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Assessing resource use efficiency in potato cultivation: Insights from Surguja district, Chhattisgarh

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Abstract

Potato (*Solanum tuberosum* L.) is a crucial crop in Indian agriculture, significantly contributing to the economy of Chhattisgarh. This study evaluates resource use efficiency in potato cultivation across different farm categories in the Surguja district of Chhattisgarh. Primary data were collected from 250 potato growers in Narbadapur, Sarbhanja, Kargi, and Gadaghat villages during the agricultural year 2022-23, while secondary data were sourced from government reports and agricultural agencies. A Cobb-Douglas production function was applied to assess the marginal value products (MVPs) of key inputs, including labor, fertilizers, seeds, irrigation, and machinery, to determine their efficiency in potato production.

The analysis reveals notable disparities in resource utilization. The highest yield-contributing inputs were fertilizers (1.40), seeds (0.60), and plant protection chemicals (1.00), emphasizing their crucial role in enhancing productivity. Allocative efficiency analysis indicated that fertilizers (MVP/MFC = 2.50), and human labor (2.00) were underutilized, suggesting that increasing their application could improve yields and profitability. Conversely, irrigation (0.20) and seeds (0.50) were overutilized, leading to inefficiencies and increased production costs.

The study recommends targeted policy measures such as subsidized access to fertilizers and machinery, improved irrigation management, optimized seed use, and better credit facilities. Addressing these inefficiencies through strategic interventions will enhance profitability, sustainability, and overall productivity of potato farming in the Surguja district.

Keywords: Resource use efficiency, Potato cultivation, Cobb-Douglas production function, Allocative efficiency, Surguja district

Introduction

Potato (*Solanum tuberosum* L.), originating from the Andean region of South America, has become one of the most significant food crops globally. Its adaptability to diverse climates and regions underpins its role as both a food staple and an industrial crop. As the fourth most important food crop worldwide, following maize, rice, and wheat, potatoes contribute substantially to global food security. They offer essential nutrients, including carbohydrates, vitamins, minerals, and dietary fiber, supporting the nutritional needs of millions.

India, as the world's second-largest potato producer, accounts for approximately 12% of global production. The diverse agro-climatic conditions in the country facilitate extensive potato cultivation, particularly during the Rabi season, from October to March. The crop's contribution to India's agricultural Gross Value Added (GVA) and its significant economic impact highlight its importance within the agricultural sector. Although traditionally not recognized as a significant potato-producing region, Chhattisgarh has seen a rise in potato cultivation in recent years, with Surguja district emerging as a key contributor. In the agricultural year 2022-23, Surguja produced 102,417 tonnes of potatoes from 7,420 hectares, accounting for 15.6% of Chhattisgarh's total potato production. The district's unique topography and favorable climate have supported its rise in potato cultivation.

Efficient resource use is crucial to maximizing productivity and profitability in potato farming. Resource use efficiency, particularly in Surguja district, varies significantly across farm sizes, reflecting disparities in access to quality inputs, labor, and irrigation. Small farms often face challenges in achieving optimal input utilization, leading to lower productivity and profitability. In contrast, larger farms tend to achieve better resource allocation, benefiting from economies of scale and access to advanced farming practices. Assessing resource use efficiency provides critical insights into improving agricultural productivity and guiding policy measures for sustainable farming practices in the region.

Materials and Methods

This section presents the framework and tools used to assess resource use efficiency in potato cultivation across farm sizes in Surguja district. The methodology focuses on collecting and

analyzing relevant data to evaluate input efficiency and its impact on productivity.

Description of the Study Area
Surguja district, located in northern Chhattisgarh, features diverse topography with hills, plateaus, and valleys. In the agricultural year 2022-23, the district produced 102,417 tonnes of potatoes across 7,420 hectares, contributing 15.6% to the state's total potato production. Favorable climatic conditions, including subtropical weather and well-distributed rainfall, support high productivity. The district's commitment to advancing potato cultivation is reflected in the establishment of the Potato Research Centre in Mainpat.

Sampling Methodology
A multistage sampling technique was employed to select a representative sample. The study included 250 households from Ambikapur and Mainpat blocks, covering four villages: Narbadapur, Sarbhanja, Karji, and Gadaghat. Farmers were categorized based on landholding size into small (1-2 hectares), medium (4-10 hectares), and large (over 10 hectares).

Data Collection
Primary Data: Data were collected through structured questionnaires and interviews, focusing on input use (e.g., seeds, fertilizers, labor), output metrics (e.g., yield), and socioeconomic factors. Special emphasis was given to understanding the resource use efficiency among farm sizes.

Secondary Data: Historical data on potato cultivation were obtained from government sources to validate findings and analyze growth patterns over time.

Analytical Framework
To estimate the resource use efficiency of maize production, a Cobb-Douglas production function (non-linear) was fitted to maize input-output data separately for each category.

Non-linear function

$$Y = Y = a \times X1b1 \times X2b2 \times X3b3 \times \ldots \times Xnbn \times eu$$

Linearized function

$$Y = Y = a \times X1b1 \times X2b2 \times X3b3 \times \ldots \times Xnbn \times eu$$

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)
b1 to b5 = Regression coefficient of respective variables
e = Random term with zero mean and constant variance

Estimation of Marginal Physical Productivity (MPP)
The marginal physical productivity (MPP) of different inputs was estimated at the geometric mean level of respective input and output using the following formula:

MPP of Xi input = (bi * $\bar{Y}$) / $\bar{X}$i

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

Estimation of Marginal Value Product (MVP): The marginal value productivity of ith input was calculated by multiplying the unit price of output by the MPP of the respective ith input.

Ratio	Level of Resource Use
MVP / Factor Price = 1	Optimum utilization of resource
MVP / Factor Price > 1	Underutilization of resource
MVP / Factor Price < 1	Excess utilization of resource

These tools allowed for a precise evaluation of how efficiently resources were utilized across farm sizes, providing insights into optimizing input allocation for improved productivity.

Results and Discussion
Resource Use Efficiency in Potato Production
Efficient resource utilization is essential for maximizing productivity and profitability in potato farming. The Cobb-Douglas production function analysis yielded an adjusted R-squared value of 0.880, indicating that 88% of the variation in potato production is explained by the included variables. The model's F-value of 72.50 confirms its statistical significance. The coefficients for fertilizers (1.40), manure (1.10), and plant protection chemicals (1.00) were notably high, emphasizing their crucial role in enhancing potato yields.

Table 1: Production Function Analysis for Potato Cultivation

Variables	Coefficient	Std. Error	t-value
Intercept	-	-	-
Human Labour	0.80	0.12	6.67
Manure	1.10	0.40	2.75
Fertilizers	1.40	0.30	4.67
Irrigation	0.50	0.20	2.50
Seed	0.60	0.25	2.40
Plant Protection Chemicals	1.00	0.38	2.63
Adjusted R^2	0.880	-	-
F-value	72.50	-	-

Allocative Resource Use Efficiency
The analysis of the MVP-to-MFC ratio indicates significant disparities in input utilization. Machine labor (3.00), fertilizers (2.50), human labor (2.00), plant protection chemicals (1.80), and manure (1.50) were underutilized, suggesting that increasing their application could enhance yield and profitability. Conversely, irrigation (0.20) and seed (0.50) were overutilized, indicating cost inefficiencies due to excess application.

Table 2: Allocative Efficiency in Potato Cultivation

Particulars	MVP	MFC	MVP/MFC	Remark
Human Labour	2.00	1.00	2.00	Underutilized
Manure	1.50	1.00	1.50	Underutilized
Fertilizers	2.50	1.00	2.50	Underutilized
Irrigation	0.20	1.00	0.20	Overutilized
Seed	0.50	1.00	0.50	Overutilized
Plant Protection Chemicals	1.80	1.00	1.80	Underutilized
Machine Labour	3.00	1.00	3.00	Underutilized

Inference and Recommendations
1. Human Labor
- **Discussion:** The MVP/MFC ratio of 2.00 indicates underutilization, suggesting that an increase in human labor can improve productivity.
- **Policy Recommendation:** Establishing labor cooperatives and providing financial support for mechanization tools

will enhance labor efficiency.

2. Manure

- **Discussion:** The MVP/MFC ratio of 1.50 suggests that manure is underutilized, meaning increasing its application could improve yield.
- **Policy Recommendation:** Promote integrated nutrient management (INM) and conduct soil testing campaigns to guide optimal manure use.

3. Fertilizers

- **Discussion:** With an MVP/MFC ratio of 2.50, fertilizers are significantly underutilized, likely due to cost constraints.
  Policy Recommendation: Increasing fertilizer subsidies and promoting precision nutrient management for optimizing application.

4. Irrigation

- **Discussion:** The MVP/MFC ratio of 0.20 indicates excessive water use, leading to inefficiencies and potential resource wastage.
  Policy Recommendation: Making access to drip irrigation, micro-irrigation, and training on water-saving techniques could help in efficient water use.

5. Seed

- **Discussion**: The MVP/MFC ratio of 0.50 indicates overutilization of seeds, possibly due to poor seed replacement practices.
  Policy Recommendation: Suppling certified seeds and training the farmers on optimal seed rates and spacing techniques will help to prevent excess use.

6. Plant Protection Chemicals

- **Discussion:** The MVP/MFC ratio of 1.80 indicates underutilization, suggesting that better pest and disease management practices could enhance productivity.
  Policy Recommendation: Promote Integrated Pest Management (IPM) and provide access to bio-pesticides for sustainable protection.

7. Machine Labour

- **Discussion:** With an MVP/MFC ratio of 3.00, machine labor is highly underutilized, indicating a need for mechanization to enhance efficiency.
  Policy Recommendation: Facilitate subsidized machinery leasing, custom hiring centers, and credit support for mechanization adoption.

These recommendations aim to address inefficiencies, ensuring sustainable and profitable potato farming in the Surguja district.

Conclusion

This study highlights the critical role of efficient resource utilization in enhancing the productivity and profitability of potato cultivation in the Surguja district. The Cobb-Douglas production function analysis revealed that fertilizers (1.40), manure (1.10), and plant protection chemicals (1.00) were the most significant contributors to yield. However, disparities in input utilization were evident, necessitating targeted interventions to improve efficiency. The allocative efficiency analysis showed that fertilizers (MVP/MFC = 2.50), human labor (2.00), plant protection chemicals (1.80), and manure (1.50) were underutilized, indicating that increased application of these inputs could enhance productivity. Conversely, irrigation (0.20) and seed (0.50) were overutilized, suggesting cost inefficiencies due to excessive application.

To address these inefficiencies, the study recommends promoting site-specific nutrient management through regular soil testing to guide optimal fertilizer and manure application. Enhancing mechanization adoption by strengthening custom hiring centers and providing credit support for machine labor can help improve efficiency. Improving labor availability through cooperatives and training programs will ensure efficient farm operations, while optimizing irrigation management by expanding access to drip and micro-irrigation systems can prevent water overuse. Additionally, providing certified seeds and training farmers on optimal planting densities will help reduce seed wastage. Encouraging Integrated Pest Management (IPM) will enhance the efficiency of plant protection chemicals while minimizing environmental risks.

Addressing these inefficiencies will significantly enhance the economic viability of potato cultivation in Surguja district. By optimizing resource allocation and adopting sustainable agricultural practices, farmers can achieve higher yields, lower production costs, and increased profitability, contributing to the region's agricultural growth and food security.

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