P-ISSN: 2618-0723
E-ISSN: 2618-0731

NAAS Rating (2025): 5.04
www.extensionjournal.com

International Journal of Agriculture Extension and Social Development

Volume 8; Issue 8; August 2025; Page No. 10-14

Received: 13-05-2025
Accepted: 17-06-2025

Indexed Journal
Peer Reviewed Journal

Technical efficiency analysis of paddy production in South Gujarat

[1]HD Patel, [2]Dr. JV Varasani and [1]Raj Patel

[1]PG Student, Department of Agricultural Economics, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, India

[2]Assistant Research Scientist, Department of Agricultural Economics, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, India

DOI: https://www.doi.org/10.33545/26180723.2025.v8.i8a.2237

Corresponding Author: HD Patel

Abstract

Paddy is the second most produced crop worldwide after maize and is a staple food for more than half of the world's population, especially in Asia and Africa. After China, India is the world's second-largest producer of paddy, with 137.83 million metric tons. Gujarat is having 15th place in paddy production in India during the year 2023-24. In present study, a total of 240 paddy farmers were selected using multistage random sampling from two districts of South Gujarat *viz.*, Valsad and Tapi. The technical efficiency was calculated by using stochastic frontier production function and the determinants was analyzed by Tobit model. The findings revealed that the coefficients of seed (0.803), human labour (0.322) were found positive and significant while machine cost (-0.069) was found negative and significant factor in the overall study area. The technical efficiency for overall South Gujarat ranged between 70.02 and 98.64 per cent with the mean of 88.79 per cent, indicating that the paddy yield can be increased by 11.21 per cent in the study area with the available resources without using any additional resources. The mean technical efficiency for Valsad and Tapi district were 88.81 and 88.23 per cent, respectively. The results of the determinants of paddy production indicated that age of the farmer (0.012), education level of the farmer (0.143), number of working members in the family (0.033) and proximity to market yard (0.010) were found to be positive and significant impact in the overall study area.

Keywords: Technical Efficiency (TE), Stochastic Frontier Analysis, Determinants, Tobit Model.

Introduction

Agriculture is the art and science of cultivating the land. Agriculture is an evolutionary process that consists of a series of activities such as the production of food, fibers, feed and the raising of domesticated animals to fulfil the demand of the population. Agriculture is a key to development in the area of human civilization.

Paddy (*Oryza sativa* L.) is an edible starchy cereal grain of Poaceae family. Paddy is the staple food for over half of the world's human population, particularly in Asia and Africa. Paddy is the second largest cereal produced in the world after maize. Total production of paddy in India during the year 2023-24 is estimated at record 1,378.25 Lakh Metric Tons (LMT) (Anonymous, 2024b) [3]. Gujarat is having 15th place in paddy production in India during the year 2023 24. Paddy crop cultivation is not evenly distributed throughout the state. In the financial year 2023, the total production in India was 135 million metric tons, among which 2.4 million metric tons of paddy production was done by the western state of Gujarat in India (Anonymous, 2024c) [4]. In South Gujarat, the area under production is 2,678.26 ("00" ha) and the production of paddy is 6,908.01 ("00" MT) in the year 2021-22 (Anonymous, 2024a) [2].

Agricultural production can be improved through either area expansion or enhanced productivity. There is a growing shortage of land due to population growth which resulted in lower carrying capacity of the land. Hence, in order to meet the need-based targets of agricultural production, the pattern of production enhancement have to rely heavily on increased yield. Agriculture's future depends on optimum utilization of available resources which boosts the farmers efficiency and results in increased production. As the farmer's efficiency *i.e.*, resource use efficiency, technical efficiency, allocative efficiency and economic efficiency increased, the overall production also increased. Paddy production is a significant agricultural activity in South Gujarat, but its economic efficiency is a major concern. Despite being a major paddy producing region in Gujarat, farmers are facing declining profitability and economic inefficiency. The economic inefficiencies in paddy production also have their impact on the regional economy and food security. Therefore, the present study has analyzed the technical efficiency and factors influencing paddy production in the South Gujarat.

Methodology

Although Gujarat is not the major paddy producing state, many farmers cultivate paddy in *kharif* season. The South Gujarat region is suitable for paddy production because of its favorable soil and agro-climatic conditions. Moreover, the paddy crop is having dominance in this region; hence, it was selected for the study. From the South Gujarat region,

two districts, namely Valsad and Tapi were purposively selected which occupied the highest area and production under paddy production. Considering the limitation of time and resources, two talukas from each districts were randomly selected. Thus, Dharampur and Valsad talukas from Valsad district and Dolvan and Vyara talukas from Tapi districts were chosen at random. From each selected talukas, two villages were randomly selected. Thus, a total of eight villages were selected from the four selected talukas of Valsad and Tapi districts. In the next stage, farmers were selected for the detailed analysis. For this purpose, a sample of 30 farmers were selected randomly from each of the selected villages. Thus, a total of 240 farmers were selected from eight villages. The primary data were collected through the personal interview method for the year 2024-25.

Statistical tools and techniques

Estimation of technical efficiency

In the present study, the stochastic frontier production function approach was used to measure technical efficiency of paddy producing farms. Technical efficiency can be referred as the ability of a firm to produce the maximum possible output from a given set of inputs and technology. The estimation of technical efficiency was done by using the econometric modelling in accordance to the stochastic frontier methodology of Aigner *et. al.* (1977) [1]. The highest output of a farm can achieve at a given level of inputs and technology is known as the frontier production function. The disturbance element in stochastic frontier is divided into two parts: symmetric component which captures randomness outside the control of the farmer, such as weather, drought, floods, *etc*. and the other is statistical noise contained in every empirical relationship. The one-sided error component capturing randomness under the control of the farmer (*i.e.*, technical inefficiency) (Vasanthi *et al.*, 2017) [17].

Specification of the Model

The Cobb-Douglas production form of stochastic frontier production was used in the study to evaluate technical efficiency, which is expressed in the following equation:

$$\mathbf{\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + (V_i - U_i)}$$

where, the subscript i denotes the ith farmer in the sample,

ln	=	natural logarithm (*i.e.* to base e)
Y_i	=	Output of Paddy (q/ha)
$\beta_0 \ldots \beta_7$	=	Parameters to be estimated
X_1	=	Quantity of seed (kg/ha)
X_2	=	Human labour (human days/ha)
X_3	=	Machine cost (Rs/hr)
X_4	=	Irrigation cost (Rs/ha)
X_5	=	Quantity of Fertilizer (kg/ha)
X_6	=	Quantity of Manure (tons/ha)
X_7	=	Plant protection cost (Rs/ha)
V_i	=	Symmetric (two sided) error component
U_i	=	One sided error component (technical inefficiency)

The model was estimated using the computer program FRONTIER 4.1 (Coelli, 1996) to estimate simultaneously the parameters of the stochastic production frontier.

Determinants of Technical Efficiency

Efficiency of paddy production can only be improved if the determinants of efficiency can be identified. The estimates of technical efficiency range from 0 to 1, indicating that the dependent variable is limited. The Tobit model can manage this distribution of efficiency estimates, providing results that can guide policies to improve performance. The Tobit model was used to find out factors that may affect farm technical inefficiency. The technical efficiency estimates derived from the stochastic frontier model was subjected to regression analysis with farm-specific explanatory variables using the two-sided Tobit model. The model for the proposed study was specified as follows (Kale *et al.*, 2024) [7]:

$$TE_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + e_i$$

where,

TE_i	=	Technical efficiency of the ith farm
X_1	=	Area under Paddy (in ha)
X_2	=	Experience in paddy cultivation (in years)
X_3	=	Age of the farmer (in years)
X_4	=	Education level of the farmer (in years)
X_5	=	Number of working members in the family
X_6	=	Proximity to the market yard (Km)
β_0	=	Constant
$\beta_1 - \beta_6$	=	Coefficients of independent variables
e_i	=	Error term

Results and Discussion

Estimation of Frontier Production Function

Stochastic Production Function approach has been used to estimate the technical efficiency. The parameters of frontier production function were estimated using the Maximum Likelihood Estimation (MLE) and the results are shown in the Table 1. The result showed that the overall study area had a high value of γ (0.913), indicating that 91.3 per cent of inefficiencies were due to farmers' inefficiency in the decision making and 8.7 per cent were due to random factors that were outside the control of the farmers. These findings are in line with the findings of Hasan *et al.* (2016) [6], Kea *et al.* (2016) [8] and Samarpitha *et al.* (2016) [14]. Similarly, the values of γ were 88.6 per cent and 97.9 per cent for Valsad and Tapi districts, respectively.

Table 1: Maximum likelihood estimates of stochastic production frontier function for paddy in the South Gujarat

Variables	Valsad		Tapi		Overall	
	Coefficients	SE	Coefficients	SE	Coefficients	SE
Constant	-3.001**	1.202	1.848*	0.949	-0.5989	0.743
Seed	0.862***	0.084	0.829***	0.061	0.803***	0.053
Human Labor	0.344***	0.074	0.237***	0.063	0.322***	0.052
Machine Cost	-0.059**	0.027	-0.069***	0.025	-0.069***	0.019
Fertilizer	0.366*	0.190	-0.171	0.123	0.075	0.112
Manure	-0.004	0.014	-0.005	0.012	-0.007	0.010
Plant protection Cost	0.017	0.055	-0.117**	0.056	-0.015	0.039
Irrigation Cost	0.058**	0.023	0.004	0.016	0.022	0.014
σ^2	0.027***	0.005	0.027***	0.004	0.026***	0.003
Gamma (γ)	0.886***	0.064	0.979***	0.018	0.913***	0.032
Log likelihood	100.88		117.77		211.19	

Note: *, ** and *** denotes significance at the 10, 5 and 1 per cent levels, respectively.
SE is the Standard Error of the factors.

The estimates of the stochastic frontier production function for the overall study area were presented in the table and the estimated values of the coefficients of seed (0.803) and human labour (0.322) were positive and significant at the 1 per cent level. This implies that an increase in seed and human labour by 1 per cent would increase paddy yield by 0.803 per cent and 0.322 per cent respectively. The findings indicated that by using good quality seeds and improved variety seeds at recommended seed rate and by allocating human labours at various stages from seed sowing, weeding to harvesting can improve the paddy yield. At the same time, the value of the coefficient of machine cost (-0.069) was found to be negative and significant at the 1 per cent level. The reason behind negative machine cost would be the higher charges of operations done by machines and prolonged use of machinery without proper knowledge. The coefficients of fertilizer and irrigation cost were found to be positive while the coefficients of manure and plant protection cost were found to be negative and statistically non-significant.

District wise Maximum Likelihood Estimates

Valsad District: For Valsad district, the coefficient of seed (0.862) and human labour (0.344) were positively correlated with paddy production and were highly significant (Table 2). This suggested that as the usage of seed and human labour increases, the output of paddy also increases. This could be understood from the fact that as the use of high yielding varieties and quality seeds and proper allocation of human labour in different stages of paddy production will ultimately increase the paddy production. The coefficients of irrigation cost (0.058) was found to be positive while machine cost (-0.059) was determined to be negative and significant at the 5 per cent level. This resulted from the irrational use of tractors for cloud crushing and puddling by farmers which cause soil degradation and ultimately reduce yield. Fertilizer was found positive and significant at 10 per cent level with the coefficient of 0.3663. However, it was discovered that the costs of plant protection was positive but not statistically significant. whereas manure was determined to be negative and statistically non-significant. These findings are in line with Meenasulochani *et al.* (2018) [10], Siagian and Soetjipto (2020) [15] and Guha and Mandal (2021) [5].

Tapi District: In case of Tapi district, the coefficient of seed (0.829) and human labour (0.237) were positive and significant while machine cost (-0.069) was negative and significant at the 1 per cent level. This showed that by using good quality seeds at recommended seed rate and by allocating the human labours at different stages of crop growth from sowing to harvesting can increase the paddy production. The negative and significant impact of machine cost can be understood by the reasons such as the higher charges of operations done by machines and prolonged use of machinery without proper knowledge. The coefficient of plant protection cost (-0.117) was found to be negative and significant at the 5 per cent level. The reason behind it would be the occurrence of insect-pest after the rainfall in the region so that the plant protection chemicals were used more than required. On the other hand, irrigation cost was found to be positive while fertilizer and manure were found to be negative and statistically non-significant. The findings are in line with Meenasulochani *et al.* (2018) [10] and Rao and Kondeti (2024) [13].

Percentage wise Technical Efficiency Score of paddy farmers in South Gujarat

Details regarding farm specific technical efficiencies are crucial because they offer valuable insights to the policymakers about the nature of production technologies used in the farms. Table 2 depicts the frequency distribution of the farmers of Valsad district, Tapi district and the overall study area by the level of technical efficiency in the paddy production. The wide variations in technical efficiencies across the paddy farmers were observed. For overall study area, the mean technical efficiency was 88.79 per cent, which means that sample farmers tend to achieve almost 89 per cent of their technological potential in terms of paddy yield. Consequently, approximately 11 per cent of this potential remains unrealized. By using efficient crop management strategies, paddy production can be increased by 11 per cent without increasing the quantity of inputs used.

Among the farmers, 56.66 per cent were found to function at technical efficiency levels more than 91 per cent. Furthermore, technology efficiencies for 15.42 per cent of farmers ranged from 86 to 90 per cent. Additionally, 14.17 per cent of the farmers in the sample were functioning at technical efficiency levels ranging from 81 to 85 per cent. For 7.08 per cent and 6.67 per cent of paddy growers, the technical efficiency level ranged from 71 to 75 per cent and 76 to 80 per cent, respectively. The majority of the sample paddy farmers were found to be operating closer to frontier with the technical efficiencies more than 91, which indicated the efficient use of some of the resources in the study area. These findings were in line with the result of Vasanthi *et al.* (2017) [17] and Paul (2020) [12].

Valsad District: The mean technical efficiency y was estimated to be 88.81 per cent for Valsad district, indicating that on average the sample farmers were able to achieve about 89 per cent of their technical potential. Consequently, about 11 per cent of this potential remains unrealized. Among the farmers, 56.67 per cent were found to operate at technical efficiency levels higher than 91 per cent. Additionally, 15.83 per cent of the farmers in the sample were functioning at technical efficiency levels ranging from 86 to 90 per cent. Furthermore, technical efficiencies ranged from 81 to 85 per cent for about 12 per cent of farmers. About 9.17 per cent and 6.67 per cent of paddy farmers were in the 76 to 80 per cent and 71 to 75 per cent technical efficiency level, respectively. The similar findings were found by Meenasulochani *et al.* (2018) [10].

Tapi District: For Tapi district, the mean technical efficiency was 88.23 per cent. This indicated that that sample farmers may frequently achieve about 88 per cent of their technical potential. Consequently, approximately 12 per cent of this potential remains unused. Among the farmers, 49.16 per cent were found to operate at technical efficiency levels higher than 91 per cent. Furthermore, technological efficiencies ranged from 81 to 85 per cent and 86 to 90 per cent for 19.17 per cent and 16.67 per cent of

farmers, respectively. Additionally, 9.17 per cent and 5.83 per cent of the farmers in the sample were functioning at technical efficiency levels ranging from 71 to 75 per cent and 76 to 80 per cent, respectively.

Table 2: Distribution of sample farmers under different levels of technical efficiency in the South Gujarat

Technical efficiency (%)	Valsad		Tapi		Overall	
	No. of Firms	% to total	No. of Firms	% to total	No. of Firms	% to total
71 - 75	8	6.67	11	9.17	17	7.08
76 - 80	11	9.17	7	5.83	16	6.67
81 - 85	14	11.67	23	19.17	34	14.17
86 - 90	19	15.83	20	16.67	37	15.42
91 - 95	47	39.17	25	20.83	86	35.83
More than 95	21	17.50	34	28.33	50	20.83
Total farms	120	100.00	120	100.00	240	100
Mean efficiency (%)	88.81		88.23		88.79	

Determinants of Technical Efficiency

The Tobit model regression analysis was presented in the Table 3. Among the socio-economic variables which may impact the technical efficiency, the coefficient of farmer's age (0.012) was found positive and significant at 1 per cent level. This may be due to the fact that old farmers have better decision-making ability. They tend to have more knowledge about the farming practices and efficient allocation of resources compared to young farmers which ultimately resulted in improved technical efficiency and increased paddy production. As the age of the farmer increases, they also give advice to other farmers about the to adopt a technology. In simple words, as the age of the farmer increases their experience also increases. The value of estimated coefficient of education level of the farmer (0.143) was positive and highly significant. As the education level of the farmers increased, the ability to perceive, interpret, respond and adoption to new and advanced technology by the farmers get increased compared to less educated farmers. The coefficient of number of working members in the family (0.033) was found positive and significant at 1 per cent level. Working family members plays significant role in farming. As the number of family members engaged in farming activity increases, more labour force can be applied to the different stages of crop growth which ultimately increased the paddy production. The value of estimated coefficient of proximity to market yard (0.010) was found positive and significant at 10 per cent level. It suggested that farmer who are nearer to the market yards have better access to sell their produce, which could lead to higher income or productivity. These results are in line with the research conducted by Narala and Zala (2010) [11], Samarpitha *et al*. (2016) [14], Meenasulochani *et al*. (2018) [10], Mariko *et al*. (2019) [9] and Subedi (2020) [16]. The remaining two variables namely, area under paddy (0.049) and experience in paddy cultivation (0.001) did not exhibit a significant relationship with technical efficiency.

Table 3: Factors influencing technical efficiency of paddy production in the study area

Variables	Coefficients	Standard Error	t value
Area under paddy	0.049	0.041	1.173
Experience in paddy cultivation (in years)	0.001	0.002	0.425
Age of the farmer (in years)	0.012***	0.001	13.025
Education level of the farmer (in years)	0.143***	0.023	6.339
Number of working members in the family	0.033***	0.011	3.069
Proximity to market yard (Km)	0.010***	0.002	5.393
Log likelihood	79.666		
Pseudo R^2	1.255		

Note: *** denotes significance at the 1 per cent level.

Conclusion

The findings revealed that the coefficients of seed (0.803), human labour (0.322) were found positive and significant while machine cost (-0.069) was found negative and significant factor in the overall study area. The study revealed that the variation in the paddy production in the study area is because of the differences in the technical efficiency levels of the farmers. The mean technical efficiency was found to be 88.79 per cent which indicated that the output can be increased by 11.21 per cent without using any additional resources in the study area. Therefore, proper allocation of the available resources and technology and proper management can lead to the increased paddy production. The results of determinants of paddy production suggested that age of the farmer, education level of the farmer, number of working members in the family and proximity to market yard were found to be positive and significant for the study area. The timely and sufficient supply of low-cost technology, fertilizer, improved seeds and farm mechanization strategies on the basis of custom hiring, the technical advisory and formal as well as informal education may contribute in increasing the level of technical efficiency.

References

1. Aigner DJ, Lovell CAK, Schmidt P. Formulation and estimation of stochastic frontier production function models. Journal of Econometrics. 6(1):21-37.
2. Anonymous Directorate of Agriculture. 2024a.
3. Anonymous. Ministry of Agriculture & Farmers Welfare; 2024b. Retrieved from https://pib.gov.in/.
4. Anonymous. Statista; 2024c. Retrieved from https://www.statista.com/.
5. Guha P, Mandal R. Technical inefficiency of maize farming and its determinants in different agro-climatic regions of Sikkim, India. Indian Journal of Agricultural Economics. 76(2):225-244.
6. Hasan M, Hossain E, Osmani AG. Technical efficiency of boro rice production in Jhenaidah district of Bangladesh: A stochastic frontier approach. International Journal of Agricultural Economics. 1(4):103-107.

7. Kale RB, Gavhane AD, Thorat VS, Gadge SS, Wayal SM, Gaikwad SY, *et al*. Efficiency dynamics among onion growers in Maharashtra: a comparative analysis of drip irrigation adopters and non-adopters. BMC Plant Biology. 24(1):237.
8. Kea S, Li H, Pich L. Technical efficiency and its determinants of rice production in Cambodia. Economies. 4(4):22.
9. Mariko K, Macalou M, Xiangmei L, Matafwali E, Alavo JPE, Eltom EA, *et al*. Stochastic meta frontier analysis of smallholder rice farmers' technical efficiency. Journal of Agricultural Science. 11:31-44.
10. Meenasulochani R, Rajendran T, Pushpa J, Senthilnathan S. Technical efficiency of paddy production and factors affecting the efficiency in Nagapattinam District, Tamil Nadu. International Journal of Agriculture Innovations and Research. 6(6):355-358.
11. Narala A, Zala YC. Technical Efficiency of Rice Farms under Irrigated Conditions in Central Gujarat. Agricultural Economics Research Review. 23(2):375-381.
12. Paul KSR, Sunandini GP, Irugu S, Suhasini K. Farm level technical efficiency of paddy production in Andhra Pradesh: An empirical evidence from the cost of cultivation survey data. Economic Affairs. 65(4):659-663.
13. Rao KM, Kondeti S. Economic Analysis of Technical Efficiency of Paddy Crop Cultivation In Andhra Pradesh. Library of Progress-Library Science, Information Technology and Computer. 44(3):9371-9378.
14. Samarpitha A, Vasudev N, Suhasini K. Technical, economic and allocative efficiencies of rice farms in Nalgonda district of Telangana state. Economic Affairs. 61(3):365-374.
15. Siagian RA, Soetjipto W. Cost efficiency of rice farming in Indonesia: Stochastic frontier approach. Agricultural Socio-Economics Journal. 2020;20(1):7-14.
16. Subedi S, Ghimire YN, Kharel M, Adhikari SP, Shrestha J, Sapkota BK. Technical efficiency of rice production in terai district of Nepal. Journal of Agriculture and Natural Resources. 2020;3(2):32-44.
17. Vasanthi R, Sivasankari R, Gitanjali BJ, Paramasivam R. Efficiency Analysis of Paddy Production in Tank Irrigated Systems of Southern Zone in Tamil Nadu, India. International Journal of Current Microbiology and Applied Sciences. 2017;6(6):1161-1167.