Asian Journal of Agricultural Extension, Economics & Sociology

39(10): 153-160, 2021; Article no.AJAEES.73982
ISSN: 2320-7027

An Economic Analysis of Paddy Cultivation in Cuddalore District

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Authors' contributions

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

Article Information

DOI: 10.9734/AJAEES/2021/v39i1030676
Editor(s):
(1) Dr. Roxana Plesa, University of Petrosani, Romania.
Reviewers:
(1) Essien Akpan Antia-Obong, Akwa Ibom State University, Nigeria.
(2) L. Prabhadevi, India.
Complete Peer review History: https://www.sdiarticle4.com/review-history/73982

Original Research Article

Received 04 July 2021
Accepted 14 September 2021
Published 16 September 2021

ABSTRACT

In this paper an attempt was made to analyze economics of paddy cultivation in Cuddalore district. Based on area under paddy, three blocks namely Kurinjipadi, Kumaratchi and Vridhachalam were selected. The total sample size was 120 paddy growers. The study revealed that area and production of paddy crop was declining during the period 1998-2008 while the productivity was growing positively during the same period. During 2009-2019, compound growth rate of area, production and productivity of paddy was depicting an increasing trend due to the role-played by high yielding varieties which created greater affinity towards paddy crop. The cost of production of paddy per hectare was estimated to be Rs. 56,617. The average gross income was found to be Rs. 92,077 per hectare and net income was observed to be Rs. 29,712 per hectare. Excessive usage of nitrogen and phosphorous fertilizers could be reduced to decrease the production cost and increase the efficiency of inputs. Adoption of System of Rice Intensification (SRI) method was suggested to increase the productivity of paddy.

Keywords: Paddy; compound growth rate; CACP; Cost and returns.

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1. INTRODUCTION

Paddy, also known as Rice (*Oryza sativa*) belongs to the family of Gramineae. About 20 per cent calorie intake is accounted by paddy [1]. India stood first in paddy exports during the year 2019-20. Other rice producers include China, Vietnam, Indonesia and Thailand. Paddy finds its place in the diet of more than 60 per cent of world population [2]. Being a complex carbohydrate food, it acts as the primary energy source to more than half of the human population. The second half of twentieth century witnessed a drastic rise in the production of paddy. The green revolution resulted in an inevitable growth in the area, production and productivity of rice dominated countries. Reports said that Some Asian countries witnessed a triple fold increase in the rice productivity during the post green revolution era [3]. Globally, area under paddy crop stood at 1.62 million hectares and its production was estimated to be 7.82 million metric tonnes [4]. At the global platform, the productivity of rice was 4,679 kg per hectare. China has been entitled as the largest consumer of rice having more than 29 per cent of global consumption followed by India. Rice plays a vital role in ensuring economic returns at macro level and achieving food security at micro level. With the coming of green revolution, India was able to achieve self-sufficiency in paddy production. Nearly 15 per cent of India's GDP is contributed by paddy [5]. During the year 2019-20, India's area and production of rice stood at 43.78 million hectares and 118.43 million metric tonnes [6]. Annual compound growth rate of area, production and productivity of paddy in India increased at the rate of 0.33, 2.22 and 1.88 per cent on average per annum, respectively, during 1970-2018 [7]. An analysis of the trends in area, production and productivity of basmati rice in all over India during 2009-10 to 2018-19 revealed that compound annual growth rate of area, production and productivity of basmati rice in India declined at 0.09 per cent, 2.18 per cent and 2,09 per cent respectively [8]. It was estimated that a near fivefold increase in paddy production was attained by India since independence (1947). India's paddy exports valued for Rs. 45,427 crores during 2019-20. In Tamil Nadu, paddy is the major grain crop cultivated under irrigated lands [9]. About 50 per cent of paddy cultivated area in Tamil Nadu is occupied by Thanjavur, Cuddalore, Thiruvarur, Thiruvannamalai, Nagapattinam and Ramanathapuram. Cuddalore district had a share of about 6.93 per cent of the total state's paddy area. The district was under the direct influence of monsoonal rains and suitable soil type created an optimum environment for the sustenance of paddy in the district. Paddy, being a water intensive crop, prevalence of adequate rainfall, easy availability of ground water and other inputs and easier marketing options aided in rise of state's paddy area and production. Being a staple food, it acts as a base for food security [10]. The general objective of the study was to economically analyse paddy cultivation in Cuddalore district and the specific objectives were 1) to analyse the trends in area, production and productivity of paddy in Cuddalore district of Tamil Nadu, 2) to estimate the cost and returns of paddy production in Cuddalore district, 3) to analyse resource use efficiency in paddy cultivation and 4) to identify the constraints in paddy cultivation and suggest possible measures to overcome. The study would give an exposure to the trends of the crop as well as helps in understanding the behaviour of the cropping pattern. The study would be useful for the farmers by estimating the cost and returns, so that this would enable the farmers in getting insights about the profitability of paddy farming. The estimation of resource use efficiency would be useful for the farming community to allocate their existing scarce resources optimally. As this study identified the major constraints of paddy farmers, the study would be helpful to suggest possible measures to overcome the constraints in paddy cultivation and to improve the paddy productivity.

2. MATERIAL AND METHODS

Cuddalore district was selected purposively for the study owing to its larger contribution to paddy's area and production of Tamil Nadu. Based on area under paddy cultivation, three blocks namely Kurinjipadi, Vridhachalam and Kumaratchi were chosen to conduct study. Further total sample of 120 paddy growers were selected based on the area under paddy crop in the study area. The trend analysis was estimated by data from secondary sources [11]. The collected primary data was tabulated and processed. Cost of production and resource use efficiency was estimated from this data.

2.1 Growth Rate

The trends in area, production and productivity of paddy in Cuddalore district was analyzed by utilizing the Compound growth rate [12]. The analysis made use of the formula which was depicted as follows:

$$Y_t = a + bt + U_t \quad (1)$$

where,

Y_t = Dependent variable for which growth rate was estimated;
t = time period, year which takes value 1,2,….n;
a= Intercept;
b = Regression coefficient;
U_t = Disturbance term in year 't'

The equation was transformed into log-linear and written in the following form

$$\text{Log } Y_t = \log a + t \log b + \log U_t \quad (2)$$

This equation was estimated using Ordinary Least Square (OLS) method. The compound growth rate (g) was estimated by the below equation

$$g = (b-1) \times 100 \quad (3)$$

where,

g = Estimated compound growth rate per annum in per cent;
b = Antilog of log 'b'

2.2 Cost Concepts

Commission for Agricultural Cost and Prices (CACP) had explained various cost concepts [13]. They were employed in the study which were detailed as follows:

Cost A_1: Included cost of hired human labor and machine labor, seed cost, irrigation cost, cost of manures and fertilizers, Depreciation of fixed capital, Irrigation charges, Interest on working capital, Land revenue and other taxes
Cost A_2: Cost A_1 plus rent paid for leased in land
Cost B_1: Cost A_1 plus interest on fixed capital (excluding land)
Cost B_2: Cost B_1 plus rental value of owned land
Cost C_1: Cost B_1 plus imputed value of family labor
Cost C_2: Cost B_2 plus imputed value of family labor
Cost C_3: Cost C_2 plus ten percent of Cost C_2 as management cost

2.3 Resource Use Efficiency

Cobb-Douglas production function was utilized to analyse the resource use efficiency of paddy cultivation in the study area [14]. Cobb-Douglas production function was fitted and the form of regression model made use as follows:

$$Y = a\, X_1^{\beta 1}\, X_2^{\beta 2}\, X_3^{\beta 3}\, X_4^{\beta 4}\, X_5^{\beta 5}\, X_6^{\beta 6}\, X_7^{\beta 7}\, X_8^{\beta 8}\, e^U$$

Where,

Y_L = Yield of paddy in qtls/ha
A = intercept
X_1 = Quantity of N (in kg/ha),
X_2 = Quantity of P (in kg/ha),
X_3 = Quantity of K (in kg/ha),
X_4 = Cost of irrigation (Rs./ha),
X_5 = Human labor (Man days/ha.),
X_6 = Machine labour (in hrs/ha),
X_7 = Plant protection chemical (in Rs. /ha) and
X_8 = Quantity of Seed material (Kgs/ha)
β_i = parameter to be estimated or regression coefficients (i = 1 to 8)
e = random error term

2.3.1 Marginal value product analysis

The marginal value product of any particular resource can be defined as "the expected addition to the output caused by the addition of one unit of that resource, while other inputs were held constant". Otherwise, the marginal value product (MVP) will be the value of the extra output obtained as a result of an increase in input used by one unit. It can also be assessed as the product of Marginal Physical Product and the unit price of output.

The marginal value productivities (MVP) of various inputs were estimated and worked out at its geometric mean level by the following equation:

$$MVP_j = \beta_j \frac{\bar{Y}}{\bar{X}_j} . P_y$$

Here,

MVP_j = Marginal value product of the j^{th} input,
$\bar{Y}$ = Geometric mean of the value of output,
$\bar{X}_j$= Geometric mean of the i^{th} input,
B_j = Estimated co-efficient of elasticity of the j^{th} input, and
P_y = Price of output

The magnitude of the marginal value product was compared to marginal input cost (MVP / MIC ratio) and this indicates the scope of resource modification needed to achieve economic optimum levels. A ratio greater than one inferred that the output needs be raised by using more of a given resource. A ratio lesser than one implied that returns to additional levels of input was negative and output could be increased by reducing the level of usage of a given resource. The circumstance where the MVP equals the MIC or price per unit input denoted an economic optimum.

2.4 Garrett Ranking Technique

Garrett ranking was used to assess the constraints in the production of paddy cultivated by farmers in the study area [15]. The farmer respondents were asked to rank their constraints and problems and then this order of merit was converted into ranks using the following formula:

$$\text{Percent position} = 100\,(R_{ij} - 0.5) / N_j$$

where,

R_{ij} = rank given for i^{th} factor j^{th} individual
N_j = number of factors ranked by j^{th} individual.

3. RESULTS AND DISCUSSION

3.1 Estimation of Compound Growth Rate

Compound growth rate was worked out separately for past two decades. The first decade was from 1998 to 2008 and the second decade was from 2009 to 2019. The results of the analysis for the period 1998-2008 were presented in the Table 1.

It could be observed that area and production of paddy was declining during 1998-2008. The documents of UNDP reported that due to tropical cyclone named Fanoos, nearly 2.84 lakh hectares of paddy crop was completely devasted by the cyclone occurred during 2005. Again in 2008, it was due to cyclone Nisha, heavy damages were inflicted on paddy fields led to reduction in production of paddy. However, the productivity was found to be in increasing trend which could be attributed to the increased usage of high yielding varieties and hybrids.

The compound growth rate in terms of area, production and productivity of paddy was worked out for 2009-19. The compound growth rate at which area, production and productivity was estimated to be 1.91 per cent, 6.69 per cent and 4.69 per cent respectively. Cuddalore district had experienced a positive growth rate in terms of area, production and productivity of paddy throughout the period. During the year 2011-12, a drastic reduction in yield was observed which was attributed to the impact of tropical cyclone Thane which devastated the paddy fields of the district. However, it was observed that after the year 2012 the production and productivity was higher than the previous levels. This was due to the introduction of high yielding and submergence tolerant varieties like CR-1009 and CO-51.

3.2 Estimation of Cost and Returns of Paddy Production

The economics of paddy production of Cuddalore district was calculated on the basis of CACP cost concepts. These costs were worked out on per hectare basis and was presented in Table 2.

The cost and returns for different groups of farmers namely marginal farmers, small farmers, semi-medium farmers and medium farmers. It could be observed that majority share in the variable cost was taken up by the human and machine labor. This was due to the fact that paddy being a labor-intensive crop increased the production cost by higher labor cost. The average gross income accrued by paddy farmer was Rs.92,077 while average net income obtained by paddy farmer was Rs. 29,712.

In case of marginal farmers, the cost of seeds was observed to be much lesser than other groups of farmers. This was because of the small-scale ownership of land which led them to have effective and efficient utilization of seeds whereas the other farmers exploitatively used up the seed input. Marginal and Small farmers had lower cost in terms of machine labor. This was due to the fact that fragmented land ownership prevented such farmers in utilizing the machineries for processes like transplanting. Even, some of the marginal farmers made use of family labor to carry out such operations. The marginal farmers had relatively lesser depreciation on fixed capital due to low levels of ownership of farm machineries and implements. Marginal farmers had insufficient storage infrastructures which prevented them from storing the produce. Even, some marginal farmers did not possess tarpaulins for protecting the harvested produce. The gross income attained by marginal farmers was Rs. 85,840 and the net income was assessed to be Rs. 27,705.

It was observed that cost of fertilizers and manure was higher in small farmers when compared to marginal and semi medium farmers. It was due to low scale ownership of land and low availability of FYM. Some of the small farmers depended on their own livestock for preparing FYM. Few of them purchased from outside sellers. Some of the small farmers had small scale storage infrastructure which enabled them to sell the produce whenever the market prices rose. The gross income obtained by small farmers was Rs. 89,752. The net income attained by small farmers was Rs. 28,187.

In case of semi-medium farmers, the overall fertilizers and manure cost mostly comprised of only fertilizers due to the lack of availability of FYM and other manures in the region for such large-scale application. It could be observed that there existed a transition in the cost incurred by family labor. It was higher in case of small and marginal farmers and it gradually reduced to its minimum for medium farmers. It indicated that many of farm activities of large-scale farmers depended on hired labor. The availability of own transportation facilities facilitated to sell their produce for their preference. Semi-medium farmers attained a gross income of Rs. 93,054 and they obtained a net income of Rs. 31,266.

Medium farmers used mainly fertilizers for healthy crop growth. Though they preferred for utilizing manures, lack of FYM and other manures in the region prevented them in doing so. In order to suffice the crop demand for FYM, medium farmers went for an extra dose of fertilizer application which led to increased costs than other categories of farmers. It could be viewed that as the increase in the size of land holding led to rise in the cost of machine labor. Increased cost in the levels of plant protection chemicals was due to much of farmers opted for weedicide rather than manual weeding. Due to higher levels of ownership of machineries and farm implements, the cost on depreciation on fixed capital was relatively higher than other groups of farmers. Added to this, medium farmers were having better storage capacity and marketing ability which gave an edge over other groups of farmers. The gross income obtained by the medium farmers was Rs. 99,660 and they obtained net income of Rs. 31,690.

Table 1. CGR of area, production and productivity of paddy during 1998-2008 and 2009-19

Particulars	Area (in lakh hectares)	Production (In lakh Tonnes)	Productivity (Tonnes/ hectare)
CGR (1998-2008)	-1.55	-5.26	3.76
CGR (2009-2019)	1.91	6.69	4.69

Table 2. Cost and returns of paddy in Cuddalore district (in Rs./hectare)

Sl. No.	Particulars	Average	Marginal	Small	Semi-medium	Medium
1	Cost A_1					
	Human Labor	18,251	18,311	18,351	17,857	18,486
	Machine Labor	14,521	13,133	13,380	14,738	16,834
	Seeds	1,289	560	1,245	1,432	1,919
	Fertilizers and manures	5,678	5,178	6,068	5,247	6,220
	Plant protection chemicals	1,188	974	1,262	1,117	1,397
	Depreciation on fixed capital	250	163	212	2,80	346
	Interest on working capital	1,432	1,335	1,411	1,414	1,570
	Land revenue	89	74	84	90	107
	Total	42,699	39,729	42,013	42,175	46,879
2	Cost A_2	42,699	39,729	42,013	42,175	46,879
	Interest on owned capital	697	338	755	791	903
3	Cost B_1	43,396	40,067	42,769	42,966	47,782
	Rental value of owned land	11,907	11,199	11,544	11,808	13,076
4	Cost B_2	55,302	51,266	54,312	54,774	60,857
	Imputed value of family Labor	1,393	1,584	1,655	1,397	934
5	Cost C_1	44,788	41,651	44,424	44,363	48,715
6	Cost C_2	56,695	52,850	55,968	56,171	61,791
7	Cost C_3	62,365	58,135	61,565	61,788	67,970
8	Gross income	92,077	85,840	89,752	93,054	99,660
9	Net income	29,712	27,705	28,187	31,266	31,690

Table 3. Resource use efficiency for marginal farmers

Sl. No.	Variables	Regression coefficient	Standard Error	MVP	MIC	MVP / MIC	Status
1	Intercept	1.531^{NS}	1.278				
2	N (Kg/ha)	0.183*	0.075	9.855	13.044	0.756	Overutilized
3	P (Kg/ha)	0.592*	0.218	24.129	150.000	0.161	Overutilized
4	K (Kg/ha)	- 0.009^{NS}	0.106	-	-	-	-
5	Irrigation cost (Rs/ha)	0.167*	0.076	21.151	21.429	0.987	Overutilized
6	Human Labor (man days)	0.011^{NS}	0.158	-	-	-	-
7	Machine Labor (Hours)	0.026^{NS}	0.080	-	-	-	-
8	Plant protection chemical (Rs. /ha)	- 0.110^{NS}	0.137	-	-	-	-
9	Seeds (Kg/ha)	- 0.380^{NS}	0.202	-	-	-	-

*Note: N = 37; * - Significant at five percent level; NS- Non-Significant*

3.3 Estimation of Resource Use Efficiency

Resource use efficiency was worked out separately for marginal and small farmers. Cobb-Douglas production function was used to determine the resource use efficiency

3.3.1 Estimation of resource use efficiency for marginal farmers

The value of R^2 indicated that about 86 percent of the systematic variation in the paddy yield was explained by the independent variables. The results of the regression analysis were presented in the Table 3.

It was inferred that nitrogen fertilizer, phosphorus fertilizer and cost of irrigation had significant relationship with the yield of paddy crop. These variables had a positive relationship with yield which indicated that the increase in these variables would increase the yield of paddy. The coefficients of nitrogen fertilizers, phosphorus fertilizers and irrigation cost were assessed to be 0.183, 0.592, 0.167 respectively. The variable inputs such as machine and human labor had a positive influence in the crop but were statistically non-significant. Other input variables like potassium fertilizers, seed and plant protection chemicals were negative and statistically non-significant. This showed that these inputs had a negative impact on the yield of the crop. Due to the misconceived idea that excessive nitrogen usage would increase the yield had resulted in excessive use of fertilizers. Irrigation cost was found to be more optimally used than other resources as its MVP and MIC ratio was nearing one.

3.3.2 Estimation of resource use efficiency for small farmers

The coefficient of multiple determination (R^2) was estimated to be 0.862 concluding that 86 per cent of the systematic variation in the yield of the crop was explicated by the explanatory variables. The results of regression analysis were presented in Table 4.

It was inferred that nitrogen fertilizer, phosphorus fertilizer and irrigation cost were positive and statistically significant. Nitrogenous and phosphorus fertilizers were being excessively used due to the flawed idea that increased application of these fertilizers would increase the yield of crop. The input variable, seed had negative influence on the yield of paddy crop but was found to be statistically significant. The negative impact indicated that seeds were excessively used which was not bringing an increase in yield. Availability of low-cost seeds in the region could be attributed to increased seed usage. Added to this, the misconception of greater seed usage would lead to increased yield but it had created competition among the crops rather than increasing the yield. Cost of irrigation was also found to be higher than the economic optimum. Prevalence of competition for various factors among the crops could be the reason for reduction in the yield of paddy. Other inputs such as plant protection chemicals and human labor were positive relationship with the yield of the crop. But these variables were statistically non-significant. potassium fertilizer and machine labor had a negative impact in the yield of the crop and were found to be statistically non-significant. From this, it was inferred that there existed a need for effective as well as efficient utilization of inputs which had a significant impact on the yield of the crop.

Table 4. Resource use efficiency for small farmers

Sl. No.	Variables	Regression coefficient	Standard error	MVP	MIC	MVP / MIC	Status
1	Intercept	0.909[NS]	1.489				
2	N (Kg/ha)	0.154*	0.069	0.546	13.044	13.043	Overutilized
3	P (Kg/ha)	0.575*	0.258	1.153	150.000	150.000	Overutilized
4	K (Kg/ha)	- 0.083[NS]	0.096	-	-		-
5	Irrigation cost (Rs/ha)	0.135*	0.062	0.836	21.429	38.000	Overutilized
6	Human Labor (man days)	0.217[NS]	0.186	-	-		-
7	Machine Labor (Hours)	- 0.022[NS]	0.073	-	-		-
8	Plant protection chemical (Rs. /ha)	0.029[NS]	0.114	-	-		-
9	Seeds (Kg/ha)	- 0.413 [NS]	0.192	9.698	21.428	21.428	Overutilized

*Note: N = 49; * - Significant at five percent level; NS- Non-Significant*

Table 5. Constraints in production of paddy

Sl. No.	Constraints	Mean Score	Rank
1	Monsoon calamity	88.88	I
2	Lack of storage facilities	84.28	II
3	High cost of inputs	70.74	III
4	Prevalence of pest and disease	63.80	IV
5	Non-availability of labor	51.88	V

3.4 Constraints in Production of Paddy

The major constraint that was faced by the farmers was monsoon calamity which had a mean score of 88.88. A majority of the farmers in the study area reported that due to heavy rainfall during monsoon, lack of proper drainage system led to stagnation of water in the field thereby leading to crop loss or failure. The second reported constraint was the lack of storage facilities which had a mean score of 84.28. Paddy crop had to be maintained at an optimum moisture content in order to prevent the harvested crop from germination. Added to this, the first reported constraint, monsoon calamity had its linkage with the second constraint. Due to rainfall in the harvest times, the lack of drying and storage infrastructures led to increase in the moisture of the produce. This degraded the quality of the produce. Thus, lack of storage structures contributed to the loss of harvested produce. High cost of inputs was the third major constraint reported by the farmers. The other identified constraints faced by the sample farmers were prevalence of pest and disease (63.80) and non-availability of labor (51.88). The results were furnished in the Table 5.

4. CONCLUSION

It was inferred from the study that the compound growth rate of area, production and productivity was estimated to be 1.91 per cent, 6.69 per cent and 4.69 per cent respectively in the period from 2009 to 2019. The introduction of high yielding varieties such as Co-51 and CR-1009 Sub 1 varieties had attributed to the positive growth in area, production and productivity. CACP cost concepts were utilized in analysing the cost of cultivation of paddy. In the analysis, average Cost C2 was worked out as Rs. 56,617 per hectare. It was reported that average net income generated by paddy farming was from Rs. 29,712 per hectare to Rs. 31,690 per hectare in the study area. It was observed in the study area that monsoon calamity was reported as major constraint with mean score of 88.88. In heavy rainfall period, lack of proper drainage system led to stagnation of water in the field thereby leading to crop loss or failure. Further lack of storage facilities, high cost of inputs, prevalence of pest and disease and non-availability of labor were reported as other major constraints in paddy cultivation. Excessive use of nitrogen and phosphorous fertilizers had not only increased the cost of production but also affected the environment by the process of leaching of fertilizers in the study area. Hence use of recommended doses of farm inputs would effectively increase the paddy productivity in the study area. As majority of the farmers in the study area reported that lack of proper drainage system led to stagnation of water in the field during monsoon. Hence improved farm technologies like draining out excess water and adopt gap filling and drenching with fungicide to prevent seedling rot in nursery and adoption of SRI method might be popularised in the study area to overcome the water stagnation problem and for better yield.

ACKNOWLEDGEMENTS

Authors are thankful to Agricultural College and Research Institute, Madurai, 625 104, Tamil Nadu Agricultural University, Coimbatore, 641003, India

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/73982