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AN ECONOMIC ANALYSIS AND RESOURCE USE EFFICIENCY OF SOYBEAN PRODUCTION IN MIDDLE GUJARAT INDIA

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ABSTRACT

The study focused on the cost and returns, resource use efficiency of the soybean production. A multistage random sampling method was used to select the sample. The study included 4 talukas, 12 villages and 120 soybean farmers comprising 45 marginal, 38 small, 26 medium and 11 large farmers from Dahod and Chhotaudepur districts. The primary analytical tools used in the study included tabular analysis, cost concepts and production function analysis. The average total cultivation cost per hectare for soybean farms was 48,333.41. The overall input-output ratio based on Cost C_2 was 1:1.89. Considering the costs, returns and input-output ratio, it is concluded that soybean cultivation was profitable in the middle Gujarat region. The resource efficiency of soybean growers was evaluated using the cobb-douglas production function, with gross income serving as the dependent variable. The analysis focused on six variables, which collectively explained 76 per cent of the variation in gross income, as indicated by an R^2 value of 0.76. The overall sum of the elasticity coefficients, which total 1.14, revealed that the soybean production operates under increasing returns to scale. MVP/MFC ratio was highest for manures (4.20) and human labour (1.11), indicating that these resources were underutilized. However, for seeds (0.54), fertilizers (-5.27), plant protection chemicals (-4.04) and tractors (0.75) were less than one, suggesting overutilization of these resources in the study area.
***Keywords*:** Cost of cultivation, returns, B-C ratio, resource use efficiency, return to scale.

Introduction

Oilseed crops play an important role in Indian agriculture, industry and export trades. Among all the oilseed crops, soybean is the second major edible oilseed crop after groundnut. Soybean (*Glycine max* L.), known as the "golden bean" or "miracle crop," holds promise due to its nutritional value and versatility. Providing a complete source of protein and oil, soybeans are crucial for addressing food security and nutritional needs. Originating from China and introduced to India around five thousand years ago. Soybean, "the miracle golden bean of the 20th century," has revolutionized agriculture as well as the general economy of many countries like China and Japan. (Gupta, 2012).

Nearly 80 per cent of children are suffering from protein malnutrition. Soybean is a good source of protein (40% and above), which is a rich and cheap source of quality vegetable protein. It is a boon crop for vegetarians, known as “poor-man’s meat” and “meat harvested from the field.” (Kale, 1985).

Brazil ranks first in terms of soybean production, followed by USA. India stands at 6th position in terms of production and it shares 3.51 per cent of soybean production in the world. In India, Madhya Pradesh covers the largest portion, with (45.66%). Gujarat stands out with the highest productivity (Anonymous 2022). In middle Gujarat, Dahod and Chhotaudepur districts emerge as notable contributors to agricultural activity with area 239.40 hundred hectares and 148.65

hundred hectares, respectively (Anonymous 2023). So, find the total cost of cultivation and resource utilization using below mentioned objectives.

1. To estimate the cost and returns in production of soybean
2. To analyze the resource use efficiency in production of soybean

Materials and Methods

The study was conducted exclusively in the middle Gujarat districts. Multistage random sampling was used for the study. Three villages were randomly chosen from each selected taluka. Thus, a total of 12 villages were choose for the study. A total of 120 soybean growers were selected for the study. The respondents were categorized based on their land holdings into four groups: 45 marginal farmers (up to 1.00 ha), 37 small farmers (>1.00 to 2.00 ha), 26 medium farmers (>2.00 to 4.00 ha) and 11 large farmers (>4.00 ha).

Data Collection

The primary data for the study was collected from the Dahod and Chhotaudepur areas using an interview schedule. The data pertains to the agricultural year 2023-24 and covers aspects related to costs, returns and resource use patterns in the study area.

Calculation of Cost and Return

The collected data was analyzed and presented in tables for easy comparison. This tabular analysis method was used to estimate the costs, returns and profitability of crop cultivation of soybean. The CACP cost concept, including cost A, cost B, cost C_1 and cost C_2, was employed to compute the cost of cultivation and production.

Cost A =	Value of hired human Labour + Value of bullock Labour (owned / hired) + Value of seeds (owned / purchased) + Value of manure (owned / purchased) + Value of fertilizer + Value of pesticides and insecticides + Irrigation charges + Charges for machineries (owned / hired) + Other paid out expenses if any + Depreciation on farm building and implements + Interest on working capital
Cost B =	Cost A + Rental value of owned land + Interest on fixed capital assets (excluding land)
Cost C_1 =	Cost B + Imputed value of family labour
Cost C_2 =	Cost C_1 + 10 per cent of the Cost C_1 as a managerial charge

Resource Use Efficiency

The cobb-douglas production function was fitted to evaluate the resource use efficiency in the production of soybean.

$$\mathbf{Y = a.\ x_1^{b1}.\ x_2^{b2}.\ x_3^{b3}.\ x_4^{b4}.\ x_5^{b5}.\ x_6^{b6}.\ x_7^{b7}.\ e^u}$$

The original equation (2) was converted into log linear from and the parameters were estimated by using the ordinary least square method.

$$\mathbf{\log Y = \log a + b_1 \log x_1 + b_2 \log x_2 + b_3 \log x_3 + b_4 \log x_4 + b_5 \log x_5 + b_6 \log x_6 + b_7 \log x_7 + e^u}$$

where, Y = gross income of soybean (≠), x_1 = Cost of human labour (≠), x_2 = Cost of bullock labour (≠), x_3 = Cost of manures (≠), x_4 = Cost of seeds (≠), x_5 = Cost of fertilizers (≠), x_6 = Cost of plant protection chemicals (≠), x_7 = Cost of irrigation charges (≠), a = Intercept b_1, b_2, …. b_7 = Regression co-efficient {output elasticity of respective input (X_i's)}, $\sum_{i=1}^{n} bi$ = Returns to scale (sum of regression co-efficient), e^u = Error term with usual assumptions

Measurement of returns to scale

The returns to scale studied the changes in output when all factors are changed. The estimated regression coefficients represent the production elasticity. Returns to scale was calculated by the summation of the regression coefficients of the model. If this sum is 1, then there are constant returns to scale, If the sum is less than 1, there are decreasing returns to scale, If the sum is greater than 1, there are increasing returns to scale.

The regression coefficients of inputs obtained were used to calculate marginal value products (MVP) at their geometric mean.

$$MVP\ (x_i) = b_i \frac{\bar{y}}{\bar{x}}$$

where, $\bar{y}$= Geometric mean of output (Y),

$\bar{x}$ = Geometric mean of respective inputs (x_i),

b_i = Regression coefficient associated with the x_i input.

In the present study, MFC was the average cost of input used. In order to test the efficiency, the ratio of MVP to the MFC for each input was computed and tested for its equality to 1 *i.e.*, (MVPxi ÷ MFCxi) = 1. The criterion for determining optimality of resource use is as follows;

MVP/MFC > 1: Under-utilization of resources
MVP/MFC = 1: Optimal use of resources
MVP/MFC < 1: Over utilization of resources

Results and Discussion

Cost and Returns Analysis of soybean growers

Among all farm expenses, human labour accounted for the highest share (22.94%). The results revealed that the average total cultivation cost per hectare of soybean farms was ≠ 48,333.41.

Table 1: Break-up of the total cost of cultivation for soybean (≠/ha)

Sr. No.	Particulars	Group of farms				
		Marginal	Small	Medium	Large	Overall
1.	Human labour	10718.85 (22.23)	11782.40 (25.17)	10602.80 (20.82)	11319.42 (21.87)	11085.55 (22.94)
	(a) Family labour	10278.69 (21.32)	8987.92 (19.20)	7908.33 (15.53)	6400.41 (12.36)	9000.86 (18.62)
	(b) Hired labour	440.16 (00.91)	2794.49 (05.97)	2694.44 (05.29)	4919.01 (09.50)	2084.69 (04.31)
2.	Tractor	4910.16 (10.18)	4173.94 (08.48)	4704.01 (09.24)	4104.30 (07.93)	4558.49 (9.43)
3.	Seed	4339.08 (09.00)	4148.36 (08.86)	4159.57 (08.17)	4380.23 (08.46)	4243.56 (08.78)
4.	Manures	4530.74 (09.65)	4808.21 (10.27)	6149.07 (12.07)	4979.34 (09.62)	5010.36 (10.37)
5.	Fertilizers	1650.34 (03.42)	1788.76 (02.57)	1696.14 (03.33)	2905.20 (05.61)	1819.33 (03.76)
6.	Plant protection	1369.23 (02.84)	2260.75 (04.83)	2575.11 (05.06)	2975.20 (05.75)	2060.03 (04.26)
7.	Irrigation	274.30 (00.57)	284.95 (00.60)	392.37 (00.77)	789.02 (01.52)	350.44 (00.73)
8.	Harvesting	3970.86 (08.24)	3324.01 (07.10)	4404.32 (08.65)	4311.57 (08.33)	3891.17 (08.05)
9.	Miscellaneous	1278.05 (02.65)	1219.86 (02.61)	1781.17 (03.50)	1176.24 (02.27)	1359.30 (02.81)
10.	Depreciation	1007.10 (02.09)	1114.31 (02.38)	1079.44 (02.12)	1183.88 (02.29)	1072.93 (02.22)
11.	Interest on working capital	1566.23 (03.25)	1015.74 (02.24)	1185.4.3 (02.33)	1259.89 (02.43)	1281.32 (02.65)
12.	Rental value of owned land	5887.98 (12.21)	5844.60 (12.49)	6129.63 (12.03)	6942.15 (13.41)	6023.23 (12.46)
13.	Interest on fixed capital	1311.00 (02.72)	1048.53 (02.24)	1445.79 (02.84)	1488.96 (02.88)	1273.40 (02.63)
14.	Managerial Cost	4972.89 (10.31)	4291.79 (09.09)	4630.48 (09.09)	4706.11 (09.09)	4555.84 (09.43)
15.	Cost A	25239.29 (54.66)	26409.32 (56.98)	30821.12 (60.51)	32257.00 (62.31)	27462.48 (56.82)
16.	Cost B	32439.09 (69.59)	33302.52 (71.71)	38396.52 (75.38)	40660.72 (78.55)	34756.94 (71.91)
17.	Cost C_1	42717.78 (90.91)	42917.92 (90.91)	46304.92 (90.91)	47660.72 (90.91)	43956.51 (90.94)
18.	Cost C_2 (Total Cost)	46939.56 (100.00)	47209.70 (100.00)	50935.35 (100.00)	51767.25 (100.00)	48333.41 (100.00)

Note: Figures in parentheses indicate the percentage (Source: Field Survey)

In the various farm categories, large farms had the highest cultivation cost at ≠ 51,767.25 per hectare. Medium farms were next with a cost of ≠ 50,935.35 per hectare. Small farms spent ≠ 47,209.70 per hectare and marginal farms had the lowest costs at ≠ 46,939.56 per hectare. Larger farms spent more on soybean cultivation compared to smaller farms. The overall per-hectare costs were observed as follows: Cost A was ≠ 27,462.48, Cost B was ≠ 34,756.94, Cost C_1 was ≠ 43,956.51 and Cost C_2 was ≠ 48,333.41. Similar observations were observed by Pachpute et al. (2017) and Medat (2015).

Yield, Price, Gross Return and Net Return

Information about yield, farm harvest price and gross income per hectare from soybean production across various farm size categories provided in Table 2.

Table 2: Group wise production and income per hectare

Sr. No.	Particulars	Category of farm				
		Marginal	**Small**	**Medium**	**Large**	**Overall**
1.	**Main product**					
	Quantity (q)	17.64	17.47	18.92	20.07	18.92
	Price (≠/q)	4566.59	4696.25	4909.52	4818.22	4797.64
	Income (≠)	80551.64	82055.86	92894.46	96702.83	90842.81
2.	**By product**					
	Quantity (q)	04.26	04.14	04.36	04.32	4.29
	Price (≠/q)	798.07	969.41	975.57	968.72	955.40
	Income (≠)	3402.24	4012.75	4255.77	4186.33	4098.83
	Gross Income (≠)	**83953.88**	**86068.61**	**97150.23**	**100889.16**	**94941.64**

Source: Field Survey

Overall, the production of the main product quantity was (18.92 q/ha), generating an income of (≠ 90,842.81/ha). The quantity of by-product was (4.29 q/ha), yielding an income of (≠ 4,098.83/ha). Thus, the total gross income from soybean production amounted to (≠ 94,941.64/ha). Large farms reported the highest gross income per hectare by ≠ 100,889.16. Medium farms followed with ≠ 97,150.23 per hectare. Small farms earned ≠ 86,068.61 per hectare, while marginal farms had the lowest income at ≠ 83,953.88 per hectare.

Net Returns over costs

Table 3 shows that large farms had the highest net returns per hectare after operational costs (Cost A), by ≠ 68,632.16.

Table 3: Net returns over different costs per hectare

Different costs (≠/q)	Category of farm				
	Marginal	**Small**	**Medium**	**Large**	**Overall**
Cost A	58714.59	59659.29	66387.70	68632.16	**65068.18**
Cost B	51514.79	51837.71	58812.27	60228.44	**57163.24**
Cost C_1	41236.10	42849.78	50903.94	53828.03	**49369.19**
Cost C_2	36964.32	38594.22	46273.45	49121.91	**44824.45**

Source: Field Survey

Overall, the average net returns per hectare were ≠ 65,068.18 after Cost A, ≠ 57,163.24 after Cost B, ≠ 49,369.19 after Cost C_1 and ≠ 44,824.45 after Cost C_2. Medium farms followed with ≠ 66,387.70, small farms with ≠ 59,659.29 and marginal farms with ≠ 58,714.59. This highlights that larger farms tend to have higher net returns after covering their operational costs.

Cost Price Relationship

The overall cost (Cost A) per quintal amounted to ≠ 1360.29, constituting 55.92 per cent of the total expenditure. Following this, Cost B about ≠ 1766.98, equivalent to 72.64 per cent of the total cost. Cost C_1 accounted for ≠ 2191.57, representing.90.10 per cent of the total expenses. The total cost, referred to as cost C_2, summed up to ≠ 2432.42. The cost of production over cost C_2 for marginal farms averaged (≠ 2472.03/q), while for small farms, it was (≠ 2471.26/q). Medium farms recorded a cost of (≠ 2467.04/q) and large farms had a cost of (≠ 2370.72/q).

Table 4: Cost of production over different costs

Different costs (≠/q)	Category of farm				
	Marginal	**Small**	**Medium**	**Large**	**Overall**
Cost A	1237.97 (50.10)	1281.81 (51.85)	1403.99 (56.91)	1398.62 (59.00)	**1360.29 (55.92)**
Cost B	1646.14 (66.62)	1676.32 (67.81)	1804.36 (73.14)	1817.34 (76.65)	**1766.98 (72.64)**
Cost C_1	2228.85 (90.20)	2226.63 (90.06)	2222.32 (90.08)	2136.24 (90.11)	**2191.57 (90.10)**
Cost C_2	2472.03 (100.00)	2471.26 (100.00)	2467.04 (100.00)	2370.72 (100.00)	**2432.42 (100.00)**

Note: Figures in parentheses indicate the percentage
Source: Field Survey

Input-Output Ratio

The overall input-output ratio for all farm categories under Cost A was 1:3.18. Similarly, for Cost B, it was 1:2.53, for Cost C1, it stood at 1:2.08 and for Cost C2, it was 1:1.89. Additionally, it was noted that the input-output ratio based on Cost A was highest (3.33) for marginal farms, followed by small farms (3.26) and medium farms (3.15), conversely, it was lowest (3.13) on large farms. Similar results were observed in the thesis of Joshi (2022).

Table 5: Input-output ratio

Different costs (≠/q)	Category of farm				
	Marginal	**Small**	**Medium**	**Large**	**Overall**
Cost A	1:3.33	1:3.26	1:3.15	1:3.13	**1:3.18**
Cost B	1:2.59	1:2.58	1:2.53	1:2.48	**1:2.53**
Cost C_1	1:1.97	1:2.01	1:2.10	1:2.14	**1:2.08**
Cost C_2	1:1.79	1:1.82	1:1.91	1:1.95	**1:1.89**

Production function analysis

In the Cobb-Douglas production function, the regression coefficient signifies the elasticity of production concerning a specific input.

Table 6: Estimated production function for soybean **(n=120)**

Sr. No.	Variables	Production Elasticity (bi)	Standard Error
1.	X_1 = Human labour (≠)	0.0943*	0.046
2.	X_2 = Cost of seeds (≠)	0.025*	0.011
3.	X_3 = Manures (≠)	0.245**	0.089
4.	X_4 = Cost of fertilizers (≠)	-0.020	0.016
5.	X_5 = Cost of plant protection chemicals (≠)	-0.001	0.016
6.	X_6 = Tractor cost (≠)	0.022	0.020
	Constant = 0.778**		
	R^2 = 0.76		
	Σ bi's = 1.14		

** Significant at 1 per cent level of significance
* Significant at 5 per cent level of significance

According to Table 4.13, the coefficient of multiple determination (R^2) was 0.76. This indicates that the six specified variables (X_1, X_2, X_3, X_4, X_5 and X_6) account for 76 per cent of the total variation in gross income. The sum of the elasticity coefficients was 1.14, which, being greater than one, indicated increasing returns to scale. In other words, the sample farmers were observed to be operating in the first zone of production.

The regression coefficient for the cost of manure was 0.245, which was highly significant. This means

that a one per cent increase in the cost of manure would have resulted in a 0.245 per cent increase in the gross income from soybean. Other significant regression coefficients included the cost of seeds (0.025) and the cost of labour (0.094), both of which were positive and significant at the five per cent level. On the other hand, the coefficients for the cost of fertilizers (-0.020) and the cost of plant protection chemicals (-0.001) were negative and not statistically significant which means that for every unit increase in spending on fertilizers, gross income decreases by 0.020 units. Similarly, each additional unit spent on plant protection chemicals reduces gross income by 0.001 units. The tractor cost coefficient (0.022) was positive but not significant. Similar findings were reported by Gadad *et al.* (2018).

Resource Use Efficiency in Soybean Production

The data furnished in the Table 4.14 reveal that the MVP/MFC ratio was the highest in case of manures (4.20) followed by human labour (1.11), this indicated that an addition of one rupee in manures and human labour charges would yield return of 4.20 and 1.11, respectively. In case of the MVP to MFC ratio of seed (0.54), fertilizer (-5.27), plant protection chemicals (-4.04) and tractor (0.75) was less than one indicating over utilization of these resources in the study area. These results were similar to those reported by Yogananda (2016).

Table 7: Resource use efficiency in soybean production

Sr. No.	Inputs	MVP	MFC	MVP:MFC ratio	Level of resource use
1.	Human labour	01.11	01.00	01.11	Under utilization
2.	Seed	00.54	01.00	00.54	Over utilization
3.	Manure	04.20	01.00	04.20	Under utilization
4.	Fertilizer	-05.27	01.00	-05.27	Over utilization
5.	Plant protection chemicals	-04.04	01.00	-04.04	Over utilization
6.	Tractor	00.75	01.00	00.75	Over utilization

Conclusion

Soybean cultivation in middle Gujarat is economically viable, with different farm sizes exhibiting varying levels of profitability. Larger farms tend to have higher production costs but also generate more significant returns due to greater yields. Efficient management of resources such as labour and inputs are crucial to maintaining cost efficiency and maximizing profits across all farm sizes. Among soybean farmers, manures and human labour were underutilized, while fertilizers and plant protection chemicals were often overused. Since soybeans are a pulse crop, they require less fertilizer and fewer chemicals. Over used these inputs can negatively impact on production, reduce overall yields and also increase the cost. By balancing the use of resources, farmers can improve both productivity and profitability. Efficient and optimized resource management is key to achieving better outcomes in soybean farming.

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