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ANALYSIS OF TECHNICAL EFFICIENCY OF RICE PRODUCTION IN RAMANATHAPURAM DISTRICT OF TAMIL NADU

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ABSTRACT

Rice is a staple food crop in Tamil Nadu. Ramanathapuram district has 68 percent of rice cultivation area and 82.12 percent of total demand of water. In this study, an attempt was made to know the technical efficiency of rice production in the district. The technical efficiency of rice production was measured using the Data Envelopment Analysis (DEA) model to assess whether rice output can be increased through improved resource use efficiency or by expanding the area under cultivation. The data were collected from 120 farmers during 2023-24 from two blocks of Ramanathapuram district i.e. Nainarkoil and Kamuthi which have the highest concentration of well-irrigated area and rice cultivation among all blocks in the district. The results of Data envelopment Analysis show that the average technical efficiency is 0.907. This indicates that rice farmers are 9.3 percent technically inefficient and 90 percent current inputs are enough to sustain the production. It means that there is less scope for exploration through enhancing resource use efficiency.

KEYWORDS: *Rice*, Data Envelopment Analysis, Technical efficiency*, Production*.

INTRODUCTION

Rice is the world's most important crop and it has been grown for more than 6000 years in South Asia. It is the staple food for more than two thirds of Indian population contributing more than 40 per cent to the total food grain production thereby occupies a pivotal role in the food and livelihood security of people. Ramanathapuram district is one of the water scarcity districts in Tamil Nadu. It has 68 percent of rice cultivation area and 82.12 percent of water demand. Recent studies investigating the technical and economic efficiencies of crop production, particularly for wheat and rice, have identified what is known as a 'yield gap'. This gap refers to the difference in productivity between farms that utilize best practices and those operating under similar conditions with comparable resource endowments. The gap between current and technically feasible crop yields signifies a substantial opportunity to boost food and agriculture production by improving productivity. This potential exists without need of further technological advancements or additional utilization of resources like land, labour and water. Mostly resources in the agricultural sector, particularly in developing countries, are typically using resources inefficiently. Farmers primarily focus on the profitability of their farming enterprises which directly or indirectly relies on the efficiency of resource utilization. Rice production can be enhanced either by expanding the rice cultivated area or by improving the efficiency of current resources allocated to rice farming. If rice farmers have already achieved technical efficiency then for increasing the productivity, it would need the adoption of new inputs and technologies to elevate the production frontier. The aim of the present study is to estimate the technical inefficiency of rice farmers which could help for removing the yield gap observed in rice production.

MATERIAL AND METHODS

Ramanathapuram district of Tamil Nadu was purposively selected as it has highest rainfed area (137099 ha) than other districts and has higher cumulative vulnerability index (0.7) (DRDA, Ramanathapuram, 2021). Out of 11 blocks, two blocks were selected based on ground water irrigation area (wells and tube-wells) and maximum area under rice cultivation i.e., Nainarkoil (1196.58 ha and 11166 ha) and Kamuthi (975.32 ha and 10376.69 ha) respectively. The rice crop with high percentage of area to the total cultivation area (68.10 per cent) and higher total water demand (82.12 per cent) in the district was selected for the study. From each block, 60 rice farmers were randomly selected making a total sample size of 120 farmers. The data were collected from the sample farmers through personal interviews on their farm input data in the year 2023-24.

Data Envelopment Analysis model was employed for measuring technical efficiency of rice. Suppose there are n homogenous Decision-Making Units (DMUs) and in order to produce r number of outputs (r=1,2,3…. k),

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s number of inputs were utilized (s=1,2,3…m) by each DMU, i (i=1,2,3…n). Assume also that the input and output vectors of i^{th} DMU are represented by x_i and y_i respectively and the data for all DMUs be denoted by the input matrix (X) m*n and output matrix (Y) k*n. Accounting for financial limitations or imperfect competitive market effects, the DEA model for variable returns to scale (VRS) which was developed by Banker, Charnes and Cooper (BCC) (Banker *et al*., 1984) was used. The input minimization process to measure technical efficiency of rice for each DMU could be expressed as equation (1):

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

Subjected to $-y_i + Y\lambda \geq 0$,

$\phi x_i - X\lambda \geq 0$,

$N_1, \lambda = 1$

$\lambda \geq 0$ …………………...Eq (1)

where,

Y - output matrix for n farms.

θ - the total technical efficiency of i^{th} farm.

λ represents N*1 vector of weights (constants)

X - input matrix for n farms.

yi – yield of the i^{th} farm in kg/ha.

xi - the input vector of x1i, x2i…x7i inputs of i^{th} farm.

x1i – Total land used by i^{th} farm (in ha)

x2i – Seed (kg/ha) used on the i^{th} farm

x3i – Total Fertilizer used (kg/ha) on the i^{th} farm

x4i – Total Plant protection chemicals used (litres/ha) on the i^{th} farm

x5i – Ground water volume (m^3/ha) used on the i^{th} farm

x6i – Total man power used (hours/ha) on the i^{th} farm

x7i – Total machine power (hours/ha) on the i^{th} farm

where, in the restriction N1' ë = 1, N1' is convexity constraint which is a N*1 vector of ones and ë is a N*1 vector of weights (constants) which defines the linear combination of peers of the ith DMU. $1 \leq \phi \leq \infty$ and $\phi - 1$ is the proportional increase in output that could be achieved by the i^{th} DMU with the input quantities held constant and 1/ ϕ defines a technical efficiency score which varies between zero and one. If ϕ = 1 then the farm is said to be technically efficient and if ϕ ≤ 1 the farm lies below the frontier and is technically inefficient.

Information about the number of irrigations for rice cultivation, time of irrigation, bore depth, diameter of suction pipe, and power of the engine were collected. Using this information in an approximate estimation model as used by Srivastava *et al*., (2009), groundwater extraction was measured in litres using the following formula and then converted into m^3.

$$Q = \frac{t * 129574.1 * BHP}{\left[d + \left(255.5998 * BHP^2\right) d^2 * D^4\right]}$$

where,

Q represents the volume of water in litres

t is the total irrigation time in hours

d is the depth of bore in m

D is the diameter of the suction pipe in inches.

BHP is the power of the engine.

RESULTS AND DISCUSSIONS

Efficiency measures

The technical efficiency is defined as the ability of a farm to produce the maximum feasible output from a given bundle of inputs or to use minimum feasible amount of inputs to produce a given level of output. These two definitions of technical efficiency lead to what is respectively known as the 'output-oriented' and the 'input-oriented' efficiency measures. Input-oriented models were chosen in the study to reflect the reality where the main aim is to use resources more efficiently and not to increase production. The study used single-output, multiple-input model, input-oriented Variable Returns to Scale Data Envelopment Analysis model to estimate the technical efficiencies.

Descriptive Statistics of inputs and outputs at farm level

To measure farm efficiency, the major inputs used by majority of rice farmers were considered. Descriptive statistics of output and input variables to analyze the technical efficiency is presented in table 1. The output was measured as yield obtained from rice crop in kg/ha. The yield was obtained from rice crop in year 2023-24 by the farmer. The average yield obtained was 5495.83

Table 1. Descriptive statistics of input and output variables of sample rice farmers

Parameter	Variables	Mean	Minimum	Maximum	Standard deviation
Output variable	Yield (kg/ha)	5495.83	5000	6000	355
Input variables	Land (hectares)	2.35	1.6	2.8	0.30
	Seed rate (kg/ha)	80.42	55	85	5.00
	Fertilizer (kg/ha)	328.43	237.5	400	48.45
	Plant protection chemical used (litres/ha)	7.22	6.25	8.5	0.93
	Human Labour (hours/ha)	454.60	424	488	17.83
	Machine power (hours/ha)	9.73	6.25	12.5	2.06
	Ground water volume (cubic.m/ha)	1462.5	862.5	1887.5	243.81

kg/hawhile the minimum yield was 5000 kg/ha and maximum yield obtained was 6000 kg/ha. The standard deviation was 355 which was quite high, which indicates large variability among the rice farmers selected in the study.

The major inputs used by farmers were land, seed, fertilizer, and plant protection chemicals, ground water for irrigation, human labor and machine labor.

The average land utilized by the farmer was 2.35 ha, the average seed consumed by the farmer was 80.42 kg per ha, the average fertilizer used by the farmer was 328.43 kg per ha, the average plant protection chemical used by the farmer was 7.22 lit/ha and the volume of ground water used by the farmer was 1462.5 cubic.m/ha. The mean human-labour utilized was 454.60 hours/ha and the mean machine power utilised was 9.73 hours/ha. The descriptive statistics of inputs state that the farmers were using larger amounts of fertilizer, human labor and water for irrigation with higher variability.

Technical Efficiency of sample rice farmers

The technical efficiency of sample rice farmers are indicated in table 2. The results from table 2 show the mean technical efficiency as 0.907. This indicates that the farmers can still reduce their inputs includes seed, fertilizer, water requirement, chemical application, machine hours and human labour by 9.3 per cent to produce same amount of output (as the model is input-oriented) (Abedullah *et al*., 2007; Ogundele and Okoruwa, 2004). Among the 120 sample rice farmers, 40 farmers were operating at an efficient level 1. This means 33.33 per cent farmers are fully efficient. Next, 15 farmers were operating from 0.9 to 0.99 efficiency level. They contributed 12.5 per cent of the sample rice farmers. This implies that 25 per cent of the farmers were operating at optimum efficient level. Furthermore, 65 farmers (54.17%) were operating at 0.80-0.89 level efficiency and no farmers were operating at less than 0.8 level efficiency. (Tipi *et al*., 2009). This indicates that 54.17 per cent of the farmers were operating at near

Table 2. Frequency distribution of technical efficiency of sample rice farmers

Efficiency Range	Technical Efficiency	
	Frequency	Percentage
1	40	33.33
0.90-0.99	15	12.50
0.80-0.89	65	54.17
0.70-0.79	0	0
Sum	120	100.00
Maximum		1
Minimum		0.8
Mean		0.903

optimum efficient level. This implies that there were technically efficient farmers in the study however most of them were striving to reach the optimum efficiencylevel. In overall, farmers were operating at more than 80 per cent efficiency level. The mean technical efficiency was 0.907. This could be implied that the 65 sample farmers (54.17%) who were just below the optimum efficiency level can reduce their inputs by 9.3 per cent and can achieve the efficiency level of those 45.83 per cent farmers who were operating at optimum efficiency level. It also indicates that 90.7 per cent of current inputs are enough to sustain the production.

The model suggested that the technical efficiency of the farmers is 0.903. On an average, the farmers are 90 percent technically efficient which means there exists less potentiafor improving resource use efficiency in rice production because they are already effectively utilizing resources such as labour, land and capital. However, to achieve long-term improvements in rice productivity, the focus should shift towards advancing the production function through the adoption of new technologies. This entails prioritizing research and development efforts aimed at creating high-yielding and superior quality rice varieties. Such initiatives require increased investment in research-related activities to innovate and enhance overall agricultural productivity.

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