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Assessing the Economics and Input Use Efficiency of Pearl Millet Cultivation in North Gujarat, India

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ABSTRACT

Millets have gained considerable attention in recent years due to increasing awareness regarding their nutritional importance. Owing to their low input requirement and resilience under adverse conditions, they are also becoming increasingly popular among producers. The present study was conducted in the Sabarkantha and Mehsana districts of Gujarat where pearl millet is widely cultivated during the summer season. A multistage sampling technique was employed for the study. The findings revealed that labour constituted the major share of the total cost of cultivation. The benefit-cost ratio was estimated at 1.44 :1.0 in Mehsana and 1.24 :1.0 in Sabarkantha, indicating that pearl millet cultivation was profitable in both districts. Resource use efficiency analysis showed that fertilizers and pesticides had a significant positive influence on output, suggesting scope for improving productivity through their optimum utilization. The study highlighted the need for coordinated efforts among all stakeholders involved in pearl millet cultivation to promote efficient input management. Capacity-building initiatives focusing on precise and effective use of inputs can further enhance increase benefits level.

Keywords: Capacity building, Efficiency, Millets, Inputs, Resources.

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INTRODUCTION

India ranks first globally in millet production. Growing concerns about climate change, along with the need to transition toward more sustainable and resilient agricultural systems, have renewed interest in millet cultivation in recent years, with India emerging as a leading force in this movement. Millets have long been a fundamental part of the diet for both humans and animals across generations. (Dixit and Ravichandran, 2023). Global millet production stands at around 98 million tonnes, of which pearl millet accounts for nearly 24 percent. India contributes about half of the world's pearl millet production, highlighting its significant role in the country's agricultural system (Yadav *et al,* 2024). India has recored 7.35 million hectare land under pearl millet in 2024-25 with total production of 11.20 million tonnes. In Gujarat, where pearl millet is primarily grown during the summer season, approximately 0.50 million hectares (constituting nearly 44 percent of the total summer cropped area) were devoted to bajra cultivation, resulting in a production of 1.26 million tonnes in 2024–25 (GoI, 2026; GoG, 2026).

Given the growing importance of millets, especially pearl millet, at both national and state levels, it becomes imperative to examine the economics and resource-use efficiency of inputs at the field level to enhance production and productivity. Accordingly, the present study was undertaken in two districts of North Gujarat, *viz.,* Sabarkantha and Mehsana with the objectives to compute the cost structure of pearl millet cultivation in selected districts and to find out the significant factors affecting production and their resource use efficiency levels.

MATERIALS AND METHODS

The present study forms a part of a broader research project aimed at assessing the water productivity of crops and livestock under both conventional and water-saving technologies in North Gujarat, India. The present study was conducted in two districts, namely Mehsana and Sabarkantha. A

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Table 1. Distribution of Pearl Millet Cultivators by Districts, Talukas and Villages

Sr. No.	District	Taluka	Village	No. of Growers
1.	Sabarkantha	Idar	Kukadiya, Umedgarh	46
		Vijayanagar	Kundla Kampa, Andropa	
2.	Mehsana	Satlasana	Vaghar, Isakpura	71
		Kheralu	Moti Hirvani, Gajipur	

multistage sampling technique was employed to select the sample, wherein districts, blocks, and villages were chosen based on livestock population and the adoption of modern water-saving technologies. The relevant data for this selection were obtained from the Gujarat Green Revolution Company, the nodal agency for micro-irrigation in the state.

The study utilised data taken from 117 pearl millet growers. Out of these, 26 were marginal farmers (<1 ha), 39 were small farmers (1–2 ha), 30 were semi-medium farmers (2–4 ha) and 22 were medium farmers (4–10 ha).

The detailed methodology employed to achieve the stated objectives is presented below. It incorporates analytical tools such as tabular analysis, percentages, ratios, and regression models.

Cost and Benefit analysis of Pearl Millet Cultivation

To assess the level of financial gain from any production activity one need to analys the cost and benefit mechanism. The production of any crop involves cost incurred on tillage operations, seeds, FYM, fertilizers, labour cost on various operations, cost incurred on plant protection chemicals and threshing. Apart from this the returns over variable cost, gross returns and benefit to cost ratio were calculated with the help of below given formulas.

- Gross Returns = Revenue generated from sell of main product+ Revenue generated from sell of by product
- Returns over variable cost = Gross Returns-Total Variable Cost
- Benefit-Cost ratio = $\frac{Gross\ Return}{Total\ Variable\ Cost}$

Resource utilization pattern, resource use efficiency and returns to scale

In analysis of assessing the influencing factors for output production and to asses the resource's efficiency in the production process Cobb–Douglas production function is popular tool in agricultural economics. It also assists in determining level of returns to scale of farm operating (Singh *et al,* 2024*;* Sharma *et al,* 2024; Borisagar *et al,* 2025*).*

The general form of the production function is as follow: $Y = \beta_0 X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} X_4^{\beta 4} X_5^{\beta 5} e^{ui}$

After applying the log transformation, the

$$ln\ Y = ln\ \beta_0 + \beta_1 ln\ X_1 + \beta_2\ ln\ X_2 + \beta_3\ ln\ X_3 + \beta_4\ ln\ X_4 + \beta_5\ ln\ X_5 + u_i$$

Where,

Y = Total returns from pearl millet production (Rs/ha)

X_1 =Total seed cost (Rs/ha)

X_2 = Total fertilizer Cost (Rs/ha)

X_3 = Total pesticide cost (Herbicides, Insecticides and fungicides) (Rs/ha)

X_4 = Total labour cost (Rs/ha)

X_5 = Total Machinery cost (Rs/ha)

β_0 = Constant term

β_1-β_5 = Regression coefficients

X_1-X_5 = Independent variables

u_i = Stochastic error term

Returns to scale refer to the change in output resulting from a simultaneous change in all input factors. In the case of a power function, which represents a homogeneous production function, the sum of its coefficients indicates the nature of returns to scale.

$$RTS = \sum_{i=1}^{j} . \beta_i$$

Here, β_i is the production or regression coefficients of variable X_1 to X_j

Consequently, if the returns to scale (RTS) > 1, it reflects increasing returns to scale; if <1, it indicates

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Table 2. Breakdown of variable cost incurred in pearl millet cultivation.

Sr. No.	Particular	Sabarkantha		Mehsana	
		Cost (Rs/ ha)	Share (%)	Cost (Rs/ ha)	Share (%)
1.	Seed	2344.50	2.70	2228.16	3.23
2.	Chemical Treatment	81.94	0.09	76.73	0.11
3.	FYM	10259.03	11.84	6154.92	8.92
4.	Pesticides	4873.81	5.62	4753.42	6.89
5.	Fertilizers	4949.21	5.71	5291.73	7.67
a)	Urea	820.91		942.42	
b)	DAP	4128.30		4349.31	
6.	Labour cost	51097.39	58.95	37973.94	55.02
7.	Machine cost	9862.34	11.38	9312.03	13.49
8.	Electricity Charges	1236.24	1.43	1658.41	2.40
9.	Sub total	84704.46		67449.33	
10.	Interest on Working Capital*	1976.437	2.28	1573.818	2.28
	Total Variable Cost	**86680.9**		**69023.15**	

*Note: - *@ 7% per annum for 4 months*

Table 3. Returns from pearl millet cultivation.

Sr. No.	Particular	Sabarkantha	Mehsana
1.	Variable Cost (Rs./ ha)	86680.90	69023.15
2.	Price (Rs. / q)- Main Product	2394.56	2355.79
3.	Price (Rs. / q)- By Product	186.41	155.79
4.	Yield - Main Product (q/ha)	40.59	38.82
5.	Yield - By Product (q/ha)	53.76	53.05
6.	Gross Returns	107216.60	99716.43
7.	ROVC (Rs. / ha) (6-1)	20535.70	30693.28
8.	BC over VC (6/1)	1.24	1.44

decreasing returns to scale; and if equal to 1, it corresponds to constant returns to scale.

The level of resource use efficiency was calculated using following formula:

$$r = \frac{MVP}{MFC}$$

Where r= Efficiency ratio

MVP = Marginal Value Product, which is the value of incremental unit of output resulting from the additional unit of inputs.

MFC = Marginal Factor Cost which is defined as the increase in the cost of inputs due to purchase of additional unit of inputs.

When value of r = 1, indicating maximum income with efficient resource use. If r < 1, this implies the input is overused. On the contrary, if r > 1 the input is underutilised, and increasing the usage can increase the returns.

RESULTS AND DISCUSSION

Economics of Pearl Millet Cultivation

The data (Table 2) represented the input wise breakdown of variable costs incurred for cultivation of pearl millet across Mehsana and Sabarkantha districts. Sabarkantha reported the highest total variable cost at ₹86,680/ ha, followed by Mehsana at ₹69,023.15/ha. Labour cost emerged as the most significant component across both districts, reaffirming the labour-intensive nature of pearl millet cultivation. It accounted for 58.95% (₹51,097.39/ha) in Sabarkantha and 55.02% (₹37,973.94/ha) in Mehsana, reflecting the substantial manual effort required for key operations such as sowing, interculture, and harvesting. Machinery costs followed it contributed 13.49% in Mehsana, and 11.38% in Sabarkantha to the total variable cost. The use of farmyard manure (FYM) was notably highest in Sabarkantha (₹10,259.03/ha, 11.84%), compared to ₹6,154.92/ha (8.92%) in Mehsana.

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Table 4. Cobb- Douglas production function for pearl millet cultivation.

Independent Variable	Sabarkantha		Mehsana	
	Coefficients	Standard Error	Coefficients	Standard Error
Constant (β_0)	1.4167	1.2059	3.2073***	0.5028
Seed (β_1)	0.2492**	0.1087	-0.0325	0.0172
Fertilizer (β_2)	0.0194	0.0362	0.2205***	0.0472
Pesticides (β_3)	0.0563	0.2591	0.3453***	0.0596
Labour Cost (β_4)	0.1231	0.1100	-0.0211	0.0405
Machinery Cost (β_5)	0.5035**	0.2169	0.0121	0.1178
R^2	84.26		68.97	
Adjusted R^2	82.25		66.47	
RTS= $\sum \beta_{1-5}$	0.95		0.52	
No. of Observations	45		68	

*Note: ***, ** indicate significance at 1% and 5 % level of significance, respectively.*

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Fertilizer application also varied slightly, with the total cost around ₹5,000/ha across districts. DAP remained the major fertilizer input, with expenditure highest in Mehsana (₹4,349.31/ha) and substantial in Sabarkantha (₹4,128.30/ha). Electricity charges were higher in Mehsana (₹1,658.41/ha, 2.40%) compared to Sabarkantha (₹1,236.24/ha, 1.43%), likely due to higher water-lifting energy requirements. Interest on working capital was found at approximately 2.28% of the total cost across all districts, amounting to ₹1,573.82/ha in Mehsana, and ₹1,976.44/ha in Sabarkantha. Similar results were also observed in other studies where they found labour cost is biggest component to the total variable cost (Sreedhar *et al,* 2021; Kumar *et al,*2023; Choudhary and Kumar, 2023).

The comprehensive overview of the returns from pearl millet cultivation across the districts of Mehsana and Sabarkantha is presented in Table 3. Sabarkantha reported the highest yield of the main product at 40.59 quintals per hectare, followed by Mehsana (38.82 q/ha). The by-product yield was relatively consistent across districts. Despite Mehsana having the lowest main product price at ₹2,355.79/q, its higher yield ensured competitive gross returns.

Gross returns were recorded to be highest in Sabarkantha at ₹1,07,216.60/ha, followed by Mehsana at ₹99,716.43/ha. However, when accounting for variable costs, Mehsana was most profitable district in pearl millet cultivation. With the lowest cultivation cost of ₹69,023.15/ha, Mehsana achieved the highest Return Over Variable Cost (ROVC) of ₹30,693.28/ha and the most favourable Benefit-Cost ratio over variable cost (BC over VC) at 1.44. While Sabarkantha, despite its highest gross returns, had the lowest ROVC (₹20,535.70/ha) and BC ratio (1.24) due to its considerably higher input cost of ₹86,680.90/ha. These findings suggest that while Sabarkantha leads in productivity and revenue generation, Mehsana emerges as the most cost-efficient district for pearl millet cultivation, delivering better profitability per rupee invested.

Resource use efficiency of Pearl Millet Cultivation

The Cobb-Douglas production function estimates for pearl millet cultivation in Sabarkantha and Mehsana was presented in Table 4, highlighting the influence of key inputs on output. In Sabarkantha, the model showed a strong fit with R^2 = 84.26%. Machinery cost (β = 0.5035) and seed cost (β = 0.2492) significantly influenced output at the 5% level, indicating the importance of mechanization and seed quality. The returns to scale (RTS) was 0.95, suggesting decreasing returns to scale. In Mehsana, the model fit was moderate (R^2 = 68.97%), but key inputs like pesticides (β = 0.3453) and fertilizers (β = 0.2205) were highly significant (1% level), highlighting the role of chemical inputs. The RTS was lower at 0.52, indicating strongly decreasing returns to scale. Overall, productivity in Sabarkantha was more influenced by mechanization and seed, whereas Mehsana depended more on fertilizers and pesticides. Both regions shown decreasing returns, suggesting the need for input efficiency rather than quantity expansion.

The data (Table 5) presented the Resource Use Efficiency (RUE) of pearl millet cultivation across the districts of Sabarkantha and Mehsana, based on the Marginal Physical Product (MPP), Marginal Value Product (MVP), and Marginal Factor Cost (MFC) of major inputs. In Sabarkantha, most inputs were found to be under-utilized. Seed (RUE = 12.66), pesticides

Table 5. RUE of pearl millet cultivation across districts.

SABARKANTHA						
	Coefficients	**MPP**	**MVP**	**MFC**	**RUE**	
Seed	0.249199	12.65625	12.65625	1	12.65625	Under-Used
Pesticides	0.056328	1.760913	1.760913	1	1.760913	Under-Used
Fertilizer	0.019359	0.609919	0.609919	1	0.609919	Over-Used
Labour	0.123125	0.368141	0.368141	1	0.368141	Over-Used
Machine	0.503464	6.775754	6.775754	1	6.775754	Under-Used
MEHSANA						
	Coefficients	**MPP**	**MVP**	**MFC**	**RUE**	
Seed	-0.03249	-2.09126	-2.09126	1	-2.09126	Over-Used
Pesticides	0.345346	10.47135	10.47135	1	10.47135	Under-Used
Fertilizer	0.220489	5.792064	5.792064	1	5.792064	Under-Used
Labour	-0.02113	-0.08876	-0.08876	1	-0.08876	Over-Used
Machine	0.012136	0.188053	0.188053	1	0.188053	Over-Used

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(1.76), and machinery (6.78) had RUE values significantly greater than 1, indicating potential for increased use to enhance productivity. In contrast, fertilizers (0.61) and labour (0.37) were over-utilized, suggesting inefficiencies in their current application levels.

In Mehsana, the pattern was more mixed. Pesticides (RUE = 10.47) and fertilizers (5.79) were clearly under-utilized, highlighting scope for improved application. However, seed (-2.09), labour (-0.09), and machinery (0.19) showed signs of over-use or negative efficiency, possibly reflecting diminishing returns or resource misallocation.

CONCLUSION

The cost and benefit analysis of pearl millet cultivation revealed that besides being a resilient and productive crop that provides valuable dry fodder for livestock during the monsoon season, pearl millet cultivation was also economically profitable in both regions covered under the study. The highest share of cultivation cost was incurred on labour, as operations such as cutting, harvesting, and threshing are still heavily dependent on manual labour, indicating considerable scope for mechanization. The resource use efficiency and returns to scale analysis further revealed that fertilizer is one of the key inputs capable of enhancing output levels. However, since pearl millet is generally considered a hardy crop, farmers tend to apply lower levels of inputs. The Resource Use Efficiency (RUE) ratio also indicated under utilization of fertilizers and pesticides. Therefore, stakeholders involved in pearl millet cultivation should focus on strengthening and refining the existing package of practices through training and awareness programmes aimed at promoting efficient and precise input use. Conducting such programmes in the study area could further enhance farmers' financial returns while ensuring sustainability in cultivation practices.

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