Energy Use Pattern and Its Efficiency in Paddy Cultivation in Tamil Nadu, India

Dr. A. Saravanan[1]

[1]*Assistant Professor, Department of Economics, PSG College of Arts & Science, Coimbatore-641014, Tamil Nadu, India.*

Email: saravananchamp@gmail.com

Abstract

The purpose of this study was to identify the socio-economic characteristics of paddy cultivating farmers of various size groups selected from the sample; to examine the resource use pattern of paddy cultivating farmers of various farm size groups; and to evaluate the farm level technical efficiencies in the production of paddy in Thadappalli ayacut of Erode District in Tamil Nadu. The study was conducted in Thadappalli ayacut of Erode District in Tamil Nadu. The research was conducted solely on a representative sample of 150 paddy farmer households drawn from five different villages located within the Thadappalli ayacut in the Erode District. A straightforward proportion, the Cobb-Douglas type stochastic production frontier function model, was utilised in order to arrive at the conclusions. The findings of the study have policy implications because they not only provide empirical efficiency indicators that can be used to plan farm production but also help us identify the potential for crop production improvement across a variety of farming systems based on efficiency. In other words, the findings not only provide policymakers with a tool that can be used to plan farm production, but they also provide policymakers with a tool The findings of the study also provide insight into long-term techniques to improve production that do not require the addition of additional resources. Because education has a big impact on how well people can use technology, it is important to help farmers in the region get both formal and informal education.

Keywords: *Cost & Returns, Technical Efficiency, OLS, Stochastic Frontier Function*

1. Introduction

Both industrialised countries and developing countries continue to place a strong emphasis on research pertaining to the technical, allocative, and economic aspects of efficiency measurement. Measurement of efficiency is important for the simple reason that it is one of the factors that contributes to an increase in productivity. This is especially true in developing agricultural economies, where resources are limited and the opportunities for developing and implementing improved technologies are limited (Ali and Chaudhry, 1990). These studies are beneficial to these economies because they determine the extent to which productivity may be boosted by boosting an underutilised source, specifically efficiency, using the resources and technology that are already in place. As a consequence of this, they might be able to lend a hand in determining whether it would be more beneficial to start by increasing effectiveness or to quickly develop a new technology. Since the late 1950s, a number of studies have been conducted that investigate the relationship between farm size and output in Indian agriculture. This is in relation to the pervasive view in the body of literature that farmers who practise traditional agriculture are "poor but efficient" and the consequent emphasis on increased investments in developing new and more productive techniques. Since the 1960s, consideration has been given to regional differences as well as input-output linkages and the roles that enterprises play (Saini, 1969; Sahota, 1968; Hopper, 1965; Saravanan, 2016).

This research was carried out with the goal of evaluating, recommending, and developing suitable productive strategies that lead to greater resource efficiency. They were unable to distinguish between causes of inefficiency due to the biological nature of agricultural production and farm-specific differences in the use of available technology because they represented the sample farms' production processes on an input-output space (production function) with a given technology. This caused them to be unable to differentiate between causes of inefficiency due to the biological nature of agricultural production and farm-specific differences in the use of available technology. Despite conceptual issues and analytical differences, efficiency assessments have been carried out in Indian agriculture since the 1970s. In fact, the latter two estimate relative technical efficiency by employing a shadow profit function. The research conducted by Shanmugam and Palanisami (1993) in the state of Tamil Nadu, by Datt and Joshi (1992) in the state of Uttar Pradesh, and by Jayaram et al. (1987) in the state of Karnataka are some of the most notable examples of the available works. These studies found that paddy fields in the different states had a mean technical efficiency of 75 percent, 66 percent, and 74 percent, respectively, despite being based on deterministic or probabilistic estimations of the frontier production function. Even though these estimates were based on the frontier production function, this is still the case.

On the other hand, despite the widespread use of efficiency measures in Indian rice farms, only a handful of these studies have examined the same thing across size groups and agro-ecological regions (zones) at the same time. This is despite the fact that the use of efficiency measures is widespread in India. In addition, there is little consensus in the research that has been done on the time-honored subject of the efficiency gaps that exist between small farms and large farms. In a similar vein, the Erode district's agricultural industry has been the subject of other research projects. Within the scope of these studies, the research on agricultural production constitutes only a small portion. Empirical investigations are required to be conducted in order to investigate the resource usage efficiency of input components in inter-size crop models. Because of this, conducting an empirical and scientific investigative examination of the resource use efficiency of input elements in the rural economy of the Erode district is a significant phenomenon. This study tries to figure out how much technical efficiency there is in paddy production in the Erode District of Tamil Nadu from an economic point of view.

2. The Problems

Since the middle of the sixties, India's agricultural sector in the post-independence period has shown significant expansion. The most noteworthy of these advancements are the use of new HYV seeds, improved irrigational methods, the application of contemporary inputs like fertiliser, herbicides, and insecticides, as well as tractors, pump sets, and other types of machinery in crop production. One other positive aspect of the Indian agricultural system is the development of organisational and institutional structures for the production, input composition, and distribution of the entire package of available inputs. This is a significant step in the right direction. Also, it is true that the increase in agricultural productivity over the past 20 years is mostly due to better use of the infrastructure and a higher yield per acre. This has helped India become self-sufficient in food grains. It is considered that technological developments, in conjunction with farmer beliefs about the use of contemporary inputs, available extension, and the impact that these factors have on the productivity network, are the reasons that can be linked to these events. However, these shifts in the process of agricultural production and how crops are grown are not universal across all crops, farms, or regions of the country. Not only has it widened the inequalities across regions, but it has also resulted in an uneven distribution of benefits among various sized groups of farmers in different places. This gap in growth can be attributed, in large part, to the fact that the areas under diverse agricultural crops have responded to technical and economic changes in these regions in a variety of different ways. As a consequence of this, the challenges that are faced by the agricultural infrastructure of a nation are numerous, which captures the attention of agricultural specialists and government officials. Among the most hotly disputed topics in the modern era of agricultural advancement are the technological obstacles that must be overcome and the efficiency metrics that must be fulfilled by the farms that are a part of the cropping system in the country. As a result of increasing populations and affluence, there is a higher demand for agricultural products, which leaves farmers with little choice but to boost crop production through the implementation of better technology and more effective use of the resources at their disposal. Because there is no room for expanding land frontiers due to the trend of diverting agricultural land to non-agricultural uses, the only option that is available to farmers is to increase crop production by adopting newer, more advanced technology and making more efficient use of the resources that are already available. Agricultural output, on the other hand, is heavily influenced by agro-climatic conditions as well as technology at the regional level; varying amounts of input utilisation have an impact on farm productivity. This is because agricultural output is directly proportional to the amount of land that is devoted to crop production. A yield gap may exist if the resources being used are being utilised in an inefficient or ineffective manner. In light of this, it is essential to investigate differences in potential and actual yields at the farm level for a given technology and resource endowment of farmers across regions in order to gain a better understanding of the productivity gap at a time when major changes in macro-policy are taking place in the context of India's economic liberalisation. A recently finished research project gives an economic analysis of the technical efficiency of paddy production in the Erode district of Tamil Nadu. This is a step in the same general direction.

3. Objectives

The purpose of this study was to identify the socio-economic characteristics of paddy cultivating farmers; examine the resource use pattern of paddy cultivating farmers of varying farm size groups; and evaluate the farm level technical efficiencies in the production of paddy in Thadappalli ayacut of Erode District in Tamil Nadu.

4. Methodology

4.1. Selection of sample

The district of Erode in Tamil Nadu was selected for the study because of the significance of agriculture as a source of income for a significant portion of the state's population and the possibility of replicating this study in other regions of the state. As a consequence of this, the neighbourhood serves as the subject of the study's universe. The research team used a technique called purposeful-cum multistage random sampling to choose the sites and sample families that would be included in the study. Both Erode and Gobichettipalayam are included as revenue divisions in the first stage of the Erode district's development. Of these, the Gobichettipalayam Revenue division was purposefully chosen for the study due to its unique agro-climatic characteristics, extensive area irrigated by canals, agricultural pattern, irrigation intensity, and other socio-economic qualities. In the second stage, the Gobichettipalayam revenue division has the Bhavani River, and it is the river that is responsible for the majority of the irrigation in the division. It has 4 ayacuts viz., Thadappalli, Arakkan Kottai, Kalingarayan, and Lower Bhavani. Thadappalli canal, one of the four ayacuts, was chosen on purpose for this study because it is more prominent than other project sites in the cultivation of High Yield Verity (HYV) paddy over a long period of time. In the third stage, the Thadappalli ayacut consists of 39 villages, out of which 5 villages were chosen at random. These villages were chosen in such a way that each village is located inside the periphery of the ayacut that is being discussed here. In the final step of the process, an exhaustive enumeration of each and every household in the five villages that were chosen for the study was carried out. This was done in order to ascertain their occupational pattern, level of operational holdings, cropping pattern, area under paddy cultivation, and any other socio-economic characteristics that were pertinent to the research. From among the 16 villages, a total of 150 farmer households were chosen because they grew paddy on an area that comprised at least half of their total cropped area. This ensured that each of the sample villages used in the research had an equal amount of representation. The selected farmers were then broadly classified into four major farm size groups, taking into consideration the composition of farms cultivating paddy as well as the area covered. These farm size groups are as follows: I. Marginal farmers (those with land holdings of less than 2.5 acres), II. Small farmers (those with land holdings of between 2.6 and 5.0 acres), III. Medium farmers (those with land holdings of 5.1 to 7.5 acres), and IV. Large farmers (those with land holdings of more than 7.5 acres). Only 150 paddy-cultivating farmer homes were included in this study. These families came from five different villages in the Thadappalli ayacut area of Tamil Nadu's Erode District.

4.2. Tools

An elementary percentage analysis was utilised in order to ascertain the socioeconomic characteristics as well as the costs and returns associated with paddy cultivation for the farmers that made up the sample group that was chosen. The Stochastic Frontier Production Function, which was developed by Aigner DJ, Lovell CAK, and Schmidt (1997), has become the most widely used method for assessing the effectiveness of technical advancements in recent years. A two-component composite error term has been utilised in order to provide a representation of the stochastic frontier (Bhende and Kalirajan, 2007). A symmetric component allows for random fluctuations between enterprises, which captures the effects of measurement error, statistical noise, and unpredictable shocks that are not under the control of the farms. One-sided components capture firm-specific influences, such as slackness in output due to labour shirking, which are within the control of the firms and influence the degree to which they are technically efficient. One-sided components are also used to measure the degree of technical efficiency. In this particular investigation, the empirical model that served as the basis for the research was split into two sections. In the first step, a stochastic production function of the following type is used to estimate farm-specific technical efficiency ratings:

$$\ln (Yi) = Xi\, \alpha + Vi – Ui \text{ -- } (1)$$

Where Y represents the dependent variable (output), and Xi represents the independent factors, such as the area under crop, the seed, the amount of family labour, the amount of hired labour, the number of machine hours, the cost of chemical fertiliser and pesticide, etc. Within the context of this paradigm, the dependent variable is constrained by the stochastic variable represented by the notation Vi-Ui. Because the random error, Vi, can take either a positive or a negative value, the stochastic outputs can take on a variety of different values with respect to the deterministic component of the frontier model. Vi is the symmetric random error term that is distributed independently and identically [N (o, v2)] and it takes into account errors that are outside the control of the farmers. Ui is the one-sided production, which is distributed independently and may be identified with a non-negative truncation of the normal distribution [N (o, v2)]. If the farm is inefficient, then the actual output produced is lower than (or equal to) the potential output. If the farm is efficient, then the actual output produced is higher than the potential output. As a result, the ratio of actual output to potential output can be regarded as a measure of the efficiency of the technology. By applying the first equation from the previous paragraph, the technical efficiency (TE) of the farm can be calculated as follows: TEi = exp (Ui) The technical efficiency of the ith farmer, denoted by the symbol TEi = I, is calculated using the density function of u and v, which may be expressed as

$$F_u (u) = 1/ \sqrt{} \tfrac{1}{2}*\pi).\ 1/ \sigma_u .\ \exp.[-u^2/2\ \sigma_u^2] \text{ for } u \leq 0 \text{ -----------------------------} (2)$$

$$= 0 \text{ otherwise}$$

F_v (v) = 1/ √ ½*π). 1/ σ_v . exp.[-v^2/2 σ_v^2] for - ∞ ≤ u ≤ ∞ -------------------- (2a)

The density function of y is the joint density function of (u+v) and is given by

F_v (y) = π .1/ √ ½*π) . 1/σ . exp. {$(u+v)^2$ / 2 σ^2 } .

1- f{((u+v) / σ) (γ/ 1+ γ))] --- (3)

Where,

$\sigma^2 = \sigma_u^2 + \sigma_v^2$ -- (4)

$\gamma = \sigma_u^2 / \sigma^2$, 0 ≤ γ ≤ 1 -- (4a)

Finally, γ is given by

σ^{ui}= - $\sigma_u\sigma_v$/ σ[{φ (.)/1-φ (.) }-{((u+v)/σ) √ (γ /1- γ)))] ----------------------- (5)

where φ (.) and φ (.) are standard density and distribution functions, respectively. The variables specified for estimation of Technical Efficiency for the individual farms and crops based on Cobb-Douglas type was;

y = output of paddy (in quintal / acre)
X_1 = seed rate in kg/acre
X_2 = Area under crop (in acres)
X_3 = Family labour (male + female) man-days/acre.
X_4 = Hired labour used in man-days/acre
X_5 = Cost on machine hours used in Rs. / acre
X_6 = Quantity of chemical fertilizer used in kg/acre
X_7 = Cost on pesticide components (in Rs./acre)

4.3. Determinants of Technical Efficiency

A simple linear regression technique of the following type was used to identify the factors that influence the technical efficiency of the selected farmer households. Because crop output is conditioned by factors such as rainfall, incidence of disease and pest, soil fertility, and other socio-economic factors, this technique was used to identify the factors that influence the technical efficiency of the selected farmer households. Saravanan (2016) says that the frontier's scores of technical efficiency are regressed on the independent variables in the following ways:

$$TE_{ij} = \boldsymbol{\alpha} + \boldsymbol{\alpha}_1 (X_1) + \boldsymbol{\alpha}_2 (X_2) + \boldsymbol{\alpha}_3 (X_3) + \boldsymbol{\alpha}_4 (X_4) + e_i$$

Where,

TE_{ij} = level of technical efficiency estimated through Maximum Likelihood Estimation (MLE)
X_1 = Farm size
X_2 = Age
X_3 = Educational status
X_4 = Family Size
$\boldsymbol{\alpha}_1$………$\boldsymbol{\alpha}_4$ = regression co-efficients
e_i = error term
$\boldsymbol{\alpha}$ = constant

5. Results and Discussion

The findings of the research are broken down into three main categories: (i) socio-economic characteristics of the sample paddy farmers; (ii) estimated costs and returns of paddy cultivation; and (iii) technical efficiency of paddy production in Thadappali ayacut of Erode District. Each of these categories is broken down further into subcategories.

5.1. Socio-Economic Characteristics of the Sample Farmer Households

This section is focused mostly on the investigation of the socio-economic features of the paddy cultivating farmer households that were chosen at random from the Thadappali ayacut in the Gobichettipalayam taluk of the Erode District. The type of family, the size of the family, age, educational status, and monthly income of the family are some of the important socio-economic characteristics that were chosen for analysis in the study. These characteristics were chosen to be compared between sampled paddy farmer households of different farm size groups using the post-stratification method.

Table-1: Socio-Economic Characteristics of the Sample Farmer Households

Socio-Economic Characteristics		N	%
Type of family	Nuclear	104	69.33
	Joint	46	30.67
	Total	150	100.00
Family Size Group	Below 2	31	20.67
	2 – 4	75	50.00
	Above 4	44	29.33
	Total	150	100.00
Age group	Below 40	44	29.33
	40 – 60	68	45.33
	Above 60	38	25.33
	Total	150	100.00
Family Monthly Income	Below Rs.15000	56	37.33
	Rs.15000 – Rs.30000	58	38.67
	Above Rs.30000	36	24.00
	Total	150	100.00
Educational status	Illiterate	34	22.67
	Primary Level	39	26.00
	Secondary Level	61	40.67
	Higher Secondary & above level	16	10.67
	Total	150	100.00
Farm Size in acres	Marginal farmer (<2.5 acres)	39	26.00
	Small farmer (2.5-5.0 acres)	47	31.33
	Medium farmer (5.0-7.5 acres)	36	24.00
	Large farmer (Above 7.5 acres)	28	18.67
	Total	150	100.00

Source: Calculated value

The majority of the 150 sample Paddy farmer households selected for the research were members of nuclear families; the size of their families ranged from two to four people; the farmers' ages ranged from forty to sixty years; and the farmers' families had a modest family income that ranged from fifteen thousand to thirty thousand rupees each month. The highest level of education any of the farmers had was secondary school.

5.2. Estimated Cost and Returns of Paddy Cultivation

Based on the information collected at the farm level from the sample farmers in Thadappalli ayacut in Erode District, Table-2 provides facts regarding the expected costs and revenues associated with paddy production.

Table-2: Estimated Cost and Revenue Particulars of Paddy Cultivation

Cost / Revenue particulars	Farm Size in acres				Total
	Marginal farmer (<2.5)	Small farmer (2.5-5.0)	Medium farmer (5.0-7.5)	Large farmer (Above 7.5)	
Average area under crop in acres	1.22	2.96	5.89	10.11	6.73
Cost of Seed	556	418	381	430	359
	(3.90)	(4.07)	(4.06)	(5.31)	(4.85)
Cost of Family Labour	7273	4306	3164	2100	2411
	(50.97)	(41.94)	(33.69)	(25.93)	(32.58)
Cost of Hired Labour	2562	2102	2552	2634	2054
	(17.96)	(20.48)	(27.17)	(32.53)	(27.76)
Cost of Machine hours	1488	1323	1353	1307	1161
	(10.43)	(12.89)	(14.41)	(16.14)	(15.69)
Cost of Chemical Fertilizer	1314	1405	1286	1201	981
	(9.21)	(13.69)	(13.69)	(14.83)	(13.26)
Cost of Pesticide in Rs.	1075	712	655	426	434
	(7.53)	(6.94)	(6.97)	(5.26)	(5.86)
Total Variable Cost (TVC)	14268.00	10266.00	9391.00	8098.00	7400.00
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
DIRTI-5	3510	3600	3710	4210	3710
Total Cost (TC)	17778.00	13866.00	13101.00	12308.00	11110.00
Total Revenue (TR)	12730	11369	14162	12851	11430
Net Revenue (TR-TC)	-5048.00	-2497.00	1061.00	543.00	320.00
Revenue over total Variable cost (TR-TVC)	-1538.00	1103.00	4771.00	4753.00	4030.00
Sample observations (in No's)	39	47	36	28	150

Source: Calculated value
(Figures in parentheses indicate percentage)

Table 2 displays the particulars of the costs and revenues incurred by paddy cultivating farmers in Thadappalli ayacut in Erode District. These farmers were chosen at random. It was determined that marginal farmers had an average farm size of 1.22 acres, small farmers had an average farm size of 2.96 acres, medium farmers had an average farm size of 5.89 acres, and larger farmers had an average farm size of 10.11 acres. When all the different sizes of farms were taken into account, the average size of a farm was determined to be 6.73 acres. The economics of paddy production in the region were determined by a number of essential factors, including the amount of land devoted to paddy, the cost of seed, the cost of family labour, the cost of hired labour, the cost of machine hours used, the cost of chemical fertiliser, and the cost of pesticide. Family labour costs (imputed) should account for 32.58 percent of total costs for the average paddy producer in the region, with paid labour coming in second (27.76 percent). To put it another way, growing paddy is a job that requires a significant amount of human labour and is highly dependent on this factor. It's conceivable that the larger number of family labourers is due to their excessive reliance on farm operations as well as a lack of available or affordable hired labour in the area. Both of these factors contribute to the high level of family labour. It can be seen from the fact that 15.69 percent of the total cost was comprised of the cost of machine hours employed for cultivation that contemporary agricultural machinery was utilised in the process of crop production. The cost of chemical fertiliser and pesticides are two more important key inputs that have a direct impact on crop productivity.

In other words, a typical farmer cultivating 2.5 acres of paddy spent 9.21 percent of his total expenditure on chemical fertilizer. Farms larger than 7.5 acres, on the other hand, spent 14.83 percent of their total expenditure on chemical fertilizer. This demonstrates that large farmers are required to spend more on fertiliser, whereas smaller farmers are not. When it came to the expense of using pesticides, farms that were smaller than 2.5 acres were responsible for a higher proportion of the cost, whereas farms that were larger than 2.5 acres were responsible for a smaller proportion of the cost. To put it another way, as the size of the farm expanded, the proportion of expenditures associated with fertiliser increased, whereas the proportion of prices associated with pesticides declined. The net revenue that was calculated for various size groups of farms in the area that grew high-yield variety paddy tended to increase with farm size up to 7.5 acres; however, farms larger than 7.5 acres showed a marginal reduction in revenue. This was the case because larger farms required more labour to cultivate their land. The lower net revenue for farms that are less than 5 acres could be due to a number of factors, including the higher usage of family labour and pesticides in comparison to other farms, as well as the higher authorised capital cost. However, with the exception of the group that farmed 2.5 acres, every other farm had favourable chances in terms of return in comparison to variable costs. To sum up, the average paddy farmer in the area only made Rs.320 net per acre, even though he or she spent 4.85%, 32.76%, 15.69%, 13.26%, 5.86%, and 5.86%, respectively, on seed, family labor, hired labor, machine hours, chemical fertilizer, and pest control.

5.3. Farm level Technical Efficiency in Paddy Production

Prior to the discussion on the technical efficiency of farm groups, Table 3 offers an overview of the input and output characteristics of chosen farmer families of varying sizes in the Thadappalli ayacut in the Erode District. These families are located in the Thadappalli ayacut.

Table-3: Average Levels of Input Use and Output per Acre by Farm Size Group

Particulars	Farm Size in acres				
	Marginal farmer (<2.5)	Small farmer (2.5-5.0)	Medium farmer (5.0-7.5)	Large farmer (Above 7.5)	All
Area under crop (in acres)	1.22	2.96	5.89	10.11	6.73
Seed (in kg)	41	30	29	32	27
Family labour (man-days)	74	76	52	52	59
Hired labour (man-days)	27	30	31	31	31
Machine hours	11	19	13	13	12
Chemicals fertilizer (in kg)	188	193	201	199	175
Pesticide components (in Rs.)	1075	913	897	911	844
Production (quintals)	19	19	20	18	17

Sample size (N)	39	47	36	28	150

Source: Calculated value

According to the data presented in table 3, the typical size of paddy farms in the region of the Thadappalli canal ranges from 1.22 acres for farms owned by marginal farmers to 2.96 acres for farms owned by small farmers, 5.89 acres for farms owned by medium farmers, and 10.11 acres for farms owned by larger farmers. When all farm groups were considered together, it was determined that the typical size of a paddy-growing farm in the Thadappalli ayacut region is 6.73 acres on average. Because the use of family labour seemed to be an important factor in agricultural productivity, in particular for smaller and medium-sized farms, the percentage of family labour used by each category of farm was calculated separately. This was done because family labour appeared to be an important factor in agricultural productivity. Each farm in the Thadappalli canal area used 74 days, 76 days, 52 days, and 52 days of family labour, respectively, for agricultural output. This indicated that family labour was a primary source of agricultural production for all sizes of farms in the region. When all farm size categories are included, a typical paddy cultivating farmer in the area surrounding the Thadappalli canal employed 59 family members' days of labour to cultivate one acre of land. The conclusion that smaller farms in the region are still handled as family farms was reached as a result of the fact that smaller farms used more family labour per acre of paddy cultivation than larger farms did. As a result, the economic viability of crop production among small farms is primarily lacking in the Thadappalli region. It was discovered that the rate of family participation in the labour force was lower among large farmers of paddy cultivation than it was among small farmers of paddy cultivation. This may be due to the fact that their reliance on contracted labour was rather high, as demonstrated in the table. In other words, it was shown that the utilisation of family labour per acre for paddy cultivation in the Thadappalli ayacut area decreased with farm size, whereas the utilisation of hired labour in the Thadappalli ayacut increased. This was shown to be the case when comparing family labour to hired labour in the Thadappalli ayacut. From the time of ploughing to the time of harvesting, it was determined that the average number of machine hours required for paddy cultivation in Thadappalli was 12 hours per acre. This was determined despite the fact that there were some small differences in the groupings of farm sizes. In the Thadappalli ayacut region, it was noted that the quantity of plant nutrients applied per acre in the form of nitrogen, phosphorus, and potassium (NPK) compounded fertiliser increased as farm size increased. To put it another way, a typical farmer in the Thadappalli ayacut used 175 kilogrammes of NPK compounded fertiliser on each acre of paddy that he cultivated. It was determined that the share of costs expended for pesticide components was higher for small farmers in the Thadappalli ayacut region. On the other hand, there was a trend for these costs to decrease with the expansion of the size of the farms. In the Thadappalli ayacut region, the paddy production that was produced by medium-sized farmers on paddy-producing land was the highest per unit of paddy.

The purpose of this study was to attempt to estimate the average output response to changes in inputs at the current technological stage. This was done before comparing the levels of technical efficiency that were achieved by the sample farms. Using the Cobb-Douglas Production Function and the Ordinary Least Square (OLS) technique, researchers in the Thadappalli ayacut area of Erode District in Tamil Nadu were able to estimate the output elasticities with respect to the primary inputs in paddy production. This was done using the Cobb-Douglas Production Function. The output elasticities for paddy are displayed in Table-4. These elasticities were calculated using OLS estimations of the Cobb-Douglas production function.

Table-4: Ordinary Least Square (OLS) Estimates of the Production Function for Paddy

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Intercept	6.310	1.010	.273	6.249	.000
Area under crop	8.374**	4.323	.607	1.937	.054
Seed	7.002*	1.480	.274	4.730	.000
Family labour	2.589*	.824	.179	3.142	.002
Hired labour	1.110*	.359	.120	3.093	.002
Machine hours used	1.045	.649	.054	1.611	.108
Chemical fertilizer	4.916*	.809	.291	6.075	.000
Cost on Pesticide Components	.669	.733	.045	.913	.362
R^2	0.894				
F	251.034				
N	150				

Source: Calculated value
* Significant at 1% level ** Significant at 5 % level Significant at 10% level

The estimated regression co-efficients of the variables pertaining to the data on the Thadappalli ayacut in Gobichettipalayam taluk provided in table-4 clearly reveals that these variables explain a significant proportion of the variability in paddy yield. This was determined by the R2 value of 0.894 for the Thadappalli ayacut in the Gobichettipalayam taluk of Erode District in Tamil Nadu. The area under crop, seed, family labour, hired labour, and chemical fertiliser used each had respective output elasticities of 8.374, 7.002, 2.589, and 1.110, 4.916, respectively. These results were statistically significant at both the 1 percent and the 5 percent levels. An analysis of the technical efficiency of paddy production was carried out by applying a Stochastic Frontier Production Function to selected farms that took part in the production of paddy in the Thadappalli ayacut, located in the Gobichettipalayam taluk of the Erode District in Tamil Nadu. The results of the Maximum Likelihood Estimation (MLE) calculation for paddy in the Erode District's Gobichettipalayam taluk in relation to the Thadappalli ayacut are shown in Table 5.

Table-5: Estimated Parameters of the Stochastic Frontier Production Function for paddy Cultivation

Variables	Co-efficient	't'	Sig.
Intercept	5.370	2.388	0.018
Area under crop	0.551**	2.528	0.013
Seed	0.122***	1.696	0.092
Family labour	0.099*	2.666	0.009
Hired labour	0.479**	2.331	0.021
Machine hours	0.006	0.181	0.857
Chemical fertilizer	0.917*	9.732	0.000
Pesticide components	0.041	0.814	0.417
σ^2	0.096		

σ_u^2	0.074		
σ_v^2	0.022		
γ	0.780		
log likelihood	13.305		
N	150		

Source: Calculated value
* Significant at 1% level ** Significant at 5 % level Significant at 10% level

The estimated regression co-efficients of the variables pertaining to the data on the Thadappalli ayacut provided in table-5 clearly reveal that these variables explained a significant proportion of the variability in paddy yield as measured by the R2 of 0.894 for the Thadappalli ayacut of Erode District in Tamil Nadu. The area under crop, seed, family labour, hired labour, and chemical fertiliser used each had output elasticities of 8.374, 7.002, 2.589, and 1.110, respectively, and were statistically significant at the 1 percent and 5 percent levels. The technical efficiency of paddy production was determined by applying a Stochastic Frontier Production Function to selected farms that took part in paddy output from the Thadappalli ayacut located in the Erode District of Tamil Nadu. The results of the Maximum Likelihood Estimation (MLE) for paddy are presented in Table-6. These results come from the Thadappalli ayacut in the Erode District.

Table-6: Level of Technical Efficiency by Farm Groups for Paddy

Levels of Technical Efficiency (percent)	**Farm size group**				Total
	Marginal farmer (<2.5)	**Small farmer (2.5-5.0)**	**Medium farmer (5.0-7.5)**	**Large farmer (Above 7.5)**	
<60	3	3	6	3	15
	(7.69)	(6.38)	(16.67)	(10.71)	(10.00)
60-70	2	6	4	6	18
	(5.13)	(12.77)	(11.11)	(21.43)	(12.00)
70-80	15	17	15	8	55
	(38.46)	(36.17)	(41.67)	(28.57)	(36.67)
80-90	16	20	10	8	54
	(41.03)	(42.55)	(27.78)	(28.57)	(36.00)
>90	3	1	1	3	8
	(7.69)	(2.13)	(2.78)	(10.71)	(5.33)
Mean TE	0.78	0.81	0.85	0.83	0.81
N	39	47	36	28	150

Source: Calculated value
(Figures in parentheses indicate percentage)

It can be seen in Table 6 that the average level of technical efficiency for the Thadappalli ayacut farms was estimated to be 81 percent. This means that adhering to better crop management practises can increase paddy output by 10% without increasing the level of input application. It was also discovered that ten percent of the farmers in the region had efficiency levels lower than sixty percent, twelve percent had efficiency levels between sixty and seventy percent, thirty-six point seven percent had efficiency levels between eighty and ninety percent, and five point three percent had efficiency levels between ninety and one hundred percent. It was determined that the mean levels of technical efficiency for marginal farmers, small farmers, medium farmers, and big farmers were correspondingly 0.78, 0.81, 0.85, and 0.83, with medium farmers having a higher level of efficiency than the other groups. It's possible that this is due to the fact that the authors' observation of the ideal farm size falls under this category.

As can be seen in table 7, the efficiency scores of the frontier model were regressed on the variables of education level, size of farm, age, and number of people in the family.

Table-7: Determinants of Technical Efficiency among Farms

Variables	Paddy	t	Sig.
Intercept	7.659	4.646	0.000
Farm size	0.880*	4.141	0.000
Age	0.322*	4.734	0.000
Education	0.706*	4.817	0.000
Family size	0.159*	3.835	0.000
R^2	0.996		
N	150		

Source: Calculated value * Significant at 5% level

The model provided an explanation of the level of technical efficiency present on the sample rice fields in terms of R2, which was determined to be 73% among paddy-growing farmer households. As expected, all of the variables are displaying encouraging results. There was a positive correlation between the size of the farm, the age of the farmer, the education level of the farmer, and the number of people living in the family in the Thadappalli ayacut of the Gobichettipalayam taluk, and the technical efficiency of paddy cultivation. Each of the coefficients was statistically significant. The presence of an educated adult in the family contributes to the efficiency of paddy output, so it is reasonable to deduce that the size of the farm has some bearing on the degree to which technical efficiency is affected.

6. Conclusions

According to the findings of the research, the input variables such as acreage under crop, seed, family labour, hired labour, and chemical fertiliser all have positive influences on the level of technical efficiency achieved at the farm level. The average degree of technical efficiency across the several farm groups in the area under study ranged from 0.78 to 0.85, with 0.81 being the overall mean value. The size of the farm, the age of the farmers, the number of years the farmers had spent in school, and the number of people living in each household were the factors that had a substantial impact on the technical efficiency of paddy production.

7. Recommendations

According to the findings of the study, a policy at the farm level should be implemented with the purpose of motivating extension workers to work harder in order to offer rural farm households the essential farm management training in order to boost agricultural output. To increase the number of people who make use of credit programmes for rice farmers, it is important to take a participatory approach to programme development and implementation that includes all relevant parties.

8. Reference

Agarwal, P. K., Yadav, P. and Mondal, S. "Economic Analysis of Cost and Return Structure of Paddy Cultivation Under Traditional and Sri Method : a Comparative Study." *International Journal of Agriculture Sciences*, vol. 10, no. 8, 2018, pp. 12-34

Aigner DJ, Lovell CAK, Schmidt P. "Formulation and Estimation of Stochastic Frontier Production Function." *Journal of Econometrics,* vol. 6, 1997, pp. 21-37.

Ajit Singh, H L Singh and V S Chaudhary. "Analysis of Resource–Use Efficiency of Paddy Production in Meerut District of Western Uttar Pradesh." *International Journal of Scientific Research*, vol. 2, no. 12, 2013, pp. 21–24.

Alam, M. M., Siwar, C. and Talib, B. "Socio-Economic Impacts of Climatic Change on Paddy Cultivation: An Empirical Investigation in Malaysia." *Journal of Knowledge Globalization,* vol. 3, no. 32, 1938.

Ali, M., Chaudhry, M.A. "Inter-Regional Farm Efficiency in Pakistan's Punjab: A Frontier Production Function Study." Journal of Agricultural Economics, vol. 41, 1990, pp. 62-74.

Bhagat, S. M., Singh, P. and Vishwavidyalaya, M. "Technical Efficiency of Paddy Cultivation: A Socio-economic Analysis of Haryana State." *The IUP Journal of Agricultural Economics,* vol. 0 no. 3, 2007, pp. 36-47.

Bhende M.J., and Kalirajan K.P. "Techincal Efficiency of Major Food and Cash Crops in Karnataka (India)." *Indian Journal of Agricultural Economics*, vol. 62, 2007, pp. 176-189.

Datt, K.K., Joshi, P.K. "Economic Efficiencies and Land Augmentation to Increase Agricultural Production: A Comparative Analysis for Investment Priorities." *Indian Journal of Agricultural Economics,* vol. 47, 1992, pp. 468-476.

Hopper, D.W. "Allocative Efficiency in Traditional Indian Agriculture." *Journal of Farm Economics,* vol. 47, 1965, pp. 611-624.

Huang, C.J., Bagi, F.S. "Technical efficiency on individual farms in North West *India." Southern Economist Journal,* vol. 51, 1984, pp. 108-115.

Jayaram, H., Chandarshekar, G.S., Achoth, L. "An Economic Analysis of Technical Efficiency in Rice Cultivation in Mandhya: Some Issues in Resource Pricing." *Indian Journal of Agricultural Economics,* vol. 47, 1987, p. 677.

Junankar, P.N. "Test of The Profit Maximization Hypothesis: A Study of Indian Agriculture." *Journal of Development Studies,* vol. 16, 1980, pp. 187-203.

Paul K.S.R. "Farm Level Technical Efficiency of Paddy Production in Andhra Pradesh: An Empirical Evidence from the Cost of Cultivation Survey Data." *Economic Affairs*, vol. 65, no. 4, 2020, pp. 659-663.

Kalirajan, K. "An Econometric Analysis of Yield Variability in Paddy Production." *Canadian Journal of Agricultural Economics,* vol. 29, 1981, pp. 283-294.

Lau, L.J., Yotopoulos, P.A. "A Test for Relative Efficiency and Application to Indian Agriculture." *American Economic Review,* vol. 61, 1971, pp. 94-109.

Meenasulochani, R. *et al.* "Technical Efficiency of Paddy Production and Factors Affecting the Efficiency in Nagapattinam District, Tamil Nadu." *International Journal of Agriculture Innovations and Research*, vol. 6, no. 6, 2018, pp. 355–358.

Paul, B. K. "The Profitability of Paddy Cultivation and Farmers' Perception in West Bengal with Special Reference to Purba Bardhaman District." *Space and Culture, India*, vol. 7, no. 3, 2019, pp. 172-183.

Sahota, G.S. “Efficiency of Resource Allocation in Indian Agriculture.” *American Journal of Agricultural Economics,* Vol. 50, 1968, pp. 584-605.

Saini, G.R. “Farm Size, Resource Use Efficiency and Income Distribution.” *Allied Pub. Pvt., New Delhi,* 1969.

Saravanan, A. “An Analysis of Cost and Returns of Sugarcane Production in Erode District of Tamilnadu.” *Indian Journal of Economics and Development,* Vol. 4, no. 8, 2016, pp. 1-4.

Saravanan, A. “Resource-Use Efficiency of Sugarcane Production in Gobichettipalayam Taluk of Erode District of Tamil Nadu: An Economic Analysis.” *Indian Journal of Economics and Development*, vol. 4, no. 9, 2016, pp. 1-10.

Shanmugam, T.R., Palanisami, K. “Measurement of Economic Efficiency: Frontier Function approach.” *Journal of the Indian Society of Agricultural Statistics,* vol. 45, 1993, pp. 235-242.

Sharma, R. S. *et al.* “Comparative Economic Study of Tulsi and Paddy Cultivation in Sitapur District of Uttar Pradesh.” *Agricultural Science Digest - A Research Journal*, vol. 39, no. 1, 2019, pp. 73–74.

Sidhu, S.S. “Relative Efficiency in Wheat Production in the Indian Punjab.” *American Economic Review,* vol. 64, 1974, pp. 742-751.

Suresh, A. and Keshava Reddy, T. R. “Resource-Use Efficiency of Paddy Cultivation in Peechi Command Area of Thrissur District of Kerala: An Economic Analysis.” *Agricultural Economics Research Review*, vol. 19, no. 1, 2006, pp. 159-171.

Tadesse, B. and Krishnamoorthy, S. “Technical Efficiency in Paddy Farms of Tamil Nadu: An Analysis Based on Farm Size and Ecological Zone.” *Agricultural Economics*, vol. 16, no. 3, 1997, pp. 185-192.

Thayaparan, A. and Jayathilaka, D. M. P. I. L. “Technical Efficiency of Paddy Farmers and its Determinants: Application of Translog Frontier Analysis.” *International Conference on Business Research University of Moratuwa, Moratuwa, Sri Lanka. Vol.* 27, 2020, pp. 199-218.