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Research Article

AN ECONOMIC ANALYSIS OF EFFICIENCY OF AGRICULTURAL PRODUCTION IN ERODE DISTRICT OF TAMIL NADU

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Abstract: In Indian economy Agriculture plays an important role. Erode district of Tamil Nadu state is agrarian in nature and about 40 percent of the total geographical area is cultivated with crops such as sugarcane, paddy, banana, turmeric and tapioca under irrigated condition. The present study attempts to analyse the resource use pattern and resource use efficiency in the production of major crops and to explore the technical and scale efficiency of agricultural production in the district by selecting 120 farms at random. Simple average and percentage and coefficient of variation were used to analyse the resource use pattern and Cobb-Douglas production to analyse the resource use efficiency of different crops; input oriented DEA was employed to examine technical and scale efficiency in the farms. The results of resource use pattern and resource use efficiency analysis indicated that farm yard manure usage in crops like sugarcane, paddy, turmeric and tapioca, human labour in the case of tapioca, sugarcane and paddy, phosphorus in sugarcane, banana and turmeric, potash in paddy and banana and machine hours usage in turmeric, banana and paddy were sub optimal and increasing the usage these inputs would increase the yield of the above said crops economically. The DEA analysis also revealed the possibility of improving technical efficiency of crop production as in lines with resource use and efficiency analysis and also indicated the existence of scale inefficiency arising due to in-efficient input combinations as indicated by the slacks in machine hours, potash, nitrogen, phosphorus and human labour in the production of crops in Erode district.

Keywords: Cobb-Douglas production function, Data Envelopment Analysis, Resource Use Efficiency, Technical and Scale Efficiency

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Introduction

India embarked on its first five year plan in 1950-51, the contribution of agricultural sector to total output was 52.20 percent. Over the last six decades, the share of agriculture has declined gradually and at present it is less than 15 percent. The production of food grains during Kharif season in India for the year 2018-19 is 141.59 million tonnes as compared to the same period of the year 2017-18 which was 140.73 million tonnes [Department of Agriculture, Cooperation & Farmers Welfare (DAC &FW)]. Tamil Nadu is the eleventh-largest state and the seventh-most-populous state in India. The contribution of agriculture sector to Gross State Domestic Product at constant prices was 12.73 percent in 2009-10. Tamil Nadu has an area of 13 million hectares of which net area sown area constitutes 37.5 percent. The major crops sown in Tamil Nadu are rice, jowar, ragi, bajra, maize, and pulses Irrigated crops accounts for 56.8 percent Gross cropped area and the rest 43.2 percent are under rain-fed crops. Erode district is one of the major districts of Tamil Nadu which is mainly agrarian in nature. Net area cultivated in Erode District is 171277 hectares and Gross area cultivated is 190698 hectares and the cropping intensity worked out to 127 percent. The net area irrigated in Erode district constitutes 42.27 percent of Gross Cropped Area [1]. Paddy, Maize, Groundnut, Sesame, Gingelly, sugarcane, Turmeric and Banana are the major irrigated crops cultivated in Erode district. Very few studies in the past were on the efficiency of Irrigated agricultural production in Tamil Nadu state and with this end in view the present study was undertaken in Erode district with the following objectives.

1.To analyse the resource use pattern of different crops cultivated in the study area;

2.To work out the resource use efficiency of different crops cultivated and the sources of inefficiency if any in the study area;

3.To examine the technical and scale efficiency of agricultural production in the sample farms of the study area; and to suggest appropriate policies to enhance agricultural production in Erode district

Materials and Methods

Erode district is considered as the universe of the study. Three-stage random sampling procedure was adopted and 120 farms were selected at random from eight revenue villages draw from four blocks of the district selected at random. The major crops cultivated in Erode district such as irrigated sugarcane, paddy, banana, turmeric and tapioca were considered for the analysis.

Tools of Analysis

Conventional analysis: Simple average and percentage were used to analyse the resource use pattern in the production of different crops. Average usage of resources such as farm yard manure, nitrogen, phosphorus, potash, labour man days, machine hours, plant protection chemical expenses in the farm were compared with the standard recommendation to delineate the under and over use of such resources in the farms

Co- efficient of Variation: Co-efficient Variation on the usage of farm yard manure, nitrogen, phosphorus, potash, labour man days, machine hours, plant protection chemicals and yield of crops were worked out to study the variation in usage of the above said resources in the farms of Erode district.

Cobb-Douglas Production Function: Cobb Douglas production function was employed to examine resource use efficiency in the production of crops such as sugarcane, paddy, banana, tapioca and Turmeric. Ordinary Least Square method (OLS) was used to estimate the parameters involved.

The Cobb-Douglas production function specified for irrigated crops is furnished below.

$\ln(y) = \ln \alpha0 + \alpha1 \ln(x1) + \alpha2 \ln(x2) + \alpha3 \ln(x3) + \alpha4 \ln(x4) + \alpha5 \ln(x5) + \alpha6 \ln(x6) + \alpha7 \ln(x7) + \alpha8 \ln(X8) + \alpha9 \ln(X9) + ui$

where,

y = Yield of crop in tonnes.

X1 = Farm yard manure in tonnes.

X2= Nitrogen in kg.

X3= Phosphorus in kg.

X4 = Potash in kg.

X5 = Human Labour in man days.

X6 = Machine usage in hours.

X7 = Expenditure on plant protection chemicals in Rupees.

X8 = Proportion of crop area to GCA in the farm

X9 = Size of the farm in hectares.

α0 = Regression constant

α1, α2, α3, α4, α5, α6, α7, α8 and α9 are partial regression co-efficient and

u = Error term

In Cobb Douglas function, which is expressed as log linear relationship, the parameters associated with different independent variables would represent the elasticity of production and the marginal products are worked out as the first order partial derivative of coefficient of yield with respect to each input.

$MPP = \alpha l\ (Qi\ /\ Xi)$

where,

MPP = Marginal product

Qi = Estimated yield of the crop around geometric mean of inputs

Xi = Geometric mean of i^{th} input and

αl = Partial regression co efficient of the input 'i '

he marginal product thus worked out would represent the change in yield of the crop resulting from unit change in i^{th} input, keeping all other inputs at a constant level.

Data Envelopment Analysis: The Data Envelopment Analysis was used to examine the technical and scale efficiency of agricultural farms under irrigated situation. The DEA method is the frontier method that does not require specification of a functional or distributional form, and can accommodate scale issues. This approach was first used by Farrell (1957) as a piecewise linear convex hull approach to frontier estimation and later by Boles (1966) and Afrait (1972). The development of methods for estimating the relative technical efficiencies of firms [2]. This approach did not receive wide attention till the publication of the paper by Charnes et al. (1978), which coined the term Data Envelopment Analysis (DEA). The following model was used to measure the technical and scale efficiency of irrigated farms.

$\text{Min}\ \theta, \lambda\ \theta$

Subject to $-y i + Y\lambda \geq 0$

$\theta x i - X\lambda \geq 0$

$N1\lambda = 1$

$\lambda \geq 0$

where, N1 is a vector (n x 1) of ones.

The DEA was applied by using both classic model CRS (Constant Returns to Scale) and VRS (Variable Returns to Scale) with input orientation, in which one seeks input minimization to obtain a particular product level.

Description of the Input and Output Variables used in the DEA analysis for Irrigated Farms

SN	Variables	Unit
I.	Output Variable (Y)	
1.	Income	Rupees
II.	Input Variables (X_i)	
1.	FYM	Tonnes
2.	Nitrogen	Kg
3.	Phosphorus	Kg
4.	Potash	Kg
5.	Machine usage	Hours
6.	Human Labour	Man days
7.	Expenses on Plant Protection chemicals	Rupees

The income from crop enterprises of the farm was taken as the output variable in DEA model and expressed as rupees per farm. The input variables(X) include human labour in man days, farmyard manure in tonnes, nitrogen in Kg, phosphorus in Kg, potash in Kg, machine power in machine hours and expenses on plant protection chemicals in rupees. The computer program DEAP version 2.1 developed by T.J. Coelli, Centre for Efficiency and Productivity Analysis, University of New England, Australia, was used for the estimation of efficiency of crop production.

Results and Discussion

Sugarcane

Resource Use Pattern in Sugarcane

The resource use pattern of sugarcane in the irrigated farms is furnished in [Table-1]. The average yield of sugarcane per hectare was 97.90 tonnes and it was found to be lesser than the standard yield of sugarcane, which stood at 100 tonnes/ ha. As regards the inputs usage, 11.65 tonnes of farm yard manure per hectare was used. The mean usage of other inputs was 243.40 kg of nitrogen, 44.43 kg of phosphorus, 126.49 kg of potash, 329.59man days of labour, 15.94 hours of machine usage and Rs. 770.78 towards plant protection chemicals, respectively. A study was conducted to analyse the land use and cropping pattern in Jaisalmer district of Rajasthan, where in the resource use pattern and resource use efficiency of dry crops were worked out [3]. The comparative analysis of average inputs usage with recommended dosage indicated that the average usage of all the inputs except potash was found to be lesser than the recommended dosage. The gap between recommended dosage and mean input use was high in the case of phosphorus, followed by plant protection chemicals, nitrogen, machine hours, farmyard manure, human labour which might indicate the scarcity of these inputs in production of sugarcane. Among these scarce inputs, phosphorus, plant protection chemicals, nitrogen and machine hours exhibited very high scarcity. The coefficient of variation indicated consistency in the usage of human labour, but exhibited high variation in plant protection expenses, followed by phosphorus, farmyard manure, nitrogen, machine hours and potash in sugarcane production.

Resource Use efficiency of Sugarcane

The results of estimated Cobb-Douglas production function for sugarcane in Erode district is furnished in [Table-2]. The coefficient of multiple determination (R2) was significant with the value of 0.98, indicating that the variables included in function could explain 98 percent of variation in the yield of sugarcane. The regression constant was positive and significant at one percent level. The coefficient of variables such as farm yard manure, nitrogen and phosphorus were positive and significant at one percent level with the value of 0.182, 0.76 and 0.33 implying that one percent increase in the above variables from the existing mean level would increase the yield of sugarcane by 0.182, 0.76 and 0.33 percent, respectively. The co-efficient of the human labour was positive and significant at five percent level with value of 0.47, indicating that one percent increase in the human labour from the existing mean level would increase the yield of sugarcane by 0.47 percent. The co-efficient of the variables such as potash, machine hours, plant protection chemicals were found non-significant. The coefficient of variables such as proportion of the crop to GCA and farm size were found to be negative and significant at one percent level, indicating that an increase in the proportion of crop area to GCA would decrease the yield by decreasing the efficiency. Similarly, the negative coefficient of farm size variable indicated a reduction in the yield of sugarcane as the farm size increased, signifying a decrease in the efficiency of operation from small to large farms. The sum of production elasticity of significant variables worked out to 6.90, which indicating the operation of increasing return to scale in the production of sugarcane. As regards economic optima, the MVP / MIC ratio worked out for farm yard manure, nitrogen, phosphorus, was found more than one, indicating suboptimal usage of these resources and the possibility of increasing the yield of sugarcane economically by increasing the usage of these resources from the existing mean level. In the case of human labour MVP/MIC ratio was found to be less than one, indicating even though the possibility of increasing the labour usage for improving sugarcane yield, that could not be undertaken unless rationalisation of wage rate and sugarcane output price was

Sugarcane

Table-1 Resource Use Pattern of Sugarcane in Irrigated Farms

SN	Variables``	Standard Requirement	Mean	Gap (%)	Coefficient of Variation
1	Farm yard Manure in tones/ha	12.5	11.65	6.81	16.92
2	Nitrogen in Kg/ha	275	243.40	11.49	11.98
3	Phosphorus in Kg/ha	60	44.43	25.96	21.17
4	Potash in Kg/ha	120	126.49	-5.40	8.86
5	Human labour in Man days /ha	340	329.59	3.06	5.89
6	Machine Hours in hrs/ha	18	15.94	11.44	9.64
7	Plant Protection Chemicals in Rs/ha	950	770.78	18.86	65.98
8	Yield in Kg/ha	100	97.90	2.1	22.82

Table-2 Estimated Cobb-Douglas Production Function for Sugarcane in Erode District

SN	Variables	Coefficients	Standard Error	Significance	MVP/MIC
1.	Regression Constant	6.6467	0.4890	**	-
2.	Farm yard Manure in tones	0.1827	0.0540	**	3.8
3.	Nitrogen in Kg	0.7607	0.2135	**	59.7
4.	Phosphorus in Kg	0.3306	0.1138	**	29.8
5.	Potash in Kg	-0.1180	0.1327	NS	-
6.	Human labour in Man days	0.4700	0.1895	*	0.68
7.	Machine Hours in hrs	0.0557	0.1498	NS	-
8.	Plant Protection Chemicals in Rs	0.0002	0.0005	NS	-
9.	Proportion of Sugarcane area to GCA (%)	-0.6650	0.1921	**	-
10.	Farm Size in Ha	-0.6590	0.1914	**	-
11.	Yield in kg (Y)				

N=56, R^2= 0.98, Adjusted R^2=0.97, F = 35**

Paddy

Table-3 Resource Use Pattern of Paddy in Irrigated Farms

SN	Variables	Standard Requirement	Mean	Gap (%)	Coefficient of Variation
1.	Farm yard Manure in tones/ha	12.5	9.28	25.76	11.88
2.	Nitrogen in Kg/ha	150	162	-8	16.71
3	Phosphorus in Kg/ha	50	50.77	-1.54	19.48
4.	Potash in Kg/ha	50	46.99	6.02	11.4
5.	Human labour in Man days /ha	164	159.12	2.98	15.16
6.	Machine Hours in hrs/ha	18	17.42	3.22	8.24
7.	Plant Protection Chemicals in Rs/ha	2500	2522.01	-0.88	9.19
8.	Yield in Kg/ha	6000	4500	25	17.07

Table-4 Estimated Cobb-Douglas Production Function for Paddy in Erode District

SN	Variables	Coefficients	Standard Error	Significance	MVP/MIC
1.	Regression Constant	6.6695	1.5033	**	-
2.	Farm yard Manure in tones	0.5997	0.2213	**	5.8
3.	Nitrogen in Kg	-0.1445	0.1865	NS	-
4.	Phosphorus in Kg	-0.4083	0.1927	*	-11.7
5.	Potash in Kg	0.5349	0.2534	*	31.1
6.	Human labour in Man days	1.6084	0.1248	**	1.7
7.	Machine Hours in hrs	1.3262	0.4852	**	4.5
8.	Plant Protection Chemicals in Rs	-0.4917	0.2730	NS	-
9.	Proportion of Paddy area to GCA (%)	-1.6284	0.2735	**	-
10.	Farm Size(Ha)	-1.7745	0.2797	**	-
11.	Yield in kg (Y)				

N= 61, R^2= 0.96, Adjusted R^2=0.96, F = 17**

Banana

Table-5 Resource Use Pattern of Banana in Irrigated Farm

SN	Variables	Standard Requirement	Mean	Gap (%)	Coefficient of Variation
1.	Farm yard Manure in tones/ha	12.5	9.29	25.7	17.27
2.	Nitrogen in Kg/ha	480	460	4.1	18.45
3.	Phosphorus in Kg/ha	154	106.6	30.8	11.02
4.	Potash in Kg/ha	885	810.5	8.4	9.83
5.	Human labour in Man days /ha	240	273.28	-13.9	11.23
6.	Machine Hours in hrs/ha	12	10.9	9.2	17.78
7.	Plant Protection Chemicals in Rs/ha	2000	2184.45	-9.2	13.03
8.	Yield in Kg/ha	40000	32051		30.59

Table-6 Estimated Cobb-Douglas Production Function for Banana in Erode District

SN	Variables	Coefficients	Standard Error	Significance	MVP/MIC
1.	Regression Constant	1.2044	0.7707	NS	-
2.	Farm yard Manure in tones	0.0368	0.1048	NS	-
3.	Nitrogen in Kg	0.3692	0.1859	NS	-
4.	Phosphorus in Kg	1.0552	0.2463	**	69.3
5.	Potash in Kg	1.7011	0.4002	**	29
6.	Human labour in Man days	-0.2526	0.2780	NS	-
7.	Machine Hours in hrs	0.2213	0.0996	*	6.1
8.	Plant Protection Chemicals in Rs	-0.1063	0.1701	NS	-
9.	Proportion of Banana area to GCA (%)	-1.0677	0.2124	**	-
10.	Farm Size(Ha)	-0.1300	0.2207	**	-
11.	Yield in kg (Y)				

N=34, R^2=0.98, Adjusted R^2=0.95, F=21**

Turmeric

Table-7 Resource Use Pattern of Turmeric in Irrigated Farms

SN	Variables	Standard Requirement	Mean	Gap (%)	Coefficient of Variation
1.	Farm yard Manure in tones/ha	25	9.9	60.4	15.9
2.	Nitrogen in Kg/ha	60	58.4	2.66	20.47
3.	Phosphorus in Kg/ha	50	47.7	4.6	13.95
4.	Potash in Kg/ha	108	117.25	-8.5	9
5.	Human labour in Man days /ha	240	228.36	4.85	7.68
6.	Machine Hours in hrs/ha	12	10.59	11.75	14.2
7.	Plant Protection Chemicals in Rs/ha	2500	2303.261	7.8	10.93
8.	Yield in Kg/ha	25000	19650		15.71

Table-8 Estimated Cobb-Douglas Production Function for Turmeric in Erode District

SN	Variables	Coefficients	Standard Error	Significance	MVP/MIC
1.	Regression Constant	6.4736	1.2898	*	-
2.	Farm yard Manure in tones	0.2433	0.3043	*	37.5
3.	Nitrogen in Kg	0.1190	0.0930	NS	-
4.	Phosphorus in Kg	0.0169	0.1835	*	8.5
5.	Potash in Kg	-0.0599	0.2667	NS	-
6.	Human labour in Man days	0.4427	0.2446	NS	-
7.	Machine Hours in hrs	0.6107	0.1666	**	58.2
8.	Plant Protection Chemicals in Rs	0.1678	0.2236	NS	-
9.	Proportion of Turmeric area to GCA (%)	-0.5048	0.2077	*	-
10.	Farm Size (Ha)	-0.6578	0.2133	*	-
11.	Yield in kg (Y)				

N=20, R2=0.85, Adjusted R2=0.83, F=48**

Tapioca

Table-9 Resource Use Pattern of Tapioca in Irrigated Farms

SN	Variables	Standard Requirement	Mean	Gap (%)	Coefficient of Variation
1.	Farm yard Manure in tones/ha	25	13.3	46.8	5.88
2.	Nitrogen in Kg/ha	90	89.2	0.89	4.74
3.	Phosphorus in Kg/ha	90	82.3	8.56	5.11
4.	Potash in Kg/ha	240	236.9	1.29	2.9
5.	Human labour in Man days /ha	120	122.8	-2.3	7.92
6.	Machine Hours in hrs/ha	18	17.6	2.2	5.89
7.	Plant Protection Chemicals in Rs/ha	2000	1800	10	62.01
8.	Yield in tones/ha	40	36.21		8.63

Table-10 Estimated Cobb-Douglas Production Function for Tapioca in Erode District

SN	Variables	Coefficients	Standard Error	Significance	MVP/MIC
1.	Regression Constant	7.5107	1.7472	**	-
2.	Farm yard Manure in tones	0.8800	0.3583	**	10.6
3.	Nitrogen in Kg	0.7547	0.6128	NS	-
4.	Phosphorus in Kg	0.4743	0.5331	NS	-
5.	Potash in Kg	0.1188	0.8074	NS	-
6.	Human Labour in Man days	-0.2574	0.2616	*	-0.67
7.	Machine Hours in hrs	0.2014	0.4253	NS	-
8.	Plant Protection Chemicals in Rs	0.0010	0.0019	NS	-
9.	Proportion of Tapioca area to GCA (%)Proportion	-0.1402	0.7028	*	-
10.	Farm Size (Ha)	-0.1073	0.7144	*	-
11.	Yield in kg (Y)				

N=20, R2=0.89, Adjusted R2=0.90, F=16**, **Significant at one percent level, *Significant at five percent level, NS Non-Significant

DEAP

Table-11 Technical and Scale Efficiency of Irrigated Farms

SN	Descriptive Statistics	CRSTE	VRSTE	SE
	No. of Efficient Farmers (More than 0.90)	29 (24.17)	38 (31.67)	47 (39.17)
1	Mean	0.535	0.609	0.808
2	Standard Deviation	0.349	0.312	0.194
3	Minimum	0.041	0.075	0.178
4	Maximum	1	1	1

Note: Figures in parentheses are percentage to total farmers in respective farm size;
CRSTE- Technical Efficiency under Constant Returns to Scale;
VRSTE- Technical Efficiency under Variable Returns to Scale;
SE - Scale Efficiency

Table-12 Mean Input Usage and Mean Input Slacks in irrigated Farms

SN	Inputs	Mean Input Slack	Mean Input Used	Excess Input (in percent)
1.	Farm Yard Manure in tones	2.14	27.07	7.92
2.	Nitrogen in Kg	56.47	498.81	11.32
3.	Phosphorus in Kg	20.22	207.82	9.73
4.	Potash in Kg	82.12	560.40	14.65
5.	Labour in Man days	52.67	575.65	9.15
6.	Machine hours in Hrs	12.68	77.01	16.46
7.	Plant protection Chemicals in Rs	418.57	4733.71	8.84

undertaken. The study revealed the suboptimal usage of farm yard manure, nitrogen and phosphorus and indicating the possibility of improving the yield of sugarcane economically in Erode district and also the need of rationalisation of wage rate and sugar cane price to improve labour use and yield in sugar cane production.

Paddy

Resource Use Pattern in Paddy

The resource use pattern in paddy is furnished in [Table-3]. The average yield of paddy per hectare was 4500 kg and it was found to be lesser than the standard yield of 6000 kg/ ha. The mean input usage per hectare of paddy were 9.28 tonnes of farm yard manure, 162 kg of nitrogen, 50.77 kg of phosphorus, 46.99 kg of potash, 159.12 man days of labour, 17.42 hours of machine usage and Rs. 2522.01 for plant protection chemicals, respectively. Comparison between average inputs usage and the standard dosage in paddy indicated that the usage of all inputs except nitrogen and phosphorus were found to be lesser than the standard recommended dosage. The gap between recommended dosage and average application was high in farmyard manure, followed by potash, machine hours and human labour, which might indicate the scarcity of these inputs in paddy production. The coefficient of variation worked out for various resource used in paddy production indicated consistency in the usage of machine hours and plant protection expenses, while exhibited high variation in Phosphorus and nitrogen.

Resource Use efficiency of Paddy

The results of estimated Cobb-Douglas production function for Paddy in Erode district is furnished in [Table-4]. The coefficient of multiple determination (R2) was significant with the value of 0.96, indicating that the variables included in function could explain 96 percent of variation in the yield of Paddy. The regression constant was positive and significant at one percent level. The coefficient of variables such as farm yard manure, labour man days and machine hours were positive and significant at one percent level with the value of 0.59, 1.6 and 1.32 implying that one percent increase in the above variables from the existing mean level would increase the yield of paddy by 0.59, 1.6 and 1.32 percent, respectively. The co-efficient of potash was positive and significant at five percent level with value of 0.53, indicating that one percent increase in potash from the existing mean level would increase the yield of paddy by 0.53 percent. The co-efficient of the variable phosphorus was negative and significant at five percent level with the value of -0.40, which indicated one percent increase in phosphorus from existing mean level would reduce paddy yield by 0.40 percent. The co-efficient of variables such as nitrogen and plant protection chemicals were non-significant. The coefficient of variables such as proportion of the crop size and farm size were found to be negative and significant at one percent level which indicated that an increase in paddy proportion and the farm size would decrease the yield of paddy by decreasing the efficiency of operation .The sum of production elasticity of significant variables worked out to 6.7, which indicated the operation of increasing return to scale in the production of Paddy. The production efficiency of crops is analysed [4]. The MVP / MIC ratio for farm yard manure, potash, labour man days and machine hours was more than one, indicating the sub-optimal usage and the possibility of improving paddy yield economically by increasing the existing level of these resources. In the case of phosphorus MVP/MIC ratio was found to be less than one, indicating the overuse of phosphorus in paddy production and the need for reducing the existing level of phosphorus usage. The study revealed the suboptimal usage of farm yard manure, potash, labour man days, machine hours and overuse of phosphorus indicating the need for increasing the farm yard manure, potash, labour man days, machine hours and reducing phosphorus usage and from the existing mean level to improve the production of paddy in Erode district

Banana

Resource Use Pattern in Banana

The resource use pattern of Banana in the irrigated farms is furnished in [Table-5]. The average yield of Banana per hectare was 40000 kg and it was less than the standard yield of Banana, which was 32051.28 kg/ ha. The mean input usage per hectare of banana were 9.29 tonnes of farm yard manure, 440 kg of nitrogen, 106.6 kg of phosphorus, 810.5 kg of potash, 273.28 man days of labour, 10.9 hours of machine hours and Rs. 2184.45 on the expenses of plant protection chemicals. Comparison between average inputs usage and the standard dosage in banana indicated that the usage of all inputs except human labour and plant protection chemicals were found to be lesser than the standard recommended dosage. The gap between standard dosage and average was high in phosphorus, followed by farm yard manure, machine hours, potash and nitrogen, which might indicate the scarcity of these inputs in banana production. The coefficient of variation worked out for various resource used in banana production indicated consistency in the usage of inputs such as potash, phosphorus and human labour in Erode district.

Resource Use efficiency of Banana

The results of estimated Cobb-Douglas production function for Banana in Erode district is furnished in [Table-6]. The coefficient of multiple determination (R2) was significant with the value of 0.98, indicating that the variables included in function could explain 98 percent of variation in the yield of Banana. The regression constant was positive and non- significant. The coefficient of variables such as phosphorus and potash were positive and significant at one percent level with the value of 1.05 and 1.70 implying that one percent increase in the above variables from the existing mean level would increase the yield of banana by 1.05 and 1.70 percent, respectively. The co-efficient of machine hours was positive and significant at five percent level with value of 0.22 indicates that one percent increase in machine hours from the existing mean level would increase the yield of banana by 0.22 percent. The co-efficient of variables such as farm yard manure, nitrogen, labour man days and plant protection chemicals were found non-significant. The coefficient of variables such as proportion of the crop size and farm size were found to be negative and significant at one percent level which indicated that an increase in banana proportion in GCA and the farm size would decrease the yield of paddy by decreasing the efficiency of operation. The sum of production elasticity of significant variables worked out to 1.76 which indicated the operation of increasing return to scale in the production of banana. The MVP / MIC ratio for the input phosphorus, potash and machine hours was more than one, indicating the suboptimal usage and the possibility of improving banana yield economically by increasing the existing level of these resources.

Turmeric

Resource Use Pattern in Turmeric

The resource use pattern in Turmeric is furnished in [Table-7]. The average yield of Turmeric per hectare was 19650 kg/ ha and it was found to be lesser than the standard yield of 25000 kg/ ha. The mean input usage per hectare of Turmeric were 9.9 tonnes of farm yard manure, 58.4 kg of nitrogen, 47.7 kg of phosphorus, 117.25 kg of potash, 228.36 man days of labour, 10.59 hours of machine hours and Rs. 2303.26 for plant protection chemicals, respectively. Comparison between average inputs usage and the standard dosage in Turmeric indicated that the usage of all inputs except potash was found to be lesser than the standard recommended dosage. The gap between recommended dosage and average application was high in farmyard manure, followed by machine hours, plant protection chemicals, labour man days, nitrogen and phosphorus, which indicate the scarcity of these inputs in Turmeric production. The coefficient of variation worked out for various resources used in Turmeric production indicated consistency in the usage of potash, human labour and plant protection expenses, while exhibited high variation in farmyard manure and machine hours.

Resource Use Efficiency of Turmeric

The results of estimated Cobb-Douglas production function for Turmeric in Erode district is furnished in [Table-8]. The coefficient of multiple determination (R2) was significant with the value of 0.85, indicating that the variables included in function could explain 85 percent of variation in the yield of Turmeric. The regression constant was positive and significant at one percent level. The coefficient of machine hours was positive and significant at one percent level with the value of

0.61 implying that one percent increase in the above variable from the existing mean level would increase the yield of Turmeric by 0.61 percent. The co-efficient of variables such as farm yard manure and phosphorus were positive and significant at five percent level with value of 0.2 and 0.01, indicating that one percent increase in potash from the existing mean level would increase the yield of Turmeric by 0.2 and 0.01 percent, respectively. The co-efficient of variables such as nitrogen, potash, human labour and plant protection chemicals were non-significant. The coefficient of variables such as proportion of the crop size and farm size were found to be negative and significant at five percent level which indicated that an increase in Turmeric proportion and the farm size would decrease the yield of Turmeric by decreasing the efficiency of operation .The sum of production elasticity of significant variables worked out to 6.06, which indicated the operation of increasing return to scale in the production of Turmeric. The resource use efficiency in tomato production was analysed in the study conducted at Dangme Wast District of Ghana.in Africa [5]. The MVP / MIC ratio for farm yard manure, phosphorus and machine hours were more than one, indicating the sub-optimal usage and the possibility of improving Turmeric yield economically by increasing the existing level of these resources. The study revealed the suboptimal usage of farm yard manure, phosphorus and machine hours indicating the need for increasing the farm yard manure, phosphorus and machine from the existing mean level to improve the production of Turmeric in Erode district.

Tapioca

Resource Use Pattern of Tapioca

The resource use pattern of Tapioca in the irrigated farms is furnished in [Table-9]. The average yield of Tapioca per hectare was 36.21 tonnes and it was found to be lesser than the standard yield of Tapioca, which stood at 40 tonnes/ ha. As regards the inputs usage, 13.3 tonnes of farm yard manure, 89.2 kg of nitrogen, 82.3 kg of phosphorus, 236.9 kg of potash, 122.8-man days of labour, 17.6 hours of machine hours and Rs. 1800 towards plant protection chemicals, respectively. The comparative analysis of average inputs usage with recommended dosage indicated that the average usage of all the inputs except, human labour was found to be lesser than the recommended dosage. The gap between recommended dosage and mean input use was high in the case of farmyard manure, followed by plant protection chemicals, phosphorus, machine hours, potash and nitrogen, which might indicate the scarcity of these inputs in production of Tapioca. Among these scarce inputs, farm yard manure and plant protection chemicals exhibited very high scarcity. The coefficient of variation indicated consistency in the usage of potash, nitrogen, phosphorus, farmyard manure, machine hours and human labour but exhibited high variation in plant protection expenses in Tapioca production.

Resource Use efficiency of Tapioca

The results of estimated Cobb-Douglas production function for Tapioca in Erode district is furnished in [Table-10]. The coefficient of multiple determination (R2) was significant with the value of 0.89, indicating that the variables included in function could explain 89 percent of variation in the yield of Tapioca. The regression constant was positive and significant at one percent level. The coefficient of farm yard manure was positive and significant at one percent level with the value of 0.80 implying that one percent increase in the above variables from the existing mean level would increase the yield of Tapioca by 0.80 percent. The co-efficient of the human labour was negative and significant at five percent level with value of -0.25, indicating that one percent increase in the human labour from the existing mean level would reduce the yield of Tapioca by 0.25 percent. The co-efficient of the variables such as nitrogen, phosphorus, potash, machine hours and plant protection chemicals were found non-significant. The coefficient of variables such as proportion of the crop to GCA and farm size were found to be negative and significant at five percent level, indicating that an increase in the proportion of crop area to GCA would decrease the yield by decreasing the efficiency. Similarly, the negative coefficient of farm size variable indicated a reduction in the yield of sugarcane as the farm size increased, signifying a decrease in the efficiency of operation from small to large farms. The sum of production elasticity of significant variables worked out to 7.70, which indicated the operation of increasing return to scale in the production of Tapioca. As regards economic optima, the MVP / MIC ratio worked out for farm yard manure was found more than one, indicating suboptimal usage of these resources and the possibility of increasing the yield of Tapioca economically by increasing its usage from the existing mean level. In the case of human labour MVP/MIC ratio was found to be less than one, indicating its overuse and the need for decreasing the labour usage for to improve Tapioca yield in erode district. The study revealed the suboptimal usage of farm yard manure and overuse human labour indicating the possibility of improving the yield of Tapioca economically by increasing farmyard manure and reducing human labour application in Erode district.

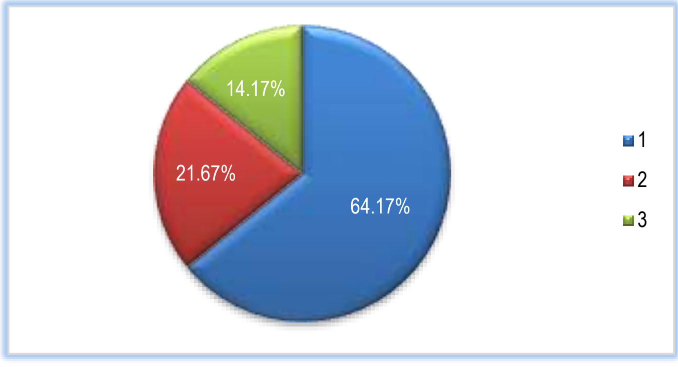
Data Envelopment Analysis- Technical and Scale Efficiency

Technical and Scale Efficiency of Irrigated Farms

The results of the Data Envelopment Analysis for the irrigated farms in Erode district is furnished in [Table-11]. From the total 120 farms in Erode District, 24.17 percent (29 Farms) were found to be operated with the overall technical efficiency of more than 0.90 under constant return to scale (CRS) and the rest 75.83 percent (91 farms) were found to be technically inefficient with respect to input allocation in crop production. The overall technical efficiency of farms ranged from 0.041 to 1.00 with the mean efficiency of 0.535. The results indicated that the 91 farms (75.83 percent) which did not operate at the maximum efficiency level (above 90 percent) could reduce the present level of input usage by 46.50 percent and could still maintain the same level of production as achieved by 24.17 percent of the technically efficient farms in the region. The level of technical efficiency in the production of three major crops of rice, groundnut and cotton in the state of Andhra Pradesh [6]. The pure technical efficiency is calculated by using variable return to scale range from 0.075 to 1.00 with the mean efficiency of 0.609. Relaxing the assumption of constant return to scale and using the convexity model with the assumption of variable returns to scale indicated that farms with pure technical efficiency score more than 90 percent of efficiency increased from 24.17 percent to 31.67 percent and the mean technical efficiency increased from 0.535 to 0.609 as compared to constant return to scale model, because pure technical efficiency calculated is devoid of scale effects and the difference between technical efficiency under constant return to scale and variable return to scale stands for scale efficiency. About 39.17 percent of the farms were found with the scale efficiency of more than 0.90 percent and the rest 60.83 percent were operating in a less than optimal size. The scale efficiency among farms ranged from 0.178 to 1.00 with mean efficiency is 0.808. The above results indicated that 60.83 percent of farms were operating less than optimal size could increase their scale efficiency by 19 percent by operating in optimal scale under current technology. This would enable the farms to operate in optimal scale and would increase the productivity and income from the farms in the region.

Scale of Operation in the irrigated Farm

Scale of operation of the farms is given in pie chart revealed that 21.67 percent is operating under decreasing returns to scale (supra optimal level) and 14.17 percent is under constant returns to scale (Optimal level) and 64.17 percent is operating under increasing returns to scale (sub optimal level).



1-Constant returns to scale, 2- Decreasing returns to scale, 3- Increasing returns to scale

Chart-1 Scale of operation of the farms

Input Slacks in Irrigated Farms

The mean input slacks, Mean input used and percentage of excess inputs available in the farm are tabulated in the [Table-12]. The slack indicates excess of an input available in a farm, so that the farm could reduce the expenditure on its input by the amount of slack without reducing the output. The greatest slack was found in Machine hours with (16.46 percent) followed by Potash (14.65 percent), Nitrogen (11.32 percent), Phosphorus (9.73 percent), Labour man days (9.15 percent), Plant protection chemicals (8.84 percent) and Farm yard manure (7.92 percent) in farms. The above results indicated that a farm could reduce its expenditure on these inputs by the amount of slack without reducing its output.

Conclusion and Policy Implications

The analysis on resource use pattern and resource use efficiency under present study indicated that farm yard manure application in crops like sugarcane, paddy, turmeric and tapioca was less than the recommended level and also found to be sub optimal in the production of the above said crops. Increasing the availability of farm yard manure and its application by converting crop residues and animal wastes in the farms would increase the yield of sugarcane , paddy, turmeric and tapioca both physically and economically in Erode district . Functional analysis indicated over-use of human labour in the case of tapioca and under-utilisation in the case of paddy which calls for increasing the labour usage in the case of paddy and reducing labour usage in the case of tapioca so as to improve the yield in the respective crops. The Department of Agriculture and extension agencies should sensitize the farmers on the over and underutilization of labour on one hand and introducing labour saving machineries in labour scarce agricultural production areas of district on the other hand would help in addressing the labour issues. Even though there exists possibility to improve yield of sugar cane physically by increasing the existing level of labour use, it could not be accomplished economically. Thus, rationalization of wage rate of labour or the price of sugarcane through appropriate price policy is urgently needed in the case of sugar cane. The study revealed the over-utilisation of phosphorus in paddy and underutilisation in sugarcane, banana and turmeric and indicated the need for reducing phosphorus in paddy and increasing its usage in sugarcane, banana and turmeric so as to improve the yield of the above said crops economically. Sub optimal usage of potash was observed in the production of paddy and banana and increasing potash use in the above crops from the existing level would increase the yield and return economically. Ensuring the availability of phosphorus and potash at nominal price to the farmers by streamlining the input delivery system in Erode district is urgently needed. Machine hours usage was found sub optimal in the case of turmeric, banana and paddy and increasing the usage of machines by making available these machines on rental basis during crop production by government agencies in Erode district would improve the production and return from these crops. The study revealed that efficiency of production decreases from small to large farms as indicated by the significant negative relationship between farm size and yield of all crops in the study area. The DEA analysis also revealed the possibility of improving technical efficiency of crop production in Erode district and also indicated the existence of scale inefficiency arising due to in-efficient input combinations as indicated by the slacks in machine hours, Potash, Nitrogen, Phosphorus and Human labour and pursuing recommended policies as provided earlier would help to correct the existing technical and scale inefficiency in the crop production of Erode district.

Application of research: Study of Efficiency of Agricultural Production in Erode District.

Research Category: Agricultural Production

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Study area / Sample Collection: Erode district, Tamil Nadu

Cultivar / Variety name: Sugarcane, Paddy, Turmeric, Banana, Tapioca

Conflict of Interest: None declared

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Ethical Committee Approval Number: Nil

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