Research Article

Determinants of Commercialization of Dairy Cattle Farms in Nepal

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Abstract | Dairy cattle farming are a vital source of income for rural farmers in Nepal. Despite its potential to enhance economic growth, milk marketing has received little attention. This study aims to identify the determinants of dairy cattle farm commercialization. It examines the factors that affect household decisions to participate in the dairy market and identifies the variables driving milk sales intensity in selected districts of Nepal. The data were collected through a survey of 407 households, randomly selected from districts of Morang (114), Chitwan (116), Kavre (91), and Ilam (86), from February to October 2024. The data were analyzed using a double hurdle model, with a binary probit model in the first stage and a truncated regression in the second stage. Among 407 dairy farmers, 83% farmers were market participants, and 17% farmers were non-participants. The results of the first hurdle model showed that the education of the Household Head (HH), family size, access to extension services, cooperative membership, and off-farm work significantly influence households' decision to participate in the dairy market. Similarly, the second hurdle confirmed that credit use, subsidy, technology, distance to milk sales center, and milk production cost significantly affected milk sales intensity. Thus, the public policy initiatives should prioritize dairy extension services that support good husbandry practices and cooperative membership. The cost-reduction technologies and ensuring access to credit and subsidies are essential to enhance milk marketing. In addition, this study provides important policy insights for enhancing dairy marketing and improving rural livelihoods by commercializing dairy farming in Nepal.

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Introduction

The economy of Nepal is mainly based on agriculture, with 61% of the labor force engaged in this sector (World Bank, 2020). The livestock sector contributes 24.01%, while the dairy sector accounts for 11.2% to Agricultural Gross Domestic Product (AGDP) (MoALD, 2023). Cattle and buffalo are the primary dairy animals in Nepal. The country has a high potential for milk production due to favorable climatic conditions, particularly in Ilam and Morang districts of Koshi Province, as well as in Chitwan

and Kavre districts of Bagmati Province (MoALD, 2023). The intake of milk and dairy-based products plays a vital role in household nutrition, providing essential proteins, vitamins, and minerals (Miller *et al*., 2020). Among the 5.20 million total cattle, 1.06 million are milking cattle, representing 61% of dairy animals (MoALD, 2025). There are 6,486 commercial livestock farms in the country, comprising 1,233 cattle farms and 914 buffalo farms, with improved breeds' accounts for 75% and an average milk yield of 10 liters (GoN, 2022). The country has 765 Small and Medium-sized Enterprises (SMEs), 36 district milk producer cooperatives, more than 1800 primary dairy cooperatives, and 55 large milk chilling centers (NDDB,2021). Milk output rose from 1.68 million tons in 2013 to 2.61 million tons in 2023 (MoALD, 2024). These trends reflect a gradual shift from subsistence-based dairy farming to market-oriented production.

To achieve better dairy outcomes, national policies have prioritized the commercialization of dairy farms (ADS, 2015; NPC, 2022). The Government of Nepal (GoN) also supports initiatives such as improved breeds, fodder missions, Artificial Insemination (AI), veterinary services, and insurance schemes. The sixteenth periodic plan (2024/25–2028/29) further emphasizes the need for a market-based approach (NPC, 2024). Collectively, these policies aim to enhance dairy farming from a traditional farm-based system to a more commercial production system.

However, the commercialization of dairy cattle farms is significantly low. Farmers still engage in subsistence production, resulting in limited livestock marketing (Chapagaee *et al*., 2024; Dhakal and Mueser, 2023; Yogi *et al*., 2025). In total, 95% households rear dairy animals, while only 15% produce marketable dairy products (CASA, 2020). This situation is impeded by weak institutional mechanisms (Shrestha and Singh, 2023), poor market infrastructure (Ghimire, 2021), limited dairy extension services (Dhungana *et al*., 2024; Neopane *et al*., 2022), high cost of production (Upadhyay *et al*., 2021), insufficient credit facilities (Devkota *et al*., 2022), and limited availability of modern technology (Yogi *et al*., 2025).

Although the issue has been recognized, previous studies have not sufficiently addressed the problem of commercialization, particularly in Nepal. Most prior studies have focused on the commercialization of crops in Africa (Gebiso *et al*., 2023; Paul *et al*., 2022; Saha *et al*., 2022) and some aspects of agriculture in Nepal (Joshi and Piya, 2021). Extensive studies have examined the factors influencing dairy market participation in Ethiopia (Bahta *et al*., 2025; Degefa *et al*., 2022; Jebessa *et al*., 2024). The existing studies in Nepal have primarily concentrated on topics such as production (Bhandari, 2022; Panta, 2022; Poudel *et al*., 2023), efficiency (Dhakal, 2022a), insurance (Ghimire *et al*., 2023), agri-enterprises (Bhatta and Mishra, 2022), and reproductive performance (Bhattarai *et al*., 2022). However, these studies do not sufficiently address the challenges related to milk market participation and its components. Currently, no research specifically examines the socio-economic, institutional, and farm-level factors that determine the commercialization of dairy cattle farms in Nepal. These knowledge gap limits policy-makers' potential to formulate tailored policies that promote market-oriented dairy cattle farming.

The rapid changes in agri-food chains have created opportunities for dairy production in both national and global markets (Tadele *et al*., 2025). The production of marketable commodities plays a key role in income generation (Belay *et al*., 2021; Saha *et al*., 2022), enhances food security (Ahmed *et al*., 2024; Manda *et al*., 2021), and contributes to poverty reduction (Mgomezulu *et al*., 2024; Singh *et al*., 2023). In this context, the study of determinants of farm commercialization is highly relevant (Gayathri *et al*., 2023; Kim *et al*., 2016; Mamo *et al*., 2022; Paudel *et al*., 2021; Von Braun *et al*., 1994).

To address this knowledge gap, the study intends to identify the determinants of dairy cattle farm commercialization by focusing on two key research questions: (a) What factors affect households' decisions to participate in the dairy market? (b) What are the determinants of the intensity of milk sales among households that do participate in the market? This study applies a double-hurdle model to analyze market participation decisions and intensity of milk sales, thereby providing a better understanding of the commercialization of milk. The findings are expected to enhance the commercialization of dairy farms and provide relevant policy insights to promote market-oriented dairy development in Nepal.

Materials and Methods

Description of the study sites

For this study, Morang and Ilam from the Koshi

province, along with Chitwan and Kavre from the Bagmati province were selected. These districts were chosen for their dominance of cattle populations and presence of dairy farms with diverse agro-ecological conditions. The Ilam and Kavre districts have milking cattle populations of 30,901 and 21,442, respectively. Meanwhile, the Morang and Chitwan districts report milking cattle populations of 85,098 and 23,064, respectively (MoALD, 2025). All four districts are recognized for high milk production potential.

Types and sources of data

The study utilized an explanatory sequential mixed-methods design (Creswell, 2003; Subedi, 2023), comprising two stages of data collection: a quantitative stage using a household survey, followed by a qualitative stage. A closed-ended, structured questionnaire was used to collect data. The questionnaire was pre-tested with non-sampled households and revised based on field feedback. The data were collected from households on dairy cattle farms in selected municipalities from February to October 2024. To obtain qualitative information, the study employed eight Key Informant Interviews (KIIs) and three Focus Group Discussions (FGDs). Official reports, literature reviews, and relevant empirical evidence were also used to enhance the interpretation of the research findings.

Sampling procedure and sample size

The dairy cattle rearing households were the study population. Sample sites were chosen through a multistage random sampling procedure (Bhandari, 2022). Three criteria were set, including the number of high AI users (NLBO, 2022), the presence of a large number of dairy cattle farms (MoICS, 2023), and high milk production volume (MoALD, 2023). The stages of sample selection were: (i) provinces, (ii) districts, (iii) municipalities, and (iv) dairy-cattle rearing households. Five municipalities per district were selected. The sampling frame was identified from selected municipalities covering four districts (Table 1). The inclusion criteria for the household survey were that households must be rearing dairy cattle and have at least one milking cattle.

The final sampling units were selected through simple random sampling (Noor *et al.*, 2022). The sample size was determined using the Probability Proportional to Size (PPS) sampling method, with the Krejcie and Morgan (1970) formula. This formula was used for populations of 5,000 or more, with a 95% confidence interval and 5% margin of error (Wangu *et al.*, 2021). The total population of dairy cattle households across the selected districts was framed at N=5,194, which justifies the use of this method. The sample size was calculated using the following formula:

$$n = \frac{(Z^2 \times p \times (1-p)}{e^2}$$

Where Z is the z-value 1.96 at 95% confidence, p=probability of happening=0.5, 1-p=1-0.5=0.5

e=margin of error=5%=0.05. Sample size (n) = ((1.96) ^2×0.5× (1-0.5))/ (0.05) ^2 =384, plus 23 (6% buffer), n=407. The sample size was calculated proportionately, including Ilam (86), Morang (114), Chitwan (116), and Kavre (91) (Table 1).

Table 1: *Study population and sample size*

Districts	Municipalities	Population (N)	Sample size (n)	Districts	Municipalities	Population (N)	Sample size(n)
Ilam (86)	Suryodaya	252	20	Kavre (91)	Dhulikhel	349	27
	Ilam	231	18		Panchkhal	221	17
	Rong	187	15		Banepa	267	21
	Sandakpur	143	11		Mandandeupur	151	12
	Deumai	285	22		Panauti	174	14
Sub-total		1098	86			1162	91
Morang (114)	Biratnagar	496	39	Chitwan (116)	Bharatpur	534	42
	Sundarharaicha	204	16		Khairahani	236	18
	Pathari	191	15		Ratnanagar	385	30
	Katahari	267	21		Madi (new)	164	13
	Dhanpalthan	292	23		Rapti(new)	165	13
Sub-total		1450	114			1484	116

Source: Field Survey, 2024

Data analysis

The data were examined using Microsoft Excel and STATA 15, with both descriptive and econometric approaches. The means, frequencies, and percentages were calculated. The T-test and Chi-square test were used to determine the statistical variations between groups (Gautam and Khadka, 2022). In this study, milk sales in the market were used as a proxy for the commercialization of dairy cattle farms (Bahta *et al*., 2021). The proxy variable captured the market participation, specifying whether farmers sell milk in the market or not, as well as the intensity of milk sales in the market. The double-hurdle model was chosen for its ability to capture two distinct hurdles (Cragg, 1971). In the first stage (hurdle 1), farmers decide to participate in the dairy market. In the second stage (hurdle 2), dairy farmers determine how much milk to sell (Jannat *et al*., 2026). The model employs a two-stage process that combines the probit model with truncated regression (Asfaw *et al*., 2023; Workie and Tasew, 2023). The second-stage dependent variable included some observations with zero values, for which Ordinary Least Squares (OLS) estimation seems inappropriate due to the lack of variance (Gujarati, 2004).

Conceptual framework of the study

Commercialization refers to the transition from subsistence farming to market-oriented production (GC and Hall, 2020; Von Braun *et al*., 1994). The commercial farming aims to generate income, whereas subsistence farming produces food for own consumption only (Joshi and Piya, 2021). The market participation theory explains this concept of how farm households decide whether and to what extent to engage in market activities (Cragg, 1971; Goetz, 1992). This decision is influenced by market access (Turkelboom *et al*., 1996), policy and institutional support (Pingali and Rosegrant, 1995), and personal characteristics (Schultz, 1964). According to Goletti *et al*. (2003), the main drivers of commercialization include technology adoption, credit and insurance schemes, and the role of farmers' organizations. The behavior of farmers in commercial production is shaped by a variety of inter-connected socio-economic, institutional and farm characteristics rather than by a single determinant (Fountas *et al*., 2006). This process involves not only the production of surplus goods but also household decision-making.

The theoretical foundations outlined here form the basis for the conceptual framework shown in Figure 1, which guides variable selection and knowledge of their relationships. This study hypothesized two models, with the dependent variables being market participation (yes/no) and milk sales intensity. The independent variables were socio-economic factors (age, gender, family size, education, off-farm work, and experience in dairy farming), institutional factors (access to extension services, membership in dairy cooperatives, credit, subsidy, training, and distance to milk sales centers), and farm characteristics (milk yield, the number of technologies used, and the cost of milk production).

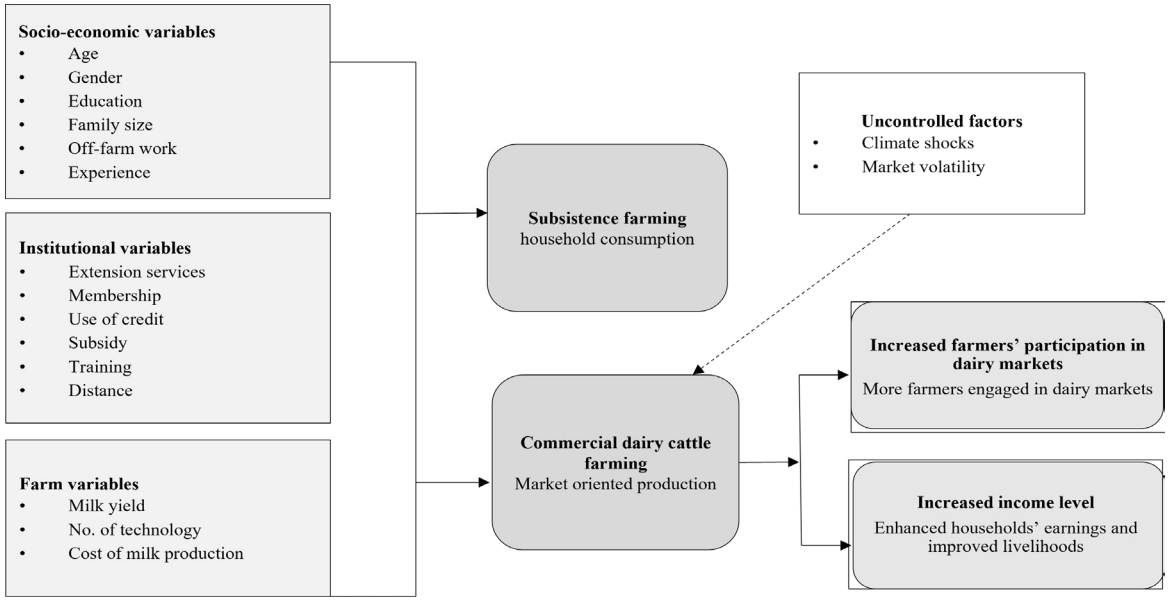

Figure 1: *Conceptual framework of the study*

Farmers typically have two approaches to milk production: subsistence or market-oriented. The market-oriented approach often leads to greater engagement in dairy markets, which can significantly increase milk supply and improve farmers' livelihoods.

Specification of the double-hurdle model

In the first stage, the influencing factors of farmers' decisions to participate in the dairy market were regressed using a binary probit model (Khanal *et al*., 2024). The model is specified below in equation (2):

$$D_i^* = \alpha Z_i + \mu_i;\ D_i = 1, \text{ if } D_i^* > 0 \text{ and } D_i = 0, \text{ if } D_i^* < 0 \quad (2)$$

Where, D_i^* is a binary dependent's latent variable, takes the value of one for those who sell milk in the market and zero otherwise. Z_i, α, and μ_i represent vectors of explanatory variables, parameter estimates, and error terms, respectively, for those market participants.

In the second stage, a truncated regression model was used, which excludes the portion of the sampled observations on the dependent variables (Wooldridge, 2002). Only households that choose market participation (value=1) are included in the regression, which limits the dependent variable to positive values and excludes zero from the estimation. The lower left censored truncation is used, equal to 0 values of dependent variables, which was described in equation (3):

$$\gamma_i = \beta_i X_i + \mu\lambda_{i+} \varepsilon_i$$
$$\gamma_i^* = \beta_i X_i + v_i,$$
$$\gamma_i = \{\gamma_i^* \text{ if } \gamma_i^* > 0 \text{ and } D_i = 1;\ 0 \text{ otherwise}\}$$

Where γ_i^* and γ_i are the latent and observed intensity of participation, respectively, X_i, β, and ε_i represent the vectors of explanatory variables, parameter estimates, and error terms respectively, for market participants. It is assumed that the error terms have an independent, normal distribution, reflecting the fact that each decision made by the individual producer is independent, namely: $ui \sim N(0, 1)$ and $vi \sim N(0, \sigma 2)$. The study tested two hypotheses as given below:

- **Hypothesis 1:** Households' decision to participate in the dairy market depends on the age of HH, gender of HH, Education of HH, family size, extension services, cooperative membership, off-farm work, and milk yield
- **Hypothesis 2:** The intensity of milk sales depends upon the experience in dairy farming, access to extension services, credit use, subsidy, training, technology, distance to milk sales center, and cost of milk production

Table 2: *Description of the variables used in the study*

Variables	Type	Description
Market participation	Dummy	1 if the household decides to sell milk in the market or 0 otherwise
Intensity of milk sales	Continuous	A continuous variable with the daily volume of milk sales in liters
Age	Continuous	Age of household in number of years
Gender	Dummy	1 if the household head is male or 0 otherwise
Education	Continuous	Schooling in years of household head
Family Size	Continuous	Number of members in the family
Extension	Dummy	1 if the household has access to extension services or 0 otherwise
Membership	Dummy	1 if the household has a membership in the dairy cooperative or 0 otherwise
Off-farm work	Dummy	1 if households have off-farm work or 0 otherwise
Milk yield	Continuous	Milk per cattle per day in liters
Experience	Continuous	Dairy farming experience in number of years
Credit use	Dummy	1 if the household used credit in previous years, or 0 otherwise
Subsidy	Dummy	1 if the household received subsidy, 0 otherwise
Training	Dummy	1 if the household received training or 0 otherwise
Technology	Continuous	Number of technologies used in the cattle farms
Distance	Continuous	Distance to milk selling center measured in Kilometers
Cost	Continuous	Cost of milk production in Nepalese Rupees (NPR)

Results and Discussion

Descriptive statistics

Table 3 presents the differences in continuous variables between milk market participants and non-participants. Out of total 407 dairy farms, 83% farmers sell milk, while 17% farmers do not sell milk in the market. The t-test results showed that the means for household head education, family size, milk yield, number of technologies, distance to the sales

Table 3: *Differences between market participants and non-participants*

Variables		Participants (n=336)	Non-participants (n=71)	Total (n-=407)	t-value
Continuous		Mean			
Age of HH		49	51	49	1.4558
Education of HH		9.2	4.49	8.38	-8.15***
Family size		5	2.87	4.7	-10.5914***
Milk yield		11	9.41	10.78	-5.69***
Experience		8.71	8.13	8.61	-1.1361
Technology		6.24	2.05	5.51	-8.8772***
Distance		1.46	2.51	1.64	5.5100***
Cost		44	54.94	44.9	6.1086***
Categorical		Frequency given in percentage (%)			χ2 value
Gender	Male	79	73	78	1.2053
	Female	21	27	22	
Extension	Yes	56	31	52	14.9851 ***
	No	44	69	48	
Membership	Yes	69	34	63	31.2008***
	No	31	66	37	
Off-farm	Yes	55	94	66	30.2535***
	No	45	6	34	
Credit use	Yes	39	59	36	33.2867***
	No	61	5	64	
Subsidy	Yes	44	39	37	42.3190***
	No	56	7	63)	
Training	Yes	60	43	57	6.46***
	No	40	57	43	

*Notes: *** represents statistical significance at 1% levels*

center, and milk production costs were statistically significant at 1% level between the two groups (Table 3). The mean years of educational attainment among participants' household heads was 9.2, almost double that of non-participants (4.49). The average family size was larger among participants, at 5 members, compared to 2.9 among non-participants (Table 3).

Market participants adopted more improved farm technologies (6.24), achieved higher milk yields (11 liters), and owned more dairy cattle (10.85) than non-participants. The average distance to the milk sales center was shorter for participants (1.46 km) compared to non-participants (2.51 km). The cost of milk production was lower for participants (NPR 44) compared to non-participants (NPR 54). No substantial differences were observed between the two groups in the age of the household head or years of dairy farming experience.

The chi-square test revealed that access to extension service, membership, off-farm work, credit use, and subsidy are significant at 1% level (Table 3). Most of the respondents (56%) had access to an extension service, and 69% of households had a membership in a dairy cooperative. Only 3% of non-participant farmers received government subsidy, however, 93% of them were engaged in off-farm activities.

Econometric analysis

The double-hurdle model with a probit regression was used to test the first hypothesis, while a truncated regression was used for the second hypothesis. Before running the regression analysis, the Variance Inflation Factor (VIF) was tested, which had a value of 1.23. It indicates the low multicollinearity among the predictor variables. Heteroskedasticity was examined through the Breusch-Pagan and White tests in the second stage of the model.

Factors influencing households' decisions to participate in the dairy market

A binary probit model was used to examine the factors influencing a household's decision to participate in

Table 4: *Factors influencing the market participation decision of dairy cattle farms*

Variables	Coefficient.	Std. Err.	Marginal effect (dy/dx)	P>|z|
Age	0.0122075	0.013575	0.0010173	0.369
Gender	0.2279547	0.3218805	0.0189959	0.479
Education	0.0884483	0 .0276903	0.0073706	0.001***
Family Size	0.4078813	0.0895037	0.0339896	0.000***
Extension	0.9563612	0.3428712	0.0796956	0.005***
Membership	1.308253	0.3289223	0.1090194	0.000***
Off-farm work	-1.241427	0.3639559	-0.1034507	0.001***
Milk Yield	0.0318071	0.0595192	0.0026506	0.593
_Cons	3.166669	1.174581		0.007***
LR chi2(8)=255.63, Prob > chi^2=0.0000, Log likelihood= -60.570452 Pseudo R^2= 0.6785				

*Notes: *** represent statistical significance of factors at 1% levels, respectively*

the dairy market. The dependent variable is binary: 1 if the household participates in the dairy market and 0 otherwise. Out of eight hypothesized explanatory variables, family size, the education (number of schooling years) of the household head, access to extension services, membership in a dairy cooperative, and off-farm work were found to be significant (Table 4).

The gender and age of the household head were found to be insignificant. Marginal effects were calculated to interpret the influence of explanatory variables. The likelihood ratio test was found to be 255.63, with a log-likelihood of -60.570, indicating good model fit. A p-value of less than 0.0001 confirmed the statistical significance. The pseudo R-squared 0.6785 indicates that the model accounts for 67.85% of the variation in market participation decisions. The following factors were found to be significant:

Education

The probit regression results show that the years of schooling of the household head are positively and significantly associated with participation in the dairy market (Table 4). Each additional year of schooling increased the likelihood of market participation by 0.74%. Educated farmers often have better access to information and negotiation skills, which can facilitate their market engagement. Similar findings in Nepal showed that the educational attainment of the household head positively affected farm production (Dhakal, 2022a). Studies from Ethiopia (Ordofa *et al.*, 2021) and Kenya (Wangu *et al.*, 2021) also found that the higher participation of educated farmers in marketing activities. A positive relationship was found between education and market awareness (Cheng *et al.*, 2025; Paul *et al.*, 2022). On the other hand, Haile *et al.* (2022) reported that each additional year of education reduced market participation by 2.74%, suggesting that more educated farmers may prefer non-farm jobs. In conclusion, these results suggest that educating farmers, particularly in financial literacy, is essential.

Family size

According to the probit model results, family size has a significant, positive effect on the household's decision to participate in the dairy market (Table 4). Each extra family member raises the probability of market participation by 3.4%. The availability of farm labor is one of the advantages of a large family size. In a similar line, previous research from Bangladesh (Nath *et al.*, 2025) and Ethiopia (Jebessa *et al.*, 2024) found that the likelihood of market participation increased by 3.3% and 12.4%, respectively, for each extra family member. However, the increasing trend of youth out-migration in Nepal has reduced the family size, resulting in a shortage of family labor (Chhetri *et al.*, 2020). In this context, labor-saving technologies and mechanization can enhance labor efficiency, particularly in smaller family sizes.

Access to extension services

The households receiving extension services are 7.97% more likely to participate in the dairy market (Table 4). Extension services, such as veterinary care, market information, and technical advice help farmers engage in marketing activities. Regular contact with local extension agents and their services enables farmers to acquire technical knowledge and market information. Similar findings have been documented by previous research in Nepal (Jaishi *et al.*, 2024), Ethiopia (Degefa *et al.*, 2022), Pakistan (Abbasi and Nawab, 2021), Nigeria (Lai-Solarin *et al.*, 2024), and

Kenya (Ogola *et al.*, 2023). They reported that regular extension services to farmers led to higher milk yields. Despite the government's provision of one technician per ward in Nepal, village-level technicians are insufficient to reach farmers (KII with farmer, Kavre). The agricultural extension system is constrained by poor institutional structure and limited technical human resources (Timsina *et al.*, 2023). Thus, they advised promoting extension programs based on commodities and communities. In contrast, a study in Bangladesh (Eyasmin and Ghosh, 2024) found that extension visits led to low levels of market activity. This was due to informal payments to extension agents, which made an additional cost burden to farmers. These insights highlighted the need for policy interventions that promote regular, farmer-focused, and accessible dairy-focused extension services to enhance milk marketing.

Cooperative membership

The analysis shows that households with cooperative membership are 10.90% more likely to participate in the dairy market (Table 4). Local cooperatives assist farmers to access in farm inputs and encourage them to sell their commodities. This finding concurs with earlier studies that highlighted the role of cooperatives in facilitating access to inputs, sharing information, and establishing market linkages (Panta *et al.*, 2023; Van Koppen *et al.*, 2022). A previous study in Nepal found that cooperative members earned agricultural incomes four times higher than non-members (Dhakal *et al.*, 2021). Studies in Nepal found positive impacts of cooperatives on trust building (Mishra and Bhatta, 2021), gender balance (Kharel *et al.*, 2020), and formation of social capital (Dhakal, 2022b). The Constitution of Nepal 2015 also recognizes cooperatives as a third pillar of development. Thus, significant contribution of dairy cooperatives includes establish a strong market network, provide non-financial services, and connect farmers with livestock insurance (FGDs, August 2024). Similar impacts have been observed in Lesotho (Rantlo *et al.*, 2020) and Ethiopia (Jebessa *et al.*, 2023), where cooperatives reduced transaction costs, enhanced bargaining power, and supported economies of scale. Given these benefits, dairy cooperatives should prioritize membership expansion in underserved areas to strengthen markets.

Off-farm work

The results reveal that households engaged in off-farm work (salaried jobs, remittance income, daily wage work, business) are 10.35% have a less likely to engage in the dairy market (Table 4). The negative coefficient indicates that income from off-farm sources may decrease their involvement in farm activities. Many Nepalese households diversify into non-farm activities to reduce risk, thereby weakens their participation in the agricultural market (World Bank, 2020). Participants engaged in off-farm activities for better income sources, hassle-free work, and greater interest in out-migration jobs (FGDs, August 2024). Haile *et al.* (2022) found that off-farm income reduced the capacity of households to produce marketable farm commodities by diverting family labor. Unlike this result, a study in the Asia region, including Nepal, found that off-farm employment significantly increased the likelihood of livestock raising (Bai *et al.*, 2024). Non-farm activities have had a positive influence on farmers' income in Kenya (Onyango *et al.*, 2023) and Ghana (Twumasi *et al.*, 2022), and increased access to farm inputs in China (Zheng *et al.*, 2023). These mixed findings indicate that income from off-farm work may be used for farm investment or redirected to marketing activities.

Determinants of the intensity of milk sales in the dairy market

The intensity of dairy farm commercialization was measured using daily milk sales volume (Table 5). Out of the eight explanatory variables, five variables, such as credit use, subsidy, technology, distance, and cost of milk production were found to be statistically significant. The model showed high explanatory power, with a log-likelihood of -221.98955 and a Wald chi-square statistic of 246.27, indicating a good overall fit. A detailed discussion of significant variables is described below:

Credit use

The analysis shows that the quantity of credit used in dairy farms during the previous year influenced milk sales, increasing them by 13.52% (Table 5). The credit enables investment in essential farm inputs. The interview with farmers in study areas revealed that the credit is beneficial for the purchase of improved breeds, shed construction, and machinery. Farmers usually access credit through cooperatives, microfinance institutions, and commercial banks. In a similar line, the study found the statistically significant positive relationship between credit use and agricultural growth in Nepal (Lamsal *et al.*, 2025). The regulations

in Nepal also mandate that banks allocate at least 15% of their entire credit to the agriculture sector (Pandey, 2022). These findings are related to studies from Kenya that found that access to credit enhanced production and sales of milk (Kurgat *et al.*, 2023) and supported technology adoption (Okello *et al.*, 2021). The results differ from those of Bahta *et al.* (2025) in Ethiopia, who reported that the use of credit reduced milk supply by 4.2 liters per household. This is because households diverted the funds for investment in non-farm goods. Therefore, credit programs offered by financial institutions need to be adjusted to fulfill the specific needs of farmers and closely monitored to ensure funds are utilized for productive purposes.

Subsidy

The analysis reveals a positive correlation between subsidies and milk sales volume, with each subsidy associated with 30.79% increase in milk sales (Table 5). These findings are consistent with the studies from Nepal (Kharel *et al.*, 2025; Sapkota and Khatiwada, 2024; Thapa *et al.*, 2023) and Sri Lanka (Nadheer and Ummah, 2020). They found a significant relationship between farm subsidies and marketable surplus. A study in Nepal found a strong positive correlation (r=0.72) between production and input subsidy (Paudel, 2024). The subsidy contributed to a 15% reduction in costs (Bhatta *et al.*, 2025). Farmers participating in FGDs reported that they were benefited from various forms of support, including grants, loan subsidies, insurance, farm inputs, and top-up payments based on milk sales volume. They received provincial subsidies for equipment such as milking and silage machines; however, the lack of a local custom hiring center has left these machines unused (KIIs with farmers, September 2024). Local governments in Nepal offer support for animal insurance, farming tools, and machinery (Gautam *et al.*, 2021). These subsidies help farmers overcome production constraints. The findings indicate that ongoing support for output-based and targeted subsidy programs is essential.

Technology

The analysis reveals that increased use of dairy technologies had a positive impact on milk sales (Table 5). Each additional technology leads to 5.91% increase in daily milk sales intensity. The most commonly adopted technologies in Nepal include improved cattle breeds, AI, commercial fodder, hay, silage, improved sheds, clean milking practices, regular vaccinations, tools and machinery, and digital media (FGDs, producer groups, September 2024). This result aligns with previous research studies in Nepal. The authors reported that overall farm productivity is directly affected by the use of technology (Kharel and Dahal, 2023; Poudel *et al.*, 2025). However, as mandated by the Good Husbandry Practices (GHP) implementation directive 2023, the rate of technology adoption is inadequate (DoLS, 2023). The technology developed by NARC has not reached smallholders adequately due to weak extension services. Similar to this study, Korir *et al.* (2023) identified 19 farm technologies used by Ethiopian dairy producers. The analysis found a significant association between improved practices and milk production. Okello *et al.* (2021) reported that the intensity of technology positively affected the number of dairy cattle. The use of improved technologies in farms helps to improve farm efficiency, promote good animal health, and achieve higher yields (Zegeye *et al.*, 2022). These findings suggest that increased adoption of diverse and appropriate dairy technologies could enhance marketable surplus and serve as a key strategy to improve outcomes in the dairy sector.

Table 5: *Determinants of intensity of milk sales in the dairy market*

Variables	Coefficient.	Std. Err.	P>|z|
Experience	0.0033357	0.006783	0.623
Extension	0.0620119	0.0604862	0.305
Credit use	0.1351691	0 .0554767	0.015**
Subsidy	0.3078877	0.0659531	0.000***
Training	0.0957961	0.07053	0.174
Technology	0.0590868	0.0077368	0.004***
Distance	-0.0519447	0.0179255	0.004***
Cost	-0.054057	0.0018927	0.004***
_cons |	3.503154	0.1281778	0.000***
/sigma	0.4684831	0.0180721	0.000***
No. of observations =336, Log likelihood = -221.98955 , Prob > chi^2= 0.0000, Wald chi^2(8) =246.27			

*Notes: *** represent statistical significance of factors at 5% and 1% levels, respectively*

Market distance

The analysis indicates that proximity to the milk sales center has a significant negative impact on milk sales. Specifically, for every additional kilometer of distance from the sales center, milk sales decrease by 5.19% (Table 5). Due to the high perishable nature of milk, longer transport times increase the risk of spoilage and

discourage regular sales. Participants from remote, hilly areas reported that reaching the milk chilling center typically requires them to walk for at least 30 minutes to an hour (KIIs, September 2024). In contrast, farmers located closer to sales centers benefit from reduced transportation time. This evidence is supported by previous studies by Ejeta and Bai (2025) and Kassahun *et al.* (2020), who reported the negative relationship between distance and sales. Jebessa *et al.* (2024) found that milk sales decrease by 2.4% for every additional kilometer to the sales center. Therefore, better road connections and shorter distances to milk sales centers can significantly enhance farmers' ability to sell milk, ultimately increasing their income.

Cost of milk production

The analysis shows that higher costs negatively affect milk sales. A one-rupee increase in the cost of milk results in a 5.41% decline in milk sales (Table 5). It aligns with the results of Thapa *et al.* (2025), which reported an NPR 74.25 per liter, higher than the national average. The high production costs are largely driven by high feed expenses, which account for 48% of costs in Nepal (Panta, 2022) and 64% in India (Gadhvi *et al.*, 2024). A key concern raised by farmers was the high production cost, driven by greater reliance on purchased pellet feed and manual labor (KII with farmers, Chitwan, August 2024). To address these issues, initiatives have been taken to reduce costs, such as forage missions and the distribution of small farm tools and machinery (KII with the agriculture officer, October 2024). In contrast, Uganda reports lower feed costs (11.4%), primarily due to widespread adoption of local fodder and pasture (Waiswa and Gunlu, 2022). Large-scale commercial farms in India (George *et al.*, 2021) and Turkey (Sarica *et al.*, 2022) benefit from lower production costs compared to smaller farms due to their modern farming practices. Therefore, farmers need access to improved feed options and cost-effective technologies (Khanal *et al.*, 2022), such as hay and silage, better feeding practices, and machinery.

Conclusions and Recommendations

Dairy farming in Nepal remains a prominent sector for addressing poverty and food insecurity. Farmers are also gradually shifting from subsistence to market-oriented production in order to commercialize their commodities. However, the rate of commercialization in the sector remains low. In response to this emerging need, the study aimed to identify the determinants of dairy cattle farm commercialization, focusing on market participation choices of households in the dairy market and milk sales intensity. Double-hurdle model results showed that market engagement is markedly influenced by the education level of the household head, family size, access to extension services, cooperative membership, and off-farm work. The intensity of milk sales is positively influenced by credit use, subsidies, and technology adoption, whereas distance to the milk sales center and production costs negatively affects milk sales. The following recommendations have been made in considering the findings mentioned above:

Short term

There is a need for policy interventions that promote regular, dairy-focused, and accessible extension services by increasing human resources at the ward level. These services should emphasize good husbandry practices in milk production and marketing, as mandated by the GHP directive. In addition, the expansion of dairy cooperative membership in low-access areas can connect farmers to markets and improve their negotiation skills.

Long term

It is essential to promote the adoption of suitable, labor-saving, cost-reducing farm technologies. This includes practices such as hay and silage conservation, improved feeding methods, and the use of tools and machinery to replace manual labor. The public policy should focus on strengthen livestock credit schemes that offer soft loans and providing targeted subsidies based on output to support market-driven milk production.

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Novelty Statement

This study uniquely applies a double-hurdle model to analyze both the decision to participate in the dairy market and the intensity of milk sales among dairy cattle farmers in Nepal. It offers policy-relevant

insights by identifying household-specific socio-economic, institutional, and farm-related factors that influence commercialization, addressing a critical gap in dairy cattle farms.

Authors' Contribution

Jyoti Dhungana: Conceptualization, data curation, formal analysis, investigation, methodology, resources, writing original draft, **Devendra Gauchan, Krishna Prasad Timsina, Hari Krishna Panta, Lok Nath Paudel**: Conceptualization, supervision, validation, review and editing

Generative AI and AI-assisted technology statement
The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Conflict of interest
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