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Impact of Agricultural Machinery and Equipment on Paddy Production (A study on Nellore district of Andhra Pradesh)

Ch. Kalpalatha[1] and N.R.V.Ramana Reddy[2]
[1] *Research Scholar, Department of Economics, V.S.U.P.G. Centre, Kavali, Nellore Dt., A.P. India.*
2 *Professor, Department of Economics, V.S.U.P.G. Centre, Kavali, Nellore Dt., A.P. India*
Corresponding Author: N.R.V.Ramana Reddy[2]

Abstract: Advanced agricultural technology has made farmers feel the need for the use of improved machinery and equipment in agriculture for lowering down the cost of unit production on one hand and improving the productivity per unit area at a point of time on the other. In this study an attempt has been made to study the impact of improved farm machinery and equipment on paddy production in Nellore district of Andhra Pradesh by using Cobb-Douglass production function. The study reveals that the mechanised tillage, irrigation and threshing, reaping & winnowing are positive and significant impact on production.

Key Words: Agricultural Technology, Farm Machinery, Tillage, Threshing, Reaping, winnowing and Productivity

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I. INTRODUCTION

Paddy is the most important food crop of India. It is predominantly a summer crop. It covers about one third of total cultivated area of the country and provides food to more than half of the Indian population. The staple food of Majority of Indian population is rice. Paddy is grown in almost all the states of India. West Bengal, Uttar Pradesh, Andhra Pradesh, Punjab, Tamil Nadu, Bihar, Orissa, Assam, Karnataka and Haryana are the major producing states. More than 50 percent of the total production comes from the first four states. It is also grown in Haryana, Madhya Pradesh, Kerala, Gujarat and Kashmir. Agriculture still remains the major source of Income for families in India. Farms cover over half the land and almost three-quarters of that land is used to grow the two major grains: paddy and wheat. India is the second largest producer of paddy in the world, next only to China. India's annual paddy production stands at about 85 to 90 million tons.

Paddy can be cultivated by different methods based on the type of region. But in India, the traditional methods are still in use for harvesting paddy. The fields are initially ploughed and then fertilizer is applied which typically consists of cow dung and then the field is smoothed. The seeds are transplanted by hand and then through proper irrigation.

The main problem of Indian agriculture is that, huge quantities of labour are needed during the winter season for preparation of fields, planting and harvesting followed by long periods of idleness. The available power sources invariably fall short during the peak time and become abundant during the slack periods. Mechanization not only contributed to improve the labour demand during harvest and post harvest operations but by virtue of considerable labour force actually required to maintain certain agricultural machinery contributes to seasonal stabilization of wage rates too.

However, the recent past is a favourable time for farm mechanization in India. Advanced agricultural technology has made farmers feel the need for the use of improved machinery and equipment in agriculture for lowering down the cost of unit production on one hand and improving the productivity per unit area at a point of time on the other. Thus, the farmers in India and particularly in Andhra Pradesh have started realizing the need for, and the advantages of farm mechanization.

II. LITARATURE REVIEWS

Ganapathy and Karunanithi (2005) revealed that the use of mechanical power was the highest for paddy and the lowest for cotton among other crops. Singh (2006) estimated a mechanization index and its impact on production and economic factors in India and constructed a mechanization index. Chandrasekaran *et al*. (2008) study indicated that there was a significant reduction in human labour use and bullock labour use in most of the crops and on the other hand, the machinery use on the increasing trend. Verma (2008) concluded that farm mechanization enhances the production and productivity of different crops due to timeliness of operations, better quality of operations and precision in the application of inputs. Ghosh (2010) study revealed that the factors such as irrigation, access to institutional credit, size of land holdings etc., were found to have positive significant bearing on the level of farm mechanization. Olaoye and Rotimi (2010) conducted a study on measurement of agricultural mechanization index and analysis of agricultural productivity of farm settlements in Southwest Nigeria. The study revealed that low production efficiency, drudgery, under utilization of mechanical power.

Singh *et al.* (2011) made a study on selective mechanization in rice cultivation for energy saving and enhancing the profitability and identified that carrying out timely operation and reducing cost of cultivation is the prerequisite for enhancing the production and productivity of rice. Rahman *et al.* (2011) studied the effect of mechanization on labour use and profitability of wheat cultivation in Bangladesh. Karunakaran (2011) level of mechanization of farms as fully mechanized and partially mechanized farms for his study on economic evaluation of mechanization in paddy in Cauvery delta zone of Tamil Nadu. Tope *et al.* (2012) conducted a study on impact of mechanization on lowland rice production in Nigeria and concluded that the power tiller was capable of primary and secondary tillage operations and was most suitable for operations in hilly regions, wet conditions and for small holdings.

Owombo *et al.* (2012) studied the economic impact of mechanization in Nigeria on Maize crop and concluded logistic regression model revealed that education, extension visit and machine access were the significant determinants of adoption of mechanization practices. Renting *et al.* (2013) conducted a study on investigation of the contribution rate of agricultural mechanization to agricultural production. Srinivasa *et al*. (2013) conducted a study of mechanization of cotton harvesting in India and its implications and concluded that the net income of the cotton farmers represented from this study group will increase considerably with the mechanization of cotton harvesting

Hence, in this study an attempt has been made to study the impact of improved farm machinery and equipment on paddy production in Nellore district of Andhra Pradesh.

III. SOURCE OF DATA :

The study extends over Nellore district of Andhra Pradesh. A multi stage random design was used. The data were collected with the help of Farm Survey Method through personal interviews of the farmers, selected through mixed sampling. In this study purposefully the researcher selected two Revenue divisions, namely Atmakur and Kavali of SPSR Nellore district for preparing a sample of 792 paddy production farms taking 392 for Atmakur Revenue division and 400 for Kavali Revenue division to know the mechanisation impact on paddy production.

IV. ANALYSIS :

To study the mechnaisation impact on paddy production, we consider the following production function:

$$Y = \beta_0 X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} \ldots\ldots\ldots X_{18}^{\beta_{18}} \qquad \ldots\ldots (1)$$

Where,

Y =	Crop output including by-products	(in Rs.)
X_1 =	Tillage Expenditure	(in Rs.)
X_2 =	Irrigation Expenditure	(in Rs.)
X_3 =	Threshing, Reaping and Winnowing Expenditure	(in Rs.)
X_4 =	Transportation Expenditure	(in Rs.)
X_5 =	Labour Expenditure	(in Rs.)
X_6 =	Seeds Expenditure	(in Rs.)
X_7 =	Fertilizers Expenditure	(in Rs.)
X_8 =	Pesticides Expenditure	(in Rs.)
X_9 =	Farm Size	(in Acres.)
X_{10} =	Age of Farmer	(in Years)
X_{11} =	Gender of Farmer	(Male-1; Female-0)
X_{12} =	Marital Status	(Married-1: Otherwise-0)
X_{13} =	Farmers Education	(in Years)
X_{14} =	Farmers Experience	(in Years)
X_{15} =	Access to Farm machinery Repairs	(Yes-1; otherwise-0)
X_{16} =	Access to Institutional Credit	(Yes-1: Otherwise-0)
X_{17} =	Extension Visit per year	(No. of Contacts)
X_{18} =	External Membership	(Yes-1: Otherwise-0)

β_0 is the constant or intercept of the function.

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5 \ldots\ldots \beta_{18}$ are Coefficients of the inputs.

This function is estimated by the method of Ordinary Least Squares (OLS) and the estimated parameters and other related statistics were presented in the Table-1. Before analysing the Table-1, we should examine the presence of multi-colinearity. Multi-colinearity test on the basis of Klein (1965) and Heady-Dillon (1961) was carried out and found that the absence of Multi-colinearity.

Table–1: Estimated Coefficients and other related Statistics of Cobb-Douglass Production Function - 1

Inputs		Atmakur	Kavali
β_0	Constant	4349.602	13536.144
X_1	Tillage Exp.	-0.130* (0.044)	0.014 (0.012)
X_2	Irrigation Exp.	0.030 (0.043)	0.012 (0.014)
X_3	Threshing, Reaping and Winnowing Exp	0.088* (0.041)	0.121* (0.028)
X_4	Transport Exp	-0.076* (0.027)	-0.151* (0.030)
X_5	Labour Exp.	-0.060 (0.039)	0.033 (0.021)
X_6	Seeds Exp.	0.001 (0.125)	-0.012 (0.012)
X_7	Fertilizers Exp	0.001 (0.111)	0.090* (0.019)
X_8	Pesticides Exp	-0.009 (0.040)	0.039* (0.012)
X_9	Farm Size	1.089* (0.089)	0.865* (0.035)
X_{10}	Age of Farmer	-0.020 (0.031)	-0.029 (0.019)
X_{11}	Gender of the Farmer	0.004 (0.019)	0.001 (0.000)
X_{12}	Marital Status	0.027 (0.020)	0.008 (0.012)
X_{13}	Education of the Farmer	0.032 (0.021)	-0.009 (0.011)
X_{14}	Experience of the Farmers	0.011 (0.030)	0.014 (0.016)
X_{15}	Access to Farm Machinery Repairs	-0.006 (0.20)	0.00 (0.000)
X_{16}	Access to Institutional Credit	-0.018 (0.017)	-0.008 (0.010)
X_{17}	Extension Officers Visit	-0.010 (0.017)	0.004* (0.009)
X_{18}	External Membership of Farmer	0.005 (0.023)	0.036 (0.011)
R^2		0.917	0.971
Multiple R		0.957	0.985
F		232.242*	710.460*
	Sample Size	397	400

* Significant at 5% Probability level. Figures in Parenthesis are Standard Errors.

Table-1 shows that the value of R^2 indicating that 92 per cent of variations in gross output is explained by all independent variables in Atmakur revenue division whereas in Kavali revenue division it is 97 per cent. On the basis of F-test both were significantly different from zero. Thus, the fit is good and the estimated function may be taken as true speciation of relationship between output and inputs.

A close look at the Table-1, we found that the coefficients of irrigation expenditure, seeds expenditure, fertilisers expenditure, farm size, gender, marital status, education, form experience external membership of the former are positive and insignificant in case of Atmakur revenue division, whereas the coefficients of tillage expenditure, irrigation expenditure, labour expenditure, gender, marital status, experience, external membership of farmer and access to farm machinery repairs are positive and insignificant in case of Kavali revenue division.

The coefficients of threshing, reaping and winnowing expenditure and form size are positive and significant at 5 percent probability level in case of Atmakur revenue division, whereas the coefficients of threshing, reaping and winnowing expenditure, fertilizers expenditure, pesticides expenditure and farm size are positive and significant at 5 percent probability level in case of Kavali division. The coefficient of farm size is (1.089) very high and greater than unity in case of Atmakur division whereas it is (0.856) very high in case of Kavali revenue division.

The coefficient of tillage and transport expenditure in negative and statistically significance at 5 per cent probability level in case of Atmakur revenue division, whereas the coefficient of transport expenditure is negative and statistically significance at 5 per cent probability level in case of Kavali revenue division

The estimated function-1, on the basis of R^2 and F-tests provides a good estimation of the relationship between output and inputs. The coefficients, however, present some results contrary to the common belief on agricultural production. The coefficients values of tillage expenditure, transport expenditure and pesticides expenditure are not according to the general belief as they are showing negative effect on output in case of Atmakur revenue division where as the coefficient values of transport expenditure, seeds expenditure are not according to the general belief as they are showing negative effect on output in case of Kavali revenue division. All the above coefficients are expected to be significantly positive. This situation might have cropped-up in the absence of true specification and inclusion of unimportant variables in the function –1.

Table – 2: Step-wise Regression of Function -1

Inputs	Atmakur		Kavali	
	R^2	R^2 change	R^2	R^2 change
X_1	0.772	0.772	0.571	0.571
X_2	0.835	0.063	0.726	0.155
X_3	0.854	0.019	0.889	0.163
X_4	0.854	0.000	0.906	0.017
X_5	0.861	0.007	0.909	0.003
X_6	0.866	0.005	0.910	0.001
X_7	0.877	0.011	0.921	0.011
X_8	0.880	0.003	0.921	0.000
X_9	0.916	0.036	0.970	0.049
X_{10}	0.917	0.001	0.970	0.000
X_{11}	0.917	0.000	0.970	0.000
X_{12}	0.917	0.000	0.970	0.000
X_{13}	0.917	0.000	0.970	0.000
X_{14}	0.917	0.000	0.970	0.000
X_{15}	0.917	0.000	0.970	0.000
X_{16}	0.917	0.000	0.970	0.000
X_{17}	0.917	0.000	0.970	0.000
X_{18}	0.917	0.000	0.971	0.000
Total	----------	0.917	--------	0.971

In the function-1, we have included large number of explanatory variables, which may not be very important from the production point of view. As regards the non-economic variables like Education and experience of farmer, access of farm machinery repairs, and access to institutional credit and membership of farmer with agriculture societies, we can say that the farmers are aware with the merits of agricultural technology and mechanization. Their deletion will not reduce the explanatory power of the function

Table-2 show that age of the farmer, gender of the farmer, marital status of the farmer does not seem an important variable and they can deleted from the list of explanatory variables. Similarly the coefficient of farm size is (1.089) very high and greater than unity in case of Atmakur division whereas it is (0.856) very high in case of Kavali revenue division, reflects that it is not accordance with the general belief of production function estimates. In general the farm size is measured in terms of acres and hence it is not an important variable from the production point of view. It can be deleted from the function-1. Now we postulate the following production function:

$$Y = \beta_0 X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} X_6^{\beta_6} X_7^{\beta_7} X_8^{\beta_8} \qquad \text{........ (2)}$$

Where,

Y = Crop output including by-products (in Rs.)
X_1 = Tillage Expenditure (in Rs.)
X_2 = Irrigation Expenditure (in Rs.)
X_3 = Threshing, Reaping and Winnowing Expenditure (in Rs.)
X_4 = Transportation Expenditure (in Rs.)
X_5 = Labour Expenditure (in Rs.)
X_6 = Seeds Expenditure (in Rs.)
X_7 = Fertilizers Expenditure (in Rs.)
X_8 = Pesticides Expenditure (in Rs.)

Function (2) is estimated by the method of Ordinary Least Squares (OLS) and the estimated parameters and other related statistics were presented in the Table -3. Before analysing the Table-3, we should examine the presence of multi-colinearity. Multi-colinearity test on the basis of Klein (1965) and Heady-Dillon (1961) was carried and that found that the absence of Multi-colinearity.

Table – 3, shows that the value of R^2 indicating that 88 per cent of variation in grosses output is explained by all independent variables in Atmakur revenue division whereas in Kavali revenue division it is 92 per cent. On the basis of F-test both were significantly different from zero. Thus, the fit is good and the estimated function may be taken as true speciation of relationship between output and inputs.

Table – 3: Estimated Coefficients and other related Statistics of Cobb-Douglass Production Function - 2

Inputs		Atmakur	Kavali
β_0	Constant	-3518490	5131.281
X_1	Tillage Exp.	0.100* (0.046)	0.093* (0.022)
X_2	Irrigation Exp.	0.182* (0.488)	0.071* (0.023)
X_3	Threshing, Reaping and Winnowing Exp	0.192* (0.047)	0.365* (0.041)
X_4	Transport Exp	-0.009 (-0.032)	0.218* (0.041)
X_5	Labour Exp.	0.117* (0.042)	0.061 (0.033)
X_6	Seeds Exp.	0.096* (0.034)	0.032 (0.018)
X_7	Fertilizers Exp	0.166* (0.036)	0.191* (0.030)
X_8	Pesticides Exp	0.163* (0.046)	0.033 (0.018)
R^2		0.880	0.921
Multiple R		0.938	0.960
F		359.683*	571.394*
$\sum \beta_i$	Sum of Coefficients	1.007	1.064

* Significant at 5% Probability level. Figures in Parenthesis are Standard Errors.

Tillage Expenditure: The coefficient of tillage expenditure is 0.100 and significant at 5 per cent probability level in case of in Atmakur revenue division, whereas it is 0.093 is positive and significant at 5 per cent probability level in case of Kavali revenue division, indicates that 1 per cent increase in tillage will leads to increase by 10 per cent in case of Atmakur revenue division, whereas it is 9 per cent in case of Kavali revenue division. Mechanisation tillage is labour saving and promotes cultivation of large land sizes. Seedling root establishment is related to how well the soil is cultivated and increase productivity (Tinsley, 2009).

Irrigation Expenditure: The coefficient of irrigation expenditure is 0.182 and significant at 5 per cent probability level in case of in Atmakur revenue division, whereas it is 0.071 is positive and significant at 5 per cent probability level in case of Kavali revenue division, reveals that 1 per cent increase in irrigation expenditure will cause to increase production by 18 per cent in case of Atmakur revenue division, whereas it is 7 per cent in case of Kavali revenue division.

Threshing, Reaping and Winnowing Expenditure: The coefficient of threshing, reaping and winnowing Expenditure is highest (0.192) and significant at 5 percent probability level in case of Atmakur revenue division, where as it is also highest (0.365) and significant at 5 percent level in case of Kavali revenue division, indicates that 1 per cent increase in threshing, reaping and winnowing expenditure will leads to increase production by 19 per cent in case of Atmakur revenue division, whereas it is 37 per cent in case of Kavali revenue division.

Transport Expenditure: The coefficient of transport is negative (-0.009) and insignificant in case of Atmakur revenue division shows that the additional increase in transport expenditure will leads to decrease in production in case of Atmakur revenue division, whereas it is positive (0.218) and significant at 5 percent probability level, shows that the relative importance of this variable in case of Kavali revenue division.

Labour Expenditure: The coefficient of labour is positive (0.117) and significant at 5 percent probability level in case of Atmakur revenue division, shows that 1 per cent increase in labour expenditure will leads to 12 percent increase in production in case of Atmakur revenue division, whereas it is positive (0.061) and insignificant in case of Kavali revenue division.

Seeds Expenditure: The coefficient of seeds expenditure is positive (0.096) and significant at 5 percent probability level in case of Atmakur revenue division, shows that 1 per cent increase in labour expenditure will leads to 10 percent increase in production in case of Atmakur revenue division, whereas it is positive (0.032) and insignificant in case of Kavali revenue division.

Fertilisers Expenditure: The coefficient of fertilisers expenditure is 0.166 and significant at 5 per cent probability level in case of in Atmakur revenue division, whereas it is 0.191 is positive and significant at 5 per cent probability level in case of Kavali revenue division, indicates that 1 per cent increase in fertilisers expenditure will leads to increase production by 16 per cent in case of Atmakur revenue division, whereas it is 19 per cent in case of Kavali revenue division.

Pesticides Expenditure: The coefficient of pesticides expenditure is positive (0.163) and significant at 5 percent probability level in case of Atmakur revenue division. shows that 1 per cent increase in pesticides expenditure will leads to 16 percent increase in production in case of Atmakur revenue division, whereas it is positive (0.033) and insignificant in case of Kavali revenue division.

From Table – 3, we revealed that the coefficients of mechanisation variables i.e. Tillage, Irrigation and Threshing, reaping & winnowing are positive and significant in both Atmakur and Kavali revenue divisions, shows that the farmers are aware with agricultural mechanisation. In addition to the mechanisation variables the technological variable i.e. fertilisers expenditure is also significant in both Atmakur and Kavali revenue divisions, shows that the relative importance of this variable in production.

RESOURCE USE EFFICIENCY:

In order to evaluate the economic efficiency of paddy formers in two revenue divisions under study, we calculate the ratios of Marginal Value Products (MVP) to their respective Marginal Costs (MC), and they are depicted in Table – 4.

From Table – 4, we found that the ratios of MVP and MC of Tillage, Irrigation, Threshing, Reaping and Winnowing, Seeds, Fertilizers and Pesticides are greater than unity in the case of Atmakur division, whereas the ratios of MVP and MC of Tillage, Irrigation, Threshing, Reaping and Winnowing, Transport, Seeds, Fertilizers and Pesticides are greater than unity in case of Kavali revenue division, indicating that the under utilization (Verma, 1984; Sharma *et al.,* 1987) of all the above said variables.

Table – 4: Ratios of Marginal Value Product (MVP) of input to the respective Marginal Cost (MC)

Inputs		Atmakur			Kavali		
		MVP	MC	Ratio	MVP	MC	Ratio
X_1	Tillage Exp.	1.782	1.000	1.782	2.0522	1.000	2.0522
X_2	Irrigation Exp.	13.09	1.000	13.09	5.9189	1.000	5.9189
X_3	Thresh, Reap and Winnow Exp	3.529	1.000	3.529	7.4599	1.000	7.4599
X_4	Transport Exp.	-0.33	1.000	-0.33	11.011	1.000	11.011
X_5	Labour Exp.	0.576	1.000	0.576	0.5409	1.000	0.5409
X_6	Seeds Exp.	2.476	1.000	2.476	1.0745	1.000	1.0745
X_7	Fertilizers Exp.	1.862	1.000	1.862	3.1338	1.000	3.1338
X_8	Pesticides Exp.	4.023	1.000	4.023	1.1016	1.000	1.1016

The ratios of MVP and MC of labour expenditure are less than unity in both the Atmakur and Kavali revenue divisions indicating that the marginally utilization of this variable in paddy production. The ratio of MVP and MC of Transport is negative in case of Atmakur revenue division. Hence, the pattern of resource use in Atmakur revenue division needs some modification particularly the application of Tillage, Irrigation, Threshing, Reaping and Winnowing, Seeds, Fertilizers and Pesticides should be increased to get more production of paddy. Whereas in case of Kavali revenue division the application of Tillage, Irrigation, Threshing, Reaping and Winnowing, Seeds, Fertilizers and Pesticides should be increase to get more production of paddy.

V. CONCLUSIONS:

This study examined the impact of improved farm machinery and equipment on paddy production in Nellore district of Andhra Pradesh by estimating the Cobb-Douglass production function with Ordinary Least Squares (OLS) techniques. The study reveals that the Tillage, Irrigation and Threshing, Reaping & Winnowing are positive and significant impact on production along with Fertilisers and Pesticides. The study suggested to the farmers of the study area, the application of Mechanised Tillage, Irrigation and Threshing, Reaping and Winnowing and Fertilizers should be increase to get more yield of paddy.

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