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# Economic Efficiency and Resource Productivity of Major Cropping System under Thamirabarani River Basin

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## ABSTRACT

*In India, there is no scope for horizontal expansion of land for increasing production. Therefore, adoption of multiple sequence of crops can increase production. Primary data have been collected from 120 sample farmers in Thamirabarani river basin during 2017-18. Resource use efficiency of individual farms has been estimated using Cobb-Douglas production function analysis. The functional analysis revealed that in cropping system-I acre, seed, machine labour were significantly contributed to the increase in gross returns and in case of allocative efficiency, MVP to MFC ratio was greater than the unity for seed and machine labour indicating greater profitability for further use of those inputs. The technical efficiency of sample farmers indicates that major proportion of farmers fall under medium efficiency group. In case of cropping system-II acre and labour were positively significant and contributed to the increase in returns and the MVP to MFC ratio was lesser than unity indicating over utilisation of resources and 69.57 per cent of farmers comes under medium efficiency group (80-90%). Input resources like acre, seed, and machine labour were positively significant and contributing a higher returns in cropping system-III. The allocative efficiency of the sample farmers in cropping system-III was greater for machine and seed and the technical efficiency computed indicates that major proportion of farmers (57.89 per cent) were in medium efficiency group.*

***Key words:*** *Cobb-Douglas production function, Resource use efficiency, Cropping system, Allocative and Technical efficiency.*

## INTRODUCTION

Indian agriculture has a diversified agro-ecological condition in soil, rainfall, temperature, and cropping pattern. Agriculture plays a major role in providing raw material to industries and human societies hinge on agriculture for food, clothing, and shelter. Economic growth in developing countries hardly depends on the agriculture particularly in India, as it contributes more than 50 per cent of employment and was widely called as the backbone of India. The GDP contribution from Indian Agriculture was around 15.45 per cent in 2017 which is at the rate of declining which emphasise the need to increase production and productivity.

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Cropping system is considered as one of the important method to increase production and it is an important component of farming system which represents the cropping pattern of a farm and their interaction with the available resources in the farm and also aims at efficient utilisation of resources. The Cropping system of a region mainly depends on the soil and climatic parameters which determine the overall Agro-ecological setting for cultivation of crops with three crops seasons namely Kharif, Rabi and summer. Rice – based cropping system is one of the strategy for achieving food security, income growth, employment generation, poverty alleviation, and sustainable agricultural development. In India, three types of system followed namely Mono – cropping, multiple – cropping, Inter-cropping. In South Asia, Rice, Wheat, Maize grown either as mono-cropping or in crop rotation, which are the major cereals contributing income and food security. Different types of cropping system are being followed in India. Some of the most important multiple cropping system are rice-wheat, rice-rice, rice-pulses, sorghum-wheat, cotton-wheat, soybean-wheat etc.

The economic position of farmers could be increased by identifying the optimum resource use towards most profitable cropping system and also choosing crop enterprise to be grown under different season. Now, with technological progress there is wider scope for farmers to adopt either monoculture, double cropping or multiple cropping.

## MATERIAL AND METHODS

The study was carried in Thamirabarani river basin, the entire river flows through only two districts namely Tirunelveli and Thoothukudi and it is perennial in nature. The river flows in ten blocks, five blocks in each district. Based on the higher area under cultivation four blocks were selected (two block from each district) and three villages from each blocks were selected based on the higher area under cultivation. Finally ten farmers from each village were selected randomly. Hence primary data were collected from 120 farmers with pre-tested interview schedule. Secondary data were also used for the study regarding demographic features, area, cropping pattern, and other data were collected from Joint Director of Agriculture, and Assistant Director of Statistics. The major cropping systems identified in the river basin was cropping system –I (Paddy and Paddy), cropping system –II (Paddy-Paddy fallow Pulses) and cropping system –III (Paddy and Cotton).

**Functional analysis**

To study the economic and resource productivity production function analysis was used. Among different production functions, Heady and Dillon indicated that Cobb-Douglas production function was the most possible functional form for farm analysis as it provides adequate fit to data, adequate degrees of freedom, and computational simplicity. Hence the Cobb-Douglas production function was used for the study and is estimated using regression analysis. The Cobb-Douglas production function used was:

$$Y = aX_1^{b_1}\, X_2^{b_2}\, X_3^{b_3}\, X_4^{b_4}\, X_5^{b_5}\, X_6^{b_6}\, X_7^{b_7}\, X_8^{b_8} \qquad \text{-------------} \qquad (1)$$

Where,

| | | |
|---|---|---|
| Y | = | Gross returns (Rs. / per farm) |
| a | = | Intercept |
| $X_1$ | = | Area under crop in acre |
| $X_2$ | = | Seeds (Rs. / per farm) |
| $X_3$ | = | Organic manure (Rs. / per farm) |
| $X_4$ | = | Human labour (Rs. / per farm) |
| $X_5$ | = | Animal / Machine labour (Rs. / per farm) |
| $X_6$ | = | Chemical fertilisers (Rs. / per farm) |
| $X_7$ | = | Plant protection chemicals (Rs. / per farm) |
| $X_8$ | = | Irrigation (Rs. / per farm) |
| U | = | Error term |
| $b_i$ | = | Output elasticity. |

The equation (1) was changed into linear form by logarithmic transformation and the parameters were estimated by ordinary least square (OLS) method.

$$\ln y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + \ln U$$

The obtained regression coefficient were tested for significance using t-test. The formula is:

$$t = \frac{bi}{SE\ (bi)}$$

where,

$b_i$ = regression coefficient of independent variable

SE ($b_i$) = standard error

The Cobb-Douglas production function does not discriminate the technical and allocative efficiency. Farrel[1] introduced the concept of efficiency, on which frontier production function was used. The main objective of the farmer is to maximize the profit it could be achieved only if the resource are used at consistent with their respective input prices. If the marginal one unit of input is greater than the price of the input, then the farmer was said to be allocating the resources efficiently. If the margin was negative, then the farmers were said to be using the input inefficiently. Hence allocative efficiency was used to study the efficiency level at farm level.

$$\text{Allocative Efficiency} = \frac{VMP_{Xi}}{MFC_{Xi}}$$

$$\text{Where, VMP} = \frac{\beta_i \bar{Y}_i}{\bar{X}_i}$$

VMP = Value marginal product of $i^{th}$ input

$\beta_i$ = Input co-efficient of $i^{th}$ input

$\bar{Y}_i$ = Geometric mean of gross returns of $i^{th}$ input

$\bar{X}_i$ = Geometric mean of input of $i^{th}$ input

the relative percentage change in MVP of each resource was calculated using the equation

$$D = (1\text{-}MFC/MVP) \times 100$$

where, D is the absolute value of percentage change in MVP of each resource[4].

**Timmer's measure of technical efficiency**

Timmer[7] modified the procedure in a number of ways and imposed Cobb-Douglas type of specification on the frontier and evolved an output based measure of efficiency. Technical efficiency is the ratio of actual gross return to the potential gross return on the production function given the level of input use on the $i^{th}$ farm.

$$\text{Technical efficiency of } i^{th} \text{ farm} = Y_i / Y_i^*$$

Where,

$Y_i$ is actual gross return from crop cultivation on $i^{th}$ farm

$Y_i^*$ is the potential gross return attainable from crop cultivation on $i^{th}$ farm

**Economic efficiency**

Economic Efficiency is the product of technical efficiency and allocative efficiency.

$$\text{Economic Efficiency} = TE*AE$$

## RESULTS AND DISCUSSION

**Resource productivity in Cropping system-I**

The estimated resource productivity for cropping system-I is furnished in table 1. The $R^2$ value was 0.87 which indicates that 87 per cent of the variations in the gross returns were influenced by the explanatory variables included in the model. The regression coefficient of acre, seed were positively significant and labour was negatively significant at 1 per cent significance level. The machine labour was positively significant at 5 per cent level. Hence increase in use of input like acre, seed, machine would increase the gross returns in cropping system-I by 0.97, 1.28 and 0.80 per cent and increase in labour would decrease the returns by 1.72 per cent respectively. Similar analysis were done in[2,3] turmeric production.

**Table 1: Estimated Cobb-Douglas production function coefficients**

| S. No | Particulars | Regression coefficient | Std. Error | t value | Significance |
|---|---|---|---|---|---|
| 1. | Intercept | 9.666 | 4.635 | 2.085 | |
| 2. | Acre | 0.974 | 0.266 | 3.665 | *** |
| 3. | Manure | -0.071 | 0.200 | -0.352 | NS |
| 4. | Seed | 1.286 | 0.412 | 3.122 | *** |
| 5. | Fertilizer | -0.081 | 0.237 | -0.343 | NS |
| 6. | Plant protection chemicals | 0.0449 | 0.268 | 1.676 | NS |
| 7. | Irrigation | -0.253 | 0.195 | -1.297 | NS |
| 8. | Labour | -1.753 | 0.603 | -2.860 | *** |
| 9. | Machine | 0.807 | 0.377 | 2.138 | ** |

Note: ***, ** and * indicate significance at 1, 5 and 10 per cent levels of significance, respectively.

**Resource productivity in cropping system-II**

It is apparent from the table 2. that the regression coefficient of acre ($X_1$) was significant at 1 per cent level. It implies that one per cent increase in acre would result in an increase of 1.060 per cent in the gross returns. Fertilizer ($X_4$) and Irrigation ($X_6$) was negatively contributed to gross return but significant at 5 per cent level indicating that one per cent increase in resource would decrease the gross returns by 0.401 and 0.378 per cent. Increase in one unit of Labour ($X_7$) would increase the gross returns by 0.408 per cent as it is significant at 10 per cent level. The adjusted coefficient of multiple determination ($R^2$) was 0.85 which implied that 85 per cent of variation in gross returns was explained by the independent variables included in the model.

**Table 2: Estimated Cobb-Douglas production function coefficients**

| S. No | Particulars | Regression coefficient | Std. Error | t value | Significance |
|---|---|---|---|---|---|
| 1. | Intercept | 10.151 | 3.951 | 2.569 | |
| 2. | Acre | 1.060 | 0.418 | 2.534 | *** |
| 3. | Manure | 0.072 | 0.099 | 0.730 | NS |
| 4. | Seed | -0.298 | 0.266 | -1.117 | NS |
| 5. | Fertilizer | -0.401 | 0.181 | -2.212 | ** |
| 6. | Plant protection chemicals | 0.074 | 0.123 | 0.597 | NS |
| 7. | Irrigation | -0.378 | 0.165 | -2.296 | ** |
| 8. | Labour | 0.408 | 0.219 | 1.864 | * |
| 9. | Machine | 0.354 | 0.285 | 1.244 | NS |

Note: ***, ** and * indicate significance at 1, 5 and 10 per cent levels of significance, respectively.

**Resource productivity in cropping system-III**

The estimated coefficients of the Cobb-Douglas production function are presented in table 3. For the cropping system-III The variables included in the function satisfactorily explained the variation in dependent variable to the extent of 0.80 (80 per cent). It is evident from the table that machine labour ($X_8$) was positively significant art 1 per cent level indicating that one per cent increase in machine labour would increase the gross returns by 0.887 per cent. Increase in Acre ($X_1$) would increase the gross returns in the cropping system by 0.974 per cent which is significant at 5 per cent level. Whereas seed ($X_3$) was significant at 10 per cent level indicating that increase in one unit results in increase of 0.606 per cent and the labour was also significant at 5 per cent level but the output elasticity was (-0.745) negative indicating increase in one unit would decrease the gross returns respectively.

**Table3. Estimated Cobb-Douglas production function coefficients**

| S. No | Particulars | Regression coefficient | Std. Error | t value | Significance |
|---|---|---|---|---|---|
| 1. | Intercept | 14.342 | 4.037 | 3.553 | |
| 2. | Acre | 0.974 | 0.400 | 2.435 | ** |
| 3. | Manure | -0.264 | 0.161 | -1.633 | NS |
| 4. | Seed | 0.606 | 0.337 | 1.798 | * |
| 5. | Fertilizer | -0.758 | 0.282 | -2.688 | *** |
| 6. | Plant protection chemicals | 0.075 | 0.218 | 0.343 | NS |
| 7. | Irrigation | -0.097 | 0.116 | -0.842 | NS |
| 8. | Labour | -0.745 | 0.420 | -1.775 | * |
| 9. | Machine | 0.887 | 0.316 | 2.811 | *** |

Note: ***, ** and * indicate significance at 1, 5 and 10 per cent levels of significance, respectively.

**Allocative efficiency of different cropping system:**

The allocative efficiency of resource used was computed by comparing the Marginal Value of Product (MVP) with Marginal Factor Cost (MFC). If MVP = MFC, the resources are said to be allocative efficient and if greater than unity shows greater potentiality for further use and if lesser than unity indicates overuse of input level. The computed ratio of MVP and MFC for different cropping systems (CS-I, CS-II, and CS-III) were presented in table 4.

It could be seen that resources like seed (14.15), Plant protection chemicals (3.20) and machine (1.50) have ratio of greater than one indicating that the resources are underutilised and in case of manure (-0.20), fertiliser (-0.21), irrigation (-6.57), labour (-1.16) are less than unity indicating heavy and imbalanced use of these inputs in cropping system-I. In case of cropping system-II the inputs like manure, seed, fertiliser, irrigation, labour and machine have ratio of less than unity indicating that there was over use of those resources and MVP/MFC ratio for plant protection chemical indicates that one rupee investment on plant protection chemical would add Rs.1.20 to the gross returns in the cropping system. Whereas in cropping system-III one more rupee of investment in seed and machine labour would increase the gross return by Rs. 6.85 and 1.71 in this system and all other inputs like manure (-0.74), fertiliser (-2.31), irrigation (-2.01), labour (-0.44) have MVP/MFC ratio of less than unity indicating a higher use of resources in cropping system-III respectively.

**Table 4: MVP to MFC ratios of resources in cropping system**

| S. No | Particulars | Cropping system-I | Cropping system-II | Cropping system-III |
|---|---|---|---|---|
| | | MVP/MFC | MVP/MFC | MVP/MFC |
| 1. | Manure | -0.20 | 0.35 | -0.74 |
| 2. | Seed | 14.15 | -2.08 | 6.85 |
| 3. | Fertilizer | -0.21 | -1.12 | -2.31 |
| 4. | Plant protection chemicals | 3.20 | 1.20 | 0.59 |
| 5. | Irrigation | -6.57 | -6.80 | -2.01 |
| 6. | Labour | -1.16 | 0.27 | -0.44 |
| 7. | Machine | 1.50 | 0.61 | 1.71 |

**Technical efficiency of different cropping system:**

The technical efficiency in different cropping system was worked out by using Timmer's method. The mean technical efficiency of different cropping system were presented in table 5. In cropping system-I most of the sample farmers (55.56 per cent) were in medium efficiency group with 80-90 % technical efficiency followed by 38.89 per cent in low efficiency group (with below 80 % technical efficiency) and 5.56 per cent farmers were in high efficiency group (with 91 % and above). The major proportion of sample farmers in cropping system-II fall under medium efficiency group (69.57 per cent), followed by the high efficiency group of about 19.57 per cent of farmers and about 10.87 per cent of farmers were in low efficiency group. In case of cropping system-III 57.89 per cent of farmers were in medium efficiency group (80-90%), and equal per cent of farmers in the high and low efficiency group. To support this similar study in paddy cultivation was done[5,6] by using the Cobb-Douglas production function.

**Table 5: Technical efficiency of different cropping system**

| S. No | Particulars | Cropping system-I (Per cent) | Cropping system-II (Per cent) | Cropping system-III (Per cent) |
|---|---|---|---|---|
| 1. | High efficiency group (91% and above) | 5.56 | 19.57 | 21.05 |
| 2. | Medium efficiency group (80-90%) | 55.56 | 69.57 | 57.89 |
| 3. | Low efficiency group (below 80%) | 38.89 | 10.87 | 21.05 |
| 4. | Mean efficiency | 81.75 | 86.38 | 84.00 |

## SUMMARY AND CONCLUSION

The functional analysis revealed that in cropping system-I acre, seed, machine labour was significantly contributed to the increase in the gross returns and in case of allocative efficiency MVP to MFC ratio was greater than the unity for seed and machine labour indicating greater profitability for further use. The technical efficiency of sample farmers was higher in medium efficiency group.

In case of cropping system-II acre and labour were positively significant and contributed to the increase in returns and the MVP to MFC ratio was lesser than unity indicating over utilisation of resources and 69.57 per cent of farmers were belong to medium efficiency group (80-90%).

Input resources like acre, seed, and machine labour were positively significant and contributing a higher returns in cropping system-III. The allocative efficiency of the sample farmers in cropping system-III was greater for machine and seed and the technical efficiency computed indicates that major proportion of farmers (57.89 per cent) were in medium efficiency group. It could be concluded that majority of farmers under cropping system-II have over utilised the resources and in cropping system-I additional income could be generated by using additional unit of machine labour.

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