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Harshkumar D Patel
Ph.D. Scholar, International Agribusiness Management Institute, Anand Agricultural University, Anand, Gujarat, India

RS Pundir
Principal & Dean, International Agribusiness Management Institute, Anand Agricultural University, Anand, Gujarat, India

Corresponding Author:
Harshkumar D Patel
Ph.D. Scholar, International Agribusiness Management Institute, Anand Agricultural University, Anand, Gujarat, India

Cost and return analysis of potato production in Gujarat

Harshkumar D Patel and RS Pundir

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Abstract
Potato (*Solanum tuberosum* L.), a globally significant crop, plays a vital role in food security and agricultural income. This study examined potato cultivation in Gujarat, focusing on five major producing districts: Banaskantha, Sabarkantha, Aravalli, Gandhinagar and Mehsana. A multistage sampling of 200 contract farmers (42 small, 66 medium, 92 large) analyzed input use, cost structures and profitability using the CACP methodology. Results revealed that small farms rely more on family labour, manure and nitrogen fertilizers, while large farms utilize mechanization, potassium and plant protection chemicals extensively. Total cultivation costs per hectare were highest on large farms (₹ 215943.39), with seed costs contributing 48 per cent of expenses. Gross returns increased with farm size, ranging from ₹ 285217.69 on small farms to ₹ 548178.20 on large farms. Benefit-cost ratios also improved, from 0.24 for small farms to 1.14 for medium farms and 1.54 for large farms, highlighting greater profitability with scale. The study underscored variations in resource allocation, productivity and economic outcomes across farm sizes, offering insights for optimizing potato cultivation practices and enhancing profitability in Gujarat's diverse agro-climatic conditions.

Keywords: Potato, contract farming, CACP, cost and returns, profitability, net income

Introduction
Potato (*Solanum tuberosum* L.) stands as one of the most significant crops globally, providing essential nutrition and acting as a vital source of income for millions of farmers. Renowned for its versatility and adaptability, the crop plays a critical role in addressing food security and agricultural development challenges. It is a root vegetable and popularly known as the king of vegetables. It is native to the Andean region of South America, has evolved into one of the most critical food crops globally. It is a member of the Solanaceae family, which includes tomato, eggplant and pepper. One reason for its global popularity is that potatoes can be cultivated in a variety of environments. Additionally, they are highly nutritious (Woolfe, 1987) [20] and can produce more food, with higher nutritional value, in less time, on less land and in more challenging climates than any other major crop (FAO, 2008). On the global stage, the potato is the fourth most important food crop, following by maize, wheat and rice. It is grown in over 100 countries, with production concentrated in both developed and developing nations **(**Marwaha *et al.*, 2009) [8]. In many developing countries, potatoes are increasingly replacing traditional staples such as rice and maize due to their higher nutritional value and shorter growing cycles (Pandey & Sarkar, 2005) [10]. The total world production of potato in 2022 was 251.23 million tons with an area of 11.91 million ha. India ranks the second position in potato production in the world after China, with production areas primarily in Uttar Pradesh, West Bengal, Bihar, Gujarat and Madhya Pradesh. The total production in the country was around 53602.60 thousand tons. Potatoes are cultivated in diverse climates ranging from cool, temperate regions to warmer, subtropical areas. Their adaptability to various soil types and conditions has contributed to their widespread adoption. Potatoes are typically grown from seed tubers, which are small tubers used as planting material. Potato cultivation in India occurs primarily in two seasons: *rabi* and *kharif*. The *rabi* season, from October to March, is the main growing period for potatoes. More than 80 per cent of the potato crop is raised in this season. During this season, the cooler temperatures and shorter days are ideal for tuber formation, leading to higher yields and better-quality produce.

The growing season can vary from 90 to 120 days, depending on the variety and climatic conditions. The potato plant itself is a herbaceous annual that grows about 60 cm high. It has leaves that die back after flowering, fruiting and tuber formation. The tubers grow underground and can vary significantly in size, shape and colour, depending on the variety. Common potato varieties include Kufri Sindhuri, Kufri Chandramukhi, Kufri Jyoti, Kufri Badshah, Kufri Bahar, Kufri Sutlej, Kufri Ashoka and Kufri Anand each suited to different culinary uses such as baking, frying, boiling and roasting (Tiwari *et al*., 2021) [17]. Overall, the potato is one of the most efficient ways to convert plant resources, land, water and labour into a tasty and nutritious food (Sahadevan, 2007) [13]. In the past, several researchers have conducted economic analyses of potato production across different regions of India (Peer *et al*., 2013; Lal and Sharma, 2006; Durgawati *et al.*, 2005; Rajput *et al.*, 2003) [11, 7, 6, 12]. In potato cultivation, the primary contributors to the total cost of production are expenditures on seeds, labour and manure and fertilizers (Sinha and Singh, 2019; Sharma *et al.*, 2017) [15, 14]. Despite its high capital requirements, potato cultivation remains a profitable enterprise (Verma and Rajput, 2002) [19]. Gujarat is a significant contributor to the country's potato production. In Gujarat, potato is regarded as a key cash crop. The state's climatic conditions, characterized by moderate winters and adequate rainfall, are conducive to potato cultivation. Key potato-growing districts in Gujarat include Banaskantha, Aravalli, Sabarkantha, Gandhinagar and Mehsana. Banaskantha is the leading potato-producing district in Gujarat, accounting for a substantial share of the state's output. The district's favourable agro-climatic conditions and well-developed irrigation infrastructure, particularly from the Sardar Sarovar Project, support high potato yields and good quality produce. Banaskantha has the largest area under potato cultivation (53548 hectare) among all potato-producing districts, with a production of 1579666 metric ton and a productivity of 29.50 MT/ha (Director of Horticulture, Government of Gujarat, 2023). In an agriculture-dependent country like India, the instability of commodity prices has long been a major concern for farmers. There are several ways to address this issue. In addition to enhancing market stability through direct government intervention, farmers can also manage their activities more effectively by considering various factors within the agricultural sector (Combe, 1997) [5].

Methodology

The present study was taken out in Gujarat State. Gujarat state comprises of 33 districts. Out of 33 districts top five districts with highest area and production of potato were selected. Banaskantha, Sabarkantha, Aravalli, Gandhinagar and Mehsana are the major potato producing districts. A multistage sampling was adopted as appropriate sampling procedure for the study. A list of talukas of these five districts was prepared with cultivation area and production. Ten respondents from each selected village were taken randomly from those who were engaged in contract farming of potato. A total of 200 respondents were selected for the study, consisting of 42 small (up to 2 ha) farmers, 66 medium (2 to 4 ha) farmers and 92 large (above 4 ha) farmers. To analyze the economics of potato production, a tabular analysis was used to estimate the disposal pattern of potatoes. The standard cost concepts approach was applied to assess the costs and returns from potato cultivation. For calculating the cost of cultivation, the method employed by the Commission of Agricultural Cost and Prices (CACP), Directorate of Economics and Statistics, Government of India, was adopted. These include Cost A_1, Cost A_2, Cost B_1, Cost B_2, Cost C_1 and Cost C_2. Various costs have been worked out by applying following method:

Cost A_1 = Value of hired human labour, value of bullock labour, value of hired and owned machine labour, value of seed (both farm seed and purchased), value of manures (owned and purchased), cost of fertilizers, plant protection charges (insecticide/pesticide), irrigation charges, land revenue, interest on working capital, miscellaneous expenses, depreciation on farm building and implements.

Cost A_2 = Cost A_1 + rent paid for leased in land

Cost B_1 = Cost A_2 + interest on fixed capital (excluding land)

Cost B_2 = Cost B_1 + rental value of owned land

Cost C_1 = Cost B_2 + imputed value of family labour

Cost C_2 = Cost C_1 + 10 percent of cost C_1 as management cost

Income measures

Gross income: The value of gross income was calculated by considering the total production and price of product.

Returns over variable cost = Gross income - Cost A_1

Farm business income = Gross income - Cost A_2

Net income = Gross income - Cost C_2

Returns per rupee = Gross income / Cost C_2

Results and Discussion

The allocation of land for specific crops is determined by factors such as input prices, technology accessibility, crop productivity and market prices. Farmers assess the profitability of their crop production by understanding input utilization, cost structure and yield returns. This information is particularly valuable for crops intended for commercial purposes, such as cash crops, oilseeds, spices, fruits, vegetables and other high-value crops. This section examines the per-hectare cultivation costs and returns of potatoes in Gujarat during the 2023 *kharif* season.

Level of input used by farmers

Table 1 outlines the utilization of key inputs in potato farming (hired labour, family labour, machine labour, seeds, manure, fertilizers, irrigation and plant protection chemicals) across small, medium and large farms. The overall averages across all farm sizes are also provided. The analysis highlights variations in input use based on farm size, reflecting differences in resource allocation and farming practices. Small farms utilized the least hired labour, averaging 7.00 man-days, whereas medium farms used 21.00 man-days and large farms required significantly more at 13.11 man-days. This highlighted the increasing reliance on external labour as farm size expands.

Small farms relied heavily on family labour, averaging 50.92 man-days, compared to 22.17 man-days for medium farms and 6.88 man-days for large farms. Small farms showed the highest reliance on family labour, whereas large farms likely replaced family labour with hired labour or mechanization.

Machine labour increased significantly with farm size. Small farms used only 11.00 machine hours, medium farms used 19.79 hours, while large farms utilized 30.17 hours. The reliance on mechanization on large farms underscores the efficiency required for large-scale operations.

Seed usage for small farms was 3760.56 kg/ha, for medium farms 3709.88 kg/ha and for large farms 3632.17 kg/ha. The decrease in seed quantity with increasing farm size attributed to better seed management or higher seed efficiency on larger farms.

Small farms applied the highest amount of manure, averaging 7726.83 kg/ha, followed by large farms at 8842.07 kg/ha and

medium farms at 6359.08 kg/ha. The significant use of manure on small farms reflected their emphasis on organic soil enrichment due to limited access to chemical fertilizers.

Small farms used the most nitrogen fertilizers at 105.16 kg/ha, followed by medium farms (84.17 kg/ha) and large farms (76.75 kg/ha). Smaller farms may focus on nitrogen to boost crop growth due to limited access to other nutrients. Phosphorus application was highest on large farms (55.56 kg), followed by medium farms (49.17 kg/ha) and small farms (45.63 kg/ha). This trend indicated a balanced approach to soil fertility management as farm size grows. Potassium usage increased significantly with farm size, with small farms applying 254.43 kg/ha, medium farms 287.22 kg/ha and large farms 326.39 kg/ha. The higher potassium levels on larger farms reflected its role in improving crop quality and yield.

Irrigation requirements were highest on large farms at 43.77 hours/ha, compared to 35.00 hours/ha for medium farms and 30.17 hours/ha for small farms. Larger farms likely require more irrigation due to their larger cultivated area.

Large farms used the most plant protection chemicals 7.16 liters/ha, reflecting the increased need for pest and disease management in larger cultivation areas. Medium farms used 4.29 liters/ha, while small farms applied only 6.19 liters/ha.

Table 1: Level of input used by farmers (per ha)

Particular		Small	Medium	Large	Overall
Hired labour (man days)		7.00	10.87	13.11	11.09
Family labour (man days)		50.92	22.17	6.88	21.17
Machine labour (hour)		11.00	19.79	30.17	22.72
Seed (kg)		3760.56	3709.88	3632.17	3684.78
Manure (kg)		7726.83	6359.08	8842.07	7788.48
Fertilizer (kg)	N	105.16	84.17	76.75	85.16
	P	45.63	49.17	55.56	51.37
	K	254.43	287.22	326.39	298.35
Irrigation (hour)		30.17	35.00	43.77	38.02
Plant protection chemicals (liter)		6.19	4.29	7.16	6.01

Cost of cultivation of potato

Table 2 presents a breakdown of costs associated with potato farming across small, medium and large farms, expressed in both absolute values and percentages. Different components, *viz*., hired labour, family labour, seed, manure, fertilizer, irrigation, plant protection chemicals, working capital cost, rental value of own land, interest on fixed capital and management cost were included in calculating the cost of cultivation.

The rate of depreciation was 5 per cent for kachha building, 2 per cent for pakka building and 20 per cent for other equipment which were used in potato cultivation. The rate of interest on working capital was 12 per cent annually. The rate of interest on fixed capital was 10 per cent annually. To calculate the interest on fixed capital the present value of fixed capital was calculated for total landholding and it was converted into the propionate area under potato cultivation form total land holding. The management cost was considered as 10 per cent of Cost C_1. The total cost of potato farming varied by farm size, with small farms averaging a total cost of 204265.13 ₹/ha, medium farms at 208771.20 ₹/ha and large farms at 215943.39 ₹/ha. This was mainly due to higher seed cost (48%), higher cost of plant protection chemicals (11.85%). Other expenditures of inputs were machine labour (4.74%), manure (3.66%), irrigation (2.91%), plant protection chemicals (2.89%), hired labour (1.20%). The highest not payable but accounted expenditure was rent on own land (9.15 per cent) followed by management cost (9.09%), interest on working capital (3.04%), family labour (2.43%), depreciation (0.30%) and interest on fixed capital (0.26%). Almost identical findings were noted by Tripathi *et al.* (2005) [18]. For medium farmers, the costs of plant protection chemicals and fertilizers were lower than those for both small and large farmers, similar findings were reported by Sudheer (2013) [16]. The cost of family labour decreases as the size of the farm increases, which aligns with the findings of Pandey *et al.* (2004) [9].

Table 2: Cost of cultivation of potato (₹/ha)

Particular	Small		Medium		Large		Overall	
	Value	Percent	Value	Percent	Value	Percent	Value	Percent
Hired labour	1644.44	0.81	2317.78	1.11	3072.03	1.42	2344.75	1.20
Machine labour	5356.11	2.62	9713.89	4.65	12353.31	5.72	9141.10	4.74
Seed	84315.87	41.28	115333.33	55.24	101278.03	46.90	100309	48.48
Manure	7450.71	3.65	6359.083	3.05	8842.074	4.09	7550.62	3.66
Fertilizer	35965.33	17.61	20654.67	7.02	27464.70	12.72	28028.23	11.85
Irrigation	5289.52	2.59	6021.11	2.88	6626.48	3.07	5979.04	2.91
Plant protection chemicals	7228.17	3.54	3643.61	1.75	7332.80	3.40	6068.19	2.89
Depreciation	406.03	0.20	612.89	0.29	761.42	0.35	593.45	0.30
Interest on working capital	5906.25	2.89	6346.25	3.04	6709.23	3.11	6320.58	3.04
Rent of own land	20000	9.79	19000	9.10	19217.39	8.90	19405.80	9.15
Interest on fixed capital	48.68	0.02	504.94	0.24	810.062	0.38	454.56	0.26
Family labour	12084.44	5.92	5284.44	2.53	1844.64	0.85	6404.51	2.43
Management cost	20790.71	9.09	18979.20	9.09	19631.22	9.09	19800.38	9.09
Total Cost (C_2)	228697.80	100.00	208771.20	100.00	215943.39	100.00	217804.13	100.00

Estimates of different cost

Table provides a breakdown of different cost categories - Cost A_1, Cost A_2, Cost B_1, Cost B_2, Cost C_1 and Cost C_2 - for potato farming, categorized by small, medium, and large farms.

Small farms have a Cost A_1 of 175773.96 ₹/ha (75.18% of total costs), medium farms 165002.61 ₹/ha (80.78%) and large farms 174440.10 ₹/ha (85.40%).

Cost B_1 for small farms 175822.64 ₹/ha, medium farms 165507.55 ₹/ha and large farms 175250.14 ₹/ha. This slight increase in percentage reflected the importance of working capital for operational flexibility, especially for larger farms that relied on credit facilities.

The values for Cost B_2 were 195822.64 ₹/ha (84.99%) for small farms, 184507.55 ₹/ha (90.33%) for medium farms and 194467.53 ₹/ha (95.20%) for large farms. The increase in this cost category across farm sizes suggested that land value plays a greater role in overall expenses as farm size grows.

Cost C_1 for small farms 207907.08 ₹/ha, medium farms

189792.00 ₹/ha and large farms 196312.18 ₹/ha.
The values for Cost C_2 were 228697.79 ₹/ha for small farms, 208771.20 ₹/ha for medium farms and 215943.39 ₹/ha for large farms. In the case of medium farmers, it was observed that all costs were decreasing which was similar to the findings reported by Venyo.

Table 3: Estimates of different cost (₹/ha)

Category of farmer	Different cost					
	Cost A_1	Cost A_2	Cost B_1	Cost B_2	Cost C_1	Cost C_2
Small	175773.96 (75.18)	175773.96 (75.18)	175822.64 (75.20)	195822.64 (84.99)	207907.08 (90.91)	228697.79 (100.00)
Medium	165002.61 (80.78)	165002.61 (80.78)	165507.55 (81.03)	184507.55 (90.33)	189792.00 (92.91)	208771.20 (100.00)
Large	174440.10 (85.40)	174440.10 (85.40)	175250.14 (85.80)	194467.53 (95.20)	196312.18 (96.11)	215943.39 (100.00)
Overall	171738.89 (79.07)	171738.89 (79.07)	172193.45 (79.33)	191599.24 (88.48)	198003.75 (90.91)	217804.13 (100.00)

Return measures and benefit cost ratio for potato cultivation
Table 4 presents gross return, net return and benefit cost ratio for potato cultivation. The yield increased with farm size, with small farmers achieved an average of 309.42 q/ha, medium farmers produced 349.03 q/ha, and large farmers reached 390.06 q/ha. The price realization also improved with scale, ranging from 921.78 ₹/q for small farmers to 1405.35 ₹/q for large farmers. Gross returns were directly proportional to farm size, with small farmers earned. 285217.69 ₹/ha, medium farmers 447790.65 ₹/ha and large farmers 548178.20 ₹/ha. The benefit cost ration increased with farm size, with small farms at 0.24, medium farms at 1.14 and large farms at 1.60 highlighting the significant profitability of potato farming in the study area. Thus, the null hypothesis stating that potato cultivation is not a profitable proposition in the study area was rejected.

Table 4: Gross return, net return and benefit cost ratio for potato cultivation

Particular	Small	Medium	Large	Overall
Average yield of product (q/ha)	309.42	349.03	390.06	359.59
Average price of product (₹/q)	921.78	1282.97	1405.35	1263.42
Gross return (₹/ha)	285217.69	447790.65	548178.20	459828.60
Net Return (₹/ha)	56519.90	239019.45	332234.81	243573.61
Farm business income (₹/ha)	109443.73	282788.04	373738.12	288222.77
Family labour income (₹/ha)	89395.05	263283.10	353710.67	268363.29
Net income (₹/ha)				
Cost A_1	108256.86	282864.74	377751.30	289844.90
Cost A_2	108256.86	282864.74	377751.30	289844.90
Cost B_1	108208.18	282359.80	376941.24	289295.42
Cost B_2	195822.64	263359.80	357723.85	292584.46
Cost C_1	76123.74	258075.36	355879.21	264855.29
Cost C_2	55333.03	239096.16	336247.99	245195.74
Benefit cost ratio				
Gross return	1.24	2.14	2.60	2.16
Net return	0.24	1.14	1.60	1.16
Cost of production (₹/q)				
Cost A_1	685.87	479.55	464.66	516.03
Cost A_2	685.87	479.55	464.66	516.03
Cost B_1	686.05	481.09	466.85	517.58
Cost B_2	765.34	536.60	518.25	576.19
Cost C_1	803.27	551.65	523.80	591.68
Cost C_2	883.60	606.81	576.18	650.85

Conclusion
Potato cultivation plays a critical role both globally and locally as a staple food source and an economic driver for farmers. A study in Gujarat highlights how farm size influences input use, costs and profitability. Small farms rely on family labour and organic inputs, while larger farms benefit from mechanization and economies of scale, achieving higher yields and returns. Medium farms balance resource use effectively. Seed and fertilizer dominate costs and land value significantly impacts larger farms. The benefit-cost ratio clearly shows that large farms outperform small and medium ones in financial returns. This underscores the importance of scaling operations, improving input efficiency and adopting modern farming practices. To enhance sustainability and profitability, efficient practices, market access and support for small farmers are crucial. Overall, potato farming in Gujarat presents a promising opportunity for enhancing food security, supporting rural livelihoods, and contributing to agricultural growth. By overcoming challenges and embracing innovations, the sector can achieve greater economic resilience and sustainability.

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