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Resource Use Efficiency in Cultivation of Major Food Crops under Rainfed Conditions in Central Dry Zone of Karnataka

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ABSTRACT

A study was conducted on the resource use efficiency of major food crops under rainfed conditions in Central Dry Zone of Karnataka (CDZ). The major crops of CDZ are ragi, maize and groundnut. The data was collected from rainfed farmers of CDZ of Karnataka. Cobb-Douglas production analysis and Data Envelopment Analysis was used. The inputs used are human labour, bullock labour, machine labour, seed, fertilizer and farm yard manure (FYM). In rainfed ragi, the regression coefficients for bullock pair (1.27) and FYM (0.94) were positive and statistically significant. In rainfed maize, the elasticity of production for human labour was highest (1.18) followed by production co-efficient of seed (0.98) and fertilizers (0.63). The elasticity co-efficient in rainfed groundnut with respect to seeds was 0.41, while that of fertilizers was 0.71 indicating the scope for higher use of these inputs from the present level to optimise returns. The ratio of MVP to MFC was differed from unity in all major crops, indicating scope for reallocation of expenditure among various resources. Among the crops technical efficiency, allocative efficiency and economic efficiency scored impressively in rainfed maize was 0.83, 0.69 and 0.6, respectively.

Keywords: Resource use efficiency, Cobb-Douglas production, data envelopment analysis, technical efficiency, allocative efficiency, economic efficiency

Agriculture continues to play an important role in the Indian economy as it supports 53% of population besides contributing to 13.9% in the country's gross domestic product. The food grain production was 263.2 million tonnes during 2013. In the wake of food shortages, food security was assigned top priority.

Efficiency in food production largely depends upon extent of management of different resources. Hence the question of allocation of resources needs to consider sustainability, resource use efficiency and optimization of crop plans across regions and production environments. With the increasing population coupled with progressive shrinkage of arable land reducing the per capita agricultural land availability, crop intensification has become a rule than an exception. Growing stress on water availability, commercialization of production, higher use of energy and other purchased inputs in agriculture necessitate optimum use of resources and reallocation of production choices.

Resource use efficiency in agriculture plays an important role in determining the farm production and income. Manures and fertilizers, irrigation facilities, manpower, seeds, bullock labour, hired human labour, working capital, farm implements and machinery and crop protection measures are the major crucial inputs in agriculture. The size of farm income depends on the efficiency with which farmers are able to utilize these resources. With higher efficiency in the use of scare resources, farmers can augment their income and savings.

This study is aimed at exploring the profitability of crops in Karnataka in general and in central dry zone of Karnataka in particular through estimation of the extent of resource use allocation and efficiency as reflected by production function analysis.

METHODOLOGY

Tumakuru district in CDZ was purposively selected for the study because the major crops grown in the sample district include ragi, maize, groundnut, redgram and horsegram in rainfed situation and paddy under irrigated condition. Groundnut is the important commercial crop in the district. Random sampling technique was employed in the selection of 90 farmers for the study *i.e.,* 45 irrigated farmers and 45 rainfed farmers. The secondary data regarding area, production and productivity data of the Madhugiri taluk, Tumakuru district were collected from the district website for the year 2013-14 for sample selection based on area dominance.

Analytical tools

Cobb-Douglas production function

Resource use efficiency in selected rainfed crops *viz.,* ragi, maize and groundnut were studied by using the Cobb-Douglas production function to the farm level data. The model specified was as follows

$$Y = a\, X_1^{bl}\, X_2^{b2}\, X_3^{b3}\, X_4^{b4}\, X_5^{b5}\, X_6^{b6} eu \qquad \ldots(1)$$

Where, Y_t = Output (Gross returns),

a = Constant

u = Random variable

e = Error term

b_i = elasticity coefficient of i^{th} input and X_1 to X_6 are independent variables

The independent variables [inputs] included were human labour (man days), bullock labour (pair days), seeds (Kg.), FYM (tons), fertilizers (Kg.) and capital cost (₹) in the case of ragi [6 variables], human labour (man days), bullock labour (pairs days), machine labour (Hours), seeds (Kg.), fertilizers (Kg.) and capital cost (₹) in the case of maize [6 variables] and human labour (mandays), seeds (Kg.), fertilizers (Kg.) and capital cost (₹) in the case of groundnut crop [4 variables]

Above equation was converted into the logarithmic form as follows to present it in a linear form:

$$\ln Y = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + b_6 \log X_6 + u \log e.$$

The economic efficiency of resource used was determined by using the MVP and MFC ratio. The estimated coefficients were used to compute the MVP and its ratio (r) with MFC.

The model used for estimation of r was as follows:

$$r = MVP/MFC \qquad \ldots(2)$$

Where,

r = Efficiency ratio

MVP = Marginal Value Product of variable inputs

MFC = Marginal Factor Cost (price of inputs)

Based on economic theory, a firm maximizes profits with regards to resource use when the ratio of the marginal return to the opportunity cost is one. The values are interpreted thus, r <1 indicates excessive use, r > 1indicates underutilization and if r = 1 the resource is optimally used and hence is the point of profit maximization

Technical, allocative and cost efficiencies

Technical Efficiency (TE) refers to the ability of a farm to produce the maximum feasible output from a given bundle of inputs, or to use the minimum feasible amounts of inputs to produce a given level of output. Allocative Efficiency (AE) refers to the ability of a technically efficient farm to use inputs in proportions that minimize production costs given input prices. Allocative efficiency is calculated as the ratio of the minimum costs required by the farm to produce a given level of output and the actual costs of the farm adjusted for TE. Economic Efficiency (EE) is the product of TE and AE. Thus, a farm is economically efficient if it is both technically and allocatively efficient. The popular method of estimating the maximum possible output has been the Data Envelopment Analysis (DEA) advocated by Charnes *et al.* (1978).

Data Envelopment Analysis

The DEA method is a frontier method that does not require specification of a functional form or a distributional form, and can accommodate scale issues. DEA was applied by using both classic models CRS (constant returns to scale) and VRS (variable returns to scale) with input orientation, in which one seeks input minimization to obtain a particular product level. Under assumption of constant returns to scale, the linear programming model used for measuring the efficiency of farms (Coelli *et al.,* 1998)

RESULTS AND DISCUSSION

In order to obtain the resource use efficiency of inputs used in cultivation of crops, functional analysis was performed for ragi, maize and groundnut grown under rainfed condition.

Resource use efficiency in rainfed ragi

The resource use efficiency in rainfed ragi estimated by using the Cobb Douglas production function was presented in Table 1. The estimated production function revealed that variables included in the model explained the variation in gross returns to the extent of 85%.

The results on efficiency of input use in rainfed ragi cultivation by farmers indicated that, the elasticity coefficients for bullock pair (1.27) and FYM (0.94) were positive and statistically significant. The MVP to MFC ratio was the highest for bullock pair (8.88) followed by FYM (6.39) and seeds (5.44), thus indicating the scope for higher use of these inputs from the present level to optimise returns. Fertilizer input was slightly over used than the economic optimum as revealed by its MVP/MFC ratio of 0.74. The MVP/MFC ratio exceeding 1 for all inputs except for fertilizers, indicated that the input use level of bullock pairs, seeds, and FYM can be enhanced up to recommended level to obtain economic optimal production of ragi crop.

Resource use efficiency in maize

The efficiency of inputs use in maize cultivation under rainfed condition was estimated using the Cobb Douglas production function (Table 2). The estimated production function significantly

Table 1: Resource use efficiency in rainfed ragi cultivation in Tumakuru district (Central Dry Zone) of Karnataka

Sl. No.	Particulars	GM level of input	Elasticity coefficient	MVP (₹)	MFC (₹)	MVP /MFC
1	Human labour (mandays)	27	-1.10	-512.7	200	-2.56
2	Bullock (pair days)	03	1.27**	5327.3	600	8.88
3	Seed (kg.)	4.63	0.05	135.9	25	5.44
4	FYM(tons)	3.70	0.94*	3197.1	500	6.39
5	Fertilizer (kg.)	121	0.10	10.4	14	0.74
6	Capital cost (₹)	2976	-0.15	-0.6	1	-0.63
7	F-value					11.9
8	R-square					0.85

*Note: GM=Geometric Mean Level, MFC = Marginal factor cost (₹) ; MVP = Marginal value product(₹),** significant at 5% and *significant at 10%*

Table 2: Resource use efficiency in rainfed maize cultivation in tumakuru district (central dry zone) of Karnataka

Sl. No.	Particulars	GM Level of input	Elasticity coefficient	MVP (₹)	MFC (₹)	MVP /MFC
1	Human labour (mandays)	27.21	1.18*	1029.64	196	5.25
2	Bullock (pair days)	2.71	-0.13	-1138.96	600	-1.89
3	Machine (hours)	5.20	-1.98	-9040.55	650	-13.90
4	Seed (kg.)	12.50	0.98**	1861.44	120	15.51
5	Fertilizer (kg.)	146.42	0.63**	102.16	13	7.85
6	Capital cost (₹)	6886	-0.63	-2.17	1	-2.17
7	F-value					5.66
8	R-square					0.82

*Note: GM=Geometric Mean Level, MFC = Marginal factor cost (₹); MVP = Marginal value product (₹), ** significant at 5% and *significant at 10%*

Table 3: Resource use efficiency in rainfed groundnut cultivation in Tumakuru district (Central Dry Zone) of Karnataka

Sl. No.	Particulars	GM level of input	Elasticity coefficient	MVP (₹)	MFC (₹)	MVP/ MFC
1	Human labour (Mandays)	25.04	-0.51	-573	187	-3.00
2	Seed (Kg.)	72.74	0.41**	158	75	2.11
3	Fertilizer (Kg.)	177.41	0.71**	112	16	7.03
4	Capital cost (₹)	5903	-0.05	-0.2384	1	-0.23
5	F-value					8.43
6	R-square					0.56

Note: *GM = Geometric Mean Level, MFC = Marginal factor cost (₹); MVP = Marginal value product (₹), ** significant at 5% level*

Table 4: Technical, allocative and cost efficiency of rainfed farms in Tumakuru district (Central Dry Zone of Karnataka) (2014)

Crop	Maize			Ragi			Groundnut		
Efficiencies	**TE**	**AE**	**CE**	**TE**	**AE**	**CE**	**TE**	**AE**	**CE**
<0.5-0.6	2 (14)	3 (21)	8 (57)	7 (37)	9 (47)	14 (73)	15 (48)	21 (68)	29 (94)
0.6-0.7	1 (7)	5 (36)	2 (14)	3 (16)	4 (21)	1 (5)	4 (13)	4 (13)	1 (3)
0.7-0.8	1 (7)	4 (29)	3 (22)	4 (21)	1 (5)	2 (11)	2 (6)	3 (10)	0 (0)
0.8-0.9	2 (14)	1 (7)	0 (0)	0 (0)	0 (0)	0 (0)	3 (10)	2 (6)	0 (0)
0.9-1.00	8 (57)	1 (7)	1 (7)	5 (26)	5 (26)	2 (11)	7 (23)	1 (3)	1 (3)
Total	**14**	**14**	**14**	**19**	**19**	**19**	**31**	**31**	**31**
Average	**0.83**	**0.69**	**0.58**	**0.7**	**0.63**	**0.46**	**0.65**	**0.57**	**0.37**

Note: ** Figures in parenthesis are percentages, TE: Technical Efficiency, AE: Allocative Efficiency, and CE: Cost / Economic Efficiency.*
Inputs Considered = Human labour, bullock labour, machine labour, seed, fertilizers, farm yard manure.

explained the variation in gross returns in maize per ha as the calculated F value was greater than the critical F value, and the independent variables included in the model explained about 82% of the variation in the gross returns.

The results on input use in rainfed maize cultivation indicated that, the elasticity of production for human labour was highest (1.18) followed by production co-efficient of seed (0.98) and fertilizers (0.63). All these coefficients were significant. The MVP/MFC ratios for various inputs indicated that there was still greater scope to use more human labour (5.25), seed quantity (15.51) and fertilizers (7.85) in maize production to maximize the net returns. In other words reallocation of expenditure on any other resources included in the model would lead to maximization of net returns by reducing expenditure on bullock pair, machine and capital cost. The results of the study conducted by Chapke (2011) were similar to that of present study.

Resource use efficiency in groundnut

Results of the Cobb Douglas production function analysis used to assess the resource use efficiency of input use in groundnut cultivated under rainfed condition was presented in Table 3. The estimated production function significantly explained the variation in gross returns as the calculated F value was greater than the critical F value, and the independent variables included in the model explained about 56% of the variation in gross returns.

The input use in rainfed groundnut cultivation by farmers revealed that, on an average 72.74 kg of seed per ha was used in rainfed groundnut cultivation. Per hectare fertilizer applied was 177.41 kg and it was found statistically significant. The elasticity of production with respect to seeds was 0.41, while that of fertilizers was 0.71. The MVP/MFC ratio indicated that there is still greater scope to use both seeds (2.11) and fertilizers (7.03) for enhancing the gross returns from groundnut under rainfed conditions. These results indicated further scope for use of human labour, seed and fertilizer to maximize the net returns. Comparable results were observed in the study conducted by Patil (1997).

Technical, allocative and economic efficiencies of farms

Technical, allocative and cost efficiency levels of major crops grown under rainfed conditions for central dry zone were estimated using data envelopment analysis. In order to obtain the efficient level of each of the production farms,data envelopment analysis model (input oriented) was used under the assumption of constant returns to scale (CRS) which operates in perfect competition. The results of technical, allocative and cost efficiencies are presented in the Table 4. Further, the criteria used by Ferreira (2005) were used in the present study to decide the cut off score for the efficient firms. The firms operating at 0.90 or more were considered as efficient firms.

The results on technical, allocative and economic or cost efficiencies of farms in maize, ragi and groundnut production under rainfed condition are provided in Table 4. The technical efficiency in rainfed maize was 0.83, allocative efficiency was also impressive at 0.69 and economic efficiency was 0.6. Thus rainfed maize scored impressively in technical,allocative and economic efficiency. The rainfed ragi has a lower level of efficiency compared to rainfed maize as the technical efficiency was 0.7 and allocative efficiency was 0.63. rainfed groundnut has still lower level of efficiency compared to ragi with technical efficiency of 0.65 and allocative efficiency of 0.57.

The results of the mean score of technical, allocative and cost efficiencies have wide differences which indicate that there is a need to train the farmers regarding optimal allocation of resources to realize maximum net returns

CONCLUSION

1. Resources are not optimally utilized in most of the crops, there is need for reallocation of the resources as the MVP to MFC ratio was more than one for most of the inputs.
2. The technical efficiency and allocative efficiency in rainfed crops with wide differences in mean scores of technical, allocative and cost efficiencies indicate that there is need to train the farmers regarding optimum allocation of resources.
3. Farmers have been trained and well equipped with technical efficiency through extension efforts of Krishi Vignyana Kendra (KVK's), State Agricultural Universities (SAU's) and Indian Council of Agricultural Research (ICAR). This component needs to be further strengthened by educating/training/capacity building of farmers with regard to allocative efficiency in most of the crops by comparing the marginal productivity of each resource with the relative price ratio of input to output. Especially this is required for use of inputs such as human labour, bullock labour and irrigation water. The WALMI (Water and Land Management Institute) and other organizations working on water use efficiency, State Departments of Agriculture and Horticulture need to take up this responsibility.

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