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Effect of Delivering Milk to Cooling Plants on Household Income among Smallholder Dairy Farmers in Sotik Sub-County, Kenya

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Abstract
Kenyan dairy sub-sector has been undergoing developments since the collapse of Kenya Cooperative Creameries (KCC) in 1992. Milk cooling plants have been established in order to reduce milk losses and benefit the smallholder dairy farmers. However, farmers seem reluctant to deliver their raw milk through the cooling plants and little information is known on the benefits accrued from cooling plants over the other market outlets. This study therefore was aimed at determining the effect of delivering milk to cooling plant on household income among smallholder dairy farmers in Sotik Sub-County. This sub-county is one of the highest milk producing zones in Rift Valley region in Kenya, with majority of its residents practicing dairy farming. A multi-stage sampling procedure was employed to select 150 smallholder farmers. Propensity score matching model was used in analyzing the data. The results indicated that, delivering milk to cooling plants positively and significantly increase the income of dairy farmers by KES 16,680 more compared to use of other market channels, per lactation period. This is an indication that a milk cooling plant is economically viable and an important tool in increasing smallholder dairy farmer's income.
Keywords: Milk Cooling Plants, Smallholder Dairy Farmer, Propensity Score Matching.

1. Introduction

Milk production is one of the most important investment enterprises in the world where small scale farmers earn a regular income, employment and contributing to the household food security on a daily basis throughout the year (Omore *et al*., 2004). In Kenya, It is the single largest agricultural sub-sector larger than even tea and is estimated to contribute about 14 percent of the agricultural GDP and approximately 4.5 percent of the national GDP (Mutua-Kiio and Muriuki, 2013; FAO, 2014). The sub-sector is providing a means of livelihood to more than 2 million Kenyan households and employs more than 600,000 smallholder dairy farmers (Muriuki *et al.*, 2007; Techno Serve, 2008). Due to the increase in milk production, the government of Kenya through the Ministry of Agriculture with the support of other private sectors in the dairy sector established milk cooling plants project (MoLD, 2010). This was aimed at supporting the main processing companies, especially by cooling the milk before processing (Wambugu *et al.,* 2011). Most of the farmers have joined hands together to form cooperatives while others establish their own cooling plants (Anjani, 2011). The milk cooling plants are considered as indirect channels characterized by low levels of organization, no taxation or regulation; low wages with transactions mainly conducted in cash, low productivity because of the reduced size of the market, limited access to credit by the farmers and activities that complement the formal economy. However, due to perishability nature of raw milk, cooling plants are seen as efficient means of reducing the milk spoilage. Additionally, milk is mainly produced by indigenous cattle which are widely distributed in different areas including remote villages with problems like poor road infrastructure and inadequate utility services (Msanga, 2009).

These challenges contribute to inefficiency in milk collection and increase the cost of collection and processing. The main aim of establishing milk cooling plants by the government and private firms in the dairy sector was to catalyze the rural economic development, reduce milk losses in places that were not easily accessible during the rainy seasons and also benefit the smallholder dairy farmers (MoLD, 2010). Despite the support and high profile given to these milk cooling plants, many farmers are still reluctant to deliver their milk through them. It is not known whether the benefits accrued from the cooling plants differ from those of other marketing outlets. Therefore this study evaluated effect of delivering milk to cooling plants on household income among smallholder dairy farmers in Sotik Sub-County, which is one of the highest milk producing zones in Rift Valley region in Kenya, where majority of the residents are practicing dairy farming.

2. METHODOLOGY

2.1 Description of the study area

This study was carried out in Sotik Sub-County. As per the report of Bomet County development profile 2013, Sotik Sub-County covers an area of 446.20 Km^2 with a population density of 167289 individuals (KNBS, 2009). The study area was selected because it is one of the highest milk producing zones in Rift Valley with an approximate of 19,481 dairy farmers. Of these, 95 percent are small scale dairy farmers (ILO, 2009). This is evidence that the dairy industry is a major player contributing to household incomes of the smallholder dairy farmers in Sotik. Milk cooling plants have also been established in every administrative ward of Sotik Sub-County.

2.2 Sampling and sample size determination

A sample of 150 farmers was selected from the population of the smallholder dairy farmers delivering milk through the existing marketing outlets in Sotik Sub-County. Multistage sampling procedure was employed in selecting the farmers. In the first stage, purposive sampling was employed to select Sotik Sub-County because dairying is a major economic activity for majority of the people in the study area. In the second stage, the 5 county assembly wards were also purposively selected because they have existing installed cooling plants. Lastly, dairy farmers were randomly selected from each ward and interviewed with the help of semi-structured questionnaires. The following formula was employed to come up an appropriate sample size for the study,

$$n = \frac{Z^2 pq}{d^2} \quad \text{(Fishers } et\ al.\text{, 1999)}$$

Where; n = Desired sample size (if the target population is greater than 10,000), Z = confidence level (α = 0.05); p = the proportion in the target population estimated to have characteristics being measured, $q = (1 - p)$, d = allowable error. Hence; Z =1.96, $p = 0.11 = \left(\frac{19481}{167289}\right)$, $q = 0.89$ and $d = 0.05$

$$n = \frac{(1.96)^2(0.11)(0.89)}{(0.05)^2} = 150$$

2.3 Empirical model specification

Delivering milk to a cooling plant is a farmer's choice decision. Milk market choice decision is seen as one of the available income strategies, whereby a farmer will select a given outlet if the utility obtained from it out-ways that of the alternatives. The decision to choose a particular marketing outlet is based on the maximization of a given utility function. A farmer is likely to choose a channel that gives the highest utility among the alternatives (McFadden, 1986; Mburu *et al.,* 2007). According to Jari (2009), household income is determined by various socio-economic factors. For farm households, income is influenced by returns from agricultural production, which depend on asset ownership and capacity to produce and market efficiently. Hence, choosing to deliver milk to a certain market outlet may directly influence household income. The analytical method employed was drawn from the work of Ravallion (2001) and Bernard *et al*. (2008). According to these scholars, one way to obtain robust impact assessments is by use of Propensity Score Matching (PSM). This model of analysis is a two-step procedure whereby in the first stage the probability model of participation is estimated to calculate the propensity score of each household's participation. In the second step, each farmer delivering his/her milk to cooling plant is matched with the one which does not with similar propensity score in order to estimate the average treatment effect for the treated (ATT). In this study it refers to the average income effect of dairy smallholder farmers who are delivering milk to cooling plants.

The outcome of farmers involved in milk cooling plants had they not deliver their milk to the cooling plant or the outcome of those who did not deliver had they participated may not be possible to observe hence is difficult to estimate the effect of milk cooling plants on household income. However, this problem can be addressed by assigning households to treatment and control in experimental studies but in this case of non-experimental study, milk cooling plants is not evenly distributed but rather households have to make a choice.

The decision of the farmer to deliver to cooling plant or not may be based on self-selection since every dairy farmer has different characteristics and this may affect the involvement decision and welfare outcome. The estimated propensity score, for subject i $(i = 1, \ldots, N)$ is therefore conditional probability of being assigned to a particular treatment given a vector of observed covariates i x_i as proposed by Rosenbaum *et al.,* (1985).Where, $Y_i = 1$, for treatment (delivering to cooling plants) $Y_i = 0$, for control (not delivering to cooling plants) and x_i= Vector of observed covariates for the i_{th} subject.

The effect of a treatment for an individual *i*, noted by δ_i is defined as the difference between the potential outcome in case of treatment and the potential outcome in absence of treatment:

$$\delta_i = Y_i 1 - Y_i 0$$

To calculate the average treatment on the treated (ATT), the actual income from milk cooling plants and its counterfactual (not delivering to cooling plants) is also calculated. Average treatment on untreated (ATU) is the difference between the actual (observed) and the counterfactual income for those not delivering to cooling plants. Therefore the impact across all the individuals in the population is obtained by finding the Average Treatment

Effect (ATE).

$$ATE = E(\delta) = E\,Y1 - Y0\,(.)$$

Where; E (δ) represents the average (or expected value).

Average Treatment Effect on the Treated, or ATT, which measures the effect of milk cooling plants on those individuals who delivered milk to cooling plants is represented as,

$$ATT = E\,(Y1 - Y0 \mid D = 1)$$

The Average Treatment Effect on the Untreated (ATU) measures the impact that milk cooling plants would have had on those who did not deliver to cooling plants (counterfactual)

$$ATU = E\,(Y1 - Y0 \mid D = 0$$

The problem is that all of these parameters are not observable, since they depend on counter-factual outcomes. For instance, using the fact that the average of a difference is the difference of the averages, the ATT can be rewritten as:

$$ATT = E\,Y1\,(\mid D = 1) - E\,Y0\,(\mid D = 1)$$

The second term ATT is the average outcome that the treated individuals would have obtained in absence of treatment, which is not observed. However, the value of $Y0$ for the untreated individual is observed. Thus, we calculate;

$$\Delta = E\,Y1\,(\mid D = 1) - E\,Y0\,(\mid D = 0$$

The difference between Δ and the ATT can be obtained by adding and subtracting the term,

$$\Delta = ATT + E\,Y0\,(\mid D = 1) - E\,Y0\,(\mid D = 0)$$
$$\Delta = ATT + SB$$

SB, is the selection bias: the difference between the counterfactual for farmers delivering to milk cooling plants (treated) and the observed outcome for the control farmers (untreated). If the SB term is equal to 0, then the ATT can be estimated by the difference between the mean observed outcomes for treated and untreated.

3. Results and Discussions

The adopted econometric model in this study is the propensity score matching (PSM). The model is commonly employed in the impact/effect evaluation studies (Rosenbaum *et al.,* 1985). Under this approach households delivering milk to cooling plants (treated group) were matched with other households that share similar characteristics but do not deliver their milk to cooling plants (control group). Similar to the adoption models in various studies, the whole sample from the survey data was used in computing the propensity score (Beker and Caliendo, 2000; Yashiko, 2010 and Dehinenet, 2014).

3.1 Estimation of the probability propensity score

Table 1 presents results of probit estimation of dairy farmers delivering milk to cooling plants. The results show that gender, household size, age, education, group membership, distance and extension services received by a dairy farmer significantly influenced the decision to sell milk to cooling plant. The estimated model appears to execute well for the intended matching exercise. The pseudo-R^2 value was 0.45 (Table 1). This indicates how well the covariates explain the probability of choosing a marketing outlet. A low pseudo R^2 value means that farmers delivering milk to cooling plant do not have much distinct characteristics overall and therefore finding a good match between treated and control households becomes easier. After matching, it is expected that there would be no systematic differences in the distribution of covariates between the treated and the control groups. Therefore, the pseudo-R2 should be lower than before matching (Caliendo and Kopeining, 2005).

Table 1: Probit Estimation of factors influencing choice decision of cooling plant

Variables	Coef.	Std. Err.	P>z
Gender	0.783	0.397	0.049**
Age	-0.054	0.031	0.083*
Marital status	0.029	0.217	0.895
Education level	0.138	0.079	0.081*
Household size	-0.151	0.090	0.094*
Occupation	-0.007	0.592	0.990
Size of the land	0.052	0.085	0.538
Off-farm income	0.000	0.000	0.314
Experience	0.041	0.034	0.234
Contract	-0.857	0.949	0.366
Group membership	0.829	0.392	0.035**
Milk volume	-0.815	0.842	0.333
Price	0.253	0.345	0.463
Distance	-0.261	0.131	0.046**
Repayment period	0.200	0.356	0.575
Access to credit	0.872	0.364	0.017**
Extension services	0.593	0.399	0.013**
Constant	-7.493	10.685	0.483

Pseudo R^2 = 0.4509, Number of Observations = 150, LR Chi^2 (18) = 97.96, Prob> Chi^2 = 0.0000, Log likelihood = - 41.568975,
Asterisks ***, **, * represents significance levels at 1%, 5% and 10 % respectively.

3.2 Distribution of propensity scores

To identify the existence of a common support, the distribution of propensity scores between the farmers delivering to cooling plant (treated) and those that do not (control) groups was done using kernel density estimator. It has been argued that common support condition is a major source of bias in evaluating conventional approaches (Heckman *et al.,* 1997). Figure 1, depicts that there is a high chance of getting good matches and large number of matched sample size from the distribution since the propensity score distribution is skewed to the left for those delivering to cooling plants and to the right for those that do not.

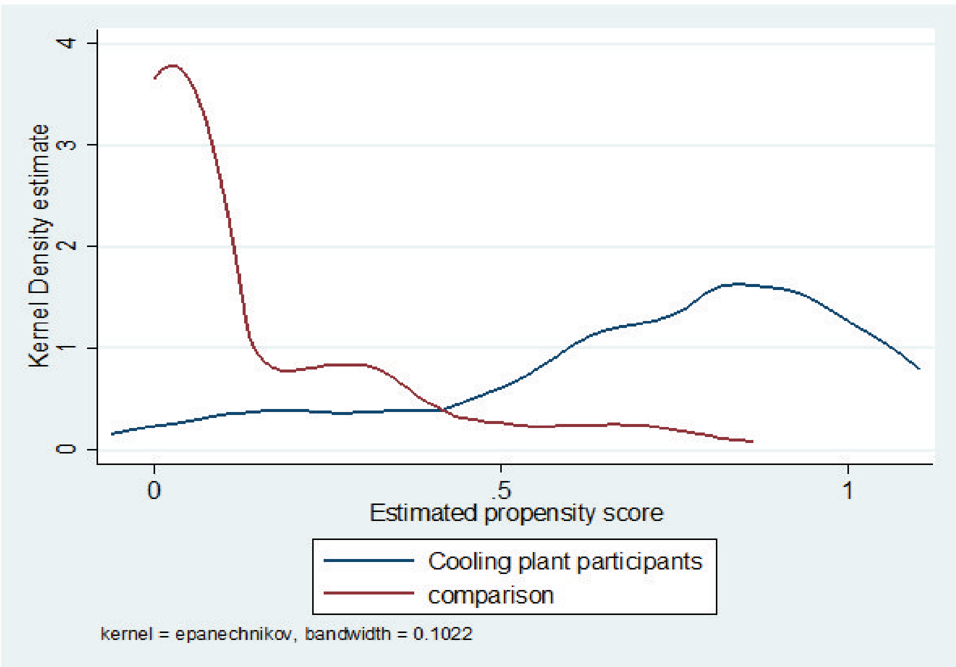

Figure 1: Propensity scores distribution among treatment and control group

3.3 Choice of matching algorithm

Table 2 show the performance measure of matching algorithm estimators in the study area. Different matching algorithm estimators were first tried in matching the treatment and control households in the common support region. Matching estimators were evaluated via matching dairy farmers delivering milk to cooling plant and those that do not in the common support region. Hence, based on the matching quality indicators, Nearest neighbor matching (NN6) which resulted in relatively low pseudo-R^2 with best balancing test (all explanatory variables are insignificant) and large matched sample size as compared to other alternative matching estimators was selected**.**

Table 2: Performance measure of matching algorithm estimators in the study area

	Performance Criteria		
Matching estimator	Balancing Test	Pseudo R^2	Matched sample size
Nearest Neighbor matching			
NN(1)	15	0.399	45
NN(2)	15	0.228	45
NN(3)	17	0.177	45
NN(4)	17	0.166	45
NN(5)	17	0.148	45
NN(6)	17	0.1453	45
Radius caliper			
(0.1)	17	0.631	45
(0.25)	17	0.197	45
(0.5)	16	0.151	45
Kernel matching (KM)			
Band width 0.6	15	0.178	45
Band width 0.1	15	0.178	45
Band width 0.25	15	0.178	45
Band width 0.5	15	0.178	45

3.4 Testing of covariates balance between treated and control groups

Table 3 reports the balancing check of covariates comparing the matching algorithm significant differences using Nearest Neighbor matching algorithm. The balancing powers of the estimations between the matched and unmatched households selling milk to cooling plant were ascertained by considering different test methods such as; the reduction in the mean, standardized bias and equality of their means using t-test. In the nearest neighbor matching algorithm, the standardized bias difference before matching range between 18.1% and 92.5% in absolute values. T-values also showed that the chosen variables exhibited statistically significant differences before matching. After matching, the standardized bias differences for almost all covariates lied between 4.7% and 34.3% and all of the covariates were balanced (Table 3). This implies that sample differences in the unmatched data significantly exceeded those in the samples of matched cases. Hence, a high degree of covariate balance was created between the treatment and control samples.

Table 3: Testing of covariates balance using Nearest Neighbor matching for farmers delivering to cooling plants and those that do not

		Mean		% reduction		T-test	
Variables	Sample	Treated	Control	%bias	bias	T	p>t
Gender(years)	Unmatched	1.4222	1.2843	28.9		1.65	0.102
	Matched	1.3571	1.4317	-15.6	46	-0.56	0.576
Age	Unmatched	31.8	36.98	-65.5		-3.23	0.002
	Matched	32.5	33.489	-12.5	80.9	-0.59	0.555
Marital status	Unmatched	1.3333	1.3627	-3.7		-0.21	0.836
	Matched	1.4286	1.3166	13.9	-280.7	0.54	0.593
Education level (years)	Unmatched	12.244	10.5	64.9		3.44	0.001
	Matched	11.821	11.695	4.7	92.8	0.21	0.836
Household size	Unmatched	4.8889	5.2157	-16.2		-0.89	0.377
	Matched	4.5357	4.8964	-17.8	-10.4	-0.66	0.515
Occupation	Unmatched	1.6222	1.7549	-28.7		-1.65	0.102
	Matched	1.6429	1.5493	20.2	29.5	0.7	0.484
Land size(ha)	Unmatched	4.5778	4.2373	14.6		0.77	0.443
	Matched	4.25	4.8089	-23.9	-64.1	-0.98	0.331
Off-farm income	Unmatched	10907	9597.1	12.1		0.67	0.504
	Matched	10929	12188	-11.6	3.8	-0.42	0.676
Experience	Unmatched	9.2667	8.1275	17.4		0.95	0.343
	Matched	8.3214	7.4528	13.3	23.8	0.61	0.546
Contract	Unmatched	1.0222	1.0784	-25.8		-1.31	0.193
	Matched	1.0357	1.0911	-25.4	1.5	-0.84	0.404
Group membership	Unmatched	0.64444	0.22549	92.5		5.32***	0.000
	Matched	0.53571	0.42583	24.2	73.8	0.81	0.42
Milk Volume	Unmatched	14.133	9.5294	62.8		3.92***	0.000
	Matched	11.286	12.035	-10.2	83.7	-0.42	0.673
Price	Unmatched	29.333	27.735	18.1		6.13***	0.000
	Matched	29.036	28.749	21.2	82	0.89	0.377
Distance to the market	Unmatched	1.9622	2.2485	-17.5		-0.93	0.354
	Matched	2.0179	1.9931	1.5	91.3	0.06	0.954
Repayment period	Unmatched	2.8667	2.6667	39.5		2.13**	0.035
	Matched	2.7857	2.8563	-13.9	64.7	-0.52	0.604
Access to credit	Unmatched	1.3333	1.6863	-74.8		-4.2***	0.000
	Matched	1.4286	1.4779	-10.5	86	-0.36	0.717
Extension service	Unmatched	1.3333	1.2843	10.5		0.59	0.553
	Matched	1.2857	1.4454	-34.3	-225.7	-1.24	0.222

% reduction /bias/= [(unmatched % bias – matched % bias) / (unmatched % bias)*100)].

****, *** represent significance level at 5% and 10% respectively.**

3.5 Estimation of Average Treatment Effect (ATT) on income

The effects of delivering milk to cooling plants as a market outlet on household income was computed based on the selected Nearest Neighbor Matching (NNM). However, Heckman *et al*. (1998) argued that for better results and understanding, more than one matching method can be used. Therefore, in addition to NNM, Stratification Matching (SM), Radius Matching (RM) and Kernel Based Matching (KBM) were used to measure the effects of delivering milk to cooling plants on household income.

The estimation results provide a supportive evidence of statistically significant effect of the cooling plant on household income in terms of KES. The results from the four matching approaches indicated a positive and significant effect on the level of household income. This suggests that cooling plants play an important role in the income status of smallholder dairy farmer. After controlling for pre-intervention differences in socio-economic, institutional and other characteristics of the treated and the control households, it was found that, on average, selling milk to cooling plants has increased income of the households by KES 16,680.00 per lactation period (Table 4). The amount was significantly higher than what was realized by their counterparts at 95% confidence level.

The empirical results based on SM, RM and KBM also shows that farmers selling to milk cooling plants received KES 4596.07, KES 843.95 and KES 2814.89, respectively more than those that do not (Table 4). This confirms that, the average household income for farmers delivering to cooling plants was more than those who do not, depending on the matching method used. Thus, this study affirmed that delivering milk to cooling plant increases the household income. The possible explanations for this increment in total income could be fairly high prices paid by cooling plants and reduction in costs of production and marketing for service users.

A number of coefficients for the interacted terms in the study were also found statistically significant, thus confirming the heterogeneity of the effects of delivering milk to cooling plants on household income. For instance, the coefficients for the interacted terms for education (0.14), extension service (0.59), gender (0.78) and group membership (0.82) were positive and statistically significant at 95% confident level. These indicate that the effect of selling to cooling plants on household was higher among households that were educated, received extension services and has membership in the cooling plant. However, the interacted terms like age, household size and distance was negative and statistically significant, suggesting that the effect of delivering to cooling plants on household income decreases with increase in the variables. The benefits of cooling plants can be witnessed through income increment among users. Generally, cooling plants has income generating opportunities by supporting and encouraging surplus milk production and by providing information to its members. While income could be direct results of cooling plant, other benefits could be resulted from new opportunities created for both milk producers and the surrounding community, in terms of employment due to the presence and functioning of cooling plants. This is because, cooling plants reduce milk spoilage and famers can also deliver their evening milk. In addition, cooling plants have the power to increase producers bargaining power in the market places and permits dairy producers to combine their strength and gain more income**.**

Table 4: Estimation average treatment effect (ATT) on income indicators (KES)

Matching methods	No. of Treated	No. of Controls	ATT	Std. Err.	T
Nearness Neighbor Matching	45	15	16680.00**	26600.07	0.62
Stratification Matching	45	45	4596.07**	20454.33	0.22
Radius Matching	34	45	843.95*	11234.49	0.07
Kernel Matching	45	45	2814.89**	15805.91	0.17

Asterisks *, **, and *** represents significance levels at 10%, 5% and 1% respectively.

3.6 Sensitivity analysis

Table 5 shows the results of Simulation based sensitivity analysis. Sensitivity analysis in this study was conducted to ascertain the robustness of the estimates. Rosenbaum (2002) argued that, matching the treated and the controls only balances the distribution of observed characteristics if there are unobserved variables that simultaneously affect the assignment into treatment. Hence, the outcome variable might lead to hidden bias. This problem was addressed using the bounding approach method suggested by Rosenbaum (2002). The goal of the approach was to determine how strongly unmeasured variables must influence the selection process to undermine the implications of the matching process.

The results of sensitivity analysis show that the estimated treatment effects were insensitive to hidden bias with gamma values ranging from 1.91 to 1.99 for the nearest neighbor matching, 1.61 to 1.72 for kernel based matching and 1.62 to 1.67 for the radius matching. A gamma level of 1.91 for instance, imply that if individuals with same X- vector differ in their odds of those selling milk to cooling plants by a factor of 91 percent, the positive significance of the cooling plant effect on income in Sotik Sub-County may be questionable. Additionally, the study revealed that, the simulated ATT of the outcome variable which is milk cooling plant income is very close to the baseline ATT. This implies that, it is only when a confounder is simulated to provide implausibly large outcome effect. The study therefore concludes that the ATT estimates for household income are robust indicators of the effect of delivering milk to cooling plant.

Table 5: Results of Simulation Based Sensitivity Analysis

Matching algorithm	Baseline ATT	Simulated ATT	Gamma level (Γ)	t-stat
Nearness Neighbor Matching	16680.00	16157.20	1.91 - 1.99	2.01
Kernel Based Matching	4596.07	4502.45	1.61 - 1.72	2.32
Radius Matching	2814.89	2760.23	1.62 - 1.67	2.13

NB: Γ- refers to the outcome effect which measures the estimated effect of the simulated confounder on the relative probability to have a positive outcome in case of no treatment.

4. Conclusion

Establishment of milk cooling plants in Sotik Sub-County plays a major role in smallholder dairy farmers' household income. Delivering milk to cooling plants positively and significantly increases the income of dairy farmers. After matching the farmers delivering their milk to cooling plant with those that do not on the basis of their propensity score, the gains from cooling plants was KES 16,680 per lactation period more than their counterparts. Generally, the finding concluded that delivering milk direct to a cooling plant is economically viable and an important tool in increasing smallholder dairy farmers income.

5. Recommendation

To reduce milk losses and increase the income of the smallholder dairy farmers, the government and non-governmental organization should further expand the modern milk market outlets through the establishment of milk cooling centers since they are more rewarding. This study recommends policy interventions in increasing milk market awareness through creation of strategies that would improve socio-economic conditions of smallholder dairy farmers. This can be done by providing farmers with extension services on the importance of milk cooling plants to improve the farmers' knowledge and increase milk productivity which in turn will lead to increased household income.

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