An Economics Analysis of Bovine Milk Production in Bhagalpur District of Bihar, India

ABSTRACT

The annual maintenance costs C of overall farms were estimated to be ₹ 1.17 lakhs crossbred cows, ₹ 86.72 thousand of buffaloes, and ₹ 36.28 thousand of local cows, The cost of production of milk overall was estimated to be ₹ 29.17 per Kg milk of crossbred cows, ₹ 29.35 per Kg milk of buffaloes, and 32.64 per Kg milk of local cows. Gross returns of crossbred cow's milk of the overall farm were accounted for in 1.52 lakh per year per crossbred cow, ₹ 1.12 lakh per year per buffalo, and ₹ 44.85 thousand per year per local cows. The annual cash flow statement of benefit-cost ratio (BCR) was estimated to be on an average 1.24 for crossbred cow, 1.19 for buffalo, and 1.11 for local cow. The project was approved as the net present value (NPV) was evaluated at ₹ 2.94 lakhs of crossbred cow, 1.65 lakhs of buffalo, and ₹ 54.99 thousand of local cow. The internal rate of return (IRR) was estimated to be 59.68 per cent of crossbred cow, 37.89 per cent of buffalo, and 12.30 percent for local cow of the cash flow statement as a positive association.

Highlight

- **The cost of production per litre milk of crossbred cow, buffalo, and local cow were declined trends when the increase in the number of herds.**
- **The cash flow statement of BCR, NPV, and IRR showed a favourable correlation between operational costs and investment costs in the production of crossbred cow, buffalo, and local cow milk production.**

Keywords: Local cow, Buffalo, and Crossbred cow milk, Costs and Returns, Cash flow, Amortized costs, Fixed and variable costs.

INTRODUCTION

India's population has been growing consistently, and since the majority of the population follows vegetarian diets, the demand for dairy products has been rising steadily and is expected to continue doing so. The top ten milk-producing states in India are Uttar Pradesh (16.06%), Rajasthan (12.89%), Madhya Pradesh (8.62%), Gujarat (7.71%), Andhra Pradesh (7.69%), Punjab (6.73%), Maharashtra (6.06%), Haryana (5.91%), Bihar (5.28%), and Karnataka (4.55%) (Source: GoI -2020).Add latest data, see BAHS,2023

Bihar is one of India's larger milk-producing states, contributing 4.99% to the country's total fluid milk production, with 10.48 million tons out of India's 209.96 million tons in 2020-21, making it the largest milk producer in the world. The country aims to produce 300 million tons of fluid milk by 2022-23. In Bihar, per capita fluid milk consumption has steadily increased from 133 grams/day in 1950-51 to 251 grams/day in 2020-21, compared to the

national average of 427 grams/day. In 2018-19, Bhagalpur district ranked sixth in fluid milk production (from cows, buffaloes, and goats) in Bihar, contributing 369.67 thousand tons or 3.80% of the state's total 9818.51 thousand tons. The leading districts were Patna (501.73 thousand tons), Samastipur (493.21 thousand tons), Muzaffarpur (380.88 thousand tons), Supaul (378.97 thousand tons), Begusarai (372.37 thousand tons), and Nalanda (372.27 thousand tons) (Source: Department of Animal Husbandry and Fisheries Resources, GoB 2020).Data are old kindly revise

A consistent rise in fluid milk prices has boosted dairy farmers' incomes and encouraged the growth of dairy farming. In Bihar and specifically in Bhagalpur district, the importance of fluid milk as a key consumption item and the improving economic conditions have shown that the area has been resilient to these price increases.

Fluid milk has a very short shelf life, lasting only a few hours due to its perishable nature, necessitating quick distribution for consumption or processing. This rapid distribution requires packaging materials for swift door-to-door delivery. Unlike fast-moving consumer goods (FMCG), it is challenging to produce these materials centrally and distribute them across India.

Problem of the Study

After 6-7 lactations, cows and buffaloes become unproductive and are replaced by younger animals. Unproductive cows and buffaloes can still fetch significant returns, ranging from Rs. 15,000 to 25,000 depending on their size and condition, which covers about 30 to 40 percent of the cost of a replacement buffaloand cows.

There is a complementary relationship between crop and animal husbandry due to the exchange of resources between the two sectors. Crop farming provides feed for livestock, while the animal sector supplies essential nutrients to crops through organic materials like compost and vermicompost. This interdependence means that improvements in the crop sector also positively impact animal husbandry.

The dairy cooperative structure in this region of India is relatively weak, particularly in terms of the coverage of dairy cooperatives for procuring surplus fluid milk. Dairy cooperative

societies struggle to collect milk from remote village areas, making full milk collection challenging. Bhagalpur, a major milk-producing district in Bihar, consists of both organized and unorganized producers, contributing to the income of local beneficiaries. However, the productivity of fluid milk per bovine herd in Bhagalpur is low compared to countries like the USA (30 liters) and the UK (25 liters).Add source of the data

Although India's fluid milk production is growing, and the herd population is increasing, Indian bovine breeds have a higher average birth rate of 10 to 12 calves compared to 8 to 10 in foreign breeds. (Add source/citation) The rearing of bovine breeds in Bhagalpur requires significant investment in inputs such as labor, dry and green fodder, concentrated feed, veterinary services, medicine, equipment, and infrastructure. The cost of these inputs is rising daily in the local market. As a result, the high production costs are often close to or even exceed the selling price of fluid milk per liter, preventing farmers from receiving a remunerative price and sometimes not even covering their production costs.

Bhagalpur in Bihar has several significant growth centers for milk production, but their potential for commercial expansion remains underutilized due to significant economic and technical challenges, as well as an inefficient production and marketing system. Therefore, this study has been developed with a specific objective: to estimate the costs and returns of crossbred cows, local cows and buffalo’s milk in the study area.

MATERIALS AND METHODS

Cross-sectional data were used to assess a multistage stratified random sampling design utilizing non-probability techniques (Agrawal and Raju 2021). In the first stage, Bhagalpur district in Bihar was deliberately selected, focusing on three blocks with a higher population of milch bovine rearers. To distinguish between DCS and Non-DCS populations, a list was created based on the cumulative square root of the population, categorizing milk producers into small, medium, and large size groups. Each individual in the population had an equal chance of being selected as a representative sample. Using the Taro Yamane method, the sample size was estimated at 278 from a population of 912 milk producers across two selected villages in each block (Tables 1 and 2). The sample selection process employed simple random sampling without replacement (SRSWOR) at all stages, ensuring that each unit had more than one chance of being selected. The Taro Yamane and cumulative square root methods were used to determine the sample size for the milk producer population survey (Adam,

2020) as follow.What is the standard criteria followed for categorization of Herd Size?Standard animal Unit should be followed

$$n = \frac{N}{1 + N*(e)^2}$$

Where,

n= the sample size

e= the acceptable sampling error

- 95 per cent confidence level and p= 0.5

$$\because \quad \frac{T}{3} = 121.56 \qquad \frac{2T}{3} = 243.12$$

$$\therefore \quad X_1 = 6.29, \; and \quad X_2 = 18.16$$

Table 1: The farm and bovine population in the selected villages of each block in Bhagalpur District, Bihar.

Sl No.	Categories of Farm	Farm Population(N)	Percent	Bovine Population	Percent
1	Small (2-6 herds)	694	76.03	2146	43.87
2	Medium (7-18 herds)	157	17.25	1470	30.05
3	Large (>18 herds)	61	6.73	1275	26.07
	Overall, All	912	100.00	4891	100.00

Table 2: Households involved in bovine rearing in villages within Bhagalpur District, Bihar

Name of Blocks in Bhagalpur District	Name of village panchayat	Categories of Household			Overall n=278
		Small: n1=210 (2-6 herd)	Medium: n2=45 (7-18 herd)	Large: n3=23 (>18 herd)	
1. Pirpainti	1. KhavaspurDiara	37 (73.18)	9 (18.32)	5 (8.50)	51 (100.00)
	2. Pirpainti	36 (75.37)	8 (17.56)	4 (7.07)	48 (100.00)
2. Sonhaula	3. Meheshpur	34 (76.62)	8 (16.78)	3 (6.60)	45 (100.00)
	4. Tarar	35 (74.24)	7 (15.54)	5 (10.22)	47 (100.00)
3. Sabour	5. Pharka	34 (78.27)	6 (14.65)	3 (7.08)	43 (100.00)
	6. Bahadurpur	34 (77.31)	7 (14.83)	3 (7.86)	44 (100.00)
	Total	210 (75.54)	45 (16.19)	23 (08.27)	278 (100.00)

Figures in parentheses indicates that per cent of the overall.

Table 2 shows that the overall sample of farms involved in bovine rearing was estimated to be 278. Of these, 75.54% were small farms, 16.19% were medium farms, and 8.27% were large farms. In Table 3, the total herd population across all farms was recorded at 1,469, with small farms accounting for 526, medium farms for 477, and large farms for 466. Among these, the crossbred cow population across all

sample farms totaled 520, which included 9.23% young stock, 3.52% heifers, 18.85% in milking, and 3.81% dry cows.

Table 3: Composition of crossbred cows' population of sample farm in Bhagalpur of Bihar

Sl. No.	Type of milch bovine	Category of Household			Overall
		Small: n1=210 (2-6 herd)	Medium: n2=45 (7-18 herd)	Large: n3=23 (>18 herd)	
A.	**Indigenous Cows**				
5.	Sub Total	428	170	57	654
		(81.32)	(35.54)	(12.27)	(44.55)
B.	**Buffaloes**				
5.	Sub total	44	137	114	295
		(8.42)	(28.74)	(24.37)	(20.08)
C.	**Crossbred Cows**				
1.	Young Stock	7	36	92	136
		(1.42)	(7.54)	(19.78)	(9.23)
2.	Heifer	9	12	30	52
		(1.70)	(2.58)	(6.53)	(3.52)
3.	In Milking	33	107	137	277
		(6.27)	(22.36)	(29.46)	(18.85)
4.	Dry	5	15	35	56
		(0.98)	(3.24)	(7.59)	(3.81)
5.	Sub Total	54	170	295	520
		(10.26)	(35.72)	(63.36)	(35.37)
D.	Total Herd Population	526	477	466	1469
		(100.00)	(100.00)	(100.00)	(100.00)

Figures in parentheses indicates that per cent of the overall

Computation of annual maintenance and investment cost of bovine animals rearing.

Fixed cost: Non-cash fixed costs has encompass the depreciation of buildings, machinery, and equipment due to aging, interest on capital investments, and charges for family labor and management services. The level of such resources is unaltered only in the short run but can be altered in the long run.On the other hand, overhead costs remain constant regardless of the farm's production levels. Overhead costs often include hidden expenses, as they do not involve direct cash transactions.Fixed costcomponents are depreciation of animals, equipment, and sheds, rental value of shed; amortize costs, cess, and interest of fixed capital.

Investment cost (Calves to fist birth of cow) as follow:

This method was used to compute amortized costs

$$P = B\frac{i}{1-(1+i)^{-n}}$$

Where,

P = amount of annual payment/Amortize costs
B = establishment cost
i - Interest rate
n = number of years (life span of cows)

Variable cost: Costs that fluctuate with changes in output are known as variable costs. These costs are directly linked to the farm's milk production and vary in proportion to the intensity of each farm activity. For a specific farm activity, variable costs give the farmer an idea of how these costs might change if the activity is either expanded or reduced. Farmers have considerable control over the level of these resources. The component of variable costs are follows asgreen fodder, dry fodder, concentrated feed, animals' health care expenses, human labour employed in man day, interest of variable capital, and miscellaneous cost.

Important terminology

i. Cost of production (CoP) refers to the total expenses incurred on all inputs, including services, needed to produce a single unit of output.
ii. Cost of cultivation (CoC) refers to the average expenses involved in all inputs, including services, required to grow a crop on a specific unit of land or fixed resources.
iii. Gross margin = *Value of production – Variable costs;(Kahan 2013).*

The costs were computed by following certain cost concept to be used: Cost A, +Cost B, + and Cost C (Family labour cost) detailed follow as:

Cost A = Expenditure on feeds (Dry + Green+ Concentrated), Veterinary expenditure (+) Expenses on hired human labour (+) Miscellaneous expenditure (+) Depreciation on fixed assets.
Cost B = Cost A (+) rental value of sheds and amortized costs, and interest on fixed investment.
Cost C = Cost B (+) Imputed value of family labour.

Gross returns:

Gross returns were obtained by multiplying fluid milk yield of an individual milch-animal with respective prevailing prices in the study area. Gross cost = Total fixed cost + Total variable cost.

Gross returns = Quantity of fluid milk × Market price of fluid milk + Value of by product (Dung) in market prices.

Lactation: The period from the day of calving to the day the cow stops producing milk is known as the lactation period, which varies by breed. In this study, the average lactation period is 7 months for crossbred cows and buffaloes, 6 months for local cows, and 11.5 months for local buffaloes. Net returns were calculated by subtracting the total costs from the gross returns.

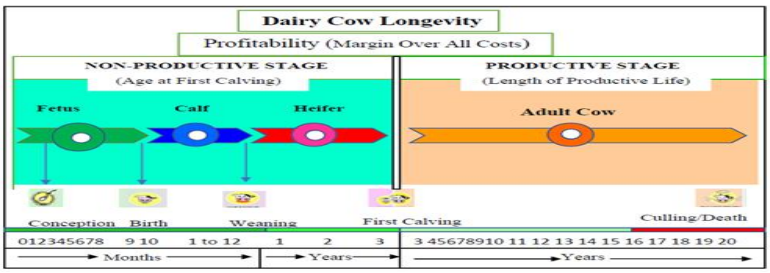

Fig. 1: Photograph showing the life span of dairy cows of productive and non-productive stage.

Cash Flow Statement Analysis: (Ingle, & Deshmukh 2017).

Benefit-Cost ratio (B-C):

This method is used to compare the present worth of costs with present worth of benefits.

B-C ratio = $\sum_{t=1}^{n} \frac{Bt}{(1+r)^t} / \frac{Ct}{(1+r)^t}$

where,

Benefit-Cost Ratio (B/C ratio)

B_t = Benefit at time t

C_t = Cost at time t

r is the discount rate or interest rate; and

t= Time of the cash flow

Net Present Value (NPV):

$$NPV = \frac{R_t}{(1+i)^t}$$

Where,

i= Discount rate

t= Time of the cash flow

R_t=net cash flow

Internal Rate of Return (IRR):

Time value of money is accounted by this method. IRR is a discount rate that makes the net present value (NPV) of all cash flows equal to zero in a discounted cash flow analysis. IRR calculations rely on the same formula as NPV does.

[Internal Rate of Return] = [Lower discount rate] + [Difference between the two discount rates] x [present worth of the cash flow at the lower discount rate ÷ absolute difference between the present worth of the cash flow at the two discount rates]

RESULTS AND DISCUSSION

The numerical results of the dissertation have been objectively analyzed to highlight the significance of the sustained conditions used. The discussion then subjectively explores the cause-and-effect relationships, which are explained as follows.

Table 4: Annual maintenance costs for milk production of crossbred cow, buffalo, and local cow

(₹ /herd/year)

Cost Concept	Categories of farms			Overall
	Small	Medium	Large	
Costs A of Crossbred Cow	96061.59	93830	92529.07	95408.11
Costs A of Buffalo	66627.25	62907.98	62616.91	65693.42
Costs A of Local Cow	27197.05	27127.59	25992.37	27086.13
Costs B of Crossbred Cow	106118.9	102979.5	100833.3	105173.4
Costs B of Buffalo	80304.76	76611.25	76298.05	79375.40
Costs B of Local Cow	33434.18	33706.66	32346.59	33388.30
Costs B of Crossbred Cow	119623.8	114766.5	108232.7	117895.1
Costs B of Buffalo	88163.49	83132.56	80599.85	86723.36
Costs B of Local Cow	36508.16	36476.18	33864.24	36284.24

Costs of BovineRearing

Table 4 shows that the crossbred cows of total cost for all farms was estimated at 1.17 lakhs, with small farms having the highest expenditure at 1.19 lakhs, followed by medium farms at 1.14 lakhs, and large farms at 1.08 lakhs. The trend indicates that as the size of dairy farms increases, costs gradually decrease. **Table 5** reveals that the annual maintenance costs for crossbred cows across all farms were also 1.17 lakhs, with 95.90% allocated to total variable costs and 9.05% to total fixed costs.

Among the annual maintenance costs, concentrate feed was the highest expenditure at 20.26%, followed by green fodder (18.10%), dry fodder (17.58%), labor costs (12.87%), veterinary care services (9.56%), and miscellaneous costs (7.77%).

In terms of fixed costs, amortized costs were the most significant, making up 4.19% of total annual maintenance costs, followed by the rental value of sheds at 4.09%, depreciation at 1.70%, and interest on fixed capital at 0.71%. The difference between amortized and depreciated costs is that while both represent losses, depreciation costs are tangible and can be observed, whereas amortized costs are not directly visible or tangible, reflecting investments made in the development of calves into cows.

Table 4 indicates that the total costs (C) for buffaloes across all farms were estimated at ₹ 86.72 thousand. Small farms incurred the highest costs at ₹ 88.16 thousand, followed by medium farms at ₹ 83.13 thousand, and large farms at ₹ 80.59 thousand. The trend shows that as the size of dairy farms increases, costs decrease.

In **Table 6**, it was found that the annual maintenance costs for buffaloes across all farms totaled ₹ 86.72 thousand, with 83.81% allocated to total variable costs and 16.19% to total fixed costs. Concentrate feed accounted for 16.98% of the total annual maintenance costs, followed by roughage. The breakdown of total annual maintenance costs across all farms included ₹ 86.72

thousand, with 12.29% for green fodder, 15.31% for dry fodder, 14.38% for labor, 10.42% for veterinary care, and 9.04% for miscellaneous expenses.

Amortized costs, a key component of fixed costs, accounted for 10.91% of the total annual maintenance costs, followed by the rental value of sheds at 4.53%, depreciation at 1.88%, and interest on fixed capital at 1.27%. The distinction between amortized and depreciated costs lies in that while both are considered losses, depreciation is a tangible and observable cost, whereas amortized costs are not directly visible or tangible, reflecting investments made in the development of buffalo calves.

In case of local cow of the overall farm costs C were estimated to be 36.28 thousand in **Table 4**, with small farms spending the most (36.50 thousand), medium farms spending 36.47 thousand, and large farms spending 33.86 thousand.According to the trends, as the size of dairy farms grows, so do the reduced costs. In the case of **Table 7**, it was discovered that the annual maintenance costs of local cow on overall farms amounted to ₹ 36.28 thousand, which were allocated to 79.62 per cent expenditure of variable costs and 17.89 per cent of fixed costs. The concentrated feed expenditure of overall farms was estimated to average 15.80 percent high of the total annual maintenance costs followed by 14.10 percent of roughage (dry fodder), 13.81 percent of labour charge, 12.84 percent of veterinary care services, 11.73 percent of roughage (green fodder), 10.94 percent of amortized costs, 9.35 percent of miscellaneous costs.The difference between amortised and depreciated costs was that both were losses, and the actual difference in costs was seen and touched in depreciation costs, but amortised costs losses were not seen or touched, where investment was taken into account as the buffalos calved during the development process.

Table 5: Annual maintenance costs for milk production of crossbred cow

(₹ /cow/year)

Sl. No. A.	Variable Costs	Categories of farms			Overall
		Small: n1=210 (2-6 herd)	Medium: n2=45 (7-18 herd)	Large: n3=23 (>18 herd)	
1	Roughage (Dry fodder)	20850.84 (17.43)	20560.58 (17.92)	19958.48 (18.44)	20730.03 (17.58)
2	Roughage (Green fodder)	21943.99 (18.34)	19783.87 (17.24)	18833.11 (17.40)	21336.95 (18.10)
3	Concentrates feeds	23927.31 (20.00)	24259.71 (21.14)	22751.65 (21.02)	23883.85 (20.26)
4	Total feed cost	66722.14 (55.78)	64604.17 (56.29)	61543.24 (56.86)	65950.83 (55.94)
5	Labour cost	15497.28 (12.96)	14713.60 (12.82)	13047.50 (12.06)	15167.75 (12.87)
6	Veterinary care services	14001.72 (11.71)	11668.00 (10.17)	10341.11 (9.56)	13321.10 (9.56)
7	Miscellaneous costs	9729.54 (8.14)	9219.38 (8.04)	8407.91 (7.77)	9537.61 (7.77)

8	Sub-Total Variable Costs	105950.68 (88.57)	100205.14 (87.31)	93339.76 (86.24)	103977.29 (88.19)
9	Rate of interest of variable capital 12.5 %	3310.96 (2.77)	3131.41 (2.73)	2916.87 (2.69)	3249.29 (2.76)
10	Total Variable Costs	109261.63 (91.34)	103336.55 (90.04)	96256.62 (88.93)	107226.58 (90.95)
B.	Non-Recurrent Costs	0.00	0.00	0.00	0.00
11	Rental value of sheds	4353.47 (3.64)	4530.06 (3.95)	4425.78 (4.09)	4388.04 (4.09)
12	Depreciation	152.42 (0.13)	1140.21 (0.99)	1835.90 (1.70)	451.60 (1.70)
13	Land revenue	52.67 (0.04)	54.77 (0.05)	55.27 (0.05)	53.23 (0.05)
14	Amortized cost	4991.80 (4.17)	4809.48 (4.19)	4720.90 (4.36)	4939.88 (4.19)
15	Sub- Total Fixed Cost	9550.38 (7.98)	10534.51 (9.18)	11037.85 (10.20)	9832.74 (8.34)
16	Rate of interest of fixed capital 8.5 %	811.78 (0.68)	895.43 (0.78)	938.22 (0.87)	835.78 (0.71)
17	Total Fixed Cost	10362.16 (8.66)	11429.95 (9.96)	11976.07 (11.07)	10668.53 (9.05)
18	Total Cost (A+B)	119623.79 (100.00)	114766.49 (100.00)	108232.69 (100.00)	117895.11 (100.00)

Figures in parentheses indicates that per cent of the total costs.

Table 6: Annual maintenance costs for milk production of buffaloes

(/buffalo/year)

A.	Variable Costs	Categories of farms			Overall
		Small	Medium	Large	
1	Roughage (Dry-fodder)	13848.95 (15.70)	12524.79 (15.06)	12341.84 (15.31)	13509.91 (15.31)
2	Roughage (Green fodder)	12232.54 (13.87)	10270.50 (12.35)	9908.46 (12.29)	11722.67 (12.29)
3	Concentrates feeds	14351.79 (16.27)	14240.92 (17.13)	13686.65 (16.98)	14278.81 (16.98)
4	Total feed cost	40433.28 (45.85)	37036.21 (44.54)	35936.96 (44.57)	39511.39 (45.56)
5	Labour cost	12557.90 (14.24)	12428.67 (14.95)	11795.42 (14.63)	12473.90 (14.38)
6	Veterinary Care Services	11027.71 (12.50)	9036.43 (10.87)	8401.08 (10.42)	10488.07 (10.42)
7	Miscellaneous Costs	8095.29 (9.18)	7947.85 (9.56)	7289.53 (9.04)	8004.76 (9.04)
8	Sub-total Variable costs	72114.17 (81.77)	66449.15 (79.91)	63422.98 (78.66)	70478.12 (81.27)
9	Rate of interest of Variable capital 12.5 %	2253.57 (2.56)	2076.54 (2.50)	1981.97 (2.46)	2202.44 (2.54)
10	Total Variable costs	74367.74 (84.33)	68525.69 (82.40)	65404.95 (81.12)	72680.56 (83.81)

B.	Non-Recurrent Costs	0.00	0.00	0.00	0.00
11	Rental Value of sheds	3377.18 (3.83)	3590.03 (4.32)	3649.18 (4.53)	3434.14 (4.53)
12	Depreciation	118.24 (0.13)	903.61 (1.09)	1513.75 (1.88)	360.83 (1.88)
13	Land revenue	43.40 (0.05)	43.64 (0.05)	43.59 (0.05)	43.45 (0.05)
14	Amortized cost	9176.16 (10.41)	8925.28 (10.73)	8797.99 (10.91)	9104.26 (10.91)
15	Sub-total Fixed Cost	12714.98 (14.42)	13462.55 (16.19)	14004.52 (17.37)	12942.68 (14.92)
16	Rate of interest of fixed capital 8.5 %	1080.77 (1.23)	1144.32 (1.38)	1190.38 (1.48)	1100.13 (1.27)
17	Total Fixed Cost	13795.76 (15.64)	14606.87 (17.57)	15194.90 (18.85)	14042.81 (16.19)
18	Total Cost (A+B)	88163.49 (100.00)	83132.56 (100.00)	80599.85 (100.00)	86723.36 (100.00)

Figures in parentheses indicates that per cent of the total costs.

Table 7: Annual maintenance costs for milk production of local cow

(₹ /herd/year)

Sl No	Variable Costs	Categories of farms			Overall
A.		Small	Medium	Large	
1	Roughage (Dry fodder)	5168.97 (14.16)	5096.84 (13.97)	4677.80 (13.81)	5116.66 (14.10)
2	Roughage (Green fodder)	4309.48 (11.80)	4257.47 (11.67)	3758.67 (11.10)	4255.49 (11.73)
3	Concentrates feeds	6188.87 (16.95)	6022.95 (16.51)	5353.23 (15.80)	6092.88 (15.80)
4	Total feed cost	15667.31 (42.90)	15377.26 (42.14)	13789.71 (40.71)	15465.02 (40.71)
5	Labour cost	4844.73 (13.27)	5117.36 (14.02)	4676.89 (13.81)	4874.97 (13.81)
6	Veterinary Care Services	5348.25 (14.64)	4676.23 (12.82)	4349.22 (12.84)	5156.81 (12.84)
7	Miscellaneous Costs	3434.17 (9.41)	3354.11 (9.20)	3102.40 (9.16)	3393.76 (9.35)
8	Sub-total Variable costs	29294.46 (80.24)	28524.96 (78.20)	25918.22 (76.54)	28890.57 (79.62)
9	Rate of interest of Variable capital 12.5 %	915.45 (2.51)	891.40 (2.44)	809.94 (2.39)	902.83 (2.49)
10	Total Variable costs	30209.91 (82.75)	29416.36 (80.65)	26728.16 (78.93)	29793.40 (82.11)
B.	Non-Recurrent Costs	0.00	0.00	0.00	0.00
11	Rental Value of sheds	1745.58 (4.78)	1910.03 (5.24)	1884.81 (5.57)	1783.72 (4.92)
12	Depreciation	61.12 (0.17)	480.75 (1.32)	781.86 (2.31)	188.67 (0.52)

13	Land revenue	40.49 (0.11)	39.31 (0.11)	39.17 (0.12)	40.19 (0.11)
14	Amortized cost	3957.65 (10.84)	4076.66 (11.18)	3871.19 (11.43)	3969.76 (10.94)
15	Sub-total Fixed Cost	5804.83 (15.90)	6506.75 (17.84)	6577.03 (19.42)	5982.34 (16.49)
16	Rate of interest of fixed capital 8.5 %	493.41 (1.35)	553.07 (1.52)	559.05 (1.65)	508.50 (1.40)
17	Total Fixed Cost	6298.25 (17.25)	7059.82 (19.35)	7136.08 (21.07)	6490.84 (17.89)
18	Total Cost (A+B)	36508.16 (100.00)	36476.19 (100.00)	33864.24 (100.00)	36284.24 (100.00)

Figures in parentheses indicates that per cent of the total costs.

Costs and Returns of Bovine Milk Production

Table 8 shows that the production cost of crossbred cow's milk across all farms was estimated at ₹ 29.17 per kg. Costs varied, with small farms at ₹ 29.29 per kg, medium farms at ₹ 27.17 per kg, and large farms at ₹ 25.17 per kg. This trend indicates that production costs decrease as the size of the farm increases. The gross returns from crossbred cow's milk averaged ₹ 151,652 per year per cow across all farms, with small farms at ₹ 151,784.50, medium farms at ₹ 159,101, and large farms at ₹ 163,123.50 per year per cow. Net returns were estimated at ₹ 33,756.89 per year overall, with small farms generating ₹ 32,160.71, medium farms ₹ 44,334.51, and large farms ₹ 54,890.81 per year. This data suggests that larger farm categories are positively associated with higher gross and net returns. The average milk yield across all farms was 13.25 liters per day per crossbred cow.

Regarding dairy cow longevity, crossbred cows exhibit both productive and non-productive stages in their lifespan. The non-productive stages include three phases: conception, the calf's birth to weaning, and the heifer's growth into a mature cow. The productive stage begins at around three years of age and lasts until the cow is 16 years old. The productive period spans from ages 3 to 16, and the cow's lifespan extends from ages 16 to 20, after which it enters the death phase.

Table 8: Costs and returns of crossbred cow' milk
(in ₹ /cow)

Sl No	Particulars	Unit	Categories of Farms			
			Small n1=210 (2-6 herd)	Medium n2=45 (7-18 herd)	Large n3=23 (>18 herd)	Overall farms
1	Birth to 6th month	Calf	9534.27	8440.56	7907.21	9222.62
2	7^{th} to 12th month	Calf	4874.36	4423.04	4244.34	4749.18
3	2^{nd} year	Weaning	10103.64	9865.17	9754.32	10036.13
4	3^{rd} year	Weaning	17346.70	17196.87	17107.78	17302.68

5	6th month of the 4th year	4th year	12241.03	12198.36	12150.35	12226.62
6	Total investment cost	Up to 4 years	54100.00	52124.00	51164.00	53537.24
7	Amortized cost	Up to 4 years	4991.80	4809.48	4720.90	4939.88
8	Annual maintenance cost	In ₹ Per year	119623.79	114766.49	108232.69	117895.11
9	Gross returns	In ₹ Per year	151784.5	159101	163123.5	151652
10	Net Returns	In ₹ Per year	32160.71	44334.51	54890.81	33756.89
11	Gross margin	In ₹ / year	74367.74	68525.69	65404.95	72680.56
12	Milk of yield	in Kg/cow/day	13.3	13.85	14.1	13.25
13	Lactation of per calve	in Kg for 305 days	4056.3	4224.25	4300.5	4041.25
14	By-product per herd(dung)	qtls/year	16.43	20.08	23.73	17.62
15	Income of main-product milk	In ₹ / lactation	146034	152073	154818	145485
16	Income of by-product (dung)	In ₹ / year	5750.5	7028	8305.5	6167
17	Gross Income	In ₹ / year	151784.5	159101	163123.5	151652
18	Sales price of milk	In ₹ / Kg	36	36	36	36
19	Sales price of by product(dung)	In ₹ /qtls	350	350	350	350
21	Cost of Production	In ₹ /Kg	29.49	27.17	25.17	29.17

Table 9 provides an overview of the costs and returns for buffalo milk production. The production cost was estimated at ₹ 29.35 per kg of milk across all farms. Costs varied by farm size, with small farms at ₹ 30.14 per kg, medium farms at ₹ 27.67 per kg, and large farms at ₹ 25.78 per kg. This trend shows that production costs decrease as farm size increases. Gross returns from buffalo milk averaged ₹ 1.12 lakh per year per buffalo, with small farms earning ₹ 1.10 lakh, medium farms ₹ 1.15 lakh, and large farms ₹ 1.19 lakh per year per buffalo. Conversely, net returns were estimated at ₹ 25,280 per year overall, with small farms at ₹ 22,460, medium farms at ₹ 31,510, and large farms at ₹ 38,850. Buffaloes produced an average of 9.69 liters of milk per day per buffalo across all farms, with small farms at 9.59 liters, medium farms at 9.85 liters, and large farms at 10.25 liters. Annual milk production averaged 2,954.44 liters per farm, ranging from 2,924.95 liters on small farms, 3,004.25 liters on medium farms, to 3,126.25 liters on large farms.

Table 9: Costs and returns of buffalo

(₹ /buffalo)

Sl No	Particulars	Unit	Categories of farms			Overall farms
			Small	Medium	Large	
1	Costs of calf (Birth to 6th month)	Calf	17795.49	17206.94	16880.14	17624.49
2	Costs of calf (7th to 12th month)	Calf	9239.97	8766.17	8431.11	9096.35
3	Costs of weaning (2nd year)	Weaning	18822.15	17575.82	17395.14	18502.34
4	Costs of weaning (3rd year)	Weaning	30850.19	30664.41	30360.78	30779.63

5	Costs of 4th year (6th month of the 4th year)	4th year	22741.27	22516.78	22283.43	22667.05
6	Total Investment cost	Up to 4 years	99449.06	96730.11	95350.60	98669.86
7	Amortised cost	Up to 4 years	9176.16	8925.28	8797.99	9104.26
8	Annual maintenance cost	In ₹/year	88163.49	83132.56	80599.85	86723.36
9	Gross return	In ₹/year	110632.20	114649	119457.5	112012.55
10	Net Returns	Per year	22468.71	31516.44	38857.65	25289.19
11	Gross margin	₹/buffalo/year	74367.74	68525.69	65404.95	72680.56
12	Yield of milk	in Kg/buffalo/day	9.59	9.85	10.25	9.69
13	Lactation of per calve	in Kg for 305 days	2924.95	3004.25	3126.25	2954.44
14	By-product per buffalo(dung)	In qtls/year	15.24	18.56	19.75	16.15
15	Income of main-product milk	In ₹/lactation	105298.2	108153	112545	106359.86
16	Income of by-product (dung)	In ₹/year	5334	6496	6912.5	5652.69
17	Gross Income	In ₹/year	110632.20	114649	119457.5	112012.55
18	Sales price of milk	In ₹/kg	36	36	36	36
19	Sales price of by product(dung)	In ₹/qtls	350	350	350	350
21	Cost of Production	In ₹/kg	30.14	27.67	25.78	29.35

Table 10 outlines the costs and returns associated with local cow milk production. The production cost across all farms was estimated at ₹ 32.64 per kg of milk. Costs varied by farm size, with small farms at ₹ 33.25 per kg, medium farms at ₹ 32.15 per kg, and large farms at ₹ 28.47 per kg. This trend shows that production costs decrease as farm size increases. Gross returns from local cow milk averaged ₹ 48,580 per year per herd, with small farms at ₹ 44,230, medium farms at ₹ 45,860, and large farms at ₹ 48,580 per year per herd. Net returns were estimated at ₹ 8,570 per year per herd overall, with small farms at ₹ 7,720, medium farms at ₹ 9,390, and large farms at ₹ 14,720. The average daily milk production from local cows across all farms was 3.64 liters per herd, and the annual milk production averaged 1,111.49 kg per herd.

Table 10: Costs and Returns of Local Cow

(in ₹ /head)

Sl No	Particulars	Unit	Categories of Farms			Overall farms
			Small	Medium	Large	
1	Birth to 6th month	Calf	9010.46	9410.15	9167.02	9084.76
2	7th to 12th month	Calf	4663.37	4807.13	4534.13	4676.05
3	2nd year	Weaning	9583.55	9569.33	9247.63	9557.64
4	3rd year	Weaning	11654.44	12335.06	11756.14	11767.32
5	6th month of the 4th year	4th year	7980.25	8060.18	7250.12	7937.56
6	Total Investment cost	Up to 4 years	42892.07	44181.85	41955.03	43023.32
7	Amortised cost	Up to 4 years	3957.65	4076.66	3871.19	3969.76
8	Annual maintenance cost	Per year	36508.16	36476.19	33864.24	36284.24

9	Gross return	Per year	44235.5	45868.1	48586.5	44859.75
10	Net Returns	Per year	7727.34	9391.91	14722.26	8575.51
11	Gross margin	/herd/year	30209.91	29416.36	26728.16	29793.40
12	Yield of milk	in Kg/herd/day	3.60	3.72	3.90	3.64
13	Lactation of per calve	in Kg for 305 days	1098	1134.60	1189.50	1111.49
14	By-product per herd(dung)	In qtls /year	13.45	14.35	16.47	13.85
15	Income of main-product milk	In ₹ / lactation	39528	40845.60	42822	40013.81
16	Income of by-product (dung)	In ₹ /year	4707.5	5022.5	5764.5	4845.94
17	Gross Income	In ₹ /year	44235.5	45868.1	48586.5	44859.75
18	Sales price of milk	In ₹ / Kg	36	36	36	36
19	Sales price of by product(dung)	In ₹ / qtls	350	350	350	350
21	Cost of Production	In ₹ /Kg	33.25	32.15	28.47	32.64

Table 11 details the cash flow statement for crossbred cows. It shows that non-productive investment costs up to the fourth year amounted to ₹ 53,537.23 per herd. The average annual maintenance cost for a 16-year-old cow was ₹ 1,17,895.11. Thus, the average annual costs and returns per cow were ₹ 1,21,241.19 and ₹ 1,51,652.00, respectively. The benefit-cost ratio (BCR) was calculated at 1.24 for cows up to 16 years old. The net present value (NPV) was ₹ 2,93,588.12, and the internal rate of return (IRR) was 59.68% based on the cash flow statement.

Table 12 presents the cash flow statement for buffaloes. It was found that non-productive costs averaged ₹ 6,166.87 per buffalo for investment up to the fourth year. In contrast, the average annual maintenance cost for each buffalo during its productive lifespan was ₹ 86,723.36. Consequently, the average annual costs and returns per buffalo were ₹ 92,890.23 and ₹ 1,12,012.55, respectively. The benefit-cost ratio (BCR) for buffaloes up to 16 years old was 1.19. The net present value (NPV) was ₹ 1,64,640.79, indicating that the project is considered viable. Additionally, the internal rate of return (IRR) was 37.89%, reflecting a positive financial outcome based on the cash flow statement.

Table 13's analysis of the cash flow statement for local cows showed that non-productive costs, or investment costs, averaged ₹ 2,688.96 per herd. The average annual maintenance costs for a 16-year-old local cow were calculated to be ₹ 36,284.84. Consequently, the annual expenses and returns per local cow were ₹ 38,973.20 and ₹ 44,859.75, respectively. The benefit-cost ratio (BCR) for local cows up to 16 years old was 1.11. The project was deemed viable with a net present value (NPV) of ₹ 54,993.13. The internal rate of return (IRR) was estimated at 12.30%, indicating a positive financial outcome based on the cash flow statement.

Table 11: Cash flow statement of crossbred cow rearing costs and returns.

(₹ /cow)

Sl. No.	ELSY	IC	AMC	GR	NR	Costs	Returns	DF	PV of C	PV of R
1	1) up to 6th months	9222.62	0.00	0.00	-9222.62	9222.62	0.00	0.94340	8700.58	0.00
2	1) 7 to 12 months	4749.18	0.00	0.00	-4749.18	4749.18	0.00	0.94340	4480.36	0.00
3	2	10036.13	0.00	0.00	-10036.13	10036.13	0.00	0.89000	8932.12	0.00
4	3	17302.68	95645.21	97998.07	-14949.82	112947.89	97998.07	0.83962	94833.22	82281.07
5	4	12226.62	140101.33	195996.13	43668.18	152327.95	195996.13	0.79209	120658.00	155247.29
6	5	0.00	141695.11	195996.01	54300.90	141695.11	195996.01	0.74726	105882.83	146459.62
7	6	0.00	143212.13	195996.13	52784.00	143212.13	195996.13	0.70496	100958.90	138169.54
8	7	0.00	145511.79	194876.15	49364.36	145511.79	194876.15	0.66506	96773.65	129603.77
9	8	0.00	146443.56	194876.15	48432.59	146443.56	194876.15	0.62741	91880.50	122267.71
10	9	0.00	146514.04	192636.20	46122.15	146514.04	192636.20	0.59190	86721.44	114021.07
11	10	0.00	149607.19	193756.18	44148.99	149607.19	193756.18	0.55839	83539.87	108192.44
12	11	0.00	152478.35	193756.18	41277.83	152478.35	193756.18	0.52679	80323.69	102068.34
13	12	0.00	152740.23	192636.20	39895.97	152740.23	192636.20	0.49697	75907.22	95734.29
14	13	0.00	155179.20	192636.20	37457.00	155179.20	192636.20	0.46884	72754.06	90315.37
15	14	0.00	157657.41	192636.20	34978.79	157657.41	192636.20	0.44230	69732.02	85203.18
16	15	0.00	159536.22	192636.20	33099.98	159536.22	192636.20	0.41727	66568.89	80380.36
17	16	0.00	161431.78	192656.37	31224.59	161431.78	192656.37	0.39365	63547.02	75838.46
18	Gross	53537.23	1886321.76	2619088.37	517797.60	2101290.77	2619088.37	SUM	1232194.38	1525782.50
19	Average	6.00%	117895.11	163693.02	32362.35	131330.67	163693.02		BCR	1.24
20									NPV	293588.12
21			Interest rate	6%					IRR	59.68%

Where, ELSY= Economic life span in year; IC = Investment costs; AMC = Annual maintenance costs; GR = Gross returns; NR = Net returns; DF= Discount factors; PV of C = Present value of costs; PV of R= Present value of returns; BCR=Benefit of cost to ratio; NPV=Net present value; IRR= Internal rate of returns.

Table 12: Cash flow statement of buffalo

(₹/buffalo)

Sl. No.	ELSY	IC	AMC	GR	NR	Costs	Returns	DF	PV of C	PV of R
1	1	17624.49	0	0	-17624.49	17624.49	0.00	0.943396	16626.88	0.00
2	2	9096.35	0	0	-9096.35	9096.35	0.00	0.889996	8095.72	0.00
3	3	18502.34	0	0	-18502.34	18502.34	0.00	0.839619	15534.92	0.00
4	4	30779.63	45985.59	71431.76	-5333.45	76765.22	71431.76	0.792094	60805.24	56580.65
5	5	22667.05	90830.85	145867.81	32369.90	113497.90	145867.81	0.747258	84812.24	109000.91
6	6	0.00	107416.89	145732.27	38315.38	107416.89	145732.27	0.704961	75724.67	102735.50
7	7	0.00	96870.83	144584.78	47713.95	96870.83	144584.78	0.665057	64424.63	96157.13
8	8	0.00	96755.64	144416.71	47661.07	96755.64	144416.71	0.627412	60705.69	90608.83
9	9	0.00	107102.28	144792.62	37690.34	107102.28	144792.62	0.591898	63393.67	85702.53
10	10	0.00	112173.07	143560.61	31387.55	112173.07	143560.61	0.558395	62636.85	80163.50
11	11	0.00	115887.86	142289.78	26401.92	115887.86	142289.78	0.526788	61048.28	74956.48
12	12	0.00	121761.59	142284.36	20522.77	121761.59	142284.36	0.496969	60511.78	70710.97
13	13	0.00	123049.28	146140.77	23091.49	123049.28	146140.77	0.468839	57690.30	68516.50
14	14	0.00	122727.90	141142.28	18414.38	122727.90	141142.28	0.442301	54282.67	62427.37
15	15	0.00	122803.20	139962.26	17159.05	122803.20	139962.26	0.417265	51241.49	58401.36
16	16	0.00	124208.78	139994.78	15786.00	124208.78	139994.78	0.393646	48894.32	55108.43
17	Gross	98669.86	1387573.76	1792200.80	305957.18	1486243.62	1792200.80	Sum	846429.36	1011070.15
18	Average	6166.87	86723.36	112012.55	19122.32	92890.23	112012.55		BCR	1.19
19									NPV	164640.79
20		Interest rate	6%						IRR	37.89%

Where, ELSY= Economic life span in year; IC = Investment costs; AMC = Annual maintenance costs; GR = Gross returns; NR = Net returns; DF= Discount factors; PV of C = Present value of costs; PV of R= Present value of returns; BCR=Benefit of cost to ratio; NPV=Net present value; IRR= Internal rate of returns.

Table 13: Cash flow statement of local cow

(In ₹ /herd)

Sl. No	ELSY	IC	AMC	GR	NR	Costs	Returns	DF	PV of C	PV of R
1	1	14518.21	0	0	-14518.2	14518.21	0	0.970874	14095.35	0
2	2	9762.552	0	0	-9762.55	9762.552	0	0.942596	9202.141	0
3	3	11493.04	0	0	-11493	11493.04	0	0.915142	10517.76	0
4	4	7249.524	30744.6	28710.24	-9283.88	37994.12	28710.24	0.888487	33757.28	25508.68
5	5	0	62848.71	61480.53	-1368.18	62848.71	61480.53	0.862609	54213.85	53033.65
6	6	0	61797.26	60327.54	-1469.72	61797.26	60327.54	0.837484	51754.23	50523.37
7	7	0	59673.79	59643.39	-30.3958	59673.79	59643.39	0.813092	48520.25	48495.53
8	8	0	49260.67	59231.27	9970.603	49260.67	59231.27	0.789409	38886.82	46757.71
9	9	0	43827.39	58120.04	14292.65	43827.39	58120.04	0.766417	33590.04	44544.17
10	10	0	37287.69	57325.72	20038.02	37287.69	57325.72	0.744094	27745.55	42655.72
11	11	0	40806.37	57360.25	16553.89	40806.37	57360.25	0.722421	29479.39	41438.27
12	12	0	39935.97	56538.2	16602.22	39935.97	56538.2	0.70138	28010.29	39654.75
13	13	0	39301.15	55663.63	16362.48	39301.15	55663.63	0.680951	26762.17	37904.22
14	14	0	38755.01	55263.75	16508.74	38755.01	55263.75	0.661118	25621.63	36535.85
15	15	0	38530.92	54167.48	15636.56	38530.92	54167.48	0.641862	24731.53	34768.04
16	16	0	37778.31	53924.01	16145.7	37778.31	53924.01	0.623167	23542.2	33603.66
17	Gross	43023.33	580547.8	717756	94184.87	623571.2	717756		480430.5	535423.6
18	Average	2688.96	36284.24	44859.75	5886.555	38973.2	44859.75		BCR	1.114466
19						Interest rate	3.00%		NPV	54993.13
20									IRR	12.30%

Where, ELSY= Economic life span in year; IC = Investment costs; AMC = Annual maintenance costs; GR = Gross returns; NR = Net returns; DF= Discount factors; PV of C = Present value of costs; PV of R= Present value of returns; BCR=Benefit of cost to ratio; NPV=Net present value; IRR= Internal rate of returns.

CONCLUSION

The trends indicate that as the size of dairy farms increases, both annual maintenance and investment costs decrease. Part of the investment cost is lost as amortized and depreciated costs; the actual difference is noticeable in depreciation costs, while amortized costs are not visible. This suggests that larger farm sizes positively impact gross and net returns. For crossbred cows, the productive stage spans from 3 to 16 years, and the death period ranges from 16 to 20 years. The average annual costs and returns per cow were ₹ 121,241.19 and ₹ 151,652.00, respectively. The benefit-cost ratio (BCR) for cows up to 16 years old was 1.24, with a net present value (NPV) of ₹ 293,588.12 and an internal rate of return (IRR) of 59.68%.

For buffaloes, as farm sizes grow, annual maintenance and investment costs decrease. Investment costs are partially lost as amortized and depreciated costs, with the actual cost difference visible in depreciation but not in amortization. This finding shows that increasing farm sizes positively affects gross and net returns. Buffaloes have a productive lifespan of 3 to 16 years and a death period of 16 to 20 years. The annual costs and returns per buffalo were ₹ 92,890.23 and ₹ 1,12,012.55, respectively. The BCR was 1.19, with an NPV of ₹ 1,64,640.79 and an IRR of 37.89%, making the project viable based on these metrics.

For local cows, as farm sizes increase, annual maintenance costs significantly decrease. The average cost of producing local cow milk was ₹ 32.64 per kilogram, with small farms at ₹ 33.25, medium farms at ₹ 32.15, and large farms at ₹ 28.47. This indicates that expanding farm sizes can lead to higher gross and net profits. Local cows have a productive stage from 3 to 16 years and a death period from 16 to 20 years. The annual costs and returns per local cow were ₹ 38,973.20 and ₹ 44,859.75, respectively. The BCR for cows up to 16 years old was 1.11, with an NPV of ₹ 54,993.13 and an IRR of 12.30%, confirming the project's viability based on these financial indicators.

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