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Resource use efficiency of maize production in Balrampur and Kondagaon district of Chhattisgarh

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Abstract

Agriculture plays a crucial role in the Indian economy, supporting a significant portion of the population and contributing substantially to the Gross Domestic Product (GDP). With a massive food grain production of 329.68 million tonnes in 2022, ensuring food security remains a paramount concern. The efficient use of resources plays a critical role in agricultural productivity, particularly amidst growing population pressures and shrinking arable land per capita. This study focuses on assessing the profitability and resource use efficiency of maize cultivation in Balrampur and Kondagaon districts of Chhattisgarh through Cobb-Douglas production function analysis. A total of 280 farmers were selected using multistage random sampling, with data collected from diverse sources including government statistics and agricultural websites. The analysis revealed that hired labor, manure & fertilizer, irrigation, and seed significantly influence maize production in both districts. However, there is evidence of overutilization of manure & fertilizer, seed, and hired labor inputs, coupled with underutilization of irrigation. Specifically, the Marginal Value Product (MVP) to Marginal Factor Cost (MFC) ratio for maize cultivation in Balrampur district indicates overutilization of Manure & Fertilizer (0.007), Seed (0.005), and Hired Human Labour (0.001), while Irrigation shows significant underutilization (1.32). In Kondagaon district, Manure & Fertilizer (0.014) and Seed (0.01) are identified as overutilized inputs, whereas Irrigation exhibits a notably high MVP/MFC ratio of 37.28, indicating substantial underutilization despite its critical role. The study underscores the need for optimizing resource allocation to enhance efficiency and reduce production costs. Strategies promoting sustainable agricultural practices, particularly in enhancing irrigation efficiency, are recommended to boost crop yields amidst varying production environments. Further research and policy initiatives should focus on incentivizing farmers to adopt technologies that maximize resource use efficiency while ensuring environmental sustainability and maintaining yield quality.

Keywords: Agriculture, resource use efficiency, maize cultivation, cobb-douglas production function, marginal value product

Introduction

Agriculture continues to be a basis of the Indian economy, supporting 58% of the population and contributing 14% to the country's gross domestic product. With food grain production reaching 329.68 million tonnes in 2022, ensuring food security remains a top priority. The efficiency of food production hinges significantly on how various resources are managed. Therefore, the allocation of resources must prioritize sustainability, resource use efficiency, and the optimization of crop planning across different regions and production environments. As the population grows and arable land diminishes per capita, intensifying crop production has become more of a norm than an exception. The increasing pressure on water resources, the commercialization of agriculture, and the heightened use of energy and other inputs underscore the need for optimal resource utilization and strategic adjustments in production decisions. Efficiency in resource utilization is pivotal in agriculture, influencing both farm production and income. Key inputs such as manures, fertilizers, irrigation, labor (Both bullock and human), seeds, working capital, farm machinery, and crop protection measures play critical roles. The income generated from farming is directly impacted by how efficiently these resources are managed. By enhancing the efficiency of scarce resources, farmers can increase their income and savings significantly. This study aims to explore the profitability of crops in Balrampur and Kondagaon districts of Chhattisgarh, particularly by estimating the allocation and efficiency of resource use as reflected in production function analysis.

Methodology

Balrampur district and Kondagaon district in Chhattisgarh was purposively selected for the study because these districts cover largest area and production of maize. Multistage random sampling technique was employed in the selection of 280 farmers for the study i.e., 150 farmers from Balrampur district and 130 farmers from Kondagaon district. The secondary data regarding area, production and productivity data of of Balrampur and Kondagaon district were collected from diverse published sources and government agencies, including the Directorate of Statistics and Agriculture official websites, among others etc.

Analytical tools

Cobb-Douglas production function

To estimate resource use efficiency in maize production, Cobb-Douglas production function (Non-linear) was fitted to maize input-output data separately for each category.

$Y= a\ x_1^{b1}.\ x_2^{b2}.\ x_3^{b3}.x_n^{bn}.\ e^u$

This function can easily be transformed into a linear form by making logarithmic transformation, after logarithmic transformation this function is.

$\text{Log } Y = \text{loga} + b_1 \log X_1 + b_2 \log X_2 + - b_5 \log X_5 + a \log^e$

Where,
Y = Yield (qt ha^{-1})
X1= Land input (ha)
X2= Labour input (Rs/ ha^{-1})
X3= Fertilizer and manure input (Rs/ ha^{-1})
X4= Seeds input (cost kg^{-1})
X5= Plant protection Chemicals (Rs ha^{-1})
b_1 to b_5 = Regression coefficient of respective variables
e = Random term with zero mean and constant variance.

Estimation of marginal physical productivity

The marginal physical productivity (MPP) of different inputs was estimated at geometric mean level of respective input and output with the help of following formula:

Marginal physical product (MPP) of Xi^{th} input = $bi \frac{Y}{Xi}$

Where,
bi = Production elasticity of i^{th} input (Regression coefficient)
$\bar{Y}$= Geometric mean of output
$\bar{Xi}$ = Geometric mean of i^{th} input

Estimation of marginal value product (MVP)

The marginal value productivity of i^{th} input was calculated by multiplying unit price of output to MPP of respective i^{th} input.

Resource use efficiency: 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

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 1indicates underutilization and if r = 1 the resource is optimally used and hence is the point of profit maximization.

Results and Discussion

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

Resource use efficiency of maize in Balrampur district.

The Cobb-Douglas production function was employed to assess resource use efficiency in maize production, as shown in Table 1. The analysis revealed an R-squared (R^2) value of 0.58, indicating that 58.00 percent of the variability in maize production across different farm sizes can be explained by the variables included in the model. This level of explanatory power was statistically significant at the 1% significance level, highlighting the reliability of the relationships identified. Specifically, hired human labour, manure & fertilizer, irrigation, and seed were identified as significant contributors to maize production. These inputs played crucial roles in enhancing yields and overall output. In contrast, while plant protection chemicals made a positive contribution to maize production, this effect was not statistically significant, suggesting that its impact may vary or be comparatively less compared to the other inputs analyzed. The allocative resource use efficiency in maize production was analyzed, and the results are summarized in Table 4.23. It shows that the Marginal Value Product (MVP) of maize to Marginal Factor Cost (MFC) ratio is less than unity for Manure & Fertilizer (0.007), Seed (0.005), and Hired Human Labour (0.001), indicating an overutilization of these resources in maize cultivation across all farms. Conversely, the MVP of maize to MFC ratio is more than unity for Irrigation (1.32), suggesting an underutilization of this resource. These findings highlight the potential for reducing the use of Manure & Fertilizer, Seed, and Hired Human Labour to improve resource efficiency in maize cultivation, while emphasizing the need to optimize the use of Irrigation inputs.

Table 1: Production Function Analysis for Resource Use Efficiency of maize in Balrampur district.

S. No.	Particulars	Parameters	Regression Coefficient	Standard Error	P-Value
1	Intercept	A	3.998	1.56	0.011
2	Hired human Labour (man days)	X1	0.419***	0.11	0.0005
3	Manure & Fertilizer (₹)	X2	0.957***	0.21	2.37E-05
4	Irrigation	X3	0.318***	0.051	6.92E-09
5	Seed (₹)	X4	0.804***	0.088	5.86E-16
6	Plant Protection chemical (₹)	X5	0.395	0.17	0.026
7	R square	R2	0.58		

Note; *** significant at 1% level of probability
(R2= Coefficient of multiple determinations)

Table 2: Resource Use Efficiency of maize in Balrampur district.

S. No.	Variables	Marginal Value Product (MVP)	Marginal Fixed Cost (MFC)	MVP/MFC Ratio (r)	Remark
1	Hired Labour	0.001	1	0.001	Overutilised
2	Manure & Fertilizers	0.007	1	0.007	Overutilised
3	Irrigation	1.32	1	1.32	Underutilised
4	Seed	0.005	1	0.005	Overutilised

Resource use efficiency of maize in Kondagaon district

The Cobb-Douglas production function was employed to analyze the efficiency of resource use in maize production, as detailed in table 3. The findings indicate that the coefficient of determination (R^2) was calculated to be 0.79 for inputs across all farm sizes. This value signifies that approximately 79.00% of the variation in maize production can be explained by the variables included in the model, demonstrating a statistically significant relationship at the 1% level of significance. The data analysis revealed that in the production of maize, manure & fertilizer, irrigation, and seed significantly contribute to the output. On the other hand, while human labor and plant protection chemicals make positive contributions, these contributions are not statistically significant in influencing maize production. This suggests that while human labor and plant protection chemicals play a role in enhancing production, their impact is not strong enough to be considered statistically significant in the context of maize cultivation. The allocative resource use efficiency in maize production was calculated and results are presented in table 4. It reveals that MVP of maize to MFC ratio is less than unity for Manure & fertilizer (0.014), followed by Seed (0.01) indicated over utilization of these resources in all farmers for maize cultivation. It means all the variables are over utilized accept irrigation (37.28) for maize cultivation which underlines the scope of decreasing the use of these inputs.

Table 3: Production Function Analysis for Resource Use Efficiency of maize in Kondagaon district.

S. No.	Particulars	Parameters	Regression Coefficient	Standard Error	P-Value
1	Intercept	A	5.47	0.40	4.83E-26
2	Hired human Labour (man days)	X1	0.03	0.03	0.43
3	Manure & Fertilizer (₹)	X2	0.48***	0.08	8.25E-08
4	Irrigation	X3	0.15***	0.02	8.78E-07
5	Seed (₹)	X4	0.56***	0.06	1.72E-13
6	Plant Protection chemical (₹)	X5	0.03	0.06	0.59
7	R square	R2	0.79		

Note; *** significant at 1% level of probability
(R2= Coefficient of multiple determinations)

Table 4: Resource Use Efficiency of maize in Kondagaon district.

S. No.	Variables	Marginal Value Product (MVP)	Marginal Fixed Cost (MFC)	MVP/MFC Ratio (r)	Remark
1	Manure & Fertilizers	0.014	1	0.014	Overutilised
2	Irrigation	37.28	1	37.28	Underutilised
3	Seed	0.01	1	0.01	Overutilised

Conclusion

1. In Balrampur district, the Cobb-Douglas production function analysis revealed that hired labor, manure & fertilizer, irrigation, and seed significantly contribute to maize production. However, there was overutilization observed for manure & fertilizer, seed, and hired labor inputs, while irrigation was underutilized. Similarly, in Kondagaon district, manure & fertilizer and seed were identified as over utilized inputs, whereas irrigation was significantly underutilized despite its high Marginal Value Product (MVP) to Marginal Fixed Cost (MFC) ratio.
2. Production Function Insights, The R-squared (R^2) values of 0.58 for Balrampur and 0.79 for Kondagaon indicate strong explanatory power of the production functions, suggesting that a substantial proportion of maize production variability can be attributed to the included variables.
3. There is a clear need to optimize the allocation of resources such as manure & fertilizer, seed, and hired labor in both districts to improve efficiency and reduce production costs.
4. Given the significant underutilization of irrigation in both districts, there is potential to enhance crop yields by increasing the use of this critical input, particularly in rainfed conditions.
5. Strategies should focus on sustainable agricultural practices that optimize resource use efficiency while minimizing environmental impact.
6. Further research and extension efforts should be directed towards promoting better agricultural practices that align with the findings of resource efficiency analyses. Policies should incentivize farmers to adopt technologies and practices that improve irrigation efficiency and reduce overdependence on inputs like manure & fertilizer and seed without compromising on yield and quality.

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