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Determinants of Farmer Choice of Milk Market Outlet Channel in Eastern Zone of Tigray, Ethiopia

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

This research investigated the factor influencing farmers' decisions on milk marketing channels in Eastern Tigray, based on primary data collected from households. Data analysis was conducted using a multivariate probit model to explore the factor affecting farmers' preferences for different milk marketing channels, including sales to consumers, cooperatives, and restaurants. Findings indicated that factors such as the household head's gender, the household's educational level, non-farm income, milk sales volume, and household size positively influenced farmers' tendency to select cooperative market channels. In contrast, the distance to markets reduced the likelihood of choosing cooperatives. Non-farm income also had a positive impact on farmers' preference for consumer-oriented channels, making them more likely to select this option. Meanwhile, access to market information lessened the appeal of consumer and restaurant channels for farmers. These results suggest that supporting women's involvement through affirmative action, enhancing educational resources, and providing relevant market information could improve farmers' engagement in formal markets. Additionally, promoting market efficiency by helping farmers organize, access timely information, and leverage improved marketing channels is necessary.

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Keywords: Milk; market channel choice; multivariate probit model.

1. INTRODUCTION

Ethiopia is a largely agrarian nation, with a significant portion of its population involved in agricultural activities. Livestock plays a crucial role in the agricultural sector, contributing approximately 40% to the agricultural economy, not accounting for the additional value from draught power, manure, and transportation. Livestock serves as a source of food, traction, manure, income, investment, foreign exchange, and holds cultural value [1]. Ethiopia hosts the largest livestock population in Africa, estimated at around 50.9 million large ruminant, 24 million small ruminants, and 2.3 million camels [2]. In the Tigray region, there are around 3.4 million cattle, or about 7.16% of the national total, with cows making up roughly half of this figure. The Wukro-Kilte Awlaelo area has an estimated livestock population of 60,000.

Ethiopia's substantial livestock base and favorable conditions for dairy production, the dairy industry has strong development potential [3]. The dairy sector is especially vital for economic growth in developing countries, providing income, employment, food security, foreign exchange earnings, and nutritional benefits. Because of its role in supporting poor households, investment in dairy can significantly contribute to poverty reduction, food availability, and income generation [4]. As economies grow and incomes rise, demand for animal products often increases at a faster rate than demand for cereals due to the higher income elasticity of these products.

Marketing agricultural goods is key to improving farmers' livelihoods and reducing poverty. Producers in countries like South Africa, Kenya, and China encounter challenges related to insecure asset ownership, market access, lack of extension services, inadequate road infrastructure, high costs, limited value addition for dairy products, and scarce input services [5-8]. Ethiopian smallholder farmers face similar difficulties, such as poor infrastructure, limited educational access, inadequate extension services, high disease rates, insufficient marketing support, limited credit access, and a lack of reliable market information [9,10].

Agricultural product markets refer to locations, often open spaces, where commodities are bought and sold. In Ethiopia, dairy products such as fresh milk, butter, buttermilk, and cottage cheese are distributed through both informal and formal channels. In the formal market, milk is collected at cooperative or private centers and then transported to processing facilities. Quality checks, including acidity tests, clot-on-boiling, and density checks, are conducted upon delivery, which has incentivized producers to maintain high standards of hygiene, storage, and transportation to prevent product rejection at collection points [11].

The informal market involves producers delivering fresh milk directly to nearby consumers or selling it to local traders or residents in nearby towns. In this system, milk may go directly from producer to consumer or pass through multiple intermediaries. Characterized by low operational costs, higher prices for producers, no licensing requirements, and a lack of regulation, the informal market is common for dairy products [12]. The informal market involves direct delivery of dairy products by producers to consumers in the immediate neighborhood and sales to itinerant traders or individuals in nearby towns [13].

A marketing channel acts as a pathway through which products, their ownership, financing, payments, and associated risks reach consumers [14]. It consists of interconnected organizations that facilitate the transfer of products from producers to end users. Marketing channels provide alternate routes for products to move from the origin to their final consumers. In certain areas, the establishment of dairy cooperatives has enhanced market access, benefiting production, marketing, and consumption within dairy communities [15].

A study by Woldemichael [16] found that informal marketing was the primary channel for milk and butter, with cooperatives and semi-wholesalers registered as milk agents but noted to be inefficient. The majority of farmers (59%) sold raw milk through informal channels, while 41% used formal ones [17]. Many smallholder farmers opt for informal markets where they receive higher prices per liter. This aligns with findings of Berhanu [18] indicating that 98% of milk in rural regions is sold informally, with only 2% reaching consumers through formal channels.

Marketing channels play a key role in physically moving goods along the supply chain, supporting

distribution by ensuring the right product reaches the right place at the right time. Farmers' choice of market outlet depends on various factors. Studies using multivariate probit, multinomial logit, and probit models have identified factors like market distance, pricing, extension services, and market information, education, farm experience, market distance, and cooperative membership as factors in selecting milk sales outlets [18,19]. Despite the area's high milk production potential, limited research has explored milk market outlet channel choices and the factors affecting these decisions. This study aims to analyze these determinant factors of milk market otlet choice for the study area.

2. METHODOLOGY

2.1 Description of the Study Area

The study was conducted in Wukro Kilteawlalo district which is found in eastern Zone of Tigray Regional State, Ethiopia. The district is geographically located at an altitude of 1900-2460 meter above sea level. The district lies at an elevation ranging from 1,900 to 2,460 meters above sea level. It is approximately 825 kilometers from Addis Ababa and about 44 kilometers from the regional capital, Mekelle. he area experiences mean temperatures of 23°C (maximum) and 17°C (minimum), with an average annual rainfall of 400 mm over the long term. The district has a total area of about 1010.28 sq km and administratively covers 16 kebeles and 59 sub kebeles.

2.2 Sampling Techniques and Sampling Size

In Wukro-Kilteawlaelo district, there are 16 kebeles with similar agro-ecological zones for dairy production. A two-stage random sampling technique was used to select sample respondents. In the first stage, four kebeles were randomly selected. From the selected kebeles, milk-producing households were identified and listed in collaboration with development agents. In the second stage, a total of 139 milk-producing households were randomly selected from these kebeles using simple random sampling with probability proportional to size. The sample size for milk-producing households was determined using Yamane's simplified formula for sample size determination:

$$n = \frac{N}{1+N(e^2)} = \frac{3225}{1+3225(0.08^2)} \sim 139 \quad (1)$$

Where, n Sample size, N is the total milk producers (3225) and e^2 level of precision (8%).

Out of the total 139 sample households, only 71 households that participated in market were included in this analysis.

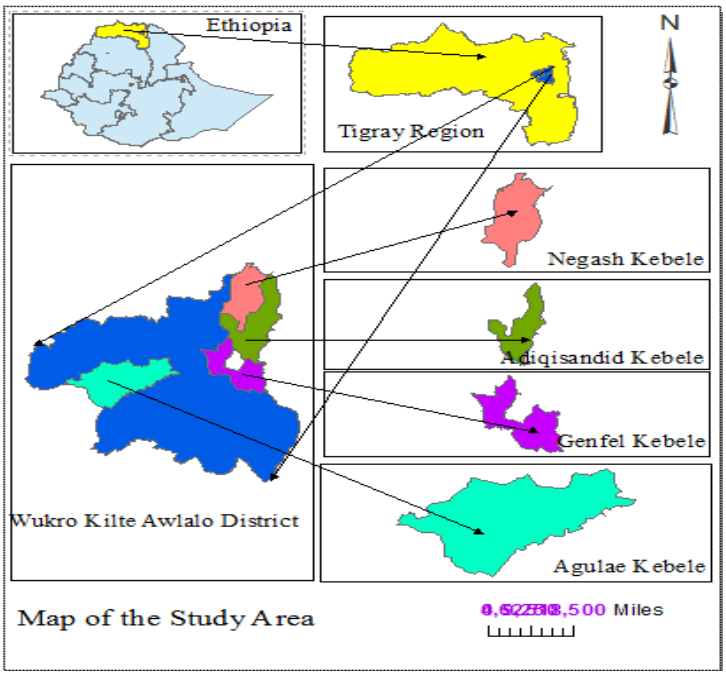

Fig. 1. Map of the study areas

2.3 Data and Data Types

This study utilized both primary and secondary data sources. Primary data were obtained through structured questionnaires distributed to milk producers. Enumerators, who serve as development agents within the district's agricultural office, were selected and trained in effective data collection methods. A pre-test of the questionnaire was conducted with seven sample producers from the study area to evaluate its clarity, question relevance, interpretation, and the time needed for each interview. Based on the pre-test feedback, adjustments were made to the questionnaire prior to the main survey. Secondary data were sourced from reports by the woreda agriculture office to complement and validate the study's findings.

2.4 Model Specification and Data Analysis

The Multinomial Logistic (MNL) model is used when selecting from multiple independent options. This model requires that the alternative categories be independent, meaning each option is mutually exclusive, and individuals can choose only one from a set of distinct, exhaustive alternatives. In an MNL model, predictors remain consistent across options, while coefficients vary, implying that each predictor has a consistent effect across choices, though its impact differs per option. Coefficients in an MNL model indicate the relative probability of selecting a given choice over a baseline choice (typically coded as 0), thereby reflecting the relative likelihood of each alternative compared to this base.

The MNL model's assumptions include independence among choices, not accounting for correlations or substitution effects among options in this study, producers' market outlet choices are not strictly independent, as they select multiple outlets simultaneously, with possible interdependencies among these choices [20,21]. To account for these complexities, a Multivariate Probit (mvprobit) model was used. This model accommodates household-level variations in market outlet choices by estimating multiple correlated binary outcomes together. The multivariate probit model allows simultaneous estimation of the influence of explanatory variables on market outlet choices while acknowledging potential correlations between unobserved factors and relationships between different market outlet choices [22,23].

The observed outcome of market outlet choice can be modeled following random utility formulation. Consider the i^{th} farm household (i=1, 2….. N), facing a decision problem on whether or not to choose available market outlets. Let U_0 represent the benefits to the farmer who chooses cooperatives, and let U_k represent the benefit of farmer to choose the K_{th} market outlet: where K denotes choice of cooperatives (Y1), consumers (Y2) and restaurants (Y3).

The farmer decides to choose the K^{th} market outlet if $Y_{ik}^{*} = U_k^{*} - U_o > 0$. The net benefit (Y_{ik}^{*}) that the farmer derives from choosing a market outlet is a latent variable determined by observed explanatory variable (Xi) and the error term (ε_i):

$$Y_{ik}^{*} = \mathrm{X}_i'\beta_k + \varepsilon_i k = Y_1, Y_2, Y_3 \quad (2)$$

Using the indicator function, the unobserved preferences in equation above translates into the observed binary outcome equation for each choice as follows:

$$Y_{ik} = \begin{cases} 1 \; if Y_{ik}^{*} > 0 \\ 0 \; otherwise \end{cases} \quad (k = Y_1, Y_2, Y_3) \quad (3)$$

In a multivariate model that allows for the selection of multiple market outlets, the error terms follow a multivariate normal distribution (MVN) with a zero conditional mean and a variance standardized to one, enabling parameter identification where $\mu_{y1}, \mu_{y2}, \mu_{y3}$ MVN $\sim (0, \Omega)$ and the symmetric covariance matrix is given by:-

$$\Omega = \begin{bmatrix} 1 & \rho_{y_1y_2} & \rho_{y_1y_3} \\ \rho_{y_2y_1} & 1 & \rho_{y_2y_3} \\ \rho_{y_3y_1} & \rho_{y_3y_2} & 1 \end{bmatrix} \quad (4)$$

Of particular interest are off-diagonal elements in the covariance matrix, which represent the unobserved correlation between the stochastic components of the different type of outlets. This assumption means that equation 4 generates a MVP model that jointly represents decision to choice particular market outlet. This specification with non-zero off-diagonal elements allows for correlation across error terms of several latent equations, which represents unobserved characteristics that affect the choice of alternative outlets.

Following the form used by Cappellari and Jenkins [24], the log-likelihood function associated with a sample outcome is then given by;

$$\ln L = \sum_{i=1}^{N} \omega_i \ln \Phi(\mu_i, \Omega) \quad (5)$$

Where is an optional weight for observation i, and Φ_i is the multivariate standard normal distribution with arguments μ_i and Ω, where $\mu_i$can be denoted as;-

$$\mu_i = (k_{i1}\beta_1 \mathrm{X}_{i1}, k_{i2}\beta_2, k_{i3}\beta_3\chi_{i3}),$$

$$while\ \Omega_{ik} = 1\ for j = k \text{ and} \quad (6)$$

$$\Omega_{ik} = \Omega_{ik} = k_{ij}k_{ik}\rho_{jk} for j \neq k,\ k = 1,2,3 \ldots with k_{ik} = 2y_{ij} - 1 \quad (7)$$

2.5 Definition of Variables and Hypothesis

Milk Marketing Channel (Mktchn): A categorical dependent variable measured by the probability of producers sells milk to either of the alternatives market outlets. It was represented in the model as Y1 for those households who choose to sell milk to cooperatives, Y2 for producers who choose restaurants and Y3 for producers who choose consumers to sell milk.

Education Level of Household Head (HHEDU): This continuous variable represents the number of years of formal schooling completed by the household head. An educated individual tends to make more efficient use of their time and resources. In a study on coffee market outlet choices, [25] found that the education level of the household head had a significant impact on the selection of market outlets for producers. Similarly, it is anticipated in this study that the education level of the household head will positively influence the choice of milk market outlet.

Family Size (FMLYSIZ): This variable is the total number of members of the household. According to the study by Michael [26] household size is positively related to the probability of the choice of neighbor households as one of the milk marketing outlets. This may be due to the fact that larger household size represents labor resource. Household size was hypothesized to have positive impact on the milk market outlet choice.

Sex of Household Head (HHSEX): Gender is a key factor in marketing decisions, though its influence varies based on societal roles and responsibilities. This variable is represented as a dummy, with a value of 1 for male household heads and 0 for female heads. While women often play a larger role in managing livestock, their participation in dairy production and marketing is hindered by limited access to capital, credit, and extension services [9]. It is hypothesized that having a male household head positively influences the choice of milk market outlet.

Distance to the Nearest Market (MKTDIST): It is a continuous variable measured in hours. It refers to the distance of the nearest market from the farmers' house. If the distance to the nearest market increases, the transportation cost also increase [27] confirmed that distance to the market is significant determinant of choice of marketing outlet. This variable was expected to have negative effect on milk market outlet choice.

Quantity of Milk Sold (VSS): It is a continuous independent variable measured in quintals and shows the quantity of milk sold per day during the survey year. If the marketable supply of milk increases, the ability of farmers to choose market increases. In this study it was expected to have positive impact on milk market outlet choice.

Access to Market Information (MKTINFO): It is dummy variable that takes a value 1 if obtained price information and 0 otherwise. According to Geoffrey [28], access to price information had positive influence on the choice of local market outlet in the marketing of pineapple. It is clear that producers are severely constrained with regard to market information. Therefore, access to market information was hypothesized to have positive influence on milk market outlet choice positively.

Number of Extension Contact (EXTCONT): This is a continuous independent variable and shows that households have number of extension contact days in a year. It is expected that agricultural extension service widens household knowledge with regard to use of improved agricultural technologies. Agricultural extension services are expected to enhance households' skills and knowledge, link households with technology and choice of markets [29]. Extension contacts hypothesized to have positive influence on the milk market outlet choice.

Nonfarm income (NFARMINC): It is a dummy variable that takes one if the household is involved in nonfarm activities and zero otherwise. Farmers who gain more income from nonfarm income want to supply their milk to any nearest

market outlet with low price than to go far. Hence, non-farm income waas hypothesized to influence market outlet choice decision of milk producers.

Number of Cross breed cows: This variable is continuous and is measured in number of crossbred milking cow owned. The number of crossbred cows ownership was hypothesized to have relation with market outlet choice to sell their product.

3. RESULTS AND DISCUSSIONS

In the study area, households that produce milk sell it to various market actors, choosing based on several factors. Important criteria include timely payment, limited awareness of alternative buyers, attractive pricing, sale volume, trust level in buyers, and buyer proximity. Three main market channels were identified: restaurants, direct sales to consumers, and cooperatives at the initial sale point. Among the sampled producers, 90.14% sold directly to consumers, 38.03% to cooperatives, and 6.90% to restaurants.

Regarding household characteristics, 87.5% of those selling to cooperatives, 35% to consumers, and 16.67% to restaurants were male-headed households. Education levels among cooperative sellers showed that 46.5% completed primary school, 25% had informal education, and 18% were illiterate. Among producers with non-farm income, 34% sold to consumers, 48.57% to cooperatives, and 17% to restaurants. Producers closer to markets generally sold to cooperatives, while those farther away favored consumers and restaurants. On average, households selling to cooperatives were 0.51 km from the market, those selling to consumers were 1.93 km away, and those selling to restaurants were 2.74 km away. Average daily milk supply was 15.84 liters to cooperatives, 8.73 liters to consumers, and 6.5 liters to restaurants.

This section discusses the determinants influencing producers' market outlet choices, as identified by the multivariate probit (MVP) model. The Wald test test (χ^2 (44) = 3299.71, p=0.000) is significant at the 1% level, showing that the model's explanatory variables are collectively significant and adequately capture the factors involved in market outlet selection. The likelihood ratio test for the model ($LR\chi^2(3) = 8.039,\ p > \chi^2 = 0.0452$ is also significant at the 5% level, suggesting that the assumption of independence among the disturbance terms, or outlet choices, is not valid. Additionally, the test for independence between market outlet choices ($\rho_{21} = \rho_{31} = \rho_{32} = 0)(\rho_{ij}$) is significant at the 5% level, which rejects the hypothesis that all ρ (Rho) values are zero, supporting the model's fit. This implies distinct patterns in outlet choice behavior among farmers, indicated by the likelihood ratio statistics.

The correlation ρ values (ρ_{ij}) reveal the relationships between pairs of outlet choices. For instance, the negative and significant ρ_{32} value, representing the correlation between choosing a restaurant and a consumer outlet, indicates that these choices are competitive. This suggests that producers use restaurant outlets as alternatives to consumer outlets. Simulation results estimate that the probabilities of choosing cooperative, consumer, and restaurant outlets are 38%, 90%, and 18%, respectively. The combined probabilities for success or failure in choosing all three outlets imply a 4.28% likelihood of successfully choosing all three, while the likelihood of failing to select all three is 3.38%.

Out of nine variables examined, six significantly influenced the cooperative outlet choice, two affected the consumer outlet, and one affected the restaurant outlet at 1%, 5%, and 10% probability levels.

Household Head's Sex (HHSEX): The gender of the household head positively impacts the likelihood of selecting the cooperative outlet, significant at the 5% level. Male-headed households are more inclined to use cooperative outlets, possibly due to fewer time constraints that limit access to alternative markets. This finding aligns with study of Lerman [29] that suggest male heads are more likely to explore market opportunities, while female heads often face household responsibilities that limit market access.

Household Head's Education Level (HHEDU): The education level of the household head significantly influences the cooperative outlet choice at a 1% probability level. Higher education levels likely increase awareness of formal markets, particularly important for perishable goods like milk. This is consistent with findings [30] indicating that educated smallholder dairy farmers tend to sale their milk to cooperatives.

Table 1. Description of explanatory variables and distribution of household characteristics by their choices of milk market outlets

Variable Name	Definition and description of variable	Local consumer 64 (90.14%)	Cooperative 27 (38.03%)	Restaurant 12 (16.90%)
HHSEX	Sex of household head (dummy, 1 if Male, 0 if Female)	87.50	35	16.67
FMLYSIZ	Family size (Continuous) number)	2.66	2.42	2.69
HHEDU	Illiterate	53.13	18.18	13.64
	Informal education	6.25	25	0
	Primary school	37.5	46.51	20.93
MKTDIST	Distance to nearest market (Continuous (minutes))	1.93	0.51	2.74
NFARMINC	Access to non farm income (dummy 1 Yes, 0 Otherwise	34.48	48.2	17.24
CRSBRD	Number of crossbreed cows own (Continuous (number))	1.5	2.48	1.5
MKTINFO	Access to market information (1 Yes, 0 Otherwise)	42.31	46.15	11.54
VSS	Volume of milk sold (Continuous (liter)	8.73	15.84	6.5
EXTCON	Extension contact (Continuous (number of days)	2.32	4.21	1.73

Table 2. Multivariate probit estimations for determinates of milk producers outlets choice

Variables	Cooperative		Consumers		Restaurant	
	Coef.	RSE	Coef.	RSE	Coef.	RSE
Constant	-75.988	19.412	6.808	1.463	0.232	2.004
HHSEX	48.718**	21.192	-0.919	0.663	0.354	0.563
HHEDU	15.356***	4.668	0.202	0.373	-0.063	0.507
CRSBRD	0.693	0.548	-0.180	0.359	0.524	0.488
FMLYSIZ	0.483**	0.223	-0.204	0.208	0.027	0.124
NFARMINC	57.495***	22.201	5.260***	0.848	-0.381	0.413
VSS	1.268***	0.374	-0.007	0.033	-0.041	0.029
MKTINFO	5.398	3.398	-4.854***	0.740	-1.432*	0.711
EXTCONT	8.910	5.841	0.682	0.832	-0.370	1.051
MKTDIST	-31.956**	12.563	-0.132	0.099	-0.010	0.105
Predicted probability	0.3803		0.9040		0.1854	
Joint Probability(Success)				0.043		
Joint Probability (Failure)				0.034		
Number Of Draws (#)				5		
Observations				71		
Log Likelihood				-37.503		
Wald(χ2(44)				3299.71		
Prob >χ2				0.0000***		
Estimated Correlation Matrix						
		ρ_1		ρ_2		ρ_3
ρ_1		1.0000				
ρ_2		0.0644		1.0000		
ρ_3		-0.3533		-0.3551***		1.0000
Likelihood Ratio Test Of: $\rho_{21} = \rho_{31} = \rho_{32} = 0$						
			$\chi^2(3) = 8.039$			
			Prob >χ^2 = 0.0452**			

*Note: *, ** and *** indicate statistical significance at 10, 5 and 1%, respectively. RSE is Robust standard error, Y1=cooperatives, Y2=consumers and Y3=restaurants Source: Survey data, 2016.*

Family Size (FMLYSIZ): Family size positively affects the decision to sell to cooperatives, significant at the 5% level. Larger households may have more labor available, enabling them to produce and sell more milk through cooperative outlets.

Non-Farm Income (NFARMINC): Farmers with non-farm income are positively and significantly associated with choosing both cooperative and consumer outlets, significant at the 1% level. This income increases the likelihood of producers opting for these outlets, possibly because non-farm income gives them the financial means to sell through various channels. This supports findings from [28], which suggest that income from other sources enables farmers to purchase necessary inputs like feed, veterinary care, and labor, which help in producing higher-quality and larger milk volumes that suit formal markets.

Quantity of Milk Supplied to Market (VVSS): The quantity of milk sold positively influences the likelihood of selecting the cooperative outlet, significant at the 1% level. This implies that higher milk volumes increase the likelihood of a producer selling to a cooperative, as cooperatives can accommodate larger quantities. This result aligns with Bezabih et al. [31], who found that larger sale volumes tend to favor cooperative market channels.

Access to Market Information (MKTINFO): Access to market information has a negative, significant influence on choosing consumer and restaurant outlets at the 1% and 5% levels, respectively. The negative association suggests that farmers with market information are less likely to sell to these outlets compared to those without market information. This finding supports [32], which indicates that price information from different outlets affects producers' decisions by helping them choose the most rewarding outlets.

Distance from the Market (MKTDIST): Distance to the nearest market is negatively associated with selling to cooperatives at a 5% significance

level. As distance increases, producers are more likely to sell to nearby consumers to avoid spoilage risks and transport costs. This finding is consistent with [33], which reported that market distance negatively affects farmers' outlet choices, as limited resources and high transport costs discourage distant market participation.

4. CONCLUSION AND RECOMMENDATIONS

This study examines the factors that influence milk marketing channel choices among farms in Tigray. Data were gathered through semi-structured questionnaires administered to seventy-one randomly selected respondents across four purposefully chosen kebeles, based on their milk production and market potential. Three main milk market outlets were identified: restaurants, direct consumer sales, and cooperatives. The majority of producers, at 90.14%, sold directly to consumers, while 38.03% sold to cooperatives and 16% to restaurants. A multivariate probit model identified key factors impacting market outlet choices, including milk quantity for sale, household head's education and gender, family size, market distance, and non-farm income.

The findings suggest that male-headed households and those with non-farm income are more likely to access diverse market outlets. Women, facing time constraints, may have limited access to distant markets; therefore, increasing their market participation through awareness and supportive actions could be beneficial. Additionally, higher education levels among household heads correlate with increased use of formal market channels, especially for perishable products like milk. Access to market information also encourages the use of organized outlets, underscoring the importance of improving market efficiency through education and reliable market data.

The study further reveals that as milk production increases, farmers tend to engage more with cooperatives, which can manage larger milk volumes. Supporting this trend requires enhancing milk supply infrastructure, providing technical and organizational support, and promoting dairy cooperatives and farmer organizations.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1. ChatGPT, GPT-4, September 2021, OpenAI

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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