

Technological Parameters in Aggregate Agricultural Production Function – A Study in Three Revenue Mandals of Nellore District: Andhra Pradesh

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Abstract: Agriculture occupies a pivotal place in the national economy. Therefore, its performance is of vital concern to the planners. The size and speed of agricultural development would naturally determine the shape of things in the rest of the economy. The impact of new farm technology has not been enough to alter significantly the trend rate of crop production. Not only is our agrarian economy, capitally deficient but it is also backward in the field of technology. Our peasantry is still by and large using the age old techniques for production. The study aims to analyse the Aggregate Agricultural Production Function and Resource use efficiency based on entire sample of Farms in Three Revenue Mandals of Nellore District, Andhra Pradesh. Data was collected for the explanatory and explained variables with the help of survey method through personal interviews of the farmers selected through mixed sampling in three revenue mandals of Nellore district. Regression co-efficients are estimated to study the relationship between gross output and various factors of production. By studying the Marginal Value Products of factors of production, we assessed the relative importance of factors of production. The sum of the elasticities and their statistical significance was also studied.

Key Words: Aggregate Agricultural Production Function, Marginal Cost, Marginal Value Product, Ordinary Least Squares Method, Regression Co-efficients.

I. Introduction

Agriculture occupies a pivotal place in the national economy. Therefore, its performance is of vital concern to the planners. The size and speed of agricultural development would naturally determine the shape of things in the rest of the economy. But the agricultural sectors grow at a rate much below its potential, the growth and requirement of the economy. It is really a great pity that a great agrarian country like India, where agriculture is the predominant occupation of the people, can hardly meet its requirement. The impact of new farm technology has not been enough to alter significantly the trend rate of crop production. Not only is our agrarian economy, capitally deficient but it is also backward in the field of technology. Our peasantry is still by and large using the age old techniques for production. Though modern technology has reached a section of the rural work force, the bulk of it still depends upon the inferior and most primitive technology. It is generally believed that even if some of the new techniques have reached villages; these have only been made use by some limited educated section of the village, whereas the larger one has remained unaffected. The main problems regarding the non-adoption of resources and modern skills among vast sections of farm population are, want of proper education and training. There are number of studies on the agricultural sector in Nellore district. Among these studies, the research on agricultural production is very limited. The empirical investigations are needed to study the agricultural production function. Hence the empirical and scientific investigational study of agricultural production function in the rural economy of Nellore district is an important phenomena. In the present study, an attempt has been made to study the aggregate production function basing on entire sample of farms of three mandals, namely, Kaligiri, Muttukur and Pellakur of Nellore district of Andhra Pradesh.

II. Review of Literature

Ghosh[1] made an attempt to examine the extent to which the new technology along with irrigation has been effective in increasing income and human-labour employment. The study reveals that the introduction of irrigation in the summer season followed by the adoption of high-yielding seeds of rice has been instrumental in enhancing income and employment. Therefore, he has concluded that there has been a sharp rise in income per farm after the introduction of the new technology.

Hasan and Parthasarathy[2] studied the variation in resource productivity among the mechanized and non-mechanized farms by means of a Cobb-Douglas production function. It was observed that there was a greater need to reduce the size of holdings in both type of farms and also to reduce cattle labour employment in mechanized farms. It was also observed that the returns from human-labour and material cost were much more in the mechanized farms.

Krishna Mohan[3] analyzed the impact of new technology on agrarian structure and agricultural production in the state of Andhra Pradesh. He has concluded that the performance of new technology in the state can be described as something between the extravagant promises of early promoters and gloom to critics. He has pointed out; the new technology has increased food production at the same time it has failed in increasing the percapita availability of food grains.

Singh[4] studied the resource allocation on the farms of Eastern Uttar Pradesh on the basis of competitive market criteria. He calculated the marginal productivity of inputs, by fitting the Cobb-Douglas Production Function, for selected individual crops and then aggregating the elasticity of output with respect of input. The broad conclusion, he has reached that the factors are not most economically allocated as the mean differences between the marginal products and factor cost was significantly different from zero. In order to promote the allocation efficiency of resources on farm, the author feels irrigation facility and education of farmers are essential for the introduction of new technology.

Chandrasekhar Rao's[5] study concerns the estimation of aggregate Agricultural supply response in Andhra Pradesh. He used Log-Linear Model, it is estimated by Ordinary Least Squares (OLS) method. According to this study, the regression co-efficients for terms of trade of aggregate agriculture, crop sector, food grain crops and non-food grain crops were positive and statistically non-significant whereas the regression co-efficient for technology variable indicated by irrigation ratio and total factor productivity are statistically significant and far higher than those for price variables.

III. Objectives of Study

The following are the objectives of the study:

- To study the Aggregate Agricultural Production Function based on entire sample of Farms in Three Revenue Mandals of Nellore District, Andhra Pradesh.
- To study the Agricultural Resource use efficiency in Three Revenue Mandals of Nellore District, Andhra Pradesh.

IV. Data and Methodology

The following methodology is adopted to study the above objectives. The present study extends over Nellore district of Andhra Pradesh. A multistage random sampling design was used. We purposefully selected three mandals, Namely Kaligiri, Muttukur and Pellakur of Nellore District at the first stage and later with help of random sampling ten to twelve villages were selected from each Mandal. After the selection of villages a complete list of agricultural families was prepared. Data was collected for the explanatory and explained variables with the help of survey method through personal interviews of the farmers selected through mixed sampling for this study relating to the agricultural year 2002-2003.

4.1. Specification of variables

A great deal of caution is essential in the selection, classification and aggregation of input variables used in the production process for studying resources productivity. Different researchers have classified and aggregated farm inputs in different ways suitable for their studies. Various ways of classifying and aggregating input variables in production function studies together with a brief description of variables used as explanatory variables in the present study are giving below.

4.1.1. Bullock-Labour

Preparation of farm is an important agricultural work and bullock-power have been taken as an explanatory variable by a number of writers. Chaudhari[6], Reddy and Sen[7], Hopper[8] and Radhakrishna[9] have used it in terms of plough unit days consisting of one pair of animal-labour day and one human-labour day comprising one plough unit. While Rajkrishna[10], Badal and Singh[11] specified this variable in terms of bullock-labour days, Robellow and Desai[12] included a labour with a pair of bullocks. Here, we also include one human-labour to a pair of bullocks and specify them in value terms. This done with the help of accounting prices.

4.1.2. Human-Labour

Human-labour too, has been used as an explanatory variable in the estimation of production functions either in physical units of time or in value of terms. Shan[13] and Goyal[14] used all human labour while, Hopper[8] and Mathur[15] used all human-labour except those associated with plough unit in value terms. Sharma and Sharma[16], Hanumantha Rao[17], Rajkrishna[10], Singh[18] and Eswara Prasad[19] have used all human-labour in terms of man-days. We also include human-labour as an explanatory variable but from it exclude those labourers who are engaged in traditional irrigation work and are associated with bullock units. Variable is specified in terms of rupees.

4.1.3. Seeds

A few writers have used seeds as explanatory variable in their functions. Prasad[20], Debnarayan Sarker and Sudipta De[21] used seeds as a separate explanatory variable in his study terms of expenditure on seeds. We also include seeds in our functions, the prices of seeds are determined at the prevailing market price of the seeds at the seeding time.

4.1.4. Irrigation

Assured and effective irrigation which has been one of the most important factors in the production function studies. Rajkrishna[10], Timothy and Krishna Moorthy[22] has specified this variable in terms of expenses on irrigation. We also specify it in the same term. Expenses on irrigation include permanent of wages to labourers used in traditional system of irrigation, water charges paid to the Government for the use of state tube-wells, hire-price of the water received from private tube-wells and pumping sets. Expenses also include accounting prices for the water received from farmers own pumping sets and tube-wells.

4.1.5. Fertilizer

Fertilizer is one of the most important components in Agricultural Production. Parikh[23] and Shan[13] Mythili and Shanmugam[24] have used chemical fertilizers as separate variable, while Basak and Choudhary[25] has included manure along with chemical fertilizers as an explanatory variable. Yadav and Gangwar[26] considered various categories of chemical fertilizers as independent explanatory variables. In the present study, though category-wise chemical fertilizer is not taken, chemical fertilizers and pesticides and natural fertilizers are specified as separate variables, and taken in value terms. While expenses on chemical fertilizer are the actual expenses, help of accounting price has been taken to determine the expenses on traditional fertilizers, like seen manure, compost burnt of waste goods and cow-dewing.

4.1.6. Plant Protection

Plant protection measures are included as explanatory variable. Prasad[20] and Badal and Singh[11] taken them in terms of expenditure on their use. In our study also this variable is specified in terms of actual expenditure.

4.1.7. Use of Dummy Variables

Dummy variables are usually associated with qualitative variables such as region, topography, occupation, caste and the like. It is a simple and useful method of introducing such variables into the regression analysis, which would otherwise be difficult to measure on a numerical scale. Introduction of dummy variables into the regression analysis permit the separation of information on certain variables into discrete categories by assuming dummy values (0 or 1) for each of the categories. In this study we include education and information as the two non-economic explanatory variables. Education includes middle to degree level education of farmer. Information incorporates paper reading, listening to radio and contact with the agricultural and extension staff of the government.

Like specification of variables, specification of an equation showing functional relationship between inputs and output is an important aspect of production function studies. Many of the economists used the generalized Cobb-Douglas Production Function to study the relation between the inputs and output in production analysis. The following production functions have been specified for aggregate analysis.

V. Model Specification

5.1. Aggregate Farm Enterprises

The following Production Functions have been formulated for the analysis of Aggregate Farm Enterprise.

$$Y = a_0 X_1^{a_1} X_2^{a_2} X_3^{a_3} X_4^{a_4} X_5^{a_5} X_6^{a_6} X_7^{a_7} X_8^{a_8} X_9^{a_9} X_{10}^{a_{10}} X_{11}^{a_{11}} \quad \rightarrow (1)$$

Where,

Y = Gross output including by-products of crops under on harvesting prices (in Rs.)

a_0 = Intercept

X_1 = Land Rent (in Rs.)

X_2 = Bullock Labour (in Rs.)

X_3 = Expenditure on Tractor (in Rs.)

X_4 = Human Labour (in Rs.)

X_5 = HYV Seeds (in Rs.)

X_6 = Irrigation (in Rs.)

X_7 = Chemical Fertilizers (in Rs.)

X_8 = Manures (in Rs.)

X_9 = Pesticides and other Plant Protection methods	(in Rs.)
X_{10} = Dummy Variable on education	(in Rs.)
X_{11} = Dummy Variable on information	(in Rs.)

and $a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9, a_{10}$ and a_{11} are the elasticities.

$$Y = a_0 X_1^{a_1} X_2^{a_2} X_3^{a_3} X_4^{a_4} X_5^{a_5} X_6^{a_6} X_7^{a_7} \rightarrow (2)$$

Where,

Y = Gross output including by-products	(in Rs.)
a_0 = Intercept	
X_1 = Bullock Labour	(in Rs.)
X_2 = Expenditure on Tractor	(in Rs.)
X_3 = Human Labour	(in Rs.)
X_4 = HYV Seeds	(in Rs.)
X_5 = Chemical Fertilizers	(in Rs.)
X_6 = Manures	(in Rs.)
X_7 = Pesticides and other Plant Protection methods	(in Rs.)

and $a_1, a_2, a_3, a_4, a_5, a_6$ and a_7 are the elasticities.

5.2. Marginal Value Products

By studying the Marginal Value Products of factors of production, we can assess by their relative importance of factors of production. Marginal Value Product of X_i , the i^{th} input is estimated by the following formula:

$$\text{MVP}(X_i) = \alpha_i \frac{\text{G.M.}(Y)}{\text{G.M.}(X_i)}$$

Where,

G.M. (Y) and G.M. (X_i) represent the geometric means of output and input respectively, α_i is the regression Co-efficient of i^{th} input.

VI. Results and Discussions

6.1. Aggregate Production Function Analysis

To study the aggregate production function based on entire sample of farms, we considered the production function – 1.

$$Y = a_0 X_1^{a_1} X_2^{a_2} X_3^{a_3} X_4^{a_4} X_5^{a_5} X_6^{a_6} X_7^{a_7} X_8^{a_8} X_9^{a_9} X_{10}^{a_{10}} X_{11}^{a_{11}} \rightarrow (1)$$

This function is estimated by the method of Ordinary Least Squares (OLS). The estimated parameters and other related statistics were given in the table-1. Initially, the presence of multi-collinearity was tested on the basis of Klein[27] and Heady – Dillon[28] was carried out and results were indicate the absence of multi-co linearity.

Table 1: Estimated Parameters and other Related Statistics of Production Function – 1

Inputs	Description of Inputs	Kaligiri	Muttukur	Pellakur
a_0	Intercept	2.5361	2.0337	2.1756
X_1	Land Rent	0.0558 (0.0390)	0.0262 (0.0571)	0.2356* (0.0648)
X_2	Bullock-labour	-1.0086* (0.0025)	0.0760* (0.0388)	0.0125 (0.0079)
X_3	Expenditure on tractor	0.0015 (0.0023)	0.1784 (0.1262)	0.0427 (0.0415)
X_4	Human-labour	0.1723* (0.0711)	0.3238* (0.1412)	0.1019* (0.0511)
X_5	HYV Seeds	0.0065 (0.0363)	0.0452 (0.0509)	-0.0016 (0.0336)
X_6	Irrigation	-0.0048 (0.0156)	0.0046 (0.0509)	0.0087 (0.0163)
X_7	Chemical Fertilizers	0.2409* (0.0742)	0.1037 (0.1129)	0.5246* (0.0823)
X_8	Manures	0.2454* (0.0605)	0.0768 (0.1066)	0.1960* (0.0683)
X_9	Pesticide and other Plant Protection Methods	0.3012* (0.0597)	0.2536* (0.0922)	-0.0811* (0.0411)

X ₁₀	Dummy Variable on Education	0.0025 (0.0023)	-0.0056 (0.0052)	-0.0002 (0.0023)
X ₁₁	Dummy Variable on Expenditure	0.0018 (0.0029)	-0.0006 (0.0066)	-0.0012 (0.0024)
-	R ²	0.97997	0.97348	0.98804
-	F	524.9295*	427.1261*	1036.399*
-	a _i sum of Co-efficients	0.0145	1.0821	1.0380

*Significant at 5% Probability level.

Figures in the Parentheses are Standard Errors.

From the table 1, the value of R² is indicating 98 percent of variation in gross output, explained by all independent variables in Kaligiri Mandal, whereas in Muttukur Mandal it is 97 percent and in Pellakur Mandal it is 99 percent. On the basis of F-test the variation in total output in all the three mandals were significantly different from zero. Thus, the fit is good and the estimated function may be taken as true specification of relationship between output and inputs.

A close look at the table 1 reveals the fact that the coefficient of pesticides and other plant protection methods (X₉) is the highest in the case of Kaligiri mandal followed by Manures (X₈), Chemical fertilizers (X₇), Human-labour (X₄), Land rent (X₁), HYV seeds (X₅), education (X₁₀) and information (X₁₁). In the case of Muttuker mandal human-labour (X₄) was maximum followed by pesticides and plant protection (X₉), expenditure on tractor (X₃), chemical fertilizers (X₇), Manures (X₈), and bullock labour (X₂). The co-efficient of Chemical fertilizers (X₇) was maximum in the case of Pellakur mandal followed by land rent (X₁), Manures (X₈), human labour (X₄) and expenditure on tractor (X₃), bullock labour (X₂). In the case of Kaligiri mandal the Co-efficient of pesticides is 0.3012 and it is significant at 5 percent probability level. The co-efficient of Manures is 0.2454 and it is also significant at 5 percent probability level, and the co-efficient of human-labour is 0.1723 and it is also significant at 5 percent probability level. In the case of Muttukur mandal the co-efficient of human-labour is 0.3238 and it is also significant at 5 percent probability level and the co-efficient of pesticides and plant protection methods is 0.2536 and is also significant at 5 percent level. In the case of Pellakur mandal the co-efficient of chemical fertilizers is 0.5246 and it is significant at 5 percent probability level. The co-efficient of land rent is 0.2356 and it is also significant at 5 percent level and the co-efficient of Manures is 0.1960 and it is also significant at 5 percent probability level. The co-efficients of bullock-labour, irrigation are negative in the case of Kaligiri mandal, where as the co-efficients of education and information are negative in the case of Muttukur mandal, and the co-efficient of HYV seeds, pesticides and plant protection, education and information are negative in the case of Pellakur mandal. In the case of Kaligiri mandal the co-efficients of expenditure on tractor and HYV seeds, education and information are quite low and they are statistically insignificant. In the case of Kaligiri mandal and Muttukur mandal, land rent was positive and statistically insignificant, where as it is positive and statistically significant in Pellakur mandal. The co-efficient of Bullock-labour is found to be the negative and statistically significant in Kaligiri mandal where as it is positive and statistically significant in Muttukur and it is positive and statistically insignificant in Pellakur mandal. It is observed that the co-efficient of Expenditure on tractor is positive and quite low and it is statistically insignificant in the case of Kaligiri mandal, where as it is positive and statistically insignificant in the case of Muttukur mandal and in the case of Pellakur mandal it is positive but, statistically insignificant. The co-efficient of human labour is found to be statistically significant in the all the three mandals Kaligiri, Muttukur and Pellakur mandal. The co-efficient of HYV seeds is found to be positive and insignificant in the case of both the mandals of Kaligiri and Muttukur, while it is found to be negative and statistically insignificant in Pellakur mandal. The co-efficient of irrigation is negative and statistically insignificant in Kaligiri mandal whereas it is positive, but quite low and insignificant in the case of both Muttukur and Pellakur mandals. The co-efficient of chemical fertilizers is observed to be positive and statistically significant in Kaligiri and Pellakur mandals, but it is positive and statistically insignificant in the case of Muttukur mandal. The co-efficient of Manures is also found to be positive and statistically significant in the case of Kaligiri and Pellakur mandals, but it is positive and statistically insignificant in Muttukur mandal. The co-efficient of pesticides and plant protection methods is observed to be positive and statistically significant in the case of both Kaligiri and Muttukur mandals, while in the case of Pellakur mandal it is negative and significant. The co-efficient of education and information are found to be negative in the case of Muttukur and Pellakur mandal while they are positive and statistically insignificant in the case of Kaligiri mandal. The negative co-efficient of inputs call for some explanation, one possible explanation, that the input is applied in excess of what is normally required for production. Another possible explanation is that there may be large fluctuations in the inputs of the aggregate data.

The regression co-efficient in a Cobb-Douglas Production Function indicates the elasticities of production with respect to input factors. From Table 1, it is found that the elasticity of output with respect to pesticides and plant protection methods is very high in the case Kaligiri mandal and hence, output is highly responsive to this variable. But the elasticity of output with respect to Human-labour is very high in the case of Muttukur mandal. Hence, output is highly response to Human-labour, where as the elasticity of output with

respect to chemical fertilizers is very high in the case of Pellakur mandal and hence, output is highly response to this variable. The elasticity of output with respect to Manures though high, it is next to the elasticity of pesticides and plant protection methods in Kaligiri mandal. This indicates the relative importance of this variable in agriculture. The elasticity of output with respect to chemical fertilizers though high, it is next to the elasticity of land rent in Pellakur mandal. In Kaligiri mandal, the output is significantly responsible to Human-labour, while the same trend is observed in the reaming two mandals namely, Muttukur and Pellakur. However, the output is not so responsive to HYV seeds, education, information and expenditure on tractor in Kaligiri mandal, and in the case of Muttukur mandal, the output is not so responsive to HYV seeds, Manures, chemical fertilizers, and irrigation, while in the case of Pellakur mandal the output is not so responsive to irrigation, bullock-labour and expenditure on tractor. Contrary to the expectations the output is adversely affected by the use of Bullock-labour and irrigation in Kaligiri mandal, while it is adversely affected by the use of education and information in Muttukur mandal, and it is adversely affected by the use of HYV seeds, pesticides and plant protection methods, education and information in Pellakur mandal. The estimated function-1, on the basis of two tests provides a good estimation of the relationship between output and inputs. The co-efficients, however, present some results contrary to the common belief. The co-efficient values of Bullock-labour are not according to the general belief in the case of Kaligiri mandal, whereas the co-efficient values of education and information are not according to general belief in Muttukur mandal. The co-efficients of HYV seeds, pesticides and plant protection methods, education and information are not according to general belief in Pellakur mandal. 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 model we have included large number of explanatory variables, which may not be very important from the production point of view. With regard to the non-economic variables, like education and information, one can say that as farmers are aware with the merits of technological variables, their deletion will not reduce the explanatory power of the function. Table 2 shows that the irrigation does not seems an important variable and it can be deleted from the list of explanatory variables. Similarly, land rent is not an important variable from the production point of view and hence, it can be deleted.

Table 2 : Change in R²

Inputs	R ²			R ² Change		
	Kaligiri	Muttukur	Pellakur	Kaligiri	Muttukur	Pellakur
X ₁	0.85808	0.90645	0.97175	0.85808	0.90645	0.97175
X ₂	0.85863	0.92329	0.97187	0.00055	0.01684	0.00012
X ₃	0.85938	0.96750	0.97793	0.00075	0.04421	0.00606
X ₄	0.95469	0.97053	0.98165	0.09531	0.00303	0.00372
X ₅	0.95631	0.97060	0.98165	0.00162	0.00007	0.00000
X ₆	0.95654	0.97075	0.98190	0.00023	0.00015	0.00025
X ₇	0.96921	0.97129	0.98570	0.01267	0.00054	0.00520
X ₈	0.97504	0.97165	0.98769	0.00583	0.00036	0.00059
X ₉	0.97973	0.97324	0.98802	0.00469	0.00159	0.00033
X ₁₀	0.97991	0.97348	0.98802	0.00018	0.00024	0.00000
X ₁₁	0.97997	0.97348	0.98804	0.00006	0.00000	0.00002
Total				0.97997	0.97348	0.98804

*Significant at 5% Probability level.

Figures in the Parentheses are Standard Errors.

After deleting the explanatory variables; irrigation and land rent, we postulate the following production function – 2.

$$Y = a_0 X_1^{a_1} X_2^{a_2} X_3^{a_3} X_4^{a_4} X_5^{a_5} X_6^{a_6} X_7^{a_7} \rightarrow (2)$$

This function is estimated by Ordinary Least Squares (OLS) method and the estimated parameters with the other related statistics are presented in the table 3. The Klein[27] and Heady-Dillon[28] test of multi-collinearity is used and it is found that the multi-collinearity is absence between the variables.

Table 3: Estimated Parameters and other Related Statistics of Production Function – 2

Inputs	Description of Inputs	Kaligiri	Muttukur	Pellakur
a ₀	Intercept	2.5397	2.1962	2.4028
X ₁	Bullock-labour	-0.0009 (0.0024)	0.0746 (0.0460)	0.0127 (0.0081)
X ₂	Expenditure on tractor	0.0026 (0.0022)	0.1769 (0.1192)	0.0599 (0.0423)
X ₃	Human-labour	0.1790* (0.0682)	0.3480* (0.1360)	0.1551* (0.0628)

X ₄	HYV Seeds	0.0010 (0.0357)	0.0386 (0.0724)	0.0204 (0.0332)
X ₅	Chemical Fertilizers	0.2797* (0.0716)	0.1038 (0.1092)	0.6407* (0.0783)
X ₆	Manures	0.2381* (0.0593)	0.0734 (0.1037)	0.2058* (0.0693)
X ₇	Pesticide and other Plant Protection Methods	0.3217* (0.0589)	0.2518* (0.0872)	-0.0568 (0.0408)
-	R ²	0.97913	0.97319	0.98686
-	F	817.7747*	684.4464*	1523.735*
-	a _i sum of Co-efficients	1.0212	1.0671	1.0378

*Significant at 5% Probability level.

Figures in the Parentheses are Standard Errors.

Table 3 shows that the value of R² indicating that 98 percent of variation in gross output is explained by all the seven independent variables in Kaligiri mandal, whereas 97 percent and 99 percent in Muttukur and Pellakur mandals respectively. On the basis of F-test, the variation in output in all the three mandal were significantly different from zero at 5 percent probability level. Thus, the fit is a good fit and the estimated function – 2 may be taken as true specification of relationship between output and inputs.

In the case of Kaligiri Mandal, the co-efficient of pesticides and other plant protection expenditure is found to be highest (0.3217) and it is significant at 5 percent probability level. The co-efficient of chemical fertilizers, Manures, human-labour, expenditure on tractor and HYV seeds. The co-efficient of chemical fertilizers is 0.2797 and it is significant at 5 percent probability level. The co-efficient of Manures is 0.2381 and it is statistically significant at 5 percent probability level. The co-efficient of human-labour is 0.1790 and statistically significant at 5 percent probability level. The co-efficient of Bullock-labour is found to be negative. In the case of Muttukur mandal the co-efficient of human-labour is found to be highest (0.3480) and it is statistically significant at 5 percent probability level. The co-efficient of human-labour is followed by co-efficients of pesticides and other plant protection expenditure, expenditure on tractor, chemical fertilizers, bullock-labour, manures and HYV seeds. The co-efficient of pesticides and other plant protection expenditure is 0.2518 and it is statistically significant at 5 percent probability level. In the case of Pellakur mandal the co-efficient of chemical fertilizers is found to be highest (0.6407) and it is statistically significant at 5 percent probability level. The co-efficient of chemical fertilizers is followed by manures, human-labour, expenditure on tractor, HYV seeds and bullock-labour. The co-efficient of natural fertilizers is 0.2058 and it is statistically significant at 5 percent probability level. The co-efficient of human-labour is 0.1551 and it is significant at 5 percent probability level. The co-efficient of pesticides and other plant protection is found to be negative.

In the case of Kaligiri mandal, a comparative study of the two models shows that human labour, chemical fertilizers, manures and pesticides and other plant protection methods are the main explanatory factor for the highest values of their estimated co-efficients. The co-efficient of bullock-labour is negative in both models. The co-efficient of expenditure on tractor has gone up from 0.0015 to 0.0026. The co-efficient of HYV seeds is decreased from 0.0065 to 0.0010. In the case of Muttukur mandal a comparative study of the two models shows that human-labour and pesticides and other plant protection methods are the main explanatory factors for the highest values of their estimated co-efficient. The co-efficient of bullock-labour is decreased from 0.0760 to 0.0746. The co-efficient of expenditure on tractor is decreased from 0.1784 to 0.1769. The co-efficient of HYV seeds is decreased from 0.452 to 0.386. The co-efficient of chemical fertilizers is increased from 0.1037 to 0.1038. The co-efficient of manures is decreased from 0.0768 to 0.0734. In the case of Pellakur mandal, the co-efficient of pesticides and other plant protection methods remain negative in both the models, where as the co-efficient of HYV seeds becomes positive in the second model. The co-efficient of bullock-labour is increased from 0.0125 to 0.0127. The co-efficient of expenditure on tractor has gone up from 0.0427 to 0.0599. The co-efficient of human-labour also gone up from 0.1019 to 0.1551. The co-efficient of chemical fertilizers also gone up from 0.5246 to 0.6407. The co-efficient of manures also increased from 0.1960 to 0.2058. In the case of Kaligiri mandal, the regression co-efficient of Bullock-labour is negative. Therefore, keeping all other variables constant at their respective geometric mean level, with the increase of one rupee in bullock-labour, the amount of gross output including by-products would tend to decline by Rs. 0.001. The regression co-efficients of expenditure on tractor, human-labour, HYV seeds, chemical fertilizers, manures and pesticides and other plant protection methods are positive and they are 0.0026, 0.1790, 0.0010, 0.2797, 0.2381 and 0.3217 respectively. Out of these six inputs, four inputs namely human-labour, chemical fertilizers, manures and pesticides and other plant protection methods are found to be significant statistically at 5 percent probability level. Keeping all other variables constant at their geometric mean level, with the increase of one rupee in human-labour, the amount of gross output including by-products would tend to increase by Rs. 0.18. In the same way all other variables are kept constant at their respective geometric mean level, with the increase of one rupee in chemical fertilizers, the amount of gross output including by-products would tend to increase by Rs. 0.28. Similarly in the case of

expenditure on tractor, HYV seeds, manures, pesticides and other plant protection methods it would be Rs. 0.003, 0.001, 0.24, 0.32 respectively.

In the case of Muttukur mandal, the production elasticities of bullock-labour, expenditure on tractor, human-labour, HYV seeds, chemical fertilizers, manures and pesticides and other plant protection methods are all positive and they are 0.0746, 0.1769, 0.3480, 0.0386, 0.1038, 0.0734 and 0.2518 respectively. Out of these seven inputs, two inputs namely human-labour, pesticides and other plant protection methods are statistically significant at 5 percent probability level. Keeping all other variables constant at their respective geometric mean level, with the increase of one rupee in bullock-labour, the amount of gross output including by-products would tend to increase by Rs. 0.07; In the same way all other variables are kept constant at their respective geometric mean level, with the increase of one rupee in expenditure on tractor, the amount of gross output including by-products would tend to increase by Rs. 0.18. Similarly in the case of human-labour, HYV seeds, chemical fertilizers, manures and pesticides and other plant protection methods it would be Rs. 0.35, Rs. 0.39, Rs. 0.10, Rs. 0.07 and Rs. 0.25 respectively. Therefore, it is observed that the amount of gross output including by-products could be increased by increasing technological factors, i.e., human-labour and pesticides and other plant protection methods.

In the case of Pellakur mandal, the regression co-efficient of pesticides and other plant protection methods are negative. Therefore, keeping all other variables constant at their respective geometric mean level, with the increase of one rupee in pesticides and other plant protection methods, the amount of gross output including by-products would tend to be decline by Rs. 0.06. The production elasticities of bullock-labour, expenditure on tractor, human-labour, HYV seeds, chemical fertilizers, manures are positive and they are 0.0127, 0.0599, 0.1551, 0.0204, 0.6407 and 0.2058 respectively. Out of these six inputs, three inputs namely human-labour, chemical fertilizers, manures are found to be statistically significant at 5 percent probability level. Keeping all other variables constant at their geometric mean level, with the increase of one rupee in human-labour, the amount of gross output including by-products would tend to increase by Rs. 0.16. In the same way all other variables are kept constant at their respective geometric mean level. An increase of one rupee in chemical fertilizers, the amount of gross output would tend to increase by Rs. 0.64. Similarly in the case of manures, bullock-labour, expenditure on tractor and HYV seeds, it would be Rs. 0.21, Rs. 0.01, Rs. 0.06 and Rs. 0.02 respectively.

In view of the above observations farmers belonging to Muttukur and Pellakur are better than Kaligiri mandal in using modern agricultural technology. But it is observed that the farmers of all the three mandal are not utilizing fully the modern technology. But Krishna Mohan[3] pointed out that the new technology has increased food production, at the same time it has failed in increasing the per capita availability of food grains. Ghosh[1] concluded that there has been a sharp rise in income per farm after the introduction of the new technology. Regarding the choice of the models, it is noticed that the second model not only serves the purpose in a better way but on the basis of R^2 also one can accept this model. The total variation explained by the seven variables is better after the deletion of four variables from the function in all three mandals. In the case of Kaligiri mandal, two co-efficients are negative in the first model and all the co-efficients are positive in the case of second model. In the case of Pellakur mandal, four co-efficients are negative in the case of first model and all the co-efficients are positive in the case of second model. In view of the above results the function – 2 is better than the function – 1 in explaining the realities.

6.2. Returns to Scale

The unrestricted form of Cobb-Douglas Production Function was estimated. It is well known that the regression co-efficients in the production function are the production elasticities and their sum represents the returns to scale. To test whether there is constant returns to scale or not, t-test was applied to test the significance of the difference.

$$\sum_{i=1}^7 a_i - 1$$

From table – 3, it is observed that the sum of the elasticities was not significantly different from unity at 5 percent probability level and this indicates constant returns to scale in the three mandals under the study.

6.3. Resource use Efficiency

In order to evaluate the economic efficiency of farmers in three mandals under the study, the ratios of marginal value products to their respective marginal cost[29] were estimated and they were depicted in table 4.

Table 4 : Ratios of Marginal Value Product (MVP) and Marginal Cost (MC) of Input Factors

Inputs	Description of Inputs	KALIGIRI			MUTTUKUR			PELLAKUR		
		MVP	MC	Ratio	MVP	MC	Ratio	MVP	MC	Ratio
X ₁	Bullock-labour	-0.0416	1.0000	-0.0416	5.0639	1.0000	5.0639	0.6926	1.0000	0.6926
X ₂	Expenditure on tractor	0.0877	1.0000	0.0877	3.4340	1.0000	3.4340	1.1852	1.0000	1.1852
X ₃	Human-labour	2.9477	1.0000	2.9477	5.6382	1.0000	5.6382	2.5612	1.0000	2.5612
X ₄	HYV Seeds	0.0241	1.0000	0.0241	0.8167	1.0000	0.8167	0.4179	1.0000	0.4179
X ₅	Chemical Fertilizers	5.4874	1.0000	5.4874	1.9491	1.0000	1.9491	12.8838	1.0000	12.8838
X ₆	Manures	4.8361	1.0000	4.8361	1.4365	1.0000	1.4365	5.0122	1.0000	5.0122
X ₇	Pesticides and other Plant Protection Expenditure	8.5721	1.0000	8.5721	6.3672	1.0000	6.3672	-0.7928	1.0000	-0.7928

In the case of Kaligiri mandal, from Table 4, it is found that the ratios of Marginal Value Product (MVP) and Marginal Cost (MC) of bullock-labour, Expenditure on tractor and HYV seeds are less than unity and it indicates the over utilization of these input variables. The ratios of MVP and MC of human-labour, chemical fertilizers, Manures and pesticides and other plant protection methods are greater than unity and it indicates the under utilization of these variables. Further, it is observed that the human-labour, chemical fertilizers, Manures and pesticides and other plant protection methods are deficient. Therefore, the pattern of resource use in Kaligiri mandal needs some modification, particularly, pesticides and other plant protection methods, chemical fertilizers, Manures and human-labour may be increased, whereas bullock-labour, expenditure on tractor and HYV seeds may be reduced.

In the case of Muttukur mandal, from Table 4, it is noticed that the ratios of MVP and MC of HYV seeds is less than unity and it indicates the over utilization of the input variable. The ratios of MVP and MC of bullock-labour, expenditure on tractor, human-labour, chemical fertilizers, Manures and pesticides and other plant protection methods are greater than one and it indicates the under utilization of all these input variables. Further, the chemical fertilizers and Manures are marginally utilized, use of bullock-labour, expenditure on tractor, human-labour and pesticides and other plant protection methods are deficient. Hence, the pattern of resource use in Muttukur mandal also needs some modification, particularly, application of technological factors—expenditure on tractor, chemical fertilizers and pesticides and other plant protection methods may be increased and HYV seeds may be decreased.

In the case of Pellakur mandal, from table 4, it is observed that the ratios of MVP and MC of bullock-labour, HYV seeds and pesticides and other plant protection methods are less than unity and it indicates the over utilization of those input variables. The ratios of MVP and MC of expenditure on tractor, human-labour, chemical fertilizers and Manures are greater than unity and it indicates the under utilization of these variables. Further, it may be observed that the expenditure on tractor is marginally underutilized, use of human-labour, chemical fertilizers and Manures are deficient. Therefore the pattern of resources use in Pellakur mandal needs some modification, particularly, application of technological factors—chemical fertilizers and expenditure on tractor may be increased whereas HYV seeds and pesticides and other plant protection methods may be reduced. Even though the Muttukur mandal is a backward area in all respects it is better than Kaligiri and Pellakur mandals in utilizing modern agricultural technology.

VII. Conclusions

In the case of Kaligiri mandal, the regression co-efficients of all the seven inputs variables except Bullock-labour are positive. Out of these seven regression co-efficients, four regression co-efficients, namely human-labour, chemical fertilizers, Manures and pesticides and other plant protection methods are statistically significant. The regression co-efficient of pesticides and other plant protection methods is highest followed by chemical fertilizers, Manures, human-labour, expenditure on tractor and HYV seeds. Keeping all other variables constant at their respective geometric mean level, with the increase of one rupee expenditure on tractor, the amount of gross output would tends to increase by Rs. 0.003. Similarly keeping all other variables constant at their respective geometric mean level, with the increase of one rupee in human-labour, the amount of gross output would tend to increase by Rs. 0.18. Similarly in the case of HYV seeds, chemical fertilizers, Manures and pesticides and other plant protection methods it would be Rs. 0.001, Rs. 0.30, Rs. 0.24 and Rs. 0.32 respectively.

In the case of Muttukur mandal, the regression Co-efficients of all the seven input variables are positive. But only two-efficients, namely, human-labour and pesticides and other plant protection methods are statistically significant. The regression co-efficient of human-labour is highest and it is followed by pesticides and other plant protection methods, expenditure on tractor, chemical fertilizers, bullock-labour, Manures and HYV seeds. Keeping all other variables constant at their respective geometric mean level, an increase of one rupee in bullock-labour, the amount of gross output would tend to increase by Rs. 0.07. Similarly a rupee

increase in expenditure on tractor, the amount of gross output would tend to increase by Rs. 0.18. In the case of human-labour, HYV seeds, chemical fertilizers, Manures and pesticides and other plant protection methods also it would be Rs. 0.35, Rs. 0.04, Rs. 0.10, Rs. 0.73 and Rs. 0.25 respectively. The technological co-efficient pesticides and other plant protection methods shows some significant positive effect on production.

In the case of Pellakur mandal, the regression co-efficients of all the seven variables, except pesticides and other plant protection methods are positive. Out of the seven regression co-efficients, three regression co-efficients, namely, human-labour, chemical fertilizers and Manures are statistically significant. The regression co-efficient of chemical fertilizers is highest followed by Manures, human-labour, expenditure on tractor, HYV seeds and bullock-labour. Keeping all other variables are constant at their respective geometric mean level, an increase of one rupee in bullock-labour, the amount of gross output would tend to increase by Rs. 0.01. In the same way an increase of one rupee in expenditure on tractor, the amount of gross output would tend to increase by Rs. 0.06. Similarly in the case of human-labour, HYV seeds, chemical fertilizers and Manures it would be Rs. 0.15, Rs. 0.02, Rs. 0.64 and Rs. 0.21 respectively. It is noticed that the sum of the elasticities was not significantly different from unity at 5 percent probability level and this indicates constant returns to scale in the three mandals under study. On the basis of ratios of MVP and MC of the input factors, it is observed that the pattern of resource use in Kaligiri mandal needs some modifications, particularly, in the application of human-labour, chemical fertilizers, Manures and pesticides and other plant protection methods which may be increased to obtain more output. It is observed that in the case of Muttukur mandal, the pattern of resource use needs some modifications, particularly, in the application of bullock-labour, expenditure on tractor, human-labour and pesticides and other plant protection methods may be raised to obtain more output. In the case of Pellakur mandal the pattern of resource use also needs some modification, particularly the application of technological factors expenditure on tractor, chemical fertilizers may be increased whereas HYV seeds and pesticides and other plant protection methods may be decreased to obtain more output. In view of the above analysis one can say that farmers belonging to Muttukur mandal is better than Kaligiri mandal and Pellakur mandals in using modern agricultural technology. But it is also observed that the farmers of all the three mandals are not utilizing fully the modern agricultural technology to obtain more output.

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