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Economic Analysis of Dairy Farming under Drought Prone Area in Maharashtra State of India

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ABSTRACT

Background: Dairy farming is a cornerstone of the rural economy in India. Maharashtra, particularly its drought-prone districts, is critical in this sector. Despite challenges posed by erratic monsoons and limited irrigation, dairy farming remains a viable strategy for economic stability in these regions. The aim of this study was to examine the financial aspects of dairy enterprises, focusing on socio-economic characteristics, economic viability and constraints faced by farmers.

Methods: The study employed a multistage stratified random sampling method. Key analytical tools included average and percentage calculations, BEP analysis and a Cobb-Douglas production function. Additionally, Garrett's ranking technique was used to ascertain constraints in dairy farming, while the MOTAD model assessed profitability and risk.

Result: The findings reveal that crossbred cow milk production is more lucrative than buffalo milk production, despite its higher average total expenditure per lactation. Break-even analysis confirmed profitability for both types of milk producers. Key determinants of milk production, such as green fodder, concentrate and labour, suggest areas for efficiency enhancements. Farmer-identified constraints include high feed costs, insufficient veterinary services and water scarcity. Utilizing the MOTAD model, the study recommends integrating dairy farming with crop cultivation to maximize returns, mitigate risks and enhance overall farm resilience in challenging environmental conditions.

Key words: BEP, Dairy farming, Drought, Economic analysis, MOTAD.

INTRODUCTION

The dairy farm industry structure has been changing rapidly worldwide (Christopher, 2003). Dairying is a deep-rooted tradition for countless rural families across India (Chale *et al*., 2018), holding a crucial position in the rural economy of the nation (Kaur and Toor, 2024). However, agriculture in India is frequently challenged by insufficient, untimely and uncertain monsoons (FAO, 2018; Birthal *et al*., 2006; Thakur *et al*., 2022). This dependence makes dryland agriculture fraught with risk and uncertainty. To mitigate these risks, farmers in dryland regions have effectively combined livestock efforts with crop farming (Singh and Meena, 2013). The national economy benefits greatly fromthelivestock industry, accounting for around 4% of the GDP and one-fourth of the GDP from agriculture and allied activities. From 1950-1951 to 2023-24, India's milk production surged from 17 million tonnes to over 230.58 million tonnes (Shraddha *et al*., 2024), underscoring the dairy industry's critical role in rural livelihoods and the overall agricultural system. Maharashtra has been pivotal in this growth, notably through its Dairy Development Department established to enhance milk production and procurement in rural areas. The success of 76 cooperative dairy societies and numerous private dairies highlights the state's significant contribution. However, technological adoption varies widely among dairy farmers across different regions, reflecting diverse agricultural practices and innovation levels (Kumar and Parappurathu, 2014). This research focuses on the Solapur, Ahmednagar and Satara districts of Maharashtra, which are major milk suppliers from the state's drought-prone regions, constituting 18.03 per cent of Maharashtra's livestock population. The dairy sector is crucial for the rural economy, supporting landless, small and marginal farm families in India. This study aimed to explore the economic aspects of dairy farming in these drought-prone areas by examining the resource structures and socio-economic traits of dairy farmers, assessing economic factors across

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different farm categories and identifying key constraints in dairy farming.

MATERIALS AND METHODS

A multistage stratified random sampling procedure was used to select sample households. Present research focuses on state's drought-prone areas *viz*., Solapur, Ahmednagar and Satara districts of Maharashtra. Two tahsils were chosen from each district based on milk procurement advancements, followed by two villages from each block, totaling twelve villages for the study. Milk producers from cooperative societies in these villages were divided into Crossbreed Cow and Buffalo groups. A random sample of households was selected from each village proportional to the sample farm's size, resulting in 120 sample farms. The study conducted in 2022–2023, combined primary data, gathered through in-person interviews using a structured questionnaire and secondary data. Basic statistical methods, such as averages and percentages, were employed. The average production cost per unit and litre of milk was estimated using fixed and variable cost methods and a break-even point (BEP) analysis was conducted to determine the minimum milk production required to break even.

$$BEP = \frac{F}{P - V}$$

Where,
F= Fixed cost.
P= Price per liter of milk.
V = Variable cost per liter of milk.

Selection and specification of variables

The production function of the Cobb-Douglas type was used in the current study to estimate the input-output connection. Given that a variety of input factors influence milk production, the available magnitude limits the choice of factor for determining the input-output connection in milk production. The following is the mathematical model of milk production used in this study.

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

Where,
Y= Value of milk produced/Animal/day (₹).
β_0= Intercept.
βi's= Regression coefficients.
X_1= Value of green fodder/Animal/day (₹).
X_2= Value of dry fodder/Animal/day (₹).
X_3= Cost of concentrates and supplements (₹).
X_4= Cost of labour (₹).
X_5= Veterinary expenditure (₹).
e_i= Random error term.

The target MOTAD model

A risk and return model with two attributes is what is suggested (Tauer, 1983). The return on investment is calculated by multiplying the total expected return of all activities by the level of each individual activity. The expected total of the solution's negative deviations from a target return level is used to calculate risk. To map out a risk-return frontier, risk is modified parametrically.

In terms of math, the model is expressed as:

$$\text{Max } E(z) = \sum_{J=1}^{n} CjXj \qquad \text{...(1)}$$

Subject to,

$$\sum_{j=1}^{n} a_{kj} X_j \leq b_k \qquad \text{...(2)}$$

k= 1,…,m

$$T - \sum_{j=1}^{n} C_{rj} X_j - Y_r \leq 0 \qquad \text{...(3)}$$

$$\sum_{r=1}^{s} P_r Y_r = \lambda \qquad \text{...(4)}$$

r= 1,…,s and λ = M→0

for all x and yr >= 0

Where,
E(z)= Expected return of the plan or solution.
C_j= Expected return of activity j.
X_j= Level of activity j.
a_{kj}= Technical requirement of activity j for resource or constraint k.
b_k= Level of resource or constraint k.
T= Target level of return.
C_{rj}= Return of activity j for state of nature or observation r.
Y_r= Deviation below T for state of nature or observation r.
Pr= Probability that state of nature or observation r will occur.
l= Constant parameterized from M to 0.

Therefore, the optimal plan having minimum risk, maximum expected return at available constraints is found out by employing this model. The various combinations of practices were used to have the optimum solution for the sample farm size.

The Garrett's ranking technique

The study utilized Garrett's ranking technique to assess farmers' perceptions of primary obstacles in dairy farming. Participants ranked each element and these rankings were converted into score values using the formula provided below:

$$\text{Per cent position} = \frac{100\,(R_{ij} - 0.5)}{N_j}$$

Where,
R_{ij}= Rank given for the i^{th} variable by j^{th} respondents.
N_j= Number of variable ranked by j^{th} respondents.

The table provided by Garett and Woodworth (1969) is used to translate the % position into scores. After calculating the total and mean scores for each factor, we ranked them by mean value to identify the most significant factors.

RESULTS AND DISCUSSION

A comprehensive overview of the information on the sample milk producers is given in Table 1. The average age of the head of the crossbred cow milk producer family is 49.22 years and for buffalo milk producers, it is 47.50 years. Regarding education levels, 22.23% of heads of families among crossbred cow milk producers have only completed primary schooling, while 58.33% have finished secondary education and 18.75% are graduates. For buffalo milk producers, 56.25% have completed secondary education. Family size averages 5.10 members for crossbred cow milk producers and 5.70 for buffalo milk producers. Additionally, there are 3.10 earners per family among crossbred cow milk producers and 2.80 earners per family among buffalo milk producers. Farming is the primary occupation across all sample groups, with dairy farming as a secondary occupation. Crossbred cow milk producers own an average of 2.14 hectares of land, while buffalo milk producers own 1.95 hectares. The total livestock owned includes 5.30 crossbred cows and 4.10 buffaloes. Conventional dairy farming has adapted well to environmental, economic and social conditions, making it suitable for the current environment (Abhijeet *et al*., 2021; Cradock-Henry, 2021; Rami *et al*., 2021; Sutawi *et al*., 2022; Perin and Enahoro, 2023).

Capital assets of sample milk producers

Table 2 reveals the value of total assets in crossbreed cow milk producer was Rs. 39.52 lakh and in buffalo milk producer was Rs. 36.09 lakhs. In that sequence, the crossbreed cow's capital assets were valued at Rs. 3.15 lakhs, Rs. 2.70 lakhs, Rs. 1.60 lakhs, Rs. 0.72 lakhs, Rs. 0.64 lakhs and Rs. 0.71 lakhs. These resources included dairy products, machinery, irrigation systems, byres and agricultural buildings. The values of Buffalo's capital assets, however, were 2.75 lakhs, 2.10 lakhs, 1.39 lakhs, 0.63 lakhs, 0.57 lakhs and 0.62 lakhs, in that order. These resources included machinery, animals, dairy equipment, irrigation systems and agricultural buildings. Over 76% of the total asset value is composed of the value of land. The worth of farm buildings, irrigation systems, equipment, tools, byres, dairy products and cattle come next (Hisham, 2000).

Cost of milk production

The cost of milk production is crucial for dairy farming profitability and sustainability. Table 3 outlines the group-wise and item-wise costs for producing milk from crossbred cows and buffaloes. The average total cost of producing milk for crossbred cows was Rs. 84,263, with 86.63% as variable costs and 13.37% as fixed costs. For buffaloes, the total cost was Rs. 75,793, with 86.88% as variable costs and 13.12% as fixed costs. Variable costs included concentrates and supplements, green and dry fodder, veterinarian bills, water, energy charges and labour charges, totaling Rs. 72,990 for crossbred cows and Rs. 65,850 for buffaloes. Major variable cost sources were concentrates, green fodder, labor, dry fodder and veterinarian fees. Fixed costs included replacement costs, interest on the animal's value and depreciation on cattle sheds, amounting to Rs. 75,793 for buffaloes and Rs.

Table 1: Information of milk producers.

Particulars	Crossbred cows	Buffalo
Number of sample milk producers	72 (100.00)	48 (100.00)
Age of sample farmer/head of family	49.22	47.50
a) Below 30 years (Low age group)	11	8
b) 31 to 50 years (Middle age group)	34	36
c) Above 50 years (High age group)	15	18
Education of head of family		
a) Illiterate	6 (8.33)	5 (10.42)
b) Primary	16 (22.23)	7 (14.58)
c) Secondary	42 (58.33)	27 (56.25)
d) Graduates	8 (11.11)	9 (18.75)
Size of family	5.10	5.70
Number of earners (No.)	3.10	2.80
Farming (No.)	2.15	2.00
Dairy (No.)	1.65	2.00
Land holding (ha.)	2.14	1.95
a) Irrigated (ha.)	1.19	0.80
b) Un-irrigated (ha.)	0.95	1.15
Livestock (No.)	5.30	4.10
Bullock (No.)	0.40	0.30
Cow (No.)	3.80	0.00
Buffalo (No.)	0.00	2.10
Calf/heifer (No.)	1.10	1.70

(Percentage is worked out to the number of sample milk producers).

84,263 for crossbred cows. The cost of producing one litre of milk was Rs. 28.96 for crossbred cows and Rs. 44.85 for buffaloes (Ponnusamy and Devi, 2017).

Profitability of crossbreed cow and buffalo milk production

Table 4 provides a detailed breakdown of profits from primary milk production and related by-products for different types of cattle. The average milk yield and price per litre were used to calculate milk returns. Dung, valuable for manure and fuel, was also considered, with its average sale price in the research area factored in. Annually, crossbred cows and buffaloes produced 2,910 and 1,690 litres of milk, priced at Rs. 32.50 and Rs. 46.30 per litre, respectively, generating milk values of Rs. 94,575 and Rs. 78,247. Milk value constituted about 88.91% and 87.09% of the gross income for crossbred cows and buffaloes. Dung value accounted for 4.51% and 6.90% and offspring value for 6.58% and 6.01%. Variable costs for crossbred cow and buffalo milk were Rs. 72,990 and Rs. 65,850, with total production costs at Rs. 84,263 and Rs. 75,793. Returns over variable costs were Rs. 33,385 and Rs. 23,997 and returns over total costs were Rs. 22,112 and Rs. 14,054. The benefit-cost ratio for crossbred cows and buffaloes was 1.27 and 1.19, respectively, indicating profitable ventures as the ratio exceeds one which can motivate the farmers (Singh *et al*., 2012 and Nina *et al*., 2018).

Break even point analysis of buffalo milk production

The break-even analysis for buffalo milk production, shown in Table 5, determines the minimum milk output needed to cover all costs and avoid losses (Syrucek and Burdych, 2022). The break-even points are 1,355.46 liters for buffaloes and 1,519.78 liters for cows, compared to actual outputs of 2,910 liters and 1,690 liters respectively, indicating profitability for the sample dairy farmers. This analysis is crucial for establishing the minimum milk volume necessary to ensure revenue covers costs (Chandra *et al*., 2014; Singh *et al*., 2017). Crossbred cows, while yielding more milk, incur higher costs but have a larger margin of safety (1,390.22 liters) compared to buffaloes, which have a lower BEP (1,355.46 liters) but a

Table 2: Capital assets (Rs.).

Particulars	Crossbred cows	Buffalo
Land	3000000 (75.91)	2800900 (77.60)
Farm buildings	315000 (7.97)	275000 (7.62)
Byre	72000 (1.82)	63000 (1.75)
Irrigation structure	270000 (6.83)	210000 (5.82)
Livestock	64000 (1.62)	57800 (1.60)
Machinery and tools	160000 (4.05)	139600 (3.87)
Dairy equipments	71300 (1.80)	62900 (1.74)
Total assets	3952300 (100.00)	3609200 (100.00)
Value of capital asset excluding land value	952300 (24.09)	808300 (22.40)

(Percentage is worked out to the total assets).

Table 3: Cost of milkproduction per animal per lactation (Rs.).

Particulars	Crossbreed cow	Buffalo
Variable cost		
Green fodder	23120 (27.44)	21400 (28.23)
Dry fodder	9800 (11.63)	7350 (9.70)
Concentrate and supplements	26350 (31.27)	25200 (33.25)
Veterinary charges and other expenses	1750 (2.08)	1400 (1.85)
Labour charges	11970 (14.21)	10500 (13.85)
Total variable cost	72990 (86.63)	65850 (86.88)
Fixed cost		
Interest on value of animal	3296 (3.91)	2977 (3.93)
Depreciation on cattle shed and accessories	5184 (6.15)	4536 (5.98)
Herd replacement cost	2793 (3.31)	2430 (3.21)
Total fixed cost	11273 (13.37)	9943 (13.12)
Total cost	84263 (100.00)	75793 (100.00)
Total milk production (liter)	2910	1690
Per liter cost of milk production	28.96	44.85

(Percentage is worked out to the total cost).

Table 4: Profitability of crossbred cow and buffalo milk production (Rs.).

Particulars	Crossbreed cow	Buffalo
Total milk production (Lit)	2910	1690
Average rate of milk (Rs./Lit)	32.50	46.30
Value of milk	94575 (88.91)	78247 (87.09)
Value of offspring	7000 (6.58)	5400 (6.01)
Value of dung	4800 (4.51)	6200 (6.90)
Gross returns	106375 (100.00)	89847 (100.00)
Total variable cost	72990	65850
Total Fixed cost	11273	9943
Total cost of milk production	84263	75793
Returns over variable cost	33385	23997
Returns over total cost	22112	14054
Benefit cost ratio (B:C)	1.27	1.19

(Percentage is worked out to the gross returns).

Table 5: Break-even point (BEP) for crossbreed cow and buffalo milk production.

Particulars	Crossbreed cow	Buffalo
Milk yield animal per lactation (litre)	2910	1690
Fixed cost per animal (Rs.)	11273	9943
Variable cost per animal (Rs.)	72990	65850
Total cost per animal (Rs.)	84263	75793
Variable cost per liter (Rs.)	25.08	38.96
Price per litre of milk (Rs.)	32.50	46.30
Break-even point (litre)	1519.78	1355.46
Margin of safety (litres)	1390.22	334.54

Table 6: Determinants of milk production.

Regression coefficients (bi)	Crossbred cow	Buffalo
Samplesize	72	48
Regression constant	1.38 (0.0356)	1.25** (0.2368)
Cost of green fodder	1.65** (0.0279)	0.245* (0.0464)
Cost of dry fodder	-0.056 (0.0094)	0.165** (0.0279)
Cost of concentrate	0.193*** (0.0165)	0.085*** (0.0118)
Cost of labour	0.312* (0.0114)	0.103 (0.0161)
Veterinary expenses	0.0933*** (0.0139)	0.121 (0.0199)
R^2 (Adjusted)	68.7	74.7
'F' Statistic	11.16	8.90

Note: Values in parentheses are standard error.

*Significant at 1% level, **Significant at 5% level and ***Significant at 10% level.

narrower margin of safety (334.54 liters), indicating higher financial risk. This assessment helps farmers make informed decisions on resource allocation and production strategies for profitability and sustainability.

Determinants of milk production

Table 6 presents the results of the production function analysis for milk production. Most factors, excluding labor and veterinary bills for buffaloes and dry feed costs for crossbred cows, significantly influence income. For crossbred cows, productivity improves with higher expenses on green fodder, concentrate, labor and veterinary care. Key findings include significant coefficients for crossbred cows in green fodder (1.65), concentrate (0.193), labor (0.312) and veterinary expenses (0.0933). For buffaloes, significant factors are green fodder (0.245), dry fodder (0.165), concentrate (0.085) and labor (0.103). The adjusted R^2 values are 68.7% for crossbred cows and 74.7% for buffaloes. The regression constants are 1.38 (crossbred cows) and 1.25 (buffaloes), with 'F' statistics of 11.16 and 8.90, respectively, indicating overall model significance.

Profitability and risk assessment of dairy farming

Assessing the profitability and risks of dairy farming is crucial for informed agricultural management. Using the Target Minimization of Total Absolute Deviation (MOTAD) model, an analysis was conducted to evaluate profit maximization and risk reduction across different farming strategies (Wilczyński A, Kołoszycz, 2021). Table 7 reveals that with a target income of Rs. 50,000 from 1 ha, the current cropping pattern yields an expected return of Rs. 31,100 with a risk of Rs. 2,719. Integrating dairy farming increases the expected return to Rs. 41,156 and reduces the risk to Rs. 2,241, resulting in a 32% return improvement and a

Table 7: Financial viability and risk exposure indairy farming.

Target income (Rs/Yr)	Solution	Expected return (Rs/Yr)	Risk level (Rs)
50000	1	31100	2719
	2	36305	2355
	3	41156	2241

Table 8: Garrett's ranking for constraints in dairy farming (N=120).

Particulars	Garrett scores	Ranks
Unavailability of green fodder round the year	73.80	IV
High cost of cattle feed and mineral mixture	62.53	VIII
Lack of knowledge about balanced diet	59.60	X
Lack of knowledge about breeding management	67.25	VI
Lack of knowledge about disease prevention and health care	70.75	V
Dairy co-operative society is far away from home	57.66	XI
High cost of cross breed dairy animal	78.20	III
Non availability of capital and loan at proper time	87.65	I
Exploitation by middle man/milk man	62.50	IX
Lack of awareness in marketing strategy	64.75	VII
Lack of training	51.00	XII
Lack of availability of labour	84.65	II

21% risk reduction. Thus, combining crops with dairy farming is optimal for maximizing profit and minimizing risk (Ponnusamy *et al.,* 2019).

Constraints faced by dairy farmers and suggest suitable measures

Table 8 represents the study surveyed dairy farmers to pinpoint their main challenges, revealing critical issues such as the lack of timely capital and loans (87.65 per cent agreement), insufficient labor (84.65 per cent), high costs of crossbreed animals (78.20 per cent), year-round shortage of green fodder (73.80 per cent) and limited knowledge about disease prevention (70.75 per cent). Addressing these challenges, particularly the capital and loan availability for small farmers, is crucial for enhancing dairy farming profitability and achieving income growth targets. Interventions like mobile veterinary units and farmer training programs in various aspects of dairy management can be instrumental in overcoming these obstacles (Zirmire and Kulkarni, 2019; Denis and Aytekin, 2023; Patel, 2023).

CONCLUSION

The research delved into the economic dynamics of dairy farming in drought-prone regions of Maharashtra, focusing on crossbred cows and buffaloes. Key insights revealed higher production costs but lower per-liter costs for crossbred cows compared to buffaloes, with both types of farming proving profitable (benefit-cost ratios of 1.27 and 1.19, respectively). Demographic analysis highlighted the educational background and family structure of dairy farmers, with land assets playing a crucial role. Cost breakdown emphasized feed and labor as major components, with crossbred cows having higher total production costs but lower per-liter costs than buffaloes. Profitability analysis favored crossbred cows, showcasing higher returns over both variable and total costs. Break-even analysis affirmed profitability for both, with crossbred cows offering more financial stability. Determinants of milk production underscored the significance of feed and labor costs. Risk assessments using the MOTAD model suggested integrating dairy farming with crop cultivation for enhanced returns and risk reduction. Constraints faced by farmers, including capital availability and labor shortages, call for targeted interventions to bolster productivity and sustainability in dairy farming.

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Conflict of interest

All authors declare that they have no conflict of interest.

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