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Economic analysis of potato cultivation in Surguja district, Chhattisgarh

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Abstract

Potato (*Solanum tuberosum* L.) is a vital crop in Indian agriculture, significantly contributing to food security and rural livelihoods. This study focuses on evaluating the cost of cultivation, returns, and marketing efficiency of potato farming in Surguja district, Chhattisgarh, using primary data from 250 sampled farmers during the agricultural year 2022-23. The findings revealed that the cost of cultivation per hectare averaged ₹106,204.37, with variations across farm sizes: ₹101,630.21 for small farms, ₹106,481.98 for medium farms, and ₹111,012.43 for large farms. Larger farms achieved higher profitability, with a benefit-cost ratio of 3.22 compared to 2.72 for small farms.

The compound annual growth rates (CAGR) for potato cultivation in Surguja district reflect an area growth of 0.61%, production growth of 2.28%, and productivity growth of 1.55%, while Chhattisgarh state shows higher rates of 7.06%, 8.94%, and 1.55%, respectively.

Marketing efficiency was higher in Channel I (direct sales to consumers) with an index of 9.05, while Channel II (sales through intermediaries) had a lower efficiency index of 1.66. Direct marketing provided higher net prices for farmers, reducing dependency on intermediaries, but was underutilized due to inadequate infrastructure and accessibility issues. Most farmers (81.2%) relied on intermediaries, citing better convenience despite higher marketing costs.

Key challenges identified include limited access to quality seeds, inadequate storage facilities, high transportation costs, and reliance on traditional practices. To enhance profitability and sustainability, the study recommends promoting direct marketing channels, strengthening infrastructure for storage and transportation, and encouraging modern farming techniques through targeted policy interventions. These measures are critical to improving the economic viability and resource use efficiency of potato farming in Surguja district.

Keywords: Potato cultivation, profitability, resource efficiency, Surguja district, cost analysis, Benefit-Cost Ratio (BCR)

Introduction

Potato (*Solanum tuberosum* L.), originating from the Andean region of South America, has emerged as one of the most essential food crops globally. Its adaptability to diverse climates and regions has elevated its significance as both a food staple and an industrial crop. Ranking as the fourth most important food crop globally after maize, rice, and wheat, potatoes contribute to food security by providing essential nutrients, including carbohydrates, vitamins, and minerals.

India ranks as the second-largest producer of potatoes globally, contributing about 12% of the world's potato output. The country's diverse agro-climatic conditions facilitate extensive potato cultivation, particularly during the Rabi season from October to March. During this time, potatoes are predominantly grown in the northern plains and central and eastern regions of India. In the 2022-23 agricultural season, India produced approximately 60.22 million tonnes of potatoes, up from 56.18 million tonnes in the previous year (Directorate of Economics and Statistics, 2022).

Although traditionally not recognized as a major potato-producing state, Chhattisgarh has emerged as a key contributor to India's potato production. Surguja district, in particular, has played a crucial role in boosting the state's potato output due to its favorable agro-climatic conditions, including undulating topography, fertile soil, and well-distributed Rabi season rainfall.

In 2022-23, Surguja produced approximately 102,417 tonnes of potatoes from 7,420 hectares, achieving an average productivity of 13.81 tonnes per hectare (Chhattisgarh Agriculture Department, 2023). This district accounted for 15.6% of Chhattisgarh's total potato production, underscoring its growing significance in the state's agricultural economy.

Surguja's success in potato cultivation stems from supportive environmental factors and the establishment of research infrastructure such as the Potato Research Centre in Mainpat. Despite these strengths, challenges persist, including limited access to quality seeds, inadequate storage facilities, and fluctuating market prices. Addressing these constraints can further enhance the district's contribution to India's potato production.

This study focuses on analyzing the growth rate of the area, production, and productivity of potatoes in Surguja district, along with assessing the cost of cultivation and returns

across different farm sizes.

Materials and Methods

Surguja district, located in Chhattisgarh, India, features a subtropical climate ideal for potato farming during the Rabi season. Spanning approximately 5,732 square kilometers, the district is characterized by undulating hills, plateaus, and valleys. Fertile soils, combined with well-distributed rainfall averaging 1,200 to 1,500 mm annually, support agricultural activities. The primary irrigation sources include tanks, bore wells, canals, and open wells. The district's diverse cropping pattern includes major crops such as rice, maize, and potatoes, with potato cultivation being a vital economic activity.

A multistage sampling method was applied. Surguja was purposely selected due to its significant share in Chhattisgarh's potato production. Two prominent blocks—Ambikapur and Mainpat—were chosen based on their extensive potato cultivation. Four villages (Narbadapur, Sarbhanja, Karji, and Gadaghat) were selected based on their high production levels. A sample of 250 farmers was drawn, categorized by farm size into small (1-2 hectares), medium (4-10 hectares), and large (over 10 hectares).

Data were collected through structured interviews with 250 potato-growing households across the selected villages. The survey covered cropping practices, input use, costs, yields, and marketing strategies. Relevant data from the Directorate of Horticulture, Chhattisgarh Agriculture Department, and official statistical records were reviewed. Time-series data from 2004-05 to 2022-23 provided insights into production trends.

The Compound Growth Rate (CGR) for area, production, and productivity was calculated using the exponential growth function represented by the following regression model:

$Y_t = a \times b^t \times e^u$

Where:

- Y_t: Area, Production, or Productivity in year t
- a: Intercept, representing the initial value
- b: Regression coefficient indicating the growth factor
- t: Time period in years
- e^u: Error term accounting for random variations

To estimate the CGR, the equation was linearized by taking the natural logarithm of both sides:

$\ln(Y_t) = \ln(a) + t \times \ln(b) + u$

After estimating the regression coefficient ln(b) from the transformed linear equation, the CGR was computed as:

CGR = (Antilog (ln(b)) - 1) × 100

This formula converts the estimated coefficient ln(b) back to its original scale, representing the annual percentage growth rate.

Cost Formulas

Total Cost (TC): TC = TVC + TFC

Where:

- TVC: Total Variable Cost
- TFC: Total Fixed Cost

Cost Concepts Based on CACP Guidelines

- **Cost A1:** Includes all actual expenses incurred by the farmer such as hired labor, machinery, fertilizers, seeds, irrigation charges, depreciation on farm implements, and land revenue.
- Cost A2 = Cost A1 + Rent paid for leased-in land
- Cost B1 = Cost A1 + Interest on owned fixed capital excluding land
- Cost B2 = Cost B1 + Rental value of owned land
- Cost C1 = Cost B1 + Imputed value of family labor
- Cost C2 = Cost B2 + Imputed value of family labor
- Cost C3 = Cost C2 + 10% of Cost C2 (Managerial cost)

Profitability Indicators

- Farm Business Income = Gross Returns - Cost A1
- Family Labor Income = Gross Returns - Cost B2
- Net Income = Gross Returns - Cost C3
- Return per Rupee = Gross Returns / Total Cost (C3)

These methods and formulas were employed to evaluate the economic viability of potato cultivation in Surguja district, ensuring a comprehensive analysis of growth trends, cost structures, and profitability indicators.

Results and Discussion

Compound Annual Growth Rate (CGR) The compound annual growth rate (CGR) analysis highlights critical trends in potato cultivation performance in Surguja district and Chhattisgarh state between 2004-2023. The figures underscore Surguja's strong standing as the most productive potato-growing district in Chhattisgarh due to its exceptional yield performance and efficient agricultural practices.

Table 1: Compound Annual Growth Rate (CGR) of Potato in Study Area (2004-2023)

Particular	Area Growth (%)	Production Growth (%)	Productivity Growth (%)
Chhattisgarh	7.06***	8.94***	1.55**
Surguja District	0.61	2.28**	1.55

Note: *** Significant at 1% level of probability; ** Significant at 5% level of probability

Area Growth: The CGR for the area under potato cultivation in Surguja district was 0.61%, indicating stable and strategic land use focused on maximizing productivity rather than expanding cultivated land unnecessarily. This calculated growth reflects Surguja's focus on intensive farming practices supported by the efficient use of available land, modern agricultural techniques, and targeted government initiatives. Compared to Chhattisgarh's area growth of 7.06%, which involved large-scale area expansion across multiple districts, Surguja demonstrates an efficiency-driven model emphasizing yield over land size.

Production Growth: Surguja's production growth rate of 2.28% (significant at 5% level) showcases consistent output increases through optimized agricultural practices. While the state-level production growth is 8.94%, driven by extensive area expansion in other districts, Surguja's

success comes from better farm management and superior productivity-enhancing methods.

Productivity Growth: Surguja's productivity growth of 1.55% matches the state average, reaffirming its position as a leading productivity hub in potato cultivation. This outcome highlights the district's adoption of high-yielding seed varieties, effective irrigation systems, and well-established farming practices, ensuring stable and competitive yields.

Comparative Insights: Despite a comparatively smaller cultivated area, Surguja maintains its status as the most productive district in Chhattisgarh. This achievement stems from its emphasis on advanced farming practices, optimal input utilization, and strategic agricultural management. Unlike other districts that depend on area expansion, Surguja focuses on enhancing per-hectare productivity through knowledge-based farming.

Policy Recommendations

- Technological Advancement: Facilitate the introduction of high-yielding potato varieties, precision irrigation systems, and integrated pest management programs tailored specifically for Surguja's agro-climatic conditions.
- Infrastructure Development: Prioritize expanding cold storage facilities, constructing farm-to-market roads, and strengthening existing irrigation infrastructure.
- Farmer Capacity Building: Conduct advanced training programs on soil fertility management, efficient irrigation scheduling, and improved crop management practices.
- Financial Incentives and Subsidies: Offer targeted input subsidies for certified seeds, modern fertilizers, and farm machinery. Expand access to low-interest credit and crop insurance tailored to potato growers.
- Customized Market Support: Establish exclusive farmer-producer organizations (FPOs) and create direct marketing channels to enhance market access and reduce post-harvest losses.
- Research and Development: Support region-specific R&D initiatives focused on developing climate-resilient potato varieties, efficient water management systems, and pest-resistant crops.

These precise and context-specific policy interventions will further strengthen Surguja's leadership in potato cultivation while addressing challenges related to limited area expansion and market accessibility.

Economic Viability: Evaluating the economic viability of potato cultivation involves analyzing the cost structure, gross returns, net returns, and the Benefit-Cost Ratio (BCR). The findings reveal critical insights into cost dynamics and profitability trends across different farm sizes in Surguja district.

Cost of Cultivation Analysis

The analysis of the cost of potato cultivation reveals a significant division between variable and fixed costs, accounting for 77.69% and 22.31% of the total cost, respectively. Larger farms experience higher total costs due to increased input usage and operational scale, yet benefit from economies of scale, spreading fixed costs more efficiently.

Table 2: Cost of Cultivation of Potato by Farm Size (₹/ha)

Cost Component	Small (₹)	Medium (₹)	Large (₹)	Overall (₹)
Total Variable Cost	78,531.31	83,260.98	87,641.83	82,981.10
Total Fixed Cost	23,098.90	23,221.00	23,370.60	23,223.27
Total Cost	101,630.21	106,481.98	111,012.43	106,204.37

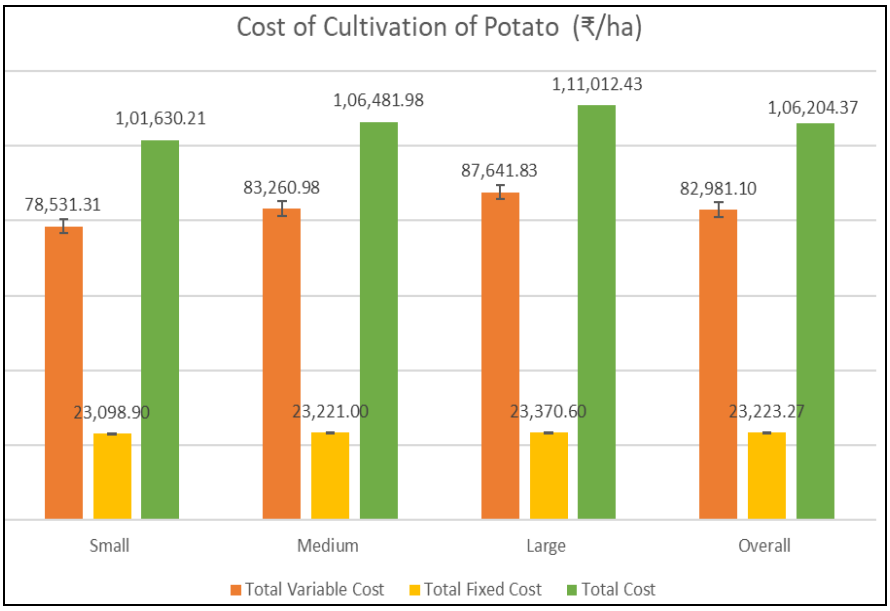

Fig 1: Cost components across different farm sizes (Rs/Ha)

Variable Costs: Variable costs include major inputs such as seeds, fertilizers, labor, and irrigation. Seeds remain the largest expense, constituting 40.16% of the total cost, underscoring their critical role in determining crop yield. To reduce cultivation expenses, ensuring access to high-quality, affordable seeds is crucial. Fertilizer costs, balanced between chemical and organic inputs, reflect an integrated approach to nutrient management that could be further optimized. Labor costs, both family and casual, represent a significant portion of variable expenses. Casual labor, averaging 8.8% across farm sizes, highlights reliance on external labor, which could be minimized through improved use of family labor during peak periods. Mechanization costs, consistent across all farm sizes, point to the necessity of shared farm equipment programs and subsidized machinery to reduce operational costs.

Fixed Costs: Fixed costs primarily comprise the imputed value of land, depreciation of farm equipment, and interest on fixed capital. Land value represents 18.83% of the total cost, emphasizing its role as a stable fixed expense. Depreciation costs increase with farm size due to larger investments in machinery and infrastructure, while interest on fixed capital remains consistent at 1.99%. These findings underline the importance of providing low-interest credit and subsidies for farm equipment to support large and medium-sized farms.

Overall, small farms benefit from lower total costs but face constraints due to limited economies of scale. Medium farms balance moderate costs with productivity, while large farms, despite incurring the highest expenses, capitalize on scale efficiencies and improved resource utilization**.**

Policy Recommendations

- Input Cost Reduction: Provide targeted subsidies on certified seeds, chemical fertilizers, and organic manures to reduce financial burdens for small and medium farmers.
- Labor Mechanization: Enhance access to affordable machinery through custom hiring centers and subsidized rates for farm equipment.
- Efficient Water Use: Promote investments in modern irrigation systems, such as drip and sprinkler irrigation, to optimize water use and lower costs.
- Financial Support: Offer low-interest loans and credit facilities specifically for potato farmers to support both working and fixed capital needs.
- Sustainable Practices: Encourage balanced nutrient management and integrated pest control methods to enhance input use efficiency and improve yields.

Profitability Indicators Overview

Table 3 presents the profitability indicators of potato cultivation across different farm sizes. The findings reveal that as farm size increases, average yield rises from 139.56 qt/ha on small farms to 155.42 qt/ha on large farms, driven by improved resource utilization and economies of scale. Average price realization also improves with farm size, reaching ₹2,300 per quintal for large farms. Consequently, gross returns and net returns increase significantly, with large farms achieving the highest net return of ₹246,453.57 per hectare.

The Benefit-Cost Ratio (BCR) ranges from 1.72 for small farms to 2.22 for large farms, reflecting greater profitability and cost efficiency on larger farms. Additionally, the input-output ratio rises with farm size, reaching 3.22 for large farms, indicating better resource utilization. These results suggest that larger farms benefit from economies of scale, higher productivity, and better price realization, leading to superior economic returns.

Table 3: Profitability Indicators in Potato Cultivation (₹/ha)

Indicator	Small	Medium	Large	Overall
Cost of Cultivation	101,630.21	106,481.98	111,012.43	106,204.37
Average Yield (Q/ha)	139.56	148.36	155.42	147.56
Average Price (₹/Q)	1,980.00	2,100.00	2,300.00	2,116.00
Gross Return (₹/ha)	276,328.80	311,556.00	357,466.00	312,924.44
Net Return (₹/ha)	174,698.59	205,074.02	246,453.57	206,720.07
Cost of Production (₹/Q)	728.22	717.73	714.27	719.98
Benefit-Cost Ratio (BCR)	1.72	1.93	2.22	1.94
Input-Output Ratio	2.72	2.93	3.22	2.94

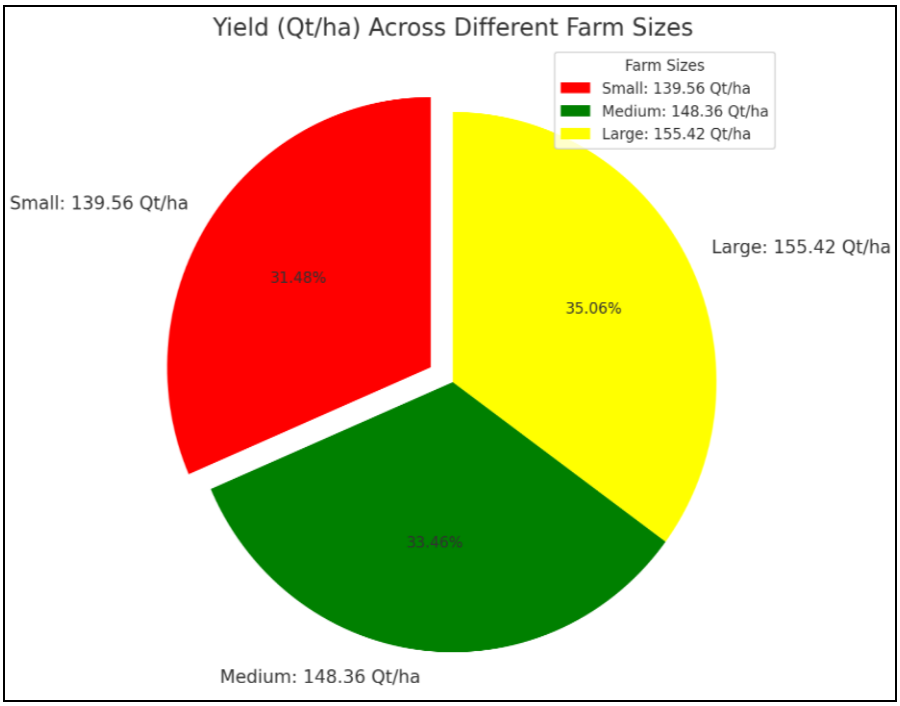

Fig 2: Yield across different farm sizes in the study area

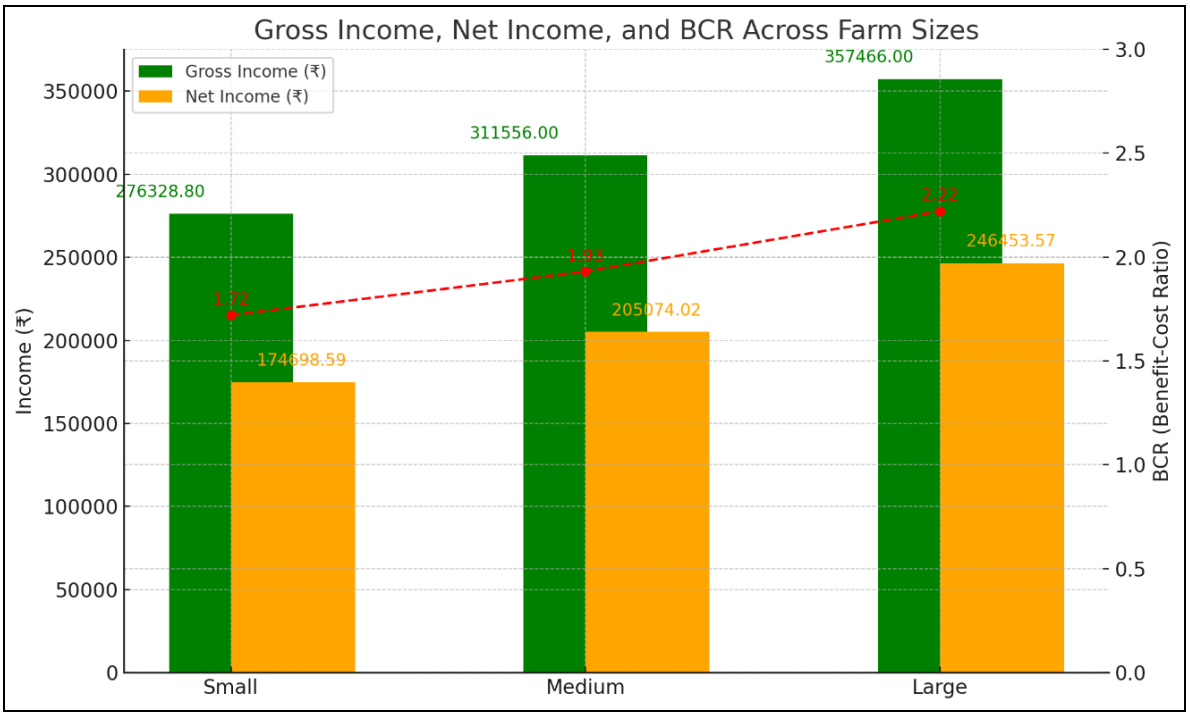

Fig 3: Gross income, net income, and BC ratio across different farm sizes in the study area

Profitability Analysis

The profitability analysis reveals that net income and the Benefit-Cost Ratio (BCR) improve significantly with farm size, highlighting the economic advantages of economies of scale. Larger farms benefit from better resource management, reduced per-unit production costs, and higher market prices, resulting in superior net incomes and BCR values.

Gross income is directly influenced by yield per hectare, with larger farms achieving the highest yield of 155.42 quintals per hectare, translating into a gross income of ₹357,466.00. Medium farms achieve a yield of 148.36 quintals, resulting in a gross income of ₹311,556.00, while small farms record a yield of 139.56 quintals, earning ₹276,328.80 in gross income. This trend emphasizes that farm size positively correlates with yield, driven by better access to modern farming techniques, intensive crop management, and economies of scale that significantly enhance returns.

Net income follows a similar trend, with large farms securing ₹246,453.57 per hectare, reflecting their ability to spread fixed costs across larger production volumes. Medium farms generate a net income of ₹205,074.02, while small farms achieve ₹174,698.59 per hectare despite higher

per-unit costs. This demonstrates that larger farms optimize input use more effectively, whereas small farms, despite their higher input expenses, maintain profitability through efficient resource management.

The Benefit-Cost Ratio (BCR), a key profitability indicator, improves steadily with farm size. Small farms achieve a BCR of 1.72, indicating a satisfactory return on investment despite limited operational scale. Medium farms record a BCR of 1.93, while large farms achieve the highest BCR of 2.22, reflecting superior cost efficiency and market integration. These findings underscore that increased farm size, combined with better operational efficiency and access to markets, translates into enhanced profitability.

Policy Recommendations

- Market Linkages: Strengthen direct market linkages through farmer-producer organizations (FPOs) to secure better prices and reduce dependency on intermediaries.
- Yield Enhancement: Promote the adoption of high-yielding seed varieties, precision farming techniques, and improved agronomic practices to enhance productivity.
- Post-Harvest Support: Establish cold storage facilities and logistical hubs to minimize post-harvest losses and stabilize farm incomes.

These policy measures aim to enhance the economic returns of potato cultivation while fostering productivity, sustainability, and income stability across all farm sizes in the Surguja district

Cost Concepts Analysis

Understanding cost concepts such as Cost A1 (direct costs), Cost B1 (capital-inclusive), and Cost C2 (total production costs) provides critical insights into farm economics. Table 4 highlights these components, showing how various costs scale with farm size. Larger farms benefit from economies of scale, resulting in decreased per-unit production costs despite higher absolute expenditures.

Table 4: Cost Concepts in Potato Farming (₹/ha)

Cost	Small	Medium	Large	Overall
cost A1	73230.31	79420.98	85512.83	79147.660
Cost B1	75330.21	81531.98	87637.43	81258.866
Cost B2	95330.21	101531.98	107637.43	101258.866
Cost C1	81630.21	106481.98	91012.43	86204.366
Cost C2	101630.21	106481.98	111012.43	106204.366
Cost C3	10163.02	10648.20	11101.24	10624.44

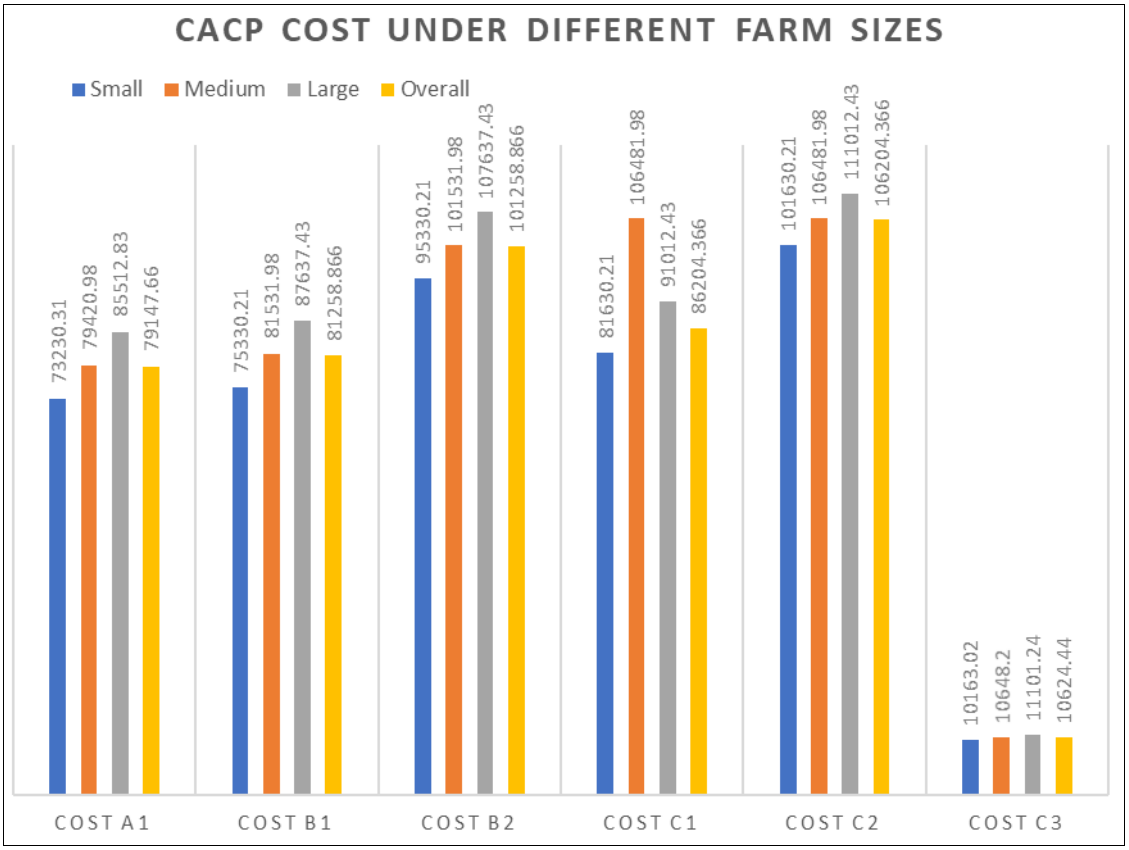

Fig 4: Cost division across different farmer categories in the study area

The analysis of cost concepts reveals notable differences in production expenses across farm sizes. Larger farms incur higher total costs due to extensive operations but benefit from reduced per-unit production costs due to economies of scale.

Direct operational expenses, captured under Cost A1, include seeds, fertilizers, and labor. These expenses range from ₹73,230.31 on small farms to ₹85,512.83 on large farms, reflecting higher input use with increased farm size. Similarly, Cost B1, which includes interest on working capital, rises proportionally, indicating larger credit requirements for bigger farms.

Cost B2, covering land rent, shows a marked increase due to higher land valuations on larger farms, with values rising from ₹95,330.21 for small farms to ₹107,637.43 for large farms. Fixed costs, such as imputed labor and depreciation, represented under Cost C1, rise steadily as farm infrastructure and machinery investments expand with farm size. Comprehensive production costs, captured under Cost C2, increase from ₹101,630.21 on small farms to ₹111,012.43 on large farms, demonstrating the impact of operational scale on total expenditure.

Cost C3, the final metric including managerial costs and entrepreneurial profits, reflects increased management intensity and operational investments, reaching ₹11,101.24 for large farms. This highlights the need for effective management practices and resource optimization.

Overall, the findings emphasize that while larger farms face higher absolute costs, they achieve lower per-unit costs due to efficient input use, resource optimization, and economies of scale.

Policy Recommendations

1. Enhancing Input Efficiency: Provide targeted subsidies on essential inputs like seeds, fertilizers, and plant protection chemicals for small farms to reduce per-unit production costs. Large farms should be supported with advanced mechanization incentives to enhance production efficiency.
2. Credit Accessibility: Offer subsidized credit schemes and low-interest loans tailored to small and medium farms to improve working capital management and enable timely input purchases.
3. Land Use Optimization: Encourage land pooling among small farms and implement regulated land-leasing frameworks for large farms to manage escalating land rental costs effectively.
4. Labor and Resource Management: Support small farms with labor-saving technologies, while providing training on modern farm management techniques for larger farms to optimize labor productivity and reduce management overhead.
5. Infrastructure Development: Invest in essential infrastructure like cold storage, irrigation systems, and farm roads to reduce post-harvest losses and enhance market accessibility for all farm sizes.
6. Research and Development Support: Promote adaptive research focused on developing region-specific, cost-effective technologies and improved potato varieties to sustain long-term farm profitability.

These targeted policy interventions address cost challenges specific to farm sizes, aiming to enhance production efficiency, profitability, and sustainability for potato farmers in Surguja district.

Profitability Components Analysis

The profitability analysis across small, medium, and large farms in the Surguja district highlights how farm size affects economic returns. Larger farms benefit from economies of scale, enabling higher incomes and greater production efficiency. Table 5 summarizes profitability components such as gross income, farm business income, and family labor income, showing significant differences by farm size.

Table 5: Profitability Components across different farmer categories (₹/ha)

Particulars	Small	Medium	Large	Overall
Gross income (Rs.)	276328.80	311556.00	357466.00	312924.44
Farm Business income	203098.49	232135.02	271953.17	233776.78
Family labour income	180998.59	210024.02	249828.57	211665.57
Net income	174698.59	205074.02	246453.57	206720.07

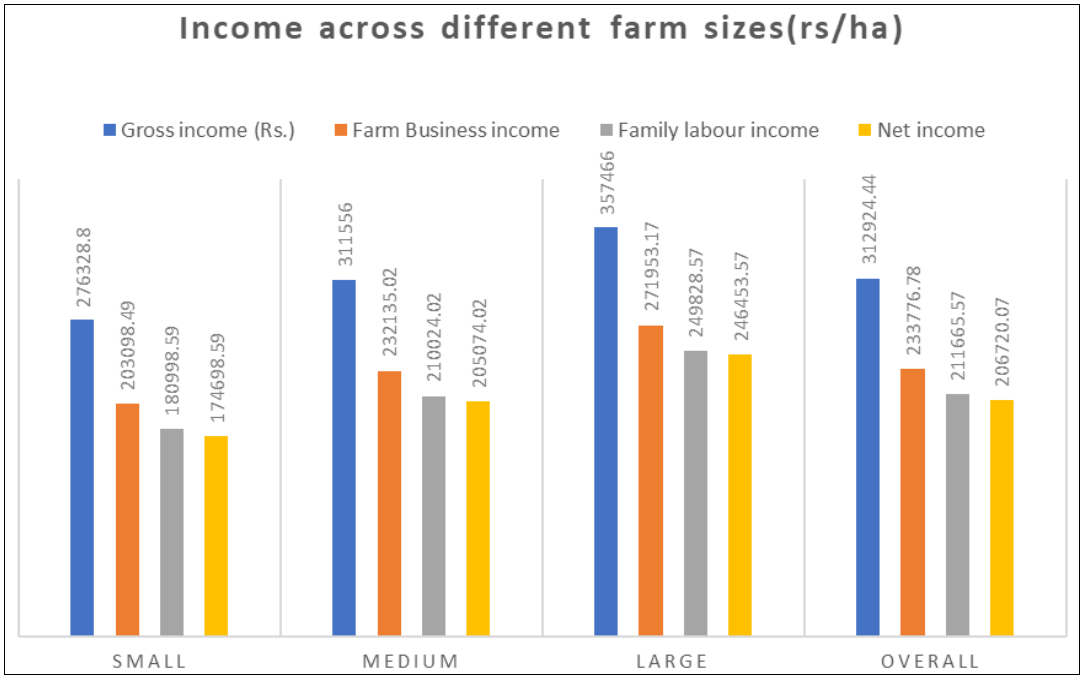

Fig 5: Various farm income across different categories of farmers

Larger farms recorded the highest gross income of ₹357,466.00 per hectare, surpassing small farms by 29.4% and medium farms by 14.7%. This income disparity reflects economies of scale, efficient input use, and improved market access. Farm business income followed a similar trend, with large farms earning ₹271,953.17, exceeding small farms by 33.9% and medium farms by 17.1%.

Family labor income, representing returns after accounting for family labor contributions, also increased with farm size. Large farms earned ₹249,828.57 per hectare, 38.0% higher than small farms and 19.0% more than medium farms. Net income, a comprehensive profitability measure, reached ₹246,453.57 per hectare on large farms, marking a 41.1% improvement over small farms and 20.2% over medium farms.

These results emphasize the significance of farm size in driving profitability through better cost management, resource efficiency, and enhanced yields.

Policy Recommendations

1. Encouraging Farmer Cooperatives: Establish farmer cooperatives to enable small farms to pool resources, share equipment, and collectively negotiate better market prices, replicating the economies of scale achieved by large farms.
2. Resource Management and Training: Provide targeted training programs on advanced farming practices, input optimization, and sustainable resource management to address efficiency gaps among small and medium farms.
3. Access to Credit and Market Support: Offer low-interest credit schemes, ensure minimum support prices (MSP), and enhance rural market infrastructure, including cold storage and transportation facilities.
4. Mechanization and Technology Adoption: Promote subsidized equipment rental centers and precision farming technologies to boost productivity and reduce operational costs.

These strategies aim to address income disparities, enhance farm profitability, and encourage sustainable agricultural practices across all farm sizes in Surguja district.

Conclusion

The economic analysis of potato cultivation in the Surguja district highlights its potential as a viable and profitable agricultural enterprise. Larger farms demonstrated superior profitability, driven by economies of scale, efficient input utilization, and improved access to markets and infrastructure. In contrast, small and medium farms faced higher per-unit production costs due to limited operational scale and constrained resource availability, yet exhibited commendable economic resilience.

The Compound Growth Rate (CGR) analysis indicated positive trends in production and productivity, with production increasing by 2.28% per annum and productivity growing by 1.55% per annum. However, land expansion remained minimal, reflecting the district's emphasis on enhancing productivity rather than increasing the area under cultivation. These trends suggest a productivity-focused approach that can be further leveraged through policy interventions.

Profitability indicators, including net income and the Benefit-Cost Ratio (BCR), confirmed that larger farms achieved maximum returns, with a BCR of 2.22, compared to 1.93 for medium farms and 1.72 for small farms. Despite these disparities, small farms managed to maintain economic viability through efficient resource allocation and adaptive farming practices.

Key recommendations for enhancing the economic viability of potato cultivation include establishing farmer cooperatives to address resource constraints on smaller farms, expanding access to credit, and strengthening market linkages. Additionally, targeted subsidies for quality seeds, fertilizers, and farm equipment, combined with investments in post-harvest infrastructure such as cold storage and transportation facilities, could reduce disparities and improve overall profitability.

Overall, the Surguja district demonstrates significant potential for scaling up potato farming. By adopting policy-driven interventions aimed at increasing productivity, lowering production costs, and ensuring sustainable agricultural practices, the region can enhance its position as a key contributor to potato cultivation in Chhattisgarh.

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