

RESEARCH ARTICLE

Determinants and Impacts of dairy farmer collective action in India

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Abstract: This article analysed the determinants of membership of a Milk Co-operative Union and a Milk Producer Company (MPC) and the impacts of membership of the two dairy farmer collective organizations taken together using primary data collected from 416 member and non-member dairy farming households from the state of Gujarat in India. Dairy households belonging to the Other Backward Class (OBC) category are significantly less likely to join cooperatives, and the association between cooperative membership and households from scheduled groups, although not statistically significant, is still negative. In contrast, the dairy households from either scheduled groups or the OBC category are significantly more likely to become members of an MPC. Annual household income negatively influences co-operative membership; while it positively influences MPC membership. By applying Propensity Score Matching, we find positive income effects for the members. The annual net returns from local cow increase significantly by INR 3,714/-, while the annual net returns from buffalo increase significantly by INR 6,430/-, thereby increasing the total annual net returns from dairy by INR 10,144/- for the members. The share of dairy in total household income increases significantly by 14 percentage points and share of milk sold increases significantly by 1.4 percentage points after membership. While the potential underlying social bias in determinants of membership needs further investigation, both milk co-operative and producer company models are efficient ways of collective action in the state.

Keywords: Dairy, farmer collective, membership, impact, smallholder farmers

Introduction

India was a milk-deficit country post-independence from the British rule in 1947 (per capita availability was 130 grams/day, as opposed to 471 grams/day in 2023-24). The Government of India set up the National Dairy Development Board (NDDB) in 1965, and in 1970, Operation Flood (*aka* OF or Flood) project was launched by NDDB to make the country self-sufficient in milk production. The vehicle to realize the aim was Dairy Cooperatives (DC), where production is linked to marketing (Banerjee, 1994). By the 1990's, India surpassed the US in its milk production, and White Revolution brought on by DCs changed many lives by providing livelihood opportunities to millions of dairy farmers (Birtal et al. 2017). The DC set-up is generally characterized by a well-established procurement and distribution system, along with backward linkages of inputs like feed/fodder, veterinary services, and trainings to the members, etc. However, it also has its own set of problems, such as delayed or irregular payments and political interference (Rajendran & Mohanty, 2004). Another form of farmer collective organization, Milk Producer Companies (MPCs) emerged in the country after the Companies Act, 1956 was amended in 2003. A Producer Company combines the benefits of professional management of a private company and welfare principle of the co-operative model. In 2012, NDDB also started promoting MPCs to aid small dairy producers and enhance milk productivity. Many old dairy cooperatives also converted to producer companies. By 2020, there were over 210 active MPCs in India (Thakur, 2020).

Smallholder dairy farms are the backbone of dairy in India. Over 73 per cent of the total milk produced in the country in 2013 came from marginal and small farmers; their share in the total milk production in Gujarat the same year was 75 per cent (Kumar et al. 2018). Dairy is also an important secondary source of income for millions of landless labourers, and marginal and small farmers in India who own less than 2 hectare land. Collectivization is known to reduce the constraints, such as high input costs, weak extension support, lack of timely veterinary services and good quality of feed, etc., faced by small farmers (Holloway et al. 2000;

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Roy and Thorat, 2008; Markelova et al. 2009; Fischer and Qaim, 2012, Bizikova et al. 2020; Zang et al. 2022). However, there is limited evidence of positive impacts of collectivization on smallholder farmers through both co-operative and producer company model in dairy sector in India.

Gujarat was purposively selected for the present study due to its progressiveness in dairying and well-established dairy farmer collective organisations, including the Gujarat Co-operative Milk Marketing Federation (GCMMF or the AMUL brand), and Maahi Milk Producer Company (Maahi MPC). It has over 30 lakh milk producers who produced 16.72 million metric tonnes of milk in 2022 (Bulletin of Animal Husbandry and Dairying Statistics, 2022-23, Directorate of Animal Husbandry, Gujarat state). The state is also the highest contributor of quantity of milk (1052 litres) marketed annually by an agricultural household in the country (Kumar et al. 2018).

This study contributes to the literature by assessing the case of member and non-member milk producers of a prominent co-operative and a milk producer company in the major dairying state of Gujarat in India. Our contributions are twofold: First, we separately examine the drivers of group membership and collective action through a co-operative and a producer company; then, we capture the impacts of group membership and collective action on four outcomes, i.e., cost, income from dairy, commercialization, and milk production. Majority of the studies limit their scope to costs and dairy incomes, but it is important to capture membership impacts on production and commercialization, since the producer company model of collectivization is still relatively young in the country.

Materials and methods

Primary data pertaining to socio-economic and farm characteristics and cost and returns in milk production from local cow and buffalo (both in the lean and flush seasons) were collected from 416 dairy farming households in the months of January-February 2020.

Household heads of the sampled households were interviewed with the help of a well-structured schedule to collect the relevant information. In order to get the most representative sample from the population of dairy farming households in Saurashtra, the region was purposively stratified into four areas, as illustrated in Table 1. The study area map with the sampling locations is presented in Figure 1.

The sample constituted 246 member households (119 members of Maahi MPC and 127 members of Rajkot Union), and 170 non-member households – all sampled through stratified random sampling. Care was taken to select non-member households that

were similar to the member households with respect to observable characteristics.

Maahi started its commercial operations a little over a decade ago (in 2013), while Rajkot union has been operational for more than fifty years. The eleven districts of Saurashtra plus Kutch district are the area of operation of Maahi. Rajkot union is predominant in five districts of Gujarat. The average daily milk procurement (6.57 LKGP) of Maahi is more than that of Rajkot union (4.53 LKGP).

Empirical framework

A note on Standard Animal Unit (SAU): To arrive at the total herd size of a household, it is not possible to simply take a sum of all animals the household possesses, as the animals differ in age and sex. Further, some animals may be in milk, while some may be dry or pregnant. Therefore, all the different categories of animals are first converted into homogenous animal units with the help of certain conversion coefficients known as Standard Animal Units (SAUs) given by Sirohi et al. 2015. The total SAUs are then calculated for a household by taking a sum of its SAU of milch animals, heifers, adult male, and calf. The SAUs for all 416 households in sample were calculated separately for local cow and buffalo before arriving at the total SAUs.

Table 2 presents the empirical framework adapted for the research. Membership of a dairy farmer collective organization is the treatment, whose effect is studied on cost, household income, commercialization, and milk production.

a) Determinants of membership

The household's decision to become member of Co-operative or MPC can be modeled in a random utility framework, which is a common approach to analyze innovation adoption under uncertainty (Feder et al. 1985; Marra et al. 2003). We model the MPC/Co-op membership as a binary choice decision, with the assumption of utility maximization subject to household resource constraints (Manski, 1977). The part of the utility function that is observable can be expressed as a function of a vector of exogenous variables X_i and a vector of parameters $\hat{a}$ to be estimated:

$$V_i(\beta X_i), \text{ where } U_i = V_i(\beta X_i) + u_i \quad \dots(1)$$

The vector X_i includes social/demographic indicators, economic indicators, govt. scheme/extension exposure indicators and dairy indicators of the household. The unobservable part of the dairy farmers' utility is represented by an error term u_i and assumed to be independently and identically distributed with mean zero. The dairy farmer will choose to be member if the utility U_i^f derived

from MPC/Co-op membership is higher than the utility U_i^f derived from non-membership.

$$P(C_i = 1) = P(u_i < \beta X_i) = \beta X_i + u_p \dots(2)$$

The probability of a dairy farmer being a member is measured by $P(u_i < \beta X_i)$. Hence, the membership model to be estimated is:

Fig 1. Study area map with sampling locations

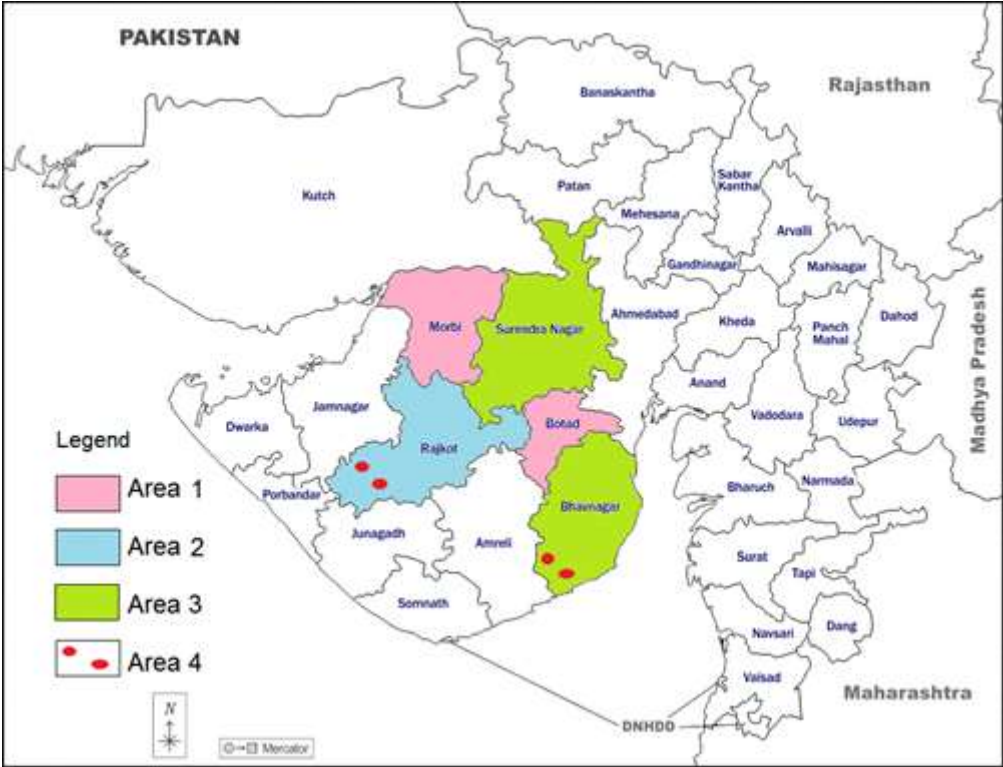


Table 1: Sampling plan

Sampling region	Rationale	Districts/villages	Districts Selected	Sampling units
Area 1	Where Maahi MPC is operational	Jamnagar, Gir Somnath, Botad, Morbi, and Devbhoomi Dwarka	Morbi and Botad	59 member households, 60 non-member households (119)
Area 2	Where Co-op Union is operational	Rojkot	Rajkot	67 member households, 74 non-member households (141)
Area 3	Where both are operational	Kutch, Surendranagar, Porbandar, Junagarh, Amreli, and Bhavnagar	Surendranagar and Bhavnagar	60 member households of Co-op, 60 member households of MPC (120)
Area 4	Pockets of villages in Rajkot and Bhavnagar with no farmer collective action	Khakhada Bela, Rojiya, Naranaka, and Borda	Khakhada Bela, Rojiya, Naranaka, and Borda	36 dairy households selected randomly

Where $C_i = 1$ if $U_i^e > U_i^f$ and $C_i = 0$ if $U_i^e < U_i^f$

The decision of membership based on comparison of its benefits and costs modelled as a binary choice is estimated with a probit specification. Since farmers in the control region do not have the chance for membership, the sample for this estimation is confined to MPC/Co-op members and non-members in treatment regions, i.e., Areas 1, 2, and 3.

b) Impacts of membership

We apply Propensity Score Matching by modelling the impact of membership in two stages: First, propensity scores $P(x)$ are generated from the probit model, now using the whole sample. Then a control group is constructed by matching members with the non-members based on the propensity scores. Second, Average Treatment Effect on the Treated (ATT) of membership is estimated on the outcome variable (Y):

$$\tau_{ATT}^{PSM} = E_{(P(X)|C=1)}\{E[Y(1)|C=1, P(X)] - E[Y(0)|C=0, P(X)]\}, \dots (3)$$

Where $Y(1)$ and $Y(0)$ are outcomes for the treated with treatment (membership) and control farmers without membership,

respectively; while $C = 1$ indicates treated farmers and $C = 0$ indicates control farmers.

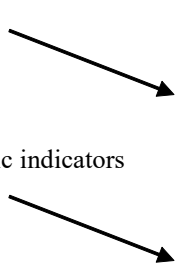
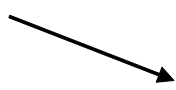
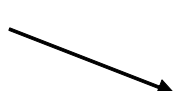
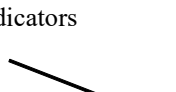
Results and Discussion

a) Determinants of group membership

Table 3 reports description and sample mean values of farm and household characteristics of farmer collective members and non-members in treatment regions. The non-members are slightly younger and more educated. Livestock is the main source of income for more member households than for the non-member households.

To assess the determinants of membership of dairy co-operative organization, i.e., Rajkot Union, the same data of 380 households in treatment regions were used with the binary dependent variable: member of Rajkot Union = 1; 0 otherwise. The probit results are presented in Table 4. A household belonging to OBC category is significantly less likely to become member of a co-operative. Association of a household belonging to a scheduled group and membership of co-operative, although non-significant, is also negative. These results may be pointing towards a social bias which needs further investigation. Distance from main market also has a negative and significant effect on membership. Similar findings were reported by Priscilla

Table 2: Empirical framework

Treatment	Confounding factors	Outcome variables/Welfare indicators
Membership of dairy farmer collective organization (Rajkot Milk Union or Maahi Milk Producer Company Ltd.: If member = 1; if non-member = 0)	Social/demographic indicators  Age and education (of head of HH), HH size, SC/ST, OBC, Dwelling structure, Distance from main market	Cost (incurred on the dairy enterprise, measured in INR)
	Economic indicators  Main source of income, Income, Landsize, Access to mass media	Household income (from dairy, measured in INR)
	Govt. schemes/extension exposure indicators  Access to govt. schemes like MGNREGA, Contact with extension personnel, Extension service of input supply	Commercialization (captured by the share of milk sold)
	Dairy indicators  Yrs. of dairy farming experience, milk marketed surplus, SAU, Milk price	Milk production (milk yield in litres/day)

(2017). A possible reason could be that there are plenty of milk marketing options available to dairy farmers in the study area. Access to government schemes, contact with extension, and contact with input supply – all positively and significantly affect the probability of membership of a dairy co-operative. Of all the economic indicators under consideration, annual income of a household has a negative and significant effect, while size of landholding (up to 8 ha.) has a positive and significant effect on membership of a co-operative. Dairy households with annual income of ten lakh or more are less likely to become members of a dairy co-operative. Among the dairy indicators, marketed surplus (up to 2.6 litres) has a positive and significant effect on the household's probability of membership of a dairy co-operative.

Similarly, the same data were analysed for the determinants of membership of Maahi MPC. For this purpose, the binary dependent variable was: member of Maahi = 1; 0 otherwise. The probit results are presented in Table 5. Age has a negative and significant effect on the probability of membership of the Milk

Producer Company. If the dairy household belongs to either scheduled group or OBC category, it is significantly more likely to become member of the MPC. This is exactly contradictory to the findings of determinants of membership of a co-operative in the study area. The probability of membership of MPC for a scheduled household increases by 21 percentage points, while the same for an OBC household increases by 28 percentage points. Here again, distance from main market is negatively and significantly associated with membership. Of all the economic indicators under consideration, annual income of a household has a positive and significant effect, while size of landholding (up to 9 ha.) has a negative and significant effect on membership of the MPC.

While smaller dairy households are more likely to choose co-operative membership, the larger, more well-off farmers are more likely to join an MPC. This is also reasonable, as an MPC requires its members to raise capital and become its shareholders.

Table 3. Description of variables and their descriptive statistics (households in treatment regions)

Sr. No.	Variable	Description	Members (n=246)		Non-members (n=134)	
			Mean	SD	Mean	SD
1	Age	Age of household head in years	44.35	9.76	42.45	9.92
2	Education	Head has primary education or above (Yes = 1; no = 0)	0.37	0.48	0.40	0.49
3	HH size	No. of household members	6.24	2.68	5.82	2.68
4	SC/ST	Household belongs to scheduled group (Yes = 1; no = 0)	0.07	0.25	0.16	0.37
5	OBC	Household belongs to OBC category (Yes = 1; no = 0)	0.63	0.48	0.55	0.49
6	Dwelling structure	Kind of dwelling structure of household (pacca house = 1; semi-kachha or kachha = 0)	0.82	0.39	0.91	0.28
7	Dis. From main mkt	Distance from nearest main market in km	5.82	3.25	7.03	4.54
8	Main source of income	Main source of income of household (livestock = 1; others = 0)	0.18	0.38	0.07	0.26
9	Annual income	Annual income of the household in Rs	116829	110271	106434	63310
10	Landsize	Size of land (in hectares) that the household owns	3.66	4.27	2.65	2.01
11	Access to mass media	Household has access to mass media, i.e., newspaper/radio/TV/internet (Yes = 1; no = 0)	0.98	0.13	0.96	0.19
12	Access to govt. schemes	Household has access to govt. schemes like MGNREGA and Ration Card (Yes = 1; no = 0)	0.33	0.47	0.32	0.47
13	Contact with extension	Household has contact with *extension services (Yes = 1; no = 0)	0.94	0.24	0.25	0.43
14	Contact with input supply	Household has access to input supply like feed, concentrates, etc. (Yes = 1; no = 0)	0.36	0.48	0.13	0.34
15	Yrs of dairy exp.	Number of years of dairy farming experience of household head	22.46	9.16	19.18	9.58
16	Marketed surplus	Total marketed surplus (of milk) per day of the household in litres	16.48	10.84	15.82	11.70
17	SAU	Herd size of household in Standard Animal Unit	4.43	3.04	3.79	2.48
18	Milk price	Per litre Price of milk in Rs	38.79	5.55	42.68	5.33

*Extension services include educational program for awareness building; technical program like animal health services, vaccination, artificial insemination (AI), and deworming; and group mobilization for social capital development

b) *Impacts of Membership***ATT: Propensity Score Matching (PSM)**

First, the propensity scores, which are conditional probabilities of a household becoming member of a dairy farmer collective, are generated with the help of the same probit model, now with the entire sample of 416 dairy farming households. The propensity scores are then used to match member households (treated observations) to non-member households (control observations) by various matching algorithms. Table 6 presents the estimates of various outcome variables that reflect the four parameters for the members (treated) as well as non-members (control), along with the ATT and their significance.

The average labour cost for local cow decreases significantly by INR 10/-, and the total labour cost decreases significantly by INR 11/- for the member households. This may be because the

non-members are using more labour in dairy farming compared to the members. The feed cost for local cow, and the total feed cost in dairy reduces significantly by INR 33/- and INR 27/-, respectively, for the members. This is plausible, as the farmer collectives provide animal feed to their members at competitive rates. A 40 kg feed packet costs INR 800/- for the members, while the same quantity of feed costs anywhere between INR 880/- to INR 1000/- from the market. The total variable cost for local cow decreases significantly by INR 36/-, and the total variable cost in dairy decreases significantly by INR 30/- for the members. This is certainly reasonable, as feed cost constitutes a majority of the total variable cost. The cost per litre in case of local cow reduces significantly by INR 4/- for the member households. In buffalo milk production, there is no significant effect of membership on labour cost, feed cost, and total variable cost.

The annual net returns from local cow increase significantly by INR 3,714/- for the member households. The annual net returns

Table 4. Determinants of membership of Rajkot Union/co-operative: Probit

Social/Demographic indicators	Coefficient	Marginal effect	Economic indicators	Coefficient	Marginal effect
Age	0.004 (0.010)	0.001	Main source of income	-0.015 (0.282)	-0.003
Education	0.066 (0.185)	0.014	Annual income	-0.001** (0.000)	-0.000
HH size	-0.025 (0.031)	-0.005	Land size	0.089*** (0.029)	0.019
SC/ST	-0.241 (0.334)	-0.053	Access to mass media	0.741 (0.497)	0.165
OBC	-0.662*** (0.215)	-0.147	Dairy indicators	Coefficient	Marginal effect
Dwelling structure	0.257 (0.253)	0.057	Yrs. Of dairy exp.	0.002 (0.010)	0.001
Dis. From main mkt	-0.098*** (0.023)	-0.021	Marketed surplus	0.026*** (0.011)	0.006
Govt scheme/ext. exposure indicators	Coefficient	Marginal effect	SAU	-0.045 (0.112)	-0.010
Access to govt. schemes	0.332* (0.198)	0.074	SAU square	-0.001 (0.006)	-0.000
Contact with extension	2.149*** (0.306)	0.479	Milk price	0.014 (0.018)	0.003
Contact with input supply	0.720*** (0.181)	0.160			

Observations: 380

*Denotes significance at the 10% level

**Denotes significance at the 5% level

***Denotes significance at the 1% level

Binary dependent variable: member of Rajkot union = 1; non-member = 0

Pseudo R-squared: 0.378

Note: Figures in parenthesis are robust standard errors

from buffalo increase significantly by INR 6,430/-, thereby increasing the total annual net returns from dairy by INR 10,144/- for the members. After membership, the share of dairy in total household income increases significantly by 14 percentage points.

Share of milk sold captures the impact of membership on commercialization. It increases significantly by 1.4 percentage points after membership. There are no significant effects of membership on milk yield.

Co-operative set-up is well-established in the state of Gujarat, however, the government's increasing focus on producer companies to bring in more farmers into the organised market is a welcome step. Pabba and Ponnusamy (2024) suggest reorienting the policy focus from the 'formation of FPCs' to the 'promotion and incubation of them' to ensure sustainability of producer companies in India.

Conclusion

Both the models of farmer collectives, i.e., milk co-operative and milk producer company, must be encouraged and promoted for a healthy competition and benefit to the member farmers. Extensive use of mass media and extension outreach in regions where there is no farmer collective action can pull more small dairy farmers towards membership of both the farmer collective models. Social platforms on mass media and influence of successful, more experienced dairy farmers can also be harnessed to target and facilitate the younger dairy farmers to join farmer collectives. The social bias found in the determinants of membership of both the farmer collective organisations needs to be investigated further with a larger sample for better insights.

Table 5. Determinants of membership of Maahi MPC: Probit

Social/Demographic indicators	Coefficient	Marginal effect	Economic indicators	Coefficient	Marginal effect
Age	-0.023** (0.010)	-0.005	Main source of income	0.154 (0.259)	0.035
Education	-0.236 (0.167)	-0.052	Annual income	0.000** (0.000)	0.000
HH size	-0.011 (0.027)	-0.002	Land size	-0.097*** (0.035)	-0.021
SC/ST	0.914*** (0.368)	0.211	Access to mass media	0.436 (0.472)	0.090
OBC	1.265*** (0.227)	0.287	Dairy indicators	Coefficient	Marginal effect
Dwelling structure	-0.096 (0.237)	-0.021	Yrs. Of dairy exp.	0.037*** (0.009)	0.008
Dis. From main mkt	-0.001*** (0.000)	-0.001	Marketed surplus	-0.001 (0.010)	-0.000
Govt scheme/ext. exposure indicators	Coefficient	Marginal effect	SAU	-0.115 (0.076)	-0.025
Access to govt. schemes	-0.721*** (0.202)	-0.150	SAU square	0.007** (0.003)	0.001
Contact with extension	1.759*** (0.241)	0.357	Milk price	-0.062*** (0.017)	-0.013
Contact with input supply	-0.792*** (0.193)	-0.167			
Observations: 380					
*Denotes significance at the 10% level					
**Denotes significance at the 5% level					
***Denotes significance at the 1% level					
Binary dependent variable: member of Maahi = 1; non-member = 0					
Pseudo R-squared: 0.361					

Note: Figures in parenthesis are robust standard errors

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Table 6. Impact of membership of dairy farmer collectives: Average treatment effects on the treated (ATT) (n=416)

Parameter measured	Outcome	Members	Non members	ATT	SE
Impact on cost	LC labour cost (INR/animal/day)	24.57	34.73	-10.15	2.93***
	Buffalo labour cost (INR/animal/day)	44.62	45.32	-0.69	3.26
	Total labour cost (INR/animal/day)	69.21	80.05	-10.85	2.71***
	LC feed cost (INR/animal/day)	100.84	133.65	-32.81	8.24***
	Buffalo feed cost (INR/animal/day)	166.67	159.71	6.96	8.71
	Total feed cost (INR/animal/day)	267.51	293.36	-26.75	11.38**
	LC TVC (INR/animal/day)	141.31	176.98	-35.67	11.58***
	Buffalo TVC (INR/animal/day)	218.36	212.47	5.88	10.77
	TVC dairy (INR/day)	359.67	389.46	-29.79	11.62***
	LC cost/litre (INR)	18.85	22.45	-3.59	1.75**
	Buffalo cost/litre (INR)	27.12	24.63	2.49	1.54
	Total cost/litre (INR)	45.97	47.08	-1.10	2.03
Impact on household income	Annual net returns from LC (INR)	5127.40	1413.46	3713.94	707.45***
	Annual net returns from buffalo (INR)	9186.91	2757.06	6429.85	830.64***
	Annual net returns from dairy (INR)	14314.32	4170.52	10143.79	1138.05***
	Share of dairy in income (%)	17.81	4.11	13.69	1.51***
Impact on commercialization	Share of milk sold (%)	78.45	77.03	1.41	0.85*
Impact on milk production	Milk yield (litres/day)	20.93	20.97	-0.04	0.97

Note: Number of participants with match = 215 of 246; LC: Local cow; TVC: Total Variable Cost;

*Denotes significance at the 10% level;

**Denotes significance at the 5% level;

***Denotes significance at the 1% level

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