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RESOURCE USE EFFICIENCY IN MAIZE CULTIVATION– DATA ENVELOPMENT ANALYSIS APPROACH

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ABSTRACT

DEA model was employed to analyze the resource use efficiency in maize cultivation. The findings revealed that, the number of farms operating at CRS are more in number in other farms (44%) followed by marginal (29.51%) and small farms (29.41%). Similarly, regarding the number of farmers operating at VRS, the other farms are again more in number with 72 per cent followed by small (47.06%) and marginal farms (44.27%). With reference to scale efficiency, again other farms dominate the scenario with 64 per cent followed by marginal (54.09%) and small farms (52.94%). At pooled level, 18.33 per cent of the farms are being operated at CRS with an average technical efficiency score of 0.6241 i.e., 22 out of 120 farms. Majority of the farmers (62.50%) are operating at IRS and only 25 per cent of the farmers are operating at DRS. This signifies that, more resources should be provided to these farms operating at IRS and the same should be decreased towards the farms operating at DRS. 12.5 per cent of the farms are operating at CRS indicating efficient utilization of resources. Log linear regression model was used to analyze the major determinants of input use efficiency of maize farms. Irrigation cost and fertilizer cost are the major determinants of maize farms across all the farmer categories and even at pooled level. In view of their positive influence on the CRS, it is essential to strengthen modern irrigation infrastructure like drip irrigation and offer more fertilizer subsidies to the farmer to enhance the crop production on cost-effective basis. It was also found that, the sample farmers are spending huge amount on applying chemical (carbofuran 3G) and fertilizers and hence, it is advocated to adopt INM, so as to ensure both cost effective and quality production of maize.

KEYWORDS: Maize, Resource use efficiency, Data envelopment analysis model

Maize is grown throughout the year in India. It is predominantly a kharif crop with 85 per cent of the area under cultivation during 2013-14. Maize is the third most important cereal crop in India after rice and wheat. It accounts for nearly nine per cent of total food grain production in the country. Maize in India, contributes nearly 9 per cent in the national food basket. In addition to staple food for human being and quality feed for animals, maize serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries etc. The maize is cultivated throughout the year in all states of the country (Table: 1) for various purposes including grain, fodder, green cobs, sweet corn, baby corn, pop corn etc. The predominant maize growing states that contributes more than 80% of the total maize production are Andhra Pradesh (20.9%), Karnataka (16.5%), Rajasthan (9.9%), Maharashtra (9.1%), Bihar (8.9%), Uttar Pradesh (6.1%), Madhya Pradesh (5.7%), Himachal Pradesh (4.4%). Apart from these States, maize is also grown in Jammu and Kashmir and North-Eastern states. Maize has emerged as important crop in the non-traditional regions i.e. peninsular India as the state like Andhra Pradesh which ranks 5th in area (0.79 m.ha) has recorded the highest production (4.14 m.tonnes) and productivity (5.26 t ha^{-1}) in the country although the productivity in some of the districts of Andhra Pradesh is more or equal to the USA. Area under hybrid seeds in 2013-14 is estimated to be around 60 per cent of the total area under maize cultivation. Andhra Pradesh has the highest productivity followed by Tamil Nadu due to majority of the area being covered under Single Cross Hybrids (SCH).

Among the cereal crops in India, maize with an annual production of around 22.5 m. tonnes from 8.67 m.ha ranked third in production and contributes to 2.40 per cent of world production with almost five per cent share in world's harvested area in 2013-2014. In Andhra Pradesh, maize has emerged as one of the major cereal crops in 3.52 lakh ha with an annual production of 22.1 lakh tonnes in 2013-2014. Kurnool district with an area of 0.52 lakh ha enjoy a production of 3.1 lakh tonnes in

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Table 1. Area and production of maize in different states in India (2013-14)

S. No.	States	Area (m. ha)	Production (m. tonnes)
1	Karnataka	1.38	3.98
2	Maharashtra	1.21	3.08
3	Andhra Pradesh	1.06	4.97
4	Madhya Pradesh	1.00	1.51
5	Rajasthan	0.93	1.50
6	Bihar	0.75	2.02
7	Uttar Pradesh	0.74	1.24
8	Gujarat	0.46	0.69
9	Tamil Nadu	0.30	1.64
10	Jammu and Kashmir	0.30	0.53
11	Himachal Pradesh	0.29	0.68
12	Jharkhand	0.26	0.52
13	West Bengal	0.13	0.52
14	Punjab	0.13	0.51
15	Others	0.48	0.97

Source: Ministry of Agriculture, Govt. of India, 2013-14.

Table 2. Efficiency measures and descriptive statistics across farms according to scale of operations

Scale of operations	Efficient farms (θ = 0.90)		Efficiency measures			
	No.	%	Mean	Standard deviation	Maximum	Minimum
Marginal farmers						
Technical efficiency (Constant returns)	18	29.51	0.6572	0.2916	1	0.0775
Technical efficiency (Variable returns)	27	44.27	0.8202	0.1751	1	0.4468
Scale efficiency	33	54.09	0.7917	0.2895	1	0.106
Small farmers						
Technical efficiency (Constant returns)	10	29.41	0.7202	0.2293	1	0.2941
Technical efficiency (Variable returns)	16	47.06	0.8594	0.1490	1	0.5043
Scale efficiency	18	52.94	0.8360	0.1997	1	0.2942
Other farmers						
Technical efficiency (Constant returns)	11	44.00	0.8290	0.1763	1	0.3962
Technical efficiency (Variable returns)	18	72.00	0.9471	0.076	1	0.776
Scale efficiency	16	64.00	0.8761	0.1724	1	0.3962
Pooled farmers						
Technical efficiency (Constant returns)	22	18.33	0.6241	0.2601	1	0.0595
Technical efficiency (Variable returns)	42	35.00	0.7537	0.2176	1	0.1923
Scale efficiency	65	54.17	0.8293	0.2316	1	0.0816

Table 3. Category-wise distribution of farmers in Kurnool district according to types of returns to scale among different scale of operations

Types of returns to scale	Marginal farmers	Small farmers	Other farmers	Total farmers
Increasing	41 (67.21)	21 (61.77)	11 (44.00)	75 (62.50)
Constant	13 (21.31)	7 (20.59)	9 (36.00)	15 (12.50)
Decreasing	7 (11.48)	6 (17.64)	5 (20.00)	30 (25.00)
Total	61 (100)	34 (100)	25 (100)	120 (100)

Figures in parentheses indicate percentages to the respective column totals

Table 4. Determinants of CRS (Resource Use Efficiency) of maize farms in Kurnool district

Variables	Marginal farms	Small farms	Other farms	Pooled farms
Intercept	0.4176	0.3107	0.1927	0.2163
(X_1) Irrigation cost	0.0427**	0.0407**	0.0316**	0.0372**
(X_2) Fertilizer cost	0.0763**	0.0614**	0.0421**	0.0626**
(X_3) Pesticide cost	0.0871^{NS}	0.0916^{NS}	0.0893*	0.0816*
(X_4) Human labour cost	0.0672*	0.0416*	0.0361**	0.0313*
Adjusted R^2	0.73**	0.64**	0.78**	0.81**

*: Significant at 5% level; **: Significant at 1% level; ^{NS}: Non–Significant

the same year thereby, accounting for 14.77 and 14.02 percents share respectively at Andhra Pradesh level. Kurnool district in Andhra Pradesh had got good reputation as an important maize grower of Andhra Pradesh since long time. In view of the potentiality of maize crop in Kurnool district, its economic analysis has assumed greater significance. However, not much of literature was available pertaining to the technical efficiency of resource usage in maize production in Rayalaseema region of Andhra Pradesh in general and in Kurnool district in particular. From this background, it emanates the need for an in depth microscopic study on analyzing the resource use efficiency in maize cultivation by using DEA approach in Kurnool district. The results of the study would be useful to maize farmers of Kurnool district in particular and of Andhra Pradesh in general in identifying the management plans for enhancing resource use efficiency in cultivating maize. They further indicate, whether there is any scope for reorganisation and reallocation of resources that would contribute to the realisation of constant returns to scale among the farmers. Keeping this goal in view, the following specific objectives were formulated for this in-depth investigation.

1. To analyse the resource use efficiency and its determinants in the production of maize.
2. To analyse the determinants of technical efficiency in the production of maize.

MATERIALS AND METHODS

Kurnool district in Andhra Pradesh was purposively selected for the study, as the district ranks first in the cultivation of maize in Rayalaseema region of Andhra Pradesh state after its bifurcation during 2013-14. Top two mandals in terms of area under maize cultivation in Kurnool district viz., Nandikotkur and Pamulapaadu were selected. From the list of villages arranged in descending order of acreage under maize, top two villages from each mandal were selected. For the selection of farmers, a list of farmers from the selected villages was obtained from the respective Gram Panchayat Offices. To analyze the resource use efficiency, the farmers were conveniently categorized according to their land holding size i.e., Marginal (<1 ha), Small (1-2 ha) and Other farmers (>2 ha). From these three different categories, a total of 120 farmers were selected at random based on probability proportional to size. So, the sampling frame consists of one district, two mandals, four villages and 120 farmers which forms the basis to elicit the requisite data. A well structured pre-tested schedule was employed to collect the requisite information from the sample farmers. The study was conducted in the year 2013-14.

DEA Model

The DEA method is a frontier method that does not require specification of a functional or distributional form, and can accommodate scale issues. This approach was first used by Farrell (1957) as a piecewise linear convex hull approach to frontier estimation and later by Boles (1966) and Afriat (1972). This approach did not receive wide attention till the publication of the paper by Charnes *et al.* (1978), which coined the term Data Envelopement Analysis. A large number of papers have extended and applied the DEA technology in the western world. Very few studies have used this approach in India, especially in agriculture and no studies were conducted so far for analyzing the resource use efficiency that too in Andhra Pradesh. DEA method has the disadvantage that it does not explicitly accommodate the effects of data noise. In the present case, the DEA method was preferred because, data noise was less of an issue as most of the variables in analyzing resource use efficiency were included and because of its ability to readily produce rich information on technical efficiency, and scale efficiency.

Several DEA models have been presented in the literature. The basic DEA model evaluates efficiency based on the productivity ratio which is the ratio of outputs to inputs. This study applied Charnes, Cooper and Rhode's (CCR) (1978) model and Banker, Charnes and Cooper (BCC) (1984) model. The production frontier has constant returns to scale in CCR model. The basic CCR model formulation (dual problem/ envelopment form) is given by:

The basic CCR model formulation (dual problem/ envelopment form)

Min è - å $\left(\sum_{j=1}^{m} s_j^- + \sum_{r=1}^{s} s_r^+\right)$

Subject to:

$$\sum_{j=1}^{n} \lambda_J x_{ij} + s^- = \theta x_{i0} \quad \text{(i=1, ..., m)}$$

$$\sum_{j=1}^{n} \lambda_J y_{rj} - s_r^+ = y_{r0} \quad \text{(r=1, ... , s)}$$

$$\lambda_j \geq 0 \quad \text{(j=1, ... ,n)}$$

Source: Zhu (2003, p. 13)

where, *è* denotes the efficiency of Decision Making Unit *(DMUj)*, while y_{rj} is the amount of r^{th} output produced by DMU*j* using x_{ij} amount of i^{th} input. Both y_{rj} and x_{ij} are exogenous variables and ë$_j$ represents the benchmarks for a specific DMU under evaluation (Zhu 2003). Slack variables are represented by s_i and s_r. According to Cooper, Seiford and Tone (2004) the constraints of this model are:

i. The combination of the input of firm *j* is less than or equal to the linear combination of inputs for the firm on the frontier;

ii. The output of firm *j* is less than or equal to the linear combination of inputs for the firm on the frontier; and

iii. The main decision variable è$_j$ lies between one and zero.

Further, the model assumes that, all firms are operating at an optimal scale. However, imperfect competition and constraints to finance may cause some firms to operate at some level different to the optimal scale (Coelli, Rao and Battese 1998). Hence, the Banker, Charnes and Cooper (1984) BCC model is developed with a production frontier that has variable returns to scale. The BCC model forms a convex combination of DMUs (Coelli, Rao and Battese 1998). Then the constant returns to scale linear programming problem can be modified to one with variable returns to scale by adding the convexity constraint Óë$_j$ = 1**.** The model given below illustrates the basic BCC formulation (dual problem/envelopment form):

The basic BCC model formulation (dual problem/ envelopment form)

Min è - å $\left(\sum_{j=1}^{m} s_j^- + \sum_{r=1}^{s} s_r^+\right)$

Subject to:

$$\sum_{j=1}^{n}\lambda_J x_{ij} + s^- = \theta x_{i0} \text{ (i=1, ..., m)}$$

$$\sum_{j=1}^{n}\lambda_J y_{rj} - s_r^+ = y_{r0} \text{ (r=1, ... , s)}$$

$$\lambda_j \geq 0 \text{ (j=1, ... ,n)}$$

$$\sum_{j=1}^{n}\lambda_j = 1$$

Source: Zhu (2003, p. 13)

This approach forms a convex hull of intersecting planes (Coelli, Rao and Battese 1998). These planes envelop the data points more tightly than the Constant Returns to Scale (CRS) conical hull. As a result, the Variable Returns to Scale (VRS) approach provides technical efficiency (TE) scores that are greater than or equal to scores obtained from the CRS approach (Coelli, Rao and Battese 1998). Moreover, VRS specifications will permit the calculation of TE decomposed into two components: Scale Efficiency (SE) and Pure Technical Efficiency (PTE). This study first uses the CCR model to assess TE then applies the BCC model to identify PTE and SE in each DMU. The relationship of these concepts is given below:

Relationship between TE, PTE and SE: This is given by

$$TE_{CRS} = PTE_{VRS} * SE$$

where,

TE_{CRS} = Technical efficiency of constant return to scale

PTE_{VRS} = Technical efficiency of variable return to scale

SE = Scale efficiency

Source: Coelli, *et al.*, (1998).

The above relationship, which is unique, depicts the sources of inefficiency, i.e., whether it is caused by inefficient operation (PTE) or by disadvantageous conditions displayed by the scale efficiency (SE) or by both. If the scale efficiency is less than 1, the DMU will be operating either at Decreasing Return to Scale (DRS) if a proportional increase of all input levels produces a less-than-proportional increase in output levels or Increasing Return to Scale (IRS) at the converse case. This implies that resources may be transferred from DMUs operating at DRS to those operating at IRS to increase average productivity at both sets of DMUs (Boussofiane *et al.,*1992).

Data and Variables considered in the Study

DEA assumes that, the inputs and outputs have been correctly identified. Usually as the number of inputs and outputs increase, more DMUs tend to get an efficiency rating of 1 as they become too specialized to be evaluated with respect to other units. On the other hand, if there are too few inputs and outputs, more DMUs tend to be comparable. In any study, it is important to focus on correctly specifying inputs and outputs. For every inefficient DMU, DEA identifies a set of corresponding efficient DMU that can be utilized as benchmarks for improvement of performance and productivity. DEA is developed based on two scales of assumptions viz., CRS model and VRS model. CRS means that the farmers are able to linearly scale the inputs and outputs without increasing or decreasing efficiency. This is a significant assumption. The assumption of CRS may be valid over limited ranges, but its use must be justified. As an aside, CRS tends to lower the efficiency scores while VRS tends to raise efficiency scores.

For enabling the study of evaluation of resource use efficiency of maize farmers, the researcher observed the resources or inputs and productivity indicators or outputs as follows:

Inputs: X_1 – Irrigation cost (Rs), X_2 - Fertilizers cost (Rs.), X_3 – Pesticides cost (Rs.), (X_4) – Human labour cost (Rs.)

Outputs: Y_1 – Assets created on the farm (Rs.), Y_2 – Gross returns from maize (Rs.)

The present study involves the application DEA to assess the resource use efficiency of 120 maize cultivating farmers in the year 2013-14. This model is executed using input-orientation with radial distances to the efficient frontier. The DEA was solved using the MAXDEA version 5.2 taking an input orientation to obtain the efficiency level

Determinants of Technical Efficiency

Ray (1991) and Worthington and Dollery (1999), used traditional DEA in the first stage to estimate the technical efficiency and in the second stage estimated the determinants of technical efficiency from the factors contributing to this technical efficiency by using econometric procedure. In the present study, the technical efficiency values obtained from the DEA model considering the CRS input-oriented model were used for examining the relationship between the technical efficiency and factors influencing it. The technical efficiency score from CRS model was chosen as the dependent variable for its high accuracy in discriminating efficiency as compared to variable returns to scale (Goncalves *et al.*, 2008). The above inputs are considered as explanatory variables. The traditional method of regression was used for this purpose and OLS analysis was carried out to estimate the regression equation. The regression model specified for the present study is given in the following equation:

$$Y = a\, X1^{b1}\, X2^{b2}\, X3^{b3}\, X4^{b4}\, \mu$$

where, Y = Technical efficiency scores (CRS), X_1 – Irrigation cost (Rs), X_2 - Fertilizers cost (Rs.), X_3 – Pesticides cost (Rs.) and X_4 – Human labour cost (Rs.), 'a' and 'bi' are the constant and the coefficients respectively, which were estimated through the OLS analysis after appropriate log conversion.

RESULTS AND DISCUSSION

To compute resource use efficiency in maize production, DEA approach was employed in the first stage to estimate the technical efficiency and in the second stage estimated the determinants of technical efficiency from the factors contributing to this technical efficiency by using econometric procedure.

i. Technical efficiency in maize

To obtain efficiency levels of each of the farms as decided by the physical inputs (quantities), DEA models, which are input-oriented, were used at different production scales under the assumption of CRS. After introducing convexity in the CRS model, the VRS were estimated. By using the efficiency levels of these CRS and VRS models, the scale efficiency for each farm was obtained. The results on efficiency measures (with constant and variable returns) and the descriptive statistics for maize producing farms in the Kurnool district are given in Table 2.

Marginal farms

It was observed from Table 2 that, only 29.51 per cent of farms under assumption of CRS performed with efficiency level equal to 0.90 or greater, i.e. 18 of the total 61 farms. The average efficiency score was 0.6572. Based on this, it could be inferred that remaining 43 farms, which did not operate at the maximum efficiency level, could reduce the input level by 34.28 per cent and maintain the same level of maize production as achieved by 29.51 per cent of the farmers. When the assumption of constant scale was relaxed and the model with VRS was calculated, the impact of production scale on technical efficiency level was visible. In marginal farms, the number of efficient farms was 44.27 per cent and the average technical efficiency score increased to 0.8202. These better results from the model with variable returns were mainly due to the inclusion of scale efficiency, which the previous model did not take into consideration. As regards to the scale efficiency, about 54.09 per cent of maize farms (33 out of 61 farms) under marginal farms category, either performed at the optimum scale or were close to the optimum scale (farms having scale efficiency values equal to or more than 0.90).

Small farms

Under the assumption of CRS, about 29.41 per cent of the farmers in this category were found efficient with values equal to or more than 0.90, i.e., (10 out of 34 farms). The average technical efficiency score in this category was 0.7202. Based on this, it could be inferred that remaining 24 farms, which did not operate at the maximum efficiency level, could reduce the input level by 27.98 per cent and maintain the same level of maize production as achieved by 29.41 per cent of the farmers. In the case of variable returns, the average technical efficiency score was 0.8594 and nearly 47.06 per cent of the farms had the score equal to or more than 0.90. As regards to the scale efficiency, nearly 53 per cent of the small farms (18 out of 34 farms) either performed at the optimum scale or were close to the optimum scale (farms having scale efficiency values equal to or more than 0.90).

Other farms

It was observed that, 44 per cent of farms under the assumption of CRS performed with efficiency level equal to 0.90 or greater, i.e., 11 out of total 25 farms. The average efficiency score was 0.8290. This indicates that remaining 14 farms, which did not operate at maximum efficiency level, could reduce the input level by 17.10 per cent and maintain the same level of maize production as achieved by 44 per cent of the farmers. Nearly 72 per cent of the other farms are being operated at VRS with an average technical efficiency score of 0.9471. As regards to the scale efficiency, 64 per cent of the farmers (16 out of 25 farmers) under other farms either performed at optimum scale or were close to the optimum scale (farms having scale efficiency values equal to or more than 0.90).

From the above analysis it is clear that, the number of farms operating at CRS are more in number in other farms (44%) followed by marginal (29.51%) and small farms (29.41%). Similarly, regarding the number of farmers operating at VRS, the other farms are again more in number with 72 per cent followed by small (47.06%) and marginal farms (44.27%). With reference to scale efficiency, again other farms dominate the scenario with 64 per cent followed by marginal (54.09%) and small farms (52.94%). At pooled level, 18.33 per cent of the farms are being operated at CRS with an average technical efficiency score of 0.6241 i.e., 22 out of 120 farms. This indicates that, remaining 98 farmers, who did not operate at the maximum efficiency level, could reduce the input level by 37.59 per cent and maintain the same level of efficiency as achieved by 18.33 per cent of the farmers. Thirty five per cent of the farmers at pooled level are being operated at VRS with an average technical efficiency score of 0.7537. As regards to scale efficiency, 54.17 per cent of the farmers (65 out of 120 farmers) at pooled level, either performed at the optimum scale or were close to the optimum scale (farms having scale efficiency values equal to or more than 0.90).

ii. Regions of Operations in the Production Frontier

In addition to knowing about the number of efficient farms, extent of inefficiency and optimum scale of operation, it is also important to understand the distribution of farms in the three regions of production frontier, i.e. how many farms are under increasing, decreasing or constant returns. These were estimated using the equations given under methodology and the results have been presented in Table 3.

Around 67 per cent of the farms in the marginal farms category were found operating in the region of increasing returns or the sub-optimal region. The production scale of these farms could be increased by decreasing the costs, since they were performing below the optimum production scale. Only 11.48 per cent of maize farms in the marginal farms category were found in the decreasing returns region and these farmers could increase their technical efficiency by reducing their input usage consequently their production levels. This region is also called as supra-optimal i.e., the farms were performing above the optimum scale of production. In the constant region of frontier i.e., optimum scale of production, 21.31 per cent of the marginal farms were found operating. Regarding small and other farms 17.64 and 20.00 per cents respectively are operating at DRS and 61.77 per cent and 44.00 per cents respectively are operating at IRS respectively. This signifies that, for the farmers operating at IRS are to be provided with more resources and the same should be decreased towards the farmers operating at DRS. Compared to other farms category, there are less number of farmers operating at CRS both in small farms category (20.59%) and marginal farms category (21.31%). This indicates that, there is more efficient utilization of resources by other farms compared to small and marginal farms**.**

On the whole, majority of the farmers (62.50%) are operating at IRS and only 25 per cent of the farmers are operating at DRS. This signifies that, more resources should be provided to these farms operating at IRS and the same should be decreased towards the farms operating at DRS. 12.5 per cent of the farms are operating at CRS indicating efficient utilization of resources.

iii. Determinants of input-use (CRS technical) efficiency of maize farms:

Log linear regression model was used to analyze the major determinants of input use efficiency of maize farms. The input variables considered under DEA model were again considered as influential factors for the CRS obtained for the three categories of farmers. The analytical findings (Table 4) revealed that, across all the categories of farmers and at pooled level, the models are statistically significant, as indicated by higher and significant Adjusted R^2 values. The two variables irrigation cost (X1) and fertilizer cost (X2) (both positively influencing at 1% level) are the major determinants of Resource Use Efficiency (CRS) of all the selected farmers categories and at pooled level. Among these two, fertilizer cost (X2) is the major influential factor for CRS compared to irrigation cost (X1) across all the categories of maize farmers and at pooled level. Human labour cost (X4) also found to be significantly influencing the CRS of all categories of maize farmers and at pooled level, but remained significant at 5% level except other farmers (at 1% level). It is heartening that, marginal and small farmers are resorting to low dosages of pesticide application in view of their higher prices in the market and hence, this variable is not exerting any significant influence on the CRS of these farmers. However, other farmers are resorting for pesticide application to control pests and diseases on the crop and this significantly influenced (5% level) the CRS. Even at pooled level, this variable (X3) was found exerting significant (5% level) influence on the CRS.

Thus, irrigation cost (X1) and fertilizer cost (X2) are the major determinants of maize farms across all the farmer categories and even at pooled level. In view of their positive influence on the CRS, it is essential to strengthen modern irrigation infrastructure like drip irrigation and offer more fertilizer subsidies to the farmer to enhance the crop production on cost-effective basis.

SUMMARY AND CONCLUSIONS

The above analysis regarding resource use efficiency of maize farmers revealed that, it is evident that, 12.5 per cent of farmers are operating at CRS indicating efficient utilization of resources. Majority of the farmers (62.50%) *i.e.,* 75 out of 120 are operating at IRS and only 25 per cent of the farmers (30 out of 120 farmers) are operating at DRS indicating that, more resources should be provided to the farms operating at IRS and the same should be decreased towards the farms operating at DRS. The following policy implications must be borne in mind to improve the resource use efficiency of maize farmers in Kurnool district:

- It was found that, the sample farmers are spending huge amount on applying chemical and fertilizers. So, it is also advocated to adopt INM, so as to ensure both cost effective and quality production of maize. The on-farm demonstrations need to be conducted to educate the farmers on these technologies.
- Since, majority of the farmers (62.50%) are operating at IRS and only 25 per cent of the farmers are operating at DRS, more resources should be provided to the farmers operating at IRS and the same should be decreased for the farmers operating at DRS, so as to make the former farms to be resource efficient.

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