

Research Article

Camel Milk Commercialization: Determinants of Milk Marketing and Input Purchasing Decisions in Isiolo and Marsabit Counties, Kenya

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Abstract

Demand for animal products is increasing, and pastoralists can seize the opportunity to advance food security and economic development. A cross-sectional study was conducted to determine how pastoralists' demographics, physical assets, and human capital relate to decision-making and the extent of market participation. Binary and multiple linear regression were performed at a 0.05 level of significance. A mixed-methods approach was employed to collect information, including Focus Group Discussions with different camel milk-producing and marketing stakeholders, facilitated by the researcher and staff from the Livestock Departments. Qualitative content analysis, involving repeated readings, was employed to identify recurrent patterns and themes. Quantitative data analysis involved determining means and applying a double-hurdle model, with a binary regression in the first stage followed by linear regression in the second stage for the decision and extent of market participation, respectively. Coefficients for every variable of regression were at a 0.05 level of significance. Pastoralists who had other sources of income were 86% and 79% in Isiolo and Marsabit counties, respectively. The odds ratio (OR) of participating in milk sales were lower among households that were not accessing extension services (OR=0.186, $p < 0.05$). Extension services were associated with a 38.9% increase in extent of milk sales during the dry season, while additional years of experience were associated with a 18.5% decrease ($p < 0.05$). Larger herd sizes significantly increased the proportion of milk sold in the dry season but reduced the percentage sold during the wet season. This is because the local demand in dry periods encouraged more sales. The study recommends strengthening extension institutions through policy formulation and implementation. Indigenous methods of increasing milk shelf life were found to have other negative effects. Therefore, investing in cold chain infrastructure could significantly enhance the efficiency, safety, and profitability of the camel milk value chain. Information generated will give policy guidelines on areas to emphasize for socio-economic development in the arid and semi-arid lands (ASALs).

Keywords

Commercialization, Milk Sales, Input Purchase, Assets, Human Capital, Demographics

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1. Introduction

Agriculture provides the most basic need for human survival: food security. Since the early 1970s, developing countries have been undergoing a 'livestock revolution'. It is part of the agricultural revolution, motivated by the demand for animal products [1]. Urbanization and increased income in most of the middle-class population have led to changes in food preferences for animal products. Therefore, developing countries can seize the opportunity to achieve food security and economic empowerment. This will be timely because they have remained underdeveloped for a long time.

Commercialization with respect to agriculture is the process of transforming agricultural activities from subsistence-based to market-oriented production systems. Therefore, it increases its interaction with the input or output market [2]. Key elements of commercialization are technology investment, institutional support, and integration into the market economy. Camel production is gaining increasing importance in the ASALs all over the world due to their resilience. The approximate global camel population is 35 million, with 89% being one-humped and the rest 11% being two-humped [3].

In sub-Saharan Africa, livestock, including camel production, contributes 18% of agricultural GDP compared with 45-50% in developed countries. Market-oriented agriculture defines the level to which resources are allocated to the production process and the consequent sale of agricultural products [4]. Output market participation has a positive economic impact on several stakeholders in the chain, including farmers, transporters, processors, storage, and packaging. Further, it improves human nutrition because farmers earn money and get other nutritious foods from the market [5]. Input market participation increases productivity and cost efficiency of production according to the consumers' demand [6].

Pastoralists possess substantial expertise in managing camels [7]. The high urban demand for camel milk has made camel keeping a key source of household income, particularly in communities near Isiolo Town [8]. This model could be replicated in other camel-rearing regions to benefit various actors along the value chain, potentially boosting demand for related products. Nonetheless, the influence of physical resources and human capital presents a governance dilemma to policymakers because it is not known which areas to emphasize [9]. Earlier studies in ASALs have emphasized factors affecting the marketing of live animals such as cattle, camels, sheep, and goats, but not camel milk [10]. Therefore, this study aimed to evaluate both the decision and extent to participate in camel milk marketing and the decision to participate in production inputs such as feeds and hiring labor. It also examined how demographic factors, physical assets, and human capital are associated with the decision to purchase camel milk production inputs.

2. Methodology

2.1. Study Area

The study was carried out in Isiolo and Marsabit Counties, which are among the traditional camel-keeping Counties in Kenya (Figure 1). The two counties demonstrated substantial commercialization potential of the Somali camel breed through established milk and livestock marketing systems [11]. Isiolo County covers an area of 25,336 km² with 65% very arid, 30% arid, and 5% semi-arid [12]. According to the Kenya National Bureau of Statistics [13], Isiolo County has 148,859 camels distributed among 6771 households in three Sub-Counties. Marsabit County is the largest in Kenya, covering an area of 70,961 km² at the end of Northern Kenya. About 80% is arid and very arid, 15% semi-arid, and 5% sub-humid and humid around Mt. Marsabit, which supports forest areas. Marsabit has 215,234 camels distributed among 22,093 households in four Sub-Counties [13].

2.2. Research Design and Sample Size Determination

The research design was cross-sectional, relying on recall from the year before the study. The sample population comprised all camel-keeping households in Isiolo and Marsabit Counties, totalling 28,864 [13]. The sample size was determined in two stages using the formulae provided [14]. The first stage determined the sample size for an infinite population and then adjusted for a finite population in the second stage. The level of statistical significance was set at 0.05, and the standard normal deviation at 1.96.

The formulae used were as follows:

The first stage was to get a sample size for an infinite population (formulae (1) and (2)).

$$n = Z^2 pq / L^2 \quad (1)$$

Where,

n = Desired sample size for an infinite population.

Z = normal deviation at the required confidence level.

p = proportion of the population estimated to have the attributes being measured.

$q = 1 - p$ and L = set statistical significance.

In this case, there is insufficient knowledge of the population with the attribute, so a value of 0.5 is recommended; the sample size was.

$$1.96^2 \times 0.5^2 \div 0.05^2 = 384 \quad (2)$$

The second stage was to get a sample for a target population of 28,864 households; the sample size was therefore adjusted using the formulae 3 and 4.

$$n' = 1 \div (1/n + 1/N)$$

(3)

 n =sample size, infinite population. N =population size, hence the sample size was

(Pfeiffer, 2010)

Where:

 n' =adjusted sample size for the finite population.

$$n' = 1 \div (1/384 + 1/28,864) = 379$$

(4)

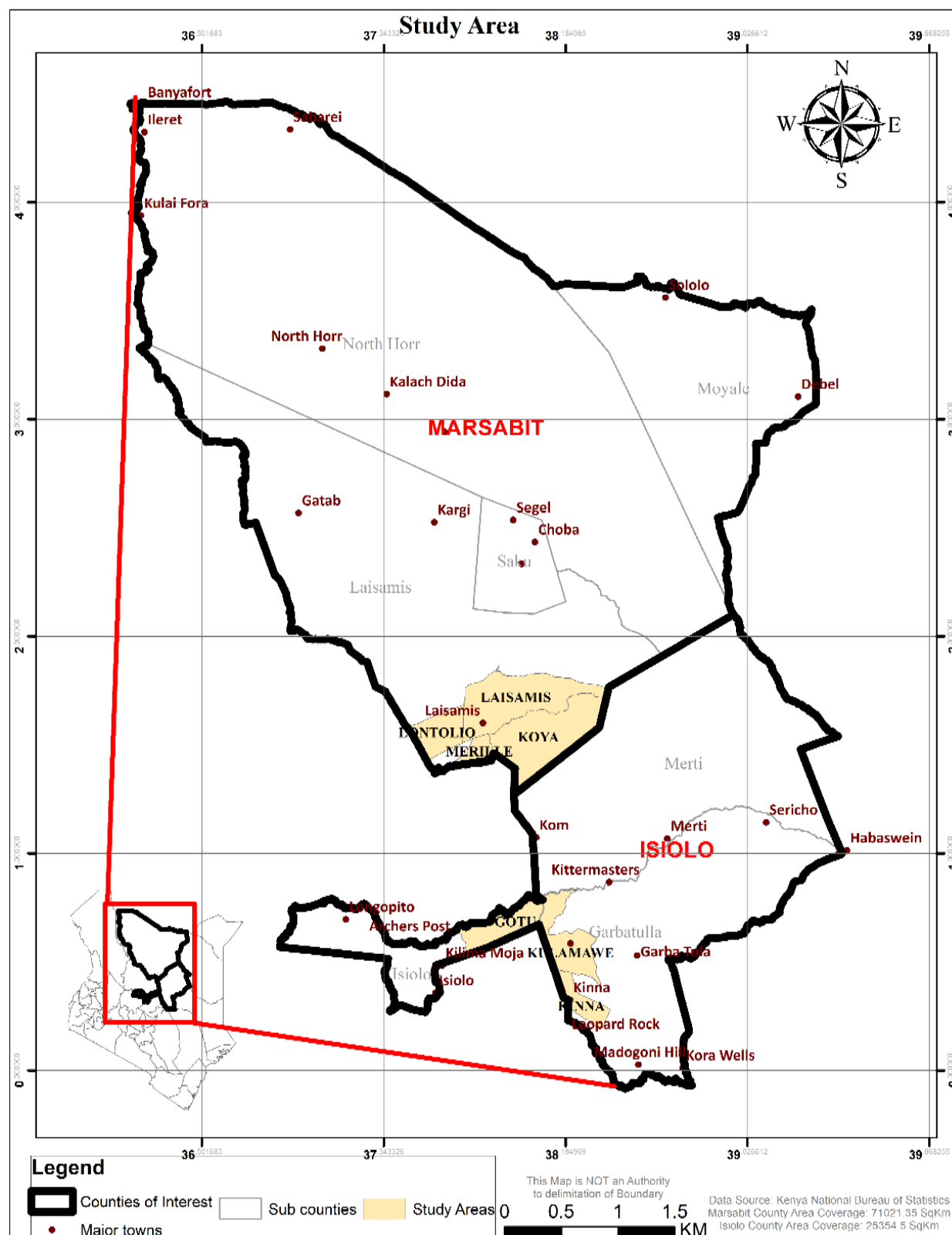


Figure 1. Map of Kenya showing the location of Isiolo and Marsabit Counties [13].

2.3. Sampling Design

A two-stage sampling method was applied because the study involved a wide geographical area. In Isiolo, there were areas referred to as camel milk clusters, which are concentrated in Isiolo and Garba Tulla Sub-Counties. Therefore, in the first stage, Garba Tulla and Isiolo Central Sub-Counties in Isiolo County were purposively sampled due to their potential for milk production [15]. In Marsabit County, the first stage purposively sampled Laisamis Sub-County based on the high camel population and a high number of households keeping camels [13]. The other sub-counties were left out due to security reasons at that time. Furthermore, all Marsabit sub-counties share similar arid ecological conditions. Their nomadic camel-rearing practices make them relatively homogenous in terms of camel production systems [16].

In the second stage, a convenient sample was drawn from camel-keeping households who were willing to participate until the sample size for every Sub-County was attained. Respondents (mainly herders) were drawn from the locations in the two sub-counties proportional to the number of households keeping camels. In Isiolo county, 137 respondents were drawn from Kulamawe, Gotu, and Kinna locations. From Marsabit County, 242 respondents were drawn from Laisamis, Lontolio, Koya, and Merile locations.

2.4. Data Collection

Focus Group Discussions (FGD) were held in Isiolo and Laisamis, comprising mainly the community disease reporters (CDRs). They are chosen by the communities based on their literacy levels, reliability, and experience with livestock production systems [17]. The aim was to capture in-depth information that could not be obtained from the scheduled interviews. In Isiolo, the FGDs comprised 7 CDRs, 2 technical staff from the Livestock department, and 2 herders. In Marsabit, FGD 10 CDRs, 3 technical staff, one social worker, and 3 herders. The discussions were guided by the researcher, assisted by the technical staff and the social worker. The information captured was on existing marketing channels, determinants of household participation in milk sales, and factors influencing the volume of milk marketed. Additional aspects explored included price-setting mechanisms, constraints affecting market access, and the role of extension services in supporting camel production and marketing. This.

Scheduled interviews were conducted through questionnaires, which were administered using a web-based and smart mobile app known as Kobo Toolbox [18]. This was uploaded to the interviewers' smartphones. Through the questionnaire, pastoralists were interviewed on demographics, assets, and market participation. The data collection tool was a questionnaire administered in specific local languages. The languages included Somali, Turkana, and Boran, mainly from Isiolo, Rendille, and Samburu from Laisamis.

2.5. Data Management

Data were recorded directly in the Kobo toolbox as the CDRs gathered information from the pastoralists. Immediately, the information was reflected in the researcher's portal of the Kobo toolbox app. The information was then uploaded to the Excel worksheet and later transferred to SPSS version 25 for statistical analysis.

2.6. Data Analysis

All discussions, originally conducted in Kiswahili, were audio-recorded, transcribed verbatim, and translated into English. The transcripts were subjected to qualitative content analysis, involving repeated readings to identify recurrent patterns, themes, and salient issues. Coding was conducted inductively, allowing themes to emerge from the data while remaining aligned with the study objectives. A comparative analysis was further undertaken to examine similarities and differences between Isiolo and Marsabit counties.

Data for the determination of input and output market participation were analyzed through descriptive statistics. These were used to determine the means and frequencies of the decision and extent of market participation, demographics, human capital, and the pastoralists' physical assets. A double hurdle model was used because it allows the separate determination of the probability of participation and the extent of participation [19]. In the first stage, a binary logistic regression was applied to predict the odds of participating in selling milk, purchasing feeds and minerals, and engaging hired labour. The second stage of the model determined the intensity equation estimated using only observations with positive outcomes [20, 21]. Coefficients for every variable of regression were at a 0.05 level of significance.

3. Results

From the FGDs, one herder noted: *"Most of the milk is sold to traders who transport it to urban centers."* This indicated that camel milk marketing is predominantly characterized by informal channels. The traders serve as key intermediaries, facilitating the movement of milk from production areas to urban markets. A community disease reporter also observed, *"In Kulamawe, camel rearing is a recent development, not lasting 20 years, and had been necessitated by frequent droughts. Before that, we used to rear Boran cattle, sheep, and goats"*. Regarding the transportation of milk, one participant reported that milk containers are smoked using a local herb known as (gayer) before milking and storage. According to the participant, the practice helps preserve milk and extend its shelf life at least before the next milking. However, participants noted that the herb imparts a characteristic odour to the milk, which may be undesirable to consumers.

3.1. Decision and Extent of Participation in Input and Output Markets

The interviewed respondents were mainly hired workers in Isiolo (82%), while in Marsabit, they were either the owners (46%) or family members (39%), with only 15% hired herders (Table 1). Unlike Marsabit, more than 90% of Isiolo pastoralists participate in milk sales. The same was observed in the purchase of feed supplements and minerals and hiring labor, where the percentages were higher in Isiolo than in Marsabit. The overall percentage of milk sold in the wet season was slightly higher than the percentage of milk sold in the dry season. The percentage of milk sold in both wet and dry seasons was more than 80% in Isiolo and less than 50% in Marsabit. There was a higher percentage of pastoralists who do not buy feeds at all in Marsabit than in Isiolo (Table 1).

Table 1. Decision and extent of market participation.

Location	Isiolo		Marsabit		Overall	
	n=137		n=242		n=379	
	No	%	No	%	No	%
Source of information (Interviewed person)						
Self	5	4	110	46	115	30
Family Member	20	14	95	39	115	30
Hired Herder	112	82	37	15	153	40
Participation in milk sales						
Yes	128	94	58	24	186	49
No	9	6	184	76	193	51
Participation in purchasing feeds						
Yes	70	51	17	7	87	23
No	67	49	225	93	292	77
Participation in purchasing minerals						
Yes	135	99	39	16	174	46
No	2	1	203	84	205	54
Participation in hiring workers						
Yes	131	96	97	40	228	60
No	6	4	145	60	151	40
Percentage of milk sold						
Wet season		87		48		62
Dry season		85		42		58
Type of agreement with the buyer						
None	9	7	184	76	193	51

Location	Isiolo		Marsabit		Overall	
	n=137		n=242		n=379	
	No	%	No	%	No	%
Verbal	124	90	54	22	178	47
Contract	4	3	4	2	8	2

3.2. Pastoralists' Demographic Characteristics

Pastoralists' demographics are shown in Table 2. More than 70% of camel owners were male and had another source of livelihood. Participants indicated that males form the majority of the resident population in the study area, as reported by one participant, *"Most of the people living in the grazing are men because they take care of the livestock and remain within the grazing areas."*

The percentage of pastoralists having another source of livelihood was highest in Kinna and Kulamawe, locations of Isiolo, and lowest in Merille and Gotu locations of Marsabit. The people who were available for interviews in both Counties were the owners or herders. The percentage of hired employees was low in both Counties. In Isiolo County, only 12% had been practicing camel rearing for more than 30 years, while in Marsabit it was 32%, which was the highest in the Koya location. In the Kulamawe and Kinna locations of Isiolo, 70% and 80% of pastoralists have practiced camel rearing for the last 11-20 years, respectively, and have not practiced beyond 30 years. One FGD participant observed that *"about 20 years ago, in Kinna and Kulamawe families had fewer camels than cattle, but the current position is the contrary and now families own more camels than cattle."*

3.3. Pastoralists' Physical Resources and Human Capital

Physical resources include the number of milking camels, herd size, transport infrastructure, and amount of milk produced. The motorbike was mostly used as marketing infrastructure. The majority of Isiolo herders own a motorbike (88%), while the number who own one in Marsabit was extremely low (8%). The percentage of milking camels and the total milk produced is higher in Isiolo than in Marsabit. Distances to marketing centers were shorter in Marsabit than in Isiolo locations, ranging from 0-7.5 kilometers and 10.7-22.3 kilometers, respectively (Table 2).

Accessing extension services was more in Isiolo than in Marsabit, with 69% and 54% respectively (Table 2). It was also observed by an FGD participant that *"In Isiolo, trainings on camel feeding were organized by the funding agency that provided the camel milk cooler. They trained us on milk handling and helped us in milk marketing."* The level of registration in marketing groups is low in both counties, but slightly

higher in Isiolo than in Marsabit. Knowledge of the milk price was mainly from the buyers, and 84% of the Isiolo herders knew the price of milk before delivery, while in Marsabit, it was only 20%. Verbal agreements were the dominant form of

marketing arrangement, being more prevalent in Isiolo (90%) than in Marsabit (47%). Formal contractual agreements were rare, with only 2% reported across both counties (Table 1).

Table 2. Pastoralists demographics, level of pastoralists' physical resources, and acquisition of human capital.

Isiolo		Marsabit		Total		Isiolo		Marsabit		Total			
N=137		N=242		N=379		N=137		N=242		N=379			
No	%	No	%	No	%	No	%	No	%	No	%		
Gender of the camel owner						Years of practicing camel rearing							
Male	118	86	175	73	293	77	Below 10	15	11	54	22	69	18
Female	19	14	67	27	86	22	11-20	84	61	59	25	143	38
Other sources of income						21-30						76	20
Yes	117	86	189	79	306	81	Above 30	16	12	75	32	91	24
No	20	14	53	21	73	19	Registration in the milk marketing group						
Distance to the market (Kms)						Yes						46	12
Mean	13.8±0.5		4.1±0.5		10.8±0.5		No	114	84	219	91	333	88
Seeking extension services						Production in the wet season							
Yes	94	69	130	54	224	59	Below 10	3	2	131	53	134	35
No	43	31	112	46	155	41	10-19	45	32	81	33	126	33
Marketing Infrastructure						20-29						92	24
None	3	2	37	15	40	11	Above 29	27	19	8	3	35	9
Refrigerator	3	2	0	0	3	1	Production in the dry season						
Motorbike	113	88	20	8	133	35	None	1	0.7	47	19	48	12
Both	9	6	1	0	10	6	Below 10	42	30	160	65	202	52
The mean number of camels						10-19						105	27
						20-29						32	8
Total	53±2		45±2		47±2		Prior knowledge of milk price						
% age milking	29±1		18±1		22±1		Yes	115	84	48	20	163	43
Milking camels	13±0		11±0		13±0		No	13	9	10	4	23	6

3.4. Factors Affecting the Decision to Participate in the Market

A binary regression model was estimated to determine how household demographic, socioeconomic, institutional, and market-related factors influence the likelihood of participating in camel milk markets.

3.4.1. Sale of Milk

The decision of market participation in the sale of milk was positively and significantly affected by being in Isiolo County. The lack of extension services negatively and significantly influenced the decision to sell milk. The odds of participating in milk sales were lower among households that were not access-

ing extension services (OR=0.186, $p<0.05$). This was confirmed by a CDR who reported: “Farmers who receive training are more likely to sell their milk.” Increase in milk production in the wet season reduced the odds of selling milk (OR = 0.887, $p<0.05$) (Table 3). Despite the growing importance of camel milk in supporting livelihoods, several constraints hinder efficient market participation. A major challenge identified was the lack of cold chain infrastructure, leading to significant post-harvest losses. This issue was highlighted by a herder who noted that “Milk often spoils before reaching the market, especially during the wet season.”

3.4.2. Purchasing Feeds

A pastoralist in Isiolo was 30 times more likely to buy feeds than not to buy feeds. The probability of purchasing feeds was reduced significantly by the number of years the pastoralists had practiced camel rearing (OR=0.05, $p<0.05$). A pastoralist was 4.27 times more likely to buy feeds if he did not access extension services. Production per camel per day in the dry season had a positive association with the purchasing of feeds (OR=1.107), while production in the wet season had a negative association (0.705) ($p<0.05$).

3.4.3. Purchasing Minerals

The decision to participate in the purchase of minerals was highly positive and significant for pastoralists in Isiolo County

($p<0.05$). Increasing the percentage of milking camels and milk sold in the wet season reduced the probability of purchasing minerals with OR=0.942 and 0.974, respectively ($p<0.05$). The qualitative evidence supports the observed seasonal differences in mineral purchasing behavior, highlighting the role of natural forage availability in reducing the demand for purchased mineral supplements during the rainy season. The probability of purchasing minerals for a pastoralist who did not have another source of livelihood was highly reduced (OR= 0.196, $p<0.05$) (Table 3).

3.4.4. Hiring Labor

The factors considered to affect the decision to hire a workforce to manage herds were positive for Isiolo. Being in Isiolo County was associated with an increase in the chances of hiring labor 32 times ($p<0.05$). One participant noted, “In Laisamis, herding camels is a family activity, and everyone in the household participates.”

The probability of hiring labor for a pastoralist who did not have another source of livelihood was reduced (OR=0.361, $p<0.05$). Increasing the number of years of practice reduced the probability of hiring labor by 3.8 times ($p<0.1$). Increasing the total number of milking camels and the percentage of milk sold in the dry season were both slightly associated with an increase in the probability of hiring the labor force (OR=1.02, $p<0.05$) (Table 3).

Table 3. Factors affecting the decision to participate in input and output markets.

Market Participation Factors	B	Sig.	Exp (B)
Milk Sales			
Constant	1.148	.145	3.15
County	6.148	.000	467.62
Lack of extension services	-1.683	.000	.186
Total no of camels	.012	.081	1.01
Milk produced in the wet season	-.120	.015	.887
Purchasing feeds			
Constant	-3.153	.009	.043
County	3.404	.000	30.08
How long has the owner practiced	-6.893	.002	.001
Lack of extension services	1.453	.001	4.27
Total no of camels	.018	.076	1.02
Milk produced in the wet season	-.350	.041	.705
Milk produced in the dry season	.101	.097	1.107
Purchasing minerals			
Constant	4.622	.001	101.66
County	9.060	.000	8608

Market Participation Factors	B	Sig.	Exp (B)
Other sources of livelihood	-1.630	.048	.196
Percentage of milking camels	-.060	.022	.942
Sale of milk	-1.088	.152	.337
Percentage of milk sold in the wet season	-.026	.004	.974
Hiring labor			
Constant	-.346	.680	.708
County	3.469	.000	32.10
How long has the owner practiced	-3.802	.060	.022
Other sources of livelihood	-1.018	.016	.361
Total no of camels	.020	.005	1.02
Percentage of milk sold in the dry season	.015	.001	1.02

3.5. Extent of Market Participation

A multiple linear regression model was estimated to examine the factors influencing the quantity of camel milk sold by participating households. The model estimates the extent to which household, production, institutional, and market-related characteristics affect the proportion of camel milk marketed.

3.5.1. Milk Sold in the Wet Season

The factors that statistically and significantly contributed to the percentage of milk sold in the wet season are shown in Table 4. They included the pastoralists' county, length of practice, extension services, total number of camels, percentage of milking camels, and the market infrastructure owned. The percentage of milk sold was negatively influenced by the length of practice, the percentage of milking camels, and the total number of camels. Being in Marsabit County was associated with a reduction in the percentage of milk sold by 22.7% ($p < 0.1$). Increasing the number of years that the owner practiced camel keeping was associated with a reduction in the

percentage of milk sold by 27.6% ($p < 0.01$). Access to extension services was associated with an increase in the percentage of milk sold by 28.9% ($p < 0.01$). Increasing the number of camels and the percentage of milking camels by one unit was associated with a reduction in the percentage of milk sold in the wet season by 23.7% and 18.2%, respectively ($p < 0.05$). Owning a marketing infrastructure was associated with a reduction in the percentage of milk sold in the wet season by 15.5% ($p < 0.1$).

3.5.2. Milk Sales in the Dry Season

Being in Marsabit County was associated with a reduction in the percentage of milk sold by 39.1% ($p < 0.05$). Increasing the number of years that the owner practices was associated with a reduction in the milk sold by 18.5% ($p < 0.05$). Access to extension services was associated with an increase in the percentage of milk sold by 38.9% ($p < 0.05$). Increasing the number of camels was associated with an increase in the percentage of milk sold in the dry season by 26.8%. Owning a marketing infrastructure reduces the percentage of milk sold in the dry season by 33.9% ($p < 0.05$).

Table 4. Factors influencing extent of Milk Sales.

	Unstd C.		Std C.		
	Beta	Std. E	Beta	t	Sig.
Percentage of milk sold in the wet season					
Constant	149.237	21.089		7.077	.000
County	-12.733	6.706	-.227	-1.899	.059

	Unstd C.		Std C.		t	Sig.
	Beta	Std. E	Beta			
How long has the owner practiced	-7.710	2.152	-.276	-3.583		.000
Extension services	16.882	4.318	.289	3.910		.000
Total no of camels	-.195	.079	-.237	-2.460		.015
Percentage of milking camels	-.367	.171	-.182	-2.145		.033
Marketing Infrastructure	-4.545	2.702	-.155	-1.682		.094
Percentage of Milk sold in the dry season						
Constant	100.93	26.61		3.792		.000
County	-28.495	8.366	-.39	-3.406		.001
Length of practice	-6.803	2.55	-.19	-2.672		.008
Extension services	29.751	5.333	.389	5.579		.000
Total no of camels	.291	.089	.268	3.261		.001
Type of agreement	18.565	10.59	.111	1.753		.081
Marketing Infrastructure	-12.964	3.219	-.339	-4.028		.000

4. Discussion

The percentage of milk sold was higher in the wet season than in the dry season. This was supported by an FGD participant observation: *“During the rainy season, camels produce more milk, and most families sell the excess after household consumption needs are met.”*

The FGDs revealed that motorcycles perform diverse transport functions in pastoral areas. Participants indicated that motorcycles are commonly used to transport people, luggage, and various commodities in addition to camel milk. This qualitative evidence supports an insignificant finding and a negative correlation in the regression results that owning a marketing infrastructure had with milk sales in wet and dry seasons, respectively.

The finding that camel milk in Kenya is traded through informal systems is consistent with previous studies showing that the systems have a loosely connected value chain, with actors [22]. The reliance on informal networks highlights both the flexibility and vulnerability of the camel milk value chain. Institutional support, including extension and training, plays a significant role in promoting commercialization and improving market participation among dairy farming households [23]. Inadequate camel milk cooling systems, poor hygiene practices, and weak infrastructure are identified as key limitations in the camel milk value chain. Indeed, milk spoilage during bulking and transportation has been reported [22].

The high percentage of market participation in Isiolo was

consistent with other studies [24, 25]. However, it was not consistent for Marsabit County due to the cultural significance of camel milk in Rendille and Samburu pastoralist communities, as it was regarded as taboo to sell camel milk [26]. In Isiolo, the Borana community was once known for the rearing of Boran cattle, but is slowly moving to camel production, and the sale of camel milk, which was once regarded as taboo, is being marketed freely [9]. Most of the pastoralist camel owners were male, an indication of the importance of men in taking care of important family assets such as camels [27]. Isiolo pastoralists had better indicators of camel milk commercialization. These included owning a high percentage of milking camels, seeking extension services, and having knowledge of milk prices before delivering the product [28]. Furthermore, the distance to their markets was longer than that of the Marsabit pastoralists, meaning they were consciously planning for milk marketing. FGDs revealed that the resident population is predominantly male. Participants attributed this pattern to the gendered division of labor in pastoral communities, where men are mainly responsible for herding, livestock management, and decisions related to livestock production and marketing. This demographic composition may influence household decision-making processes and participation in livestock and camel milk markets.

4.1. Effect of Demographic Characteristics on Market Participation

Isiolo is dominated by fodder producer groups who harvest

and market to the camel owners [29]. This may contribute to the reason there were more chances of participating in the purchase of fodder and other feed concentrates. Lack of off-farm income negatively influenced a decision to buy minerals and hire labor, which was consistent with other studies [24]. Off-farm income provides an alternative source of finances to purchase farm inputs, which in turn increases production and hence surplus for the market.

Distance to the consumer did not have any influence on milk sales in both wet and dry seasons. This is consistent with findings from another research [19]. In some instances, market participation was positively affected by the distance because the areas that are far away produce and sell agricultural products due to the availability of land, and those that are near do not have production resources. The non-significant effect of distance to market may reflect the development of milk collection and transportation systems in the study area. Qualitative evidence indicated that transporters facilitated the movement of milk from producers to markets, thereby reducing transaction costs associated with distance. As a result, proximity to a market was less important than access to reliable marketing channels and collection infrastructure.

4.2. Effect of Physical Assets on Market Participation

Herd size had a statistically significant positive effect on the proportion sold during the dry season and was consistent with findings [30, 31], although these studies did not account for seasonal differences. In contrast, herd size has a significant but negative impact on the percentage of milk sold during the wet season. This is because specific communities primarily consumed camel milk, and the surplus cannot be redistributed to non-consuming communities [7]. Consequently, about 50% of camel milk produced during the wet season was wasted [32]. Furthermore, poor hygiene and storage practices often result in milk spoilage, rendering it unsellable [33]. Likewise, herd size positively affected decisions to hire labor, as larger herds require more resources and personnel for management. In the dry season, higher local demand leads to a greater proportion of milk being sold [19]. This finding aligns with other studies indicating that the sale of crops such as chickpeas depends on production volume [34].

Milk production per camel and the percentage of milk sold during the dry season were the primary factors influencing the decision for feed purchases. Sustaining production requires fodder purchase, a common practice in arid and semi-arid lands during the dry season [29]. The percentage of milking camels negatively and significantly affected mineral purchases, as this coincided with the rainy season and camels had access to mineral-rich, salty shrubs [11].

Owning a motorbike negatively influenced the percentage of milk sold in both wet and dry seasons, contrasting with other findings [35]. In this study, motorbikes and refrigerators were the main marketing infrastructure. However, motorbikes

used for milk transport were often hired rather than owned by pastoralists and may be shared among multiple farmers. The FGDs participants indicated that motorcycles are commonly used to transport people, luggage, and various commodities in addition to camel milk.

4.3. Effect of Human Capital on Market Participation

The decision and proportion of milk sold in both wet and dry seasons were positively and significantly influenced by herders seeking extension services, and this was consistent with other studies [31, 36]. Herders who sought such services gained a better knowledge of production techniques and milk marketing channels compared to those who did not. In contrast, those without access to extension services often fail to plan for the dry season and resort to uncoordinated feed purchases.

Unexpectedly, the length of time practicing camel husbandry had a negative and significant impact on the percentage of milk sold. While this finding contrasts with some studies [30], it aligns with others [37]. The length of practice also negatively affects mineral purchases and decisions to hire labor, reflecting low commercialization levels in Marsabit County. Marsabit pastoralists, unlike those in Isiolo, were less inclined to purchase feed or participate in milk sales due to their focus on subsistence rather than commercial production [29]. Having a contractual agreement significantly increased the proportion of milk sold in the dry season. During the period of scarce milk production, producers with contractual obligations tend to prioritize sales over home and calf consumption.

5. Conclusions

In Isiolo, camel rearing for commercial milk production is a relatively recent adaptation to climate change. Qualitative evidence strongly reinforced this finding. FGDs in Isiolo County indicated that the presence of the Anolei camel milk cooling plant has enhanced market participation by improving milk handling, reducing spoilage, and allowing producers to access organized markets. Participants emphasized that the ability to store milk before sale increased their willingness to engage in commercial marketing. Meanwhile, Marsabit pastoralists have practiced camel husbandry for a long time and uphold traditional values, limiting commercialization. Enhancing market participation can be achieved through extension services, increasing the number of camels, and the utilization of production inputs. Distance to consumer markets, especially in Isiolo, did not hinder milk commercialization, indicating robust demand for camel milk in distant urban areas. Additionally, ownership of milk marketing infrastructure, such as motorcycles, did not affect commercialization. This was evidenced by the fact that the transportation infrastructure was shared by many pastoralists who still performed other activities to earn a living.

6. Recommendation

This study recommends strengthening extension institutions by allocating some of the resources offered by development partners. A CDR reported ongoing efforts to improve cold-chain infrastructure within the camel milk value chain. According to the informant, a milk marketing group is exploring the possibility of equipping motorcycles used for milk transportation with cooling facilities. This innovation is expected to reduce spoilage during transit, maintain milk quality, and enhance marketability, particularly in areas where long travel distances and high ambient temperatures pose challenges to milk preservation. Such initiatives demonstrate increasing investment in post-harvest handling technologies aimed at strengthening camel milk commercialization. This study, therefore, contributes to the knowledge on the areas that governments should have institutional policies in order to alleviate poverty in the ASALs and embrace the camel as a dairy animal whose potential is not yet exploited.

Abbreviations

ASAL	Arid and Semi-Arid Land
CDR	Community Disease Reporter
FGD	Focus Group Discussion
KNB	Kenya National Bureau of Statistics
OR:	Odds Ratio

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Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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