The allocative efficiency of farmers operating at 75-80 per cent TE indicated that the sample farmers were allocatively inefficient with respect to all the inputs. The resources such as number of layings, leaf-cocoon ratio, farmyard manure, fertiliser and human labour were excessively used by 11.03 per cent, 14.41 per cent, 2.56 per cent, 18.48 per cent and 21.71 per cent respectively for producing the given level of output.

The allocative efficiency of the farmers operating at 81-85 per cent TE also showed that there was a high degree of inefficiency in input usage. The excessive usage of inputs for the given level of output was 12.24 per cent, 13.01 per cent, 7.07 per cent, 19.78 per cent and 25.93 per cent in the case of number of layings, leaf-cocoon ratio, farmyard manure, fertiliser and human labour respectively.

In the case of farmers operating at 86-90 per cent TE, the percentage of excess usage of the above five inputs was 8.49, 9.34, 6.94, 19.26 and 19.86 respectively. The excess usage of inputs in farms operating at above 90 per cent TE was 12.38 per cent, 14.78 per cent, 4.61 per cent, 19.03 per cent and 25.66 per cent respectively.

(b) Dindigul Anna District (Non-traditional area)

The production function indicated that the coefficient of multiple determination (\bar{R}^2) was 0.95 and the summation of elasticities of resources indicated constant returns to scale in the district. The elasticity of cocoon output with respect to number of layings, fertiliser and human labour was 0.53, 0.15 and 0.35 respectively and they were significant at 1 per cent level. The ratio of MVP to price showed that there exists scope for increasing the variable factors such as number of layings, human labour and fertiliser for maximising cocoon output.

The overall technical efficiency of sericulture farms in Dindigul Anna district was 76.65 per cent and the allocative efficiency was 74.99 per cent. The technical efficiency of sericulture farmers in Dindigul district ranged between 56.32 per cent and 100 per cent. The maximum realisable potential cocoon production per hectare was estimated at 1,344.58 kg. The highest actual cocoon production worked out to 1,025.58 kg/ha and the lowest cocoon production was 606.67 kg/ha. Of the total 60 farmers, one was found between 50 and 60 per cent TE; 23 between 61 and 70 per cent TE, 24 between 71 and 80 per cent TE, 9 between 81-90 per cent TE and 3 above 90 per cent TE, nearing the frontier. Average cocoon yield, potential output, yield gap and TE for the sericulture farms in the five groups of this district are highlighted in Table 3. The results presented in Table 4 revealed that the farmers were allocatively inefficient in input usage also.

CONCLUSION AND POLICY IMPLICATION

The study reveals that the economics of sericulture is highly profitable both in the traditional and non-traditional areas. The rate of return per rupee worked out to Rs. 2.78 and Rs. 2.88 in Pennagaram block and Veppanapalli block of Dharmapuri district (traditional area). The rate of return per rupee of investment in cocoon production was Rs. 2.01 in Athoor block and Rs. 2.09 in Palani block of Dindigul Anna district (non-traditional area). Production function analysis revealed the scope for increasing cocoon productivity through increased use of disease free layings, better silkworm germplasm and efficient use of labour. The farm-specific technical efficiency and input-specific allocative efficiency exhibited scope for minimising inefficiency in sericulture units, both in traditional and non-traditional areas.

For improving productivity and efficiency of sericulture enterprise, mulberry cultivation and silkworm rearing technological extension support have to be strengthened, besides developing infrastructure facilities, such as grainages, cocoon auction markets, silk reeling units and training centres more in non-traditional areas. Agricultural extension should cover sericulture promotion in its broad-based agricultural extension strategy. Short and medium-term credit for mulberry cultivation, cocoon production and silk reeling units needs to be organised through financial institutions.

One of the major constraints in sericulture development is related to inadequate trained manpower. Management input is the missing link for the yield gap. This called for adequate training to the farmers in latest technologies for mulberry production and silkworm rearing.

Production of bivoltine cocoons was found very marginal in the study region and the crop failures of bivoltine breeds were also reported due to poor quality of leaf and poor silkworm rearing management. For popularising bivoltine races, and to provide cover against risks, special insurance scheme is worth attempting.

Good chawkie rearing is the first step towards successful silkworm crop. It is advantageous to organise chawkie rearing activities collectively to meet the requirement of a group of farmers. Private and co-operative chawkie rearing centres should be encouraged.

The problems in sericulture development are area-specific. Since Tamil Nadu is popularising sericulture both in traditional and non-traditional areas, with varying environmental situations, area-specific issues need to be identified and sericultural research programmes have to be initiated. On-farm research should be assigned priority.

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APPENDIX I

LEAST QUANTITY OF RESOURCES REQUIRED TO PRODUCE THE GIVEN LEVEL OF OUTPUT OF FARMS OPERATING AT 75 TO 80 PER CENT TECHNICAL EFFICIENCY IN DHARMAPURI DISTRICT

Sr. No. (1)	Resources (2)	Actual (3)	Frontier (4)	Excess use (per cent) (5)
1.	Number of layings (100 DFSL)	15.30	13.78	11.03
2.	Leaf-cocoon ratio	33.50	29.28	14.41
3.	Farmyard manure (tonnes)	4.00	3.90	2.56
4.	Fertiliser (kg)	162.00	136.73	18.48
5.	Human labour	550.72	452.48	21.71

The representative farmer under this category had 0.50 ha mulberry area and produced 490 kg of cocoons.

LEAST QUANTITY OF RESOURCES REQUIRED TO PRODUCE THE GIVEN LEVEL OF OUTPUT OF FARMS OPERATING AT 81 TO 85 PER CENT TECHNICAL EFFICIENCY IN DHARMAPURI DISTRICT

Sr. No. (1)	Resources (2)	Actual (3)	Frontier (4)	Excess use (per cent) (5)
1.	Number of layings (100 DFLS)	23.29	20.75	12.24
2.	Leaf-cocoon ratio	31.00	27.43	13.01
3.	Farmyard manure (tonnes)	5.00	4.67	7.07
4.	Fertiliser (kg)	220.00	183.67	19.78
5.	Human labour	898.15	716.06	25.43

The representative farmer under this category had 0.88 ha mulberry area and produced 792 kg of cocoons.

LEAST QUANTITY OF RESOURCES REQUIRED TO PRODUCE THE GIVEN LEVEL OF OUTPUT OF FARMS OPERATING AT 86 TO 90 PER CENT TECHNICAL EFFICIENCY IN DHARMAPURI DISTRICT

Sr. No. (1)	Resources (2)	Actual (3)	Frontier (4)	Excess use (per cent) (5)
1.	Number of layings (100 DFLS)	11.30	10.60	8.49
2.	Leaf-cocoon ratio	31.50	28.81	9.34
3.	Farmyard manure (tonnes)	6.93	6.48	6.94
4.	Fertiliser (kg)	168.50	141.29	19.26
5.	Human labour	326.26	272.20	19.86

The representative farmer under this category had 0.55 ha mulberry area and produced 437 kg of cocoons.

LEAST QUANTITY OF RESOURCES REQUIRED TO PRODUCE THE GIVEN LEVEL OF OUTPUT OF FARMS OPERATING ABOVE 90 PER CENT TECHNICAL EFFICIENCY IN DHARMAPURI DISTRICT

Sr. No. (1)	Resources (2)	Actual (3)	Frontier (4)	Excess use (per cent) (5)
1.	Number of layings (100 DFLS)	18.24	16.26	12.38
2.	Leaf-cocoon ratio	32.00	27.89	14.78
3.	Farmyard manure (tonnes)	6.35	6.07	4.61
4.	Fertiliser (kg)	211.56	177.74	19.03
5.	Human labour	870.80	692.97	25.66

The representative farmer under this category had 0.86 ha mulberry area and produced 766 kg of cocoons.

APPENDIX II

LEAST QUANTITY OF RESOURCES REQUIRED TO PRODUCE THE GIVEN LEVEL OF OUTPUT OF FARMS OPERATING AT 51 TO 60 PER CENT TECHNICAL EFFICIENCY IN DINDIGUL ANNA DISTRICT

Sr. No. (1)	Resources (2)	Actual (3)	Frontier (4)	Excess use (per cent) (5)
1.	Number of layings (100 DFLS)	13.75	10.62	29.47
2.	Leaf-cocoon ratio	34.00	26.38	28.89
3.	Farmyard manure (tonnes)	4.80	4.18	14.53
4.	Fertiliser (kg)	268.80	154.47	74.01
5.	Human labour	432.20	235.10	83.84

The representative farmer under this category had 0.51 ha mulberry area and produced 315.01 kg of cocoons.

LEAST QUANTITY OF RESOURCES REQUIRED TO PRODUCE THE GIVEN LEVEL OF OUTPUT OF FARMS OPERATING AT 61 TO 70 PER CENT TECHNICAL EFFICIENCY IN DINDIGUL ANNA DISTRICT

Sr. No. (1)	Resources (2)	Actual (3)	Frontier (4)	Excess use (per cent) (5)
1.	Number of layings (100 DFSL)	12.83	10.07	27.41
2.	Leaf-cocoon ratio	28.00	27.14	3.17
3.	Farmyard manure (tonnes)	11.50	9.21	24.86
4.	Fertiliser (kg)	642.43	333.62	92.56
5.	Human labour	827.83	421.68	96.32

The representative farmer under this category had 0.82 ha mulberry area and produced 561.83 kg of cocoons.

LEAST QUANTITY OF RESOURCES REQUIRED TO PRODUCE THE GIVEN LEVEL OF OUTPUT OF FARMS OPERATING AT 71 TO 80 PER CENT TECHNICAL EFFICIENCY IN DINDIGUL ANNA DISTRICT

Sr. No. (1)	Resources (2)	Actual (3)	Frontier (4)	Excess use (per cent) (5)
1.	Number of layings (100 DFSL)	12.94	10.07	28.50
2.	Leaf-cocoon ratio	32.00	30.79	3.93
3.	Farmyard manure (tonnes)	6.00	5.10	17.65
4.	Fertiliser (kg)	168.08	99.48	68.96
5.	Human labour	443.85	239.85	85.05

The representative farmer under this category had 0.50 ha mulberry area and produced 382.23 kg of cocoons.

LEAST QUANTITY OF RESOURCES REQUIRED TO PRODUCE THE GIVEN LEVEL OF OUTPUT OF FARMS OPERATING AT 81 TO 90 PER CENT TECHNICAL EFFICIENCY IN DINDIGUL ANNA DISTRICT

Sr. No. (1)	Resources (2)	Actual (3)	Frontier (4)	Excess use (per cent) (5)
1.	Number of layings (100 DFSL)	3.30	3.03	8.91
2.	Leaf-cocoon ratio	28.00	27.14	3.17
3.	Farmyard manure (tonnes)	5.00	4.35	14.94
4.	Fertiliser (kg)	307.00	172.43	78.04
5.	Human labour	210.24	145.47	44.52

The representative farmer under this category had 0.20 ha mulberry area and produced 179 kg of cocoons.

LEAST QUANTITY OF RESOURCES REQUIRED TO PRODUCE THE GIVEN LEVEL OF OUTPUT OF FARMS OPERATING ABOVE 90 PER CENT TECHNICAL EFFICIENCY IN DINDIGUL ANNA DISTRICT

Sr. No. (1)	Resources (2)	Actual (3)	Frontier (4)	Excess use (per cent) (5)
1.	Number of layings (100 DFSL)	6.86	5.75	19.30
2.	Leaf-cocoon ratio	29.50	28.49	3.55
3.	Farmyard manure (tonnes)	4.50	3.94	14.21
4.	Fertiliser (kg)	119.17	73.70	61.70
5.	Human labour	160.67	95.58	68.10

The representative farmer under this category had 0.31 ha mulberry area and produced 237.50 kg of cocoons.

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