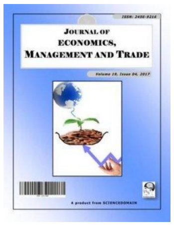

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Economic Efficiency of Farmers on Paddy Cultivated Farms in Raichur District of Karnataka, India

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

This work is focused on investigating the economic efficiency of farmers on paddy cultivated farms in Raichur district of Karnataka, India. The Raichur district was selected as study area because of highest fertilizer consumption in the Karnataka state. Paddy crops were selected for the study because which has highest net cultivable area and also highest chemical fertilizer consumption in the study area. In the study area, there were very few recent studies focused on usage of inputs for the crops under cultivation, this study help in found that farmers are using efficient inputs for the crops under cultivation, which result into a gap in input use. The results of the study will be great useful to the policy makers to formulate policy related to efficient utilisation inputs to enhance the crop output at the same time reduce the cost of cultivation and maximise the profit. The study was based on the primary data collected through survey method from paddy cultivated farmers 60 farmers in Raichur district during 2015-16. For paddy cultivation among small farmers results of technical, allocative and economic efficiency indicated that 36.67 per cent, 16.67 per cent and 10

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per cent of small farmers had efficiency scores above 0.9 in production of paddy, about 26.67 per cent and 16.67 per cent of the farmers were technically efficient with score ranges between 0.7-0.8 and 0.8-0.9. Similarly in large farmers 33.33 per cent, 26.67 per cent and 10 per cent of technical, allocative and economic efficiency scores above 0.9 in the production of paddy. It is clear that most of the small and large farmers were economically inefficient, however, there is scope to utilise the available resources for paddy cultivation farmers in the study area. Therefore both the categories of farmers need to practice recommended dosage of application in fertilizers and also other inputs as per the package of practice given by State Agriculture Universities (SAU) in order to achieve the 100 per cent efficiency. Hence, there is a need to conduct the awareness programmes on the efficient use of farm resources without affecting the crop yield.

Keywords: Allocative efficiency; cultivation; economic efficiency and technically efficiency.

1. INTRODUCTION

Agricultural sector plays an important role in economic development of developing countries. In India, this sector occupies a predominant position in the economy. It contributes about 13.9 per cent to the national income of the country for the year 2015-16 and sustains a two-thirds population of India. It is the single largest sector providing employment to the extent of more than 50 per cent of the country's work force, thus agriculture continues to be a mainstay for livelihood of rural people. The most challenging problem today is as the population growth increases the demand for food grain increases over the year. Whereas, the production of food grains dropped 259.29 million tone to 252.33 million tonne from 2011-12 to 2015-16.

The agricultural production can be increased by either expansion of area or productivity. In the Indian context, land is becoming a shrinking resource for agriculture owing to competing for demand for its use. Also, the population growth has resulted in lower carrying capacity of the land. Hence, in order to realize the need-based targets of agricultural production, the pattern of production enhancement will have to rest heavily on increased yield. This essentially calls for optimizing the usage of the existing farm land by adopting new strategy for agricultural development. One of the strategies includes judicious use of chemical fertilizers. Chemical fertilizers have been considered as an essential input to enhance yield in Indian agriculture for meeting the foodgrain requirements of the growing population of the country. The use of chemical fertilizers to increase the agricultural production particularly in a developing country is well known fact. Some argue that fertilizer was as important as seed in the Green Revolution [1] contributed as much as 50 per cent to the yield growth in Asia [2,3]. Fertilizer consumption in India has been increasing over the years and today India is one of the largest producer and consumer of chemical fertilizers in the world.

Chemical fertilizers bear a direct relationship with food grain production along with a number of supporting factors like High Yielding Varieties (HYVs), irrigation, access to credit and enhanced total factors of productivity. The importance of the chemical fertilizer sector in Indian agriculture hardly be emphasized as it provides very vital input for the growth of Indian agriculture and is an expected factor that has to be reckoned within the attainment of the goal of self-sufficiency in food grains. Accurate forecasting of fertilizer demand and supply is essential, both for companies producing, importing and marketing fertilizer and for governments in their efforts to monitor the development of agriculture.

Chemical fertilizer is a substance to soil to improve plants' growth and yield. First used by ancient farmer's fertilizer technology developed significantly as the chemical needs of growing plants were discovered. Chemical fertilizer was identified as one of the three most important factors, along with seed and irrigation, for raising agricultural production and sustaining food self-sufficiency in India [4].

The importance of fertilizer is because of shrinking cropping land and production need is high. The Indian National Food Security Act. 2013 aims to provide subsidized food grains to approximately two-thirds of India's 1.2 billion people. India needs to produce an additional 5-6 million tonnes of food grains annually to meet the requirement of an increasing population. The plant requires three major plant nutrients, namely, nitrogen, phosphorous and potassium to be used in the balanced use *i.e* ratio of 4:2:1. If any deviation in fertiliser use from this norm would constrain growth in crop productivity, this trend will continuous in India as well as in Karnataka and also in North Eastern Karnataka (NEK) region. The results of the study will be greatly useful to the policy makers to formulate policy related to efficient utilisation of chemical fertilizers to enhance the crop output at the same time reduce the cost of cultivation and maximise the profit.

The application of inputs is essential to prevent soil degradation, keeping agriculture land productive and economically viable. However, it was observed in last few years that the marginal response of agricultural productivity to additional fertilizer usage in the country had fallen sharply, leading to near stagnation in agricultural productivity and consequently agricultural production. However, with the rapid growth of population, urbanization, and infrastructural development the use of land for the production of food is diminishing.

Though there are very few recent studies focused on usage of inputs for the crops under cultivation, this study help in found that farmers are using efficient inputs for the crops under cultivation, which result into a gap in input use. The usage of inputs may differ widely in respect of soil, climatic conditions, irrigation, and adoption of HYVs, the average size of farm and so on. Therefore, important from the farmers' point of view to use this input up to the level where the net income can be maximized and the gap in efficient use of inputs.

The selected region for the study has wider variability in paddy cultivation and the farmers are applying inputs as per their needs ignoring the RDA, ultimately it led to over usage of inputs and increased cost of cultivation. The results of the study will be a great use to the policymakers to formulate policy related to efficient utilisation inputs to enhance the crop output at the same time reduce the cost of cultivation and maximise the profit. It is appropriate and most conducive to undertake study on for examined the economic efficiency of paddy production in Raichur district.

2. METHODOLOGY

Primary data were obtained from the farmers who are growing paddy crops through personal interviews with the help of pre-tested and structured schedule. Multistage purposive random sampling techniques were employed for the study. In the first stage, Karnataka state was selected purposively, in the second stage North Eastern Karnataka (NEK) region was selected from Karnataka state based on highest chemical fertilizer consumption. In the third stage, Raichur district was selected in the North Eastern Karnataka region based on highest chemical fertilizer consumption. In the fourth stage from Raichur districts, two taluks were selected by considering based on highest chemical fertilizer consumption, Shindhanur and manvi taluks were selected, in the fifth stage three villages from each taluks were randomly selected, from the selected villages ten farmers were randomly chosen. Thus data were collected from 60 (30 from each taluk) sample farmers. Paddy crops were selected for the study because which has highest net cultivable area and also the highest chemical fertilizer consumption in the study area.

The Data Envelopment Analysis (DEA) tool was applied for analysis by using both classic models 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 [5]. In this study, to estimate the technical efficiency, allocative efficiency and economic efficiency input oriented and cost minimization DEA was used. This approach was first used by Farrell [6] as a piecewise linear convex hull approach to frontier estimation and later by Boles [7] and Afriat [8]. This approach did not receive wide attention till the publication of paper of Charnes et al. [9], which coined the term data envelopment analysis.

Mathematical form of data envelopment analysis as follows:

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

$$\text{Subject to}\quad -y_i + Y\lambda \geq 0$$
$$\theta X_i - X\lambda \geq 0$$
$$\lambda \geq 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Where,

y_i is a vector (m × 1) of output of the ith Producing Farms TPF (Total productivity factor),
x_i is a vector (k × 1) of inputs of the i^{th} TPF
Y is an output matrix (n × m) for n TPFs
X is an input matrix (n × k) for n TPFs
θ is the efficiency score

A scalar whose value will be the efficiency measure for the i^{th} TPF. If $\theta = 1$, TPF (Total productivity factor) will be efficient; If $\theta \neq 1$it will be inefficient, and λ is a vector (n × 1) whose values are calculated to obtain the optimum solution. For an inefficient TPF, the λ values will be the weights used in the linear combination of other, for efficient, TPFs, which influence the projection of the inefficient TPF on the calculated frontier.

The DEAP version 2.1 software developed by Coelli and Battese, [10], Centre for Efficiency and Productivity Analysis, University of Queensland, Australia, was used in this study by taking input orientation to obtain the efficiency levels of paddy farms.

Gross return (Rs/acre) was used as a output (Y) in the present case and seed (kg), farm yard manure (tonnes), plant nutrients N (Kg), P (kg), K (kg) separately, total labour (man days), plant protection chemicals (Rs), other input costs and fixed input costs as inputs (X). The models were solved using the DEAP version 2.1 taking an input orientation to obtain the efficiency levels.

2.1 Concepts and Terms Used in the Study

Technical Efficiency (TE) refers to the ability of a farm to produce the maximum feasible output from a given bundle of inputs or the minimum feasible amounts of inputs to produce a given level of output.

Allocative Efficiency (AE) refers to the ability of a technically efficient farm to use inputs in proportions that minimize production costs given input prices. Allocative efficiency is calculated as the ratio of the minimum costs required by the farm to produce a given level of outputs and the actual costs of the farm adjusted for TE.

Economic Efficiency (EE) is the product of both TE and AE. Thus, a farm is economically efficient if it is both technically and allocative efficient input-orientated technical efficiency: “By how much can input quantities be proportionally reduced without changing the output quantities produced” Output orientated technical efficiency “By how much can output quantities be proportionally expanded without altering the input quantities used” Here we adopted the input orientated technical efficiency.

Small farms: Farmer whose land holdings were less than or equal to 2.5 ha irrigation land and 5 ha of rainfed land.

Large farms: Farmer whose land holdings were more than 2.5 ha irrigation land and 5 ha of rainfed land.

3. RESULTS AND DISCUSSION

Table 1 depicts the chemical fertilizer use efficiency among small and large holder farmers for paddy cultivation. It is revealed from the table that, value of coefficients of multiple determinations was found 68 per cent and 79 per cent in small and large holder farmers respectively for paddy cultivation. In smallholder farmers the regression coefficients of the resource variables were found positive for seed (0.05), FYM (0.39) potash (0.18) and labour usage (0.12), negative regression coefficients was observed for nitrogen (-1.68) phosphorous (-1.10), and PPC (-0.16). The highly significant regression coefficient was observed for nitrogen indicated that one per cent change in its use level would decrease the output of paddy by 1.68 per cent, phosphorous 1.10 per cent, keeping the use levels of the other variable constant. Similarly plant protection chemical (PPC) reflected the negative effect on paddy yield but it was non-significant. The significant regression coefficient was observed in case of FYM indicated that the one per cent changes in its use level would increase the output of paddy by 0.39 per cent, potash 0.18 per cent.

With regard to large holder farmers, the significant regression coefficient of nitrogen indicates that one per cent change in its use level would decrease the output of paddy by 1.24 per cent keeping the use levels of the other variable constant. Whereas regression coefficients of the resource variables for seed (0.14), FYM (0.51), potash (0.13) and labour usage (0.03) were found positive. The significant regression coefficient was observed in case of FYM indicated that the one per cent changes in its use level would increase the output of paddy by 0.51 per cent, potash 0.13 per cent.

The regression model adequacy was examined with coefficient of multiple determination (R^2) 68 per cent and 79 per cent in case of small and large holder farmers for paddy cultivation. This implies that about 68 per cent and 79 per cent of the variation in the output was explained by the selected exogenous variables such as seed, FYM, nitrogen, phosphorous, potash, PPC and labour. Small holder farmers regression variable coefficients were negative for nitrogen consumption and phosphorous which indicate that there was no scope for attaining an optimal level of output by increasing the input application. With regard to large holder farmers nitrogen consumption, paddy cultivation was negative which indicated that additional unit increase in nitrogen application reduces the output.

The results of technical, allocative and economic efficiency are presented in Table 2. The results indicated that 40 per cent of small farmers and 46.67 per cent of large scale farms have efficiency scores above 0.9 under the assumption of constant returns to scale in paddy cultivation. While, 10 per cent and 16.67 per cent of the small scale and large scale farms had technical efficiency score with ranges between 0.8-0.9 under the assumption of constant returns to scale in paddy cultivation. The average technical efficiency score was 0.74 in small farmers and 0.81 in large farmers under the assumptions of constant returns to scale in paddy cultivation. With regard to variable returns to scale, 46.67 per cent of small scale farmers and 53.33 per cent of large scale farmers have efficiency scores above 0.9 under the assumption of variable returns to scale in paddy cultivation. While 23.33 per cent and 20 per cent of the small scale and large scale farmers were technical efficiency score with ranges between 0.8-0.9 under the assumption of variable returns to scale in paddy cultivation respectively. The average technical efficiency score was 0.83 in small farmers and 0.89 in large farms under the assumptions of variable returns to scale in paddy cultivation. However, the large scale farms were technically more efficient as compared to small scale farms under the assumptions of constant returns to scale and variable returns to scale in paddy cultivation.

The results pertaining to technical efficiency revealed the estimated mean of 0.74 and 0.81 for small scale and large scale farmers under the assumption of CRS in paddy cultivation. This implied that, there exists a 26 per cent and 19 per cent potential for increasing small scale and large scale farmers cultivation respectively by using the present technology. With respect to variable returns to scale technical efficiency mean of 0.83 and 0.89 for small scale and large scale farmers under the assumption of variable returns to scale in paddy cultivation. It indicated that there exists a 17 per cent and 11 per cent potential for increasing small scale and large scale farmers cultivation by using the present technology. Therefore both categories of farmers need to practice recommended dosage of application in fertilizers and also other inputs as per the package of practice given by State Agriculture Universities (SAU) in order to achieve the 100 per cent efficiency.

With regard to allocative efficiency in paddy cultivation, about 16.67 per cent and 26.67 per cent of small scale and large scale farmers attained efficiency level 90 per cent and above under CRS assumption respectively. With a score of 13.33 per cent, both small-scale and large scale farmers attained efficiency level 0.80 to 0.90 respectively under CRS assumption. The average technical efficiency score was 0.58 in small farmers and 0.62 in large farmers under the assumptions of CRS in paddy cultivation. With respect to variable returns to scale in paddy cultivation 33.33 per cent of both small scale farmers and large scale farmers have efficiency scores above 0.9 respectively. While 6.67 per cent and 10 per cent of the small and large farmers had allocative efficiency score with ranges between 0.8-0.9 respectively. The average technical efficiency score was 0.67 in small farmers and 0.71 in large farmers under the assumptions of variable returns to scale in paddy cultivation. It implies that the large farmers were allocative more efficient as compared to small farmers under the assumptions of CRS in paddy cultivation.

Table 1. Chemical fertilizer use efficiency for small and large holder farmers for paddy cultivation

Sl. no.	Variables	Small holder farmers (n=30)		Large holder farmers (n=30)	
		Coefficient	t-value	Coefficient	t-value
1	Constant	5.98**	2.384	6.52**	3.413
2	Seed (kg/acre)	0.05	0.729	0.14	1.625
3	FYM (kg/acre)	0.39*	2.130	0.51*	3.13
4	Nitrogen (kg/acre)	-1.68**	3.158	-1.24**	2.914
5	Phosphorus (kg/acre)	-1.10*	-2.075	-1.04	-1.569
6	Potash (kg/acre)	0.18**	3.180	0.13**	2.680
7	PPC (Rs./acre)	-0.16	-1.374	-0.28	-1.705
8	Labour usage (Rs./acre)	0.12	0.093	0.03	0.374
	R^2	**0.68**		**0.79**	

*Note: * Significance at 5 per cent level ** Significance at 1 per cent level*

Table 2. Economic efficiency of farmers in paddy cultivation

Efficiency score	Small farms (n=30)			Large farms (n=30)		
	Constant returns to scale					
	Technical efficiency	Allocative efficiency	Economic efficiency	Technical efficiency	Allocative efficiency	Economic efficiency
<0.5	2 (6.67)	7(23.33)	11 (36.67)	--	6 (20.00)	9 (23.33)
0.5-0.6	4 (13.33)	8 (26.67)	4 (13.33)	2 (6.67)	6 (20.00)	5 (16.67)
0.6-07	3 (10.00)	4 (13.33)	6 (20.00)	2 (6.67)	3 (10.00)	2 (6.67)
0.7-0.8	6 (20.00)	2(6.67)	4 (13.33)	7 (23.33)	3 (10.00)	4 (13.33)
0.8-0.9	3 (10.00)	4 (13.33)	2 (6.67)	5 (16.67)	4 (13.33)	6 (20.00)
0.9-1.00	12 (40.00)	5 (16.67)	3 (10.00)	14 (46.67)	8 (26.67)	4 (13.33)
Total	30 (100.00)	30 (100.00)	30 (100.00)	30 (100.00)	30 (100.00)	30 (100.00)
Mean	**0.74**	**0.58**	**0.51**	**0.81**	**0.62**	**0.56**
	Variable returns to scale					
<0.5	2 (6.67)	4 (13.33)	8 (26.67)	--	3 (10.00)	3 (10.00)
0.5-0.6	1 (3.33)	6 (20.00)	5 (16.67)	1 (3.33)	5 (16.67)	4 (13.33)
0.6-07	3 (10.00)	4 (13.33)	3(10.00)	2 (6.67)	5 (16.67)	5 (16.67)
0.7-0.8	3 (10.00)	4 (13.33)	5 (16.67)	5 (16.67)	4 (13.33)	5 (16.67)
0.8-0.9	7 (23.33)	2 (6.67)	5 (16.67)	6 (20.00)	3 (10.00)	7 (23.33)
0.9-1.00	14 (46.67)	10 (33.33)	4 (13.33)	16 (53.33)	10 (33.33)	6 (20.00)
Total	30 (100.00)	30 (100.00)	30 (100.00)	30 (100.00)	30 (100.00)	30 (100.00)
Mean	**0.83**	**0.67**	**0.59**	**0.89**	**0.71**	**0.63**

Note: Figures in parenthesis are percentages

The small and large farmers in paddy cultivation have an allocative efficiency mean level of 0.58 and 0.67 under the assumption of CRS. This means that, there exist a 42 per cent and 33 per cent potential for increasing output by using optimum input combination. While under VRS assumption, the allocative efficiency means level were 0.67 and 0.71 for small and large farms respectively. This implied that there exist a 33 per cent and 29 per cent potential for increasing output by using optimum input combination.

The average economic efficiency score was 0.51 and 0.56 of small and large farmers under the assumptions of CRS in paddy cultivation respectively. 10 per cent of small farmers and 13.33 of large farmers and have efficiency scores above 0.9 under the assumption of constant returns to scale in paddy cultivation. While 6.67 10 per cent of small farmers and 20 per cent of large farmers were economic efficiency score with ranges between 0.8-0.9 under the assumption of CRS in paddy cultivation. With regard to variable returns to scale, 13.33 per cent and 20 per cent of small and large farmers have efficiency scores above 0.9 under the assumption of VRS in paddy cultivation. Economic efficiency score with ranges between 0.8-0.9 was shown 16.67 per cent and 23.33 per cent of the small and large farmers under the assumption of VRS in paddy cultivation respectively. The average economic efficiency score was 0.59 in small farms and 0.63 in large farms under the assumptions of VRS in paddy cultivation. However, the large farmers economic efficiency score was higher compared to small farmers under the assumptions of CRS and VRS in paddy cultivation. The economic efficiency means of 0.51 and 0.59 for small farmers and large farmers respectively, under the assumption of CRS in paddy cultivation, implies that there exists a 49 per cent and 41 per cent potential for increasing small scale and large scale farms cultivation at the existing level of their resources.

Under the assumption of VRS in paddy cultivation economic efficiency mean of 0.59 and 0.63 for small farmers and large farmers under the assumption of VRS in paddy cultivation indicates that there exists a 41 per cent and 37 per cent potential for increasing small and large farmers cultivation at the existing level of their resources. The results were in conformity with Samarpitha et al. [11] who found that the mean economic efficiency of the sample farms was 81.68 per cent in rice farms in Nalgonda district of Telangana.

4. CONCLUSION

The economic efficiency mean of 0.51 and 0.59 for small farms and large farmers under the assumption of CRS in paddy cultivation, implies that there exists a 49 per cent and 41 per cent potential for increasing small and large farms cultivation at the existing level of their resources. Under the assumption of VRS in paddy cultivation economic efficiency exists a 41 per cent and 37 per cent potential for increasing small and large farms cultivation at the existing level of their resources. The small and large farms in paddy cultivation have an allocative efficiency mean level of 0.58 and 0.67 under the assumption of CRS. This means that, there exist a 42 per cent and 33 per cent potential for increasing output by using optimum input combination. Under VRS assumption, the allocative efficiency mean level was 0.67 and 0.71 for small and large farms respectively. This implied that, there exists a 33 per cent and 29 per cent potential for increasing output by using optimum input combination.

The results pertaining to technical efficiency revealed the estimated mean of 0.74 and 0.81 for small and large farms under the assumption of CRS in paddy cultivation. This implied that there exists a 26 per cent and 19 per cent potential for increasing small and large farms cultivation by using the present technology. With respect to technical efficiency mean of 0.83 and 0.89 for small and large farms under the assumption of VRS in paddy cultivation respectively. It indicated that there exists a 17 per cent and 11 per cent potential for increasing small and large farms cultivation by using the present technology. Therefore both the categories of farms need to practice recommended dosage of application in fertilizers and also other inputs as per the package of practice given by State Agriculture Universities (SAU) in order to achieve the 100 per cent efficiency. Hence, there is a need to conduct the awareness programmes on the efficient use of farm resources without affecting the crop yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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