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IMPACT OF ADOPTION OF RISK MANAGEMENT STRATEGIES ON MILK PRODUCTION AMONG SMALLHOLDER DAIRY CATTLE FARMERS IN, MERU COUNTY, KENYA

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ABSTRACT

A majority of smallholder dairy cattle farmers make their income primarily from milk production. The dairy sector contributes 14% of Kenya's agricultural GDP. The SDC farmers face a number of risks throughout the process of milk production. These include environmental, economic, and social factors; that are caused by production, marketing, and finance activity. The ramifications of the risks have not been addressed, and risk mitigation strategies have not been applied correctly. The study was conducted to determine the impact of adoption of risk management strategies in milk production among smallholder dairy cow farmers in Imenti South Sub County, Meru County, Kenya. Propensity score matching regression model was used to investigate the impact of risk management strategies adoption on milk output. The results showed that adoption of vaccination, insurance and milk preservation were statistically significant in improving milk production. However, off-farm investment and diversification were statistically insignificant in improving milk production. This was due to the fact that there would be divided attention and less time allocation on milk production if the farmer adopted off-farm investment. Limited land size factor affected the adopted diversification since the farmer will allocated more land to one enterprise example crop production hence limiting the other which is dairy cattle production. The results will provide baseline data for prospective risk analysis studies on smallholder dairy farming enterprise. Findings of this study will enable the dairy cattle farmers to understand the impact risk has on their production and the benefit of adopting risk management strategies in order to increase productivity.

Keywords: Dairy cattle, milk income, smallholder farmers, adoption, risk management strategies, Meru County, Kenya.

INTRODUCTION

In Kenya, the agricultural sector contributed approximately 23% of the GDP in 2021 and employed 53.82 % of the total

working population both formally and informally (Agriculture & food security, 2021). The contribution of livestock toward the GDP was 12% of the country's GDP and 42% of agricultural GDP in the same year. Additionally, the dairy sector contributed 14% of Agricultural GDP (FAO, 2021). The mean production in litres per cow per day was 10 and 28 was the optimum among smallholder dairy cattle farmers (GOK, 2021).

Dairy cattle production in Kenya is mostly practiced by the (SDC) farmers who account for more than 80 percent of the total raw milk output in Kenya, with the rest coming from large scale producers (Wangu, 2021). Besides, the practice is preferred for provision of manure for use on farm as fuel or organic fertilizer. Dairy cattle are also sold in times of need of income and are a form of capital investment (Odero, 2017). Milk production is an important source of income for most (SDC) farmers (Bennett *et al.*, 2015). In Meru County, intensive dairy cattle farming is practiced under zero-grazing units in areas with limited size of land. Cows are fed using grass and crop residues, with most forages being cut and brought to the animals rather than using a grazing system (Njeru, 2022). South Imenti Sub County in Meru County is one of the high potential areas for intensive dairy cattle production. Dairy cattle's farming in the area is practiced under the intensive production systems due to the limited land size. According to KNBS, Imenti South has 39,517 dairy cattle and 20,822 households with dairy cattle producing an average of 7 to 9 liters/cow/day with each farmer having on average two cows (KNBS, 2019).

Although cattle dairy sector has a significant contribution towards the national economy, there are numerous risks that hinder optimal milk production (Muunda, 2021). These include; production risks, unreliable marketing channel and lack of proper storage facilities (Nyokabi *et al.*, 2021). The SDC farmers have also faced other risks in cause of milk production such as; financial risks, unpredictable weather conditions, human resource risk and changes in policies and regulations from the Government (Dohlman, 2020). Some of the mitigation measures by smallholder farmers involve; vaccination against diseases, diversification into other enterprises, insurance for the dairy cattle and joining cooperative groups (Sciabarrasi, 2021).

The SDC farmers have also faced financial risks that make them unable to meet expected obligations such as purchasing inputs, generating low milk production, leading to less expected profits and losing equity in the farm (Kahan & FAO, 2013). Another risk smallholder dairy cattle farmer's face is unpredictable weather conditions, leading to poor planning for feed availability and irregular milk production (Godde *et al.*, 2021). Smallholder dairy cattle farmers need more expertise and reliable human labour working in a dairy enterprise as human resource risk mitigation (Sciabarrasi, 2021). The farmers are also exposed to government policies and regulations changes. The risks include increased taxes, poor regulations for chemical use and fluctuation in the prices of commercial feeds and other inputs (Dohlman, 2020).

Some of the mitigation measures by smallholder farmers involve; vaccination against diseases such as East Coast Fever and Foot and Mouth Disease (Akalu, 2017). In addition, diversification into other enterprises, such as crop and livestock production, is practiced to mitigate financial risk (Dohlman, 2020). Further, some dairy farmers have insured their animals against the risks. They include death or injuries; the farmer is compensated when such losses occur (GOK, 2020). Farmers also form groups that help them in bargaining for better milk prices (Sciabarrasi, 2021).

Analysing the impact of adopting RMS on milk production will enhance SDC farmers decision making regarding adopting the methods. It will also increase their preparedness towards the risks so that they can have continuous milk production all year round in line with the big four agenda and vision 2030, which is achieving zero hunger. The ramifications of the risks have not been addressed, and risk mitigation strategies have not been fully adopted by the small holder dairy farmers; which could affect milk production. The study was conducted to determine the impact of adoption of risk management strategies in milk production among smallholder dairy cow farmers in Imenti South Sub County, Meru County, Kenya. The study results will inform the Government in developing risk management policies and allocating resources towards risk mitigation strategies to safeguard smallholder dairy cattle farmers. The findings will also provide baseline data for prospective risk analysis on smallholder dairy farming enterprise.

MATERIAL AND METHODS

The study was conducted in Meru County, Imenti South Sub- County. Imenti South is located in latitude of -0.131° to $0^{\circ} 7' 52''$ south and longitude of $37^{\circ} 36' 36''$ to 37.61° east. The Sub County constituency has a tropical type of climate. The average annual temperature is 20.5°C and the average rainfall ranges between 500 mm to 1200 mm. It covers an area of 413.9 square km and is the most developed Sub County in Meru County with a good and vast road network that facilitates transport of inputs and produce to markets (KNBS, 2019). It has six wards which include; Nkuene, Abogeta East, Abogeta West, Mitunguu, Igoji East and Igoji West. Agriculture is the major economic activity in this county due to the rich volcanic soils in the high altitude areas. Coffee, tea, banana, potatoes, French-beans and dairy production are the primary produce. South Imenti was purposively selected among the nine constituencies due to its favorable agro-ecological zones which support dairy production. According to KNBS, Imenti South has 206,506 people and 39,517 dairy cattle. It contains 64,186 numbers of household among which 20,822 households have dairy cattle (KNBS, 2019).

The research used descriptive cross-sectional research design. It is a type of research design in which data is collected from different individuals at a single point in time while observing variables without influencing them. The goal of conducting descriptive studies was to describe people and conditions as they are found in nature.

The target population involved smallholder dairy cattle farmers from the six wards (Nkuene, Abogeta East, Abogeta West, Mitunguu, Igoji East and Igoji West). Farming household were used as the sampling frame, with household head as the sampling unit. The target population was 20822.

Data was collected by administration of the questionnaires through interviews to the respondents. During the administration of the questions, the purpose of the study was clearly explained to the respondents who were smallholder dairy cattle farmers.

A sample of 222 dairy cattle farmers was obtained using (Nassiuma, 2000), formula. Sampling was done proportionally according to the distribution of the SDC farmers in all the wards using cluster sampling procedure. Each Cluster constituted a ward and therefore there were six clusters; Nkuene, Igoji east, Igoji west, Mitunguu, Abogeta east and Abogeta west. Primary data was collected using structured questionnaires. The data was collected on risk, farmer characteristics, farm characteristics and risk mitigation strategies adopted.

After data collection, data coding was done to present and summarize information obtained from farmers on risk and risk management strategies. Social-Economic factors influencing the adoption of risk management strategies were analyzed using binary logit. Stata version 17 was used to analyze data.

Estimation of parameters

The research employed a propensity score matching regression model to examine the impact of risk management techniques on milk production. The conditional likelihood of obtaining a therapy given pre-treatment characteristics is represented by the propensity score $p(X)$ (Rosenbaum and Rubin, 1983). Thus,

$$p(X) = Pr\{T=1 | X\} = E\{T | X\} \dots\dots\dots(1)$$

Where $T = 0, 1$ represents the value of the measure of treatment exposure (risk management strategy adoption), and X represents the vector of pre-treatment characteristics. In the calculation of propensity score, the parameter of interest is the Average Treatment Effect on the Treated (ATT), which may be calculated as;

$$E\{\hat{\gamma}^1 - \hat{\gamma}^0 | T_i = 1\} = E\{E\{\gamma^1 | T_i = 1, p(X_i)\} - E\{\gamma^0 | T_i = 0, p(X_i)\} | T_i = 1\} \quad (2)$$

Where pX_i denotes the p-score, and \bar{i}_1 and \bar{i}_0 denote the probable outcomes in the two counterfactual scenarios of getting therapy (participation in risk management strategy adoption) and not receiving treatment (non-participation in risk management strategy adoption).

According to Caliendo and Kopeinig (2008), the logit model with a higher density mass in the borders might be utilized to calculate the propensity score $p(X)$. The matching method that best predicts the p-score is selected. Matching quality and variation are traded off in the matching approach. Many matching estimators have been suggested in the literature. These include nearest neighbour matching, radius matching, and kernel matching. In nearest neighbour matching, just the participant and its closest neighbour are utilized. According to Abadie and Imbens (2006), nearest-neighbor matching estimators for average treatment effects allow individual observations to be used as a match on numerous occasions and compared to matching without replacement. In contrast, kernel-based matching utilizes more non-participants for each responder, which decreases variance but may raise bias.

RESULTS AND DISCUSSION

Descriptive analysis of Socio-economic and institutional factors influencing the adoption of risk management strategies

Table1 describes the summary of the continuous variables. These are variables that can assume an infinite number of real values within a given interval. In the study they were age, household size, land size and market distance.

Table 1: Summary statistics for continuous variables used in logit regression

V a r i a b l e	O b s e r v a t i o n	M e a n	S t a n d a r d D e v i a t i o n	M i n i m u m	M a x i m u m
A g e	2 2 2	4 6 8 9 3 1	1 1 3 4 8 6 5	2 8	7 9
H o u	2 2 2	3 . 7	1 . 1	1	7

s		9	9		
e		2	2		
h		7	8		
o		9	6		
l		3	8		
d					
s					
i					
z					
e					
L	2	1	1	0	1
a	2	.	.	.	5
n	2	9	2	5	
d		1	4		
		3	3		
s		3	8		
i		8	1		
z			7		
e					
M	2	0	0	0	3
a	2	.	.	.	
r	2	6	5	1	
k		8	1		
e		1	4		
t		0	0		
		8	5		
d		1	8		
i					
s					
t					
a					
n					
c					
e					

The study findings deduced that the minimum age for the dairy cattle farmers was 28 years while the maximum age was 79 years and the mean age was 46 years. These result alien to those of Job *et al.* (2020) where the youngest and the oldest smallholder dairy farmer were aged 25 and 90 years, respectively. This indicated that the farmers practicing dairy cattle farming are in their middle age. Secondly, the average household size was 3 members. The least family had 1 member while the maximum was 7 members. Study findings by Brar *et al.* (2018) indicated that dairy farmers with a large household size may or may not affect the adoption of risk management strategies.

The minimum size of land that the farmer owned was 0.5 acres while the maximum was 15 acres. The average land size was 1 acre indicating that most farmers had small land acreage. Farmers with large size of land adopted risk management strategies such as diversification. Lastly, the minimum distance to the market is 0.1 kilometers while the

maximum is 3. The mean is 1.5, which indicates that most of the farmers have access to the market.

shows that most of the farmers have access to the market.

hence can easily access the market.

Table 2 describes the distribution of farmers across different categories.

1. In regression analysis its adopters

			r	Cumulative
Gender	Male	174	78.38	78.38
	Female	48	21.62	100
Membership	No	20	9.01	9.01
	Yes	202	90.99	100
Access to credit	No	190	85.59	85.59
	Yes	32	14.41	100

78% of the smallholder dairy cattle farmer's households were male headed while 22% were female as shown above. The results concur with the findings of Caroline (2017), who revealed that 78% of respondents were males and 20% were female. Therefore, these current study findings imply that male-headed households are more likely to participate in adoption of risk management strategies than female-headed households. The study findings show that 90% are members of a farmers' organization, which made farmers more likely to acquire the technologies needed to apply sustainable agricultural techniques. Kanyenji *et al.* (2020) also found out that membership interactions with agricultural extension agents are rated to have an impact on the uptake of agricultural technologies.

The results in Table 2 show that only 14% of the farmers accessed credit for dairy cattle purpose. This shows that credit borrowing is not commonly practiced among dairy cattle farmers. Their main source of credit is the subsidiary bank where they milk payment is made. Farmers with the potential of accessing credit can easily mitigate against several risks. For instance, can acquire chaff cutter and reduce the need for less to credit enables a farmer to improve production due to availability of funds for needed resources (Nkegbe, 2018).

Determinants of Adoption of Risk Management Strategies

Table 3 shows the results of the factors influencing adoption of risk management strategies in dairy cattle farming using the Logit model. The results show that socio-economic and institutional factors are significant determinants of the logit model in the adoption of RMS. The overall model is statistically significant at p < 0.001. RMS is strongly associated with socioeconomic and institutional variables.

Table 3: Logit Model Estimates of Socio-Economic and Institution Factors on Adoption of Risk Management Strategies.

RMS	vaccination		insurance		Off-farm investment		Milk preservation	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Socio-economic & Institution factors								
Household head gender	0.051	0.35	0.143	0.61	-0.687***	0.36	-0.075	0.2
Age	-0.033***	0.02	-0.012	0.04	0.039***	0.02	0.003	0.0
Household size	0.065	0.14	0.330	0.27	-0.294***	0.14	-0.111	0.0
Land size	0.758***	0.35	-0.229	0.26	0.132	0.13	-0.025	0.0
Farmer's experience	0.029	0.03	0.008	0.06	-0.025	0.03	-0.006	0.0
membership	0.924***	0.39			-0.458	0.68		5

Extension services	-0.194	0.66					-0.651	0.50
Credit access			1.375** *	0.50	0.095	0.43	0.315	0.26
Market distance	0.044	0.28	1.147	0.45	0.753** *	0.45	0.867***	0.21
cons	0.435	1.08	-3.775	1.83	1.012	1.15	-1.176	0.62

The present research found that age, land size and membership influenced the adoption of vaccination. Age had a negative but significant influence on farmers' choice to adopt vaccination. These findings show that when the dairy farmer household head's age grows by a year, the likelihood of embracing immunization decreases by 3.3%. This indicates that young dairy producers may accept vaccination more rapidly than elderly farmers. These results are consistent with Tesfaw (2013), who found that the age of the household head has a detrimental impact on market participation decisions because as the head becomes older, they migrate to less labor-intensive agricultural choices. Total land size another factor that was positively associated with vaccine adoption. A one-acre increase in overall land area increases the likelihood of a farmer embracing immunization by 7.6%. The present research findings are consistent with the findings of Bushara *et al.* (2018), who observed that farmers with small farms are more likely to embrace enhanced technology than those with bigger farms, owing to the fact that small land parcels need less work. Lastly, membership in a farmer group was shown to be statistically significant. This suggests that a farmer's chance of adopting immunization was 9.2% if they belonged to a dairy union. The societies provide services that farmers cannot afford such as; milk marketing, extension services, input access. The study's results are consistent with those of Fischer and Qaim (2012), who discovered that one of the advantages of joining to a farmer organization is access to information. Dairy farmers may get information on disease outbreaks from farmer associations, allowing them to vaccinate against them in time. The results also support the findings of Elias *et al.* (2013), who discovered that membership in farmers' organizations might favorably improve involvement. This is because extension workers may discover those targeting farmers' groups is more cost-effective, enabling them to maximize the advantages of their efforts to develop farmers' ability to demand advisory services. As a result, farmers who are members of a group are more inclined to use vaccination than non-members.

The present research found that access to credit has a beneficial impact on insurance adoption. The access to credit coefficient, which consists of a dummy variable with values 1 for adopters and 0 for non-adopters, indicates that if a respondent acquired a loan, they were 137% more likely to adopt insurance. These findings support Mwaura *et al.'s* (2021) claim that credit is vital in the promotion of agricultural innovations. Plenty of farmers cannot afford to use agricultural technology if they do not have access to funding. The results also coincide with Chepng'etich *et al.*, (2015), who suggested that credit availability offers a buffer against any risk that may arise during manufacturing.

Gender, age of the family head, household size, and market distance all had an influence on off-farm investment. Gender had a negative but statistically significant impact on farmers' decision to participate in off-farm businesses. Since gender was a dummy variable with values of 1 for male respondents and 0 for female respondents, the gender coefficient indicates that female respondents are 68% less likely than male respondents to invest in off-farm projects. The results are congruent with those of Adesina and Chianu (2002), who observed that the female head is less likely to welcome change since she is more concerned with domestic activities and family management than male counterparts. Secondly, age had positively and statistically significant to off-farm investment adoption. This finding indicates that when the age of the dairy farmer household head grows by a year, they are 3.9% more likely to invest in off-farm ventures. This means older dairy farmers can quickly adopt off-farm investment as opposed to young farmers. The youths who were the minority in this study are known not to appreciate farming. This could be attributed to the fact that younger generation do not engage in farming either because of lack of interest since most prefer white-collar jobs or due to lack of production factors, especially land. This study's results are consistent with those of Achungo (2015), who said that age positively represents the experience that one has gathered over the years, which is important for enhanced effectiveness and efficiency in agricultural output. Furthermore, household size was shown to be adversely linked with off-farm investment. This suggests that increasing the size of a farmer's family diminishes the likelihood of off-farm

investment. The present study's results were congruent with those of Caroline (2017), who indicated that dairy farmers with a large household size do not embrace off-farm investment mostly because agricultural and animal production is done by family members. As a result, this absorbs the majority of their time, and they are unable to attend to other matters. Finally, distance to the market was positively and statistically significant in impacting the adoption of off-farm investment. As a result, the closer you are to the market, the greater your chances of acceptance by 75%. Therefore, the closer the farmer is to the market, the more likely the farmer is to participate in off-farm investing. The findings coincide with Caroline (2017), who suggested that the further a farmer is from cities

and markets, the less likely the farmer is to participate in risk management techniques. This might be explained by the time required to travel, which could result in higher transaction costs.

Distance to the market was the only factor that was found to significantly influence adoption of milk preservation. The closer the market distance, the greater the chances of adoption by 86%. As a result, the closer the farmer is to the market, where the majority of the coolers are situated, the more likely the farmer is to participate in milk preservation. These results are consistent with those of Brar *et al.* (2018), who found that the further a farmer is from the market, the greater the likelihood of milk deterioration if no preservation methods are in place.

Impact of Adoption of Risk Management Strategies on Milk Productivity

Table 4 shows the average treatment effect on the treated (ATT). It measures the difference between the milk productivity and welfare of the participants and what they would have had if they adopted the risk management strategies.

Table 4: Parameter estimates of Propensity Score Matching

Treatment	Matching Methods	n. treatment.	n. control.	ATT	Std. Err.	t
Vaccination.	Nearest neighbour	205	13	67.243	41.547	1.618
	Radius matching	173	16	58.967	32.692	1.804
	Stratification	172	18	60.453	23.667	2.554
Insurance	Nearest neighbour	7	7	92.571	40.609	2.28
	Radius matching	6	183	54.081	27.059	1.999
Off-farm investment	Radius matching	193	17	-21.62	23.805	-0.908
	Stratification	193	17	-11.549	20.186	-0.572
Diversification	Nearest neighbour	216	6	-42.68	101.471	-0.421
	Radius matching	147	6	-88.041	77.037	-1.143
	Stratification	147	6	-88.041	77.037	-1.143
Milk preservation	Nearest neighbour	89	49	9.921	18.586	0.534
	Radius matching	89	113	7.845	13.556	0.579

production and livestock subject them to the twin whammy of revenue loss and debt default. This may be mitigated to some degree by insurance, since when a loss happens, the farmer gets reimbursed.

According to radius or stratification method, the study indicates that if the farmer adopted off-farm investment, their production would decrease by 21.6 and 11.5 litres respectively. This is because farmer's attention will be divided towards different production entities. Hence, one production entity might receive more attention leading to the failure of the other. This finding is consistent with the findings of Melesse *et al.* (2015), who established that off-farm investment by family heads was positively connected to technical inadequacy in rain-fed agriculture. Increased earnings from off-farm investment will entice the farmer. If they spend more time on off-farm activities, agricultural practices will get less attention and management, thus reducing yield.

The current study also shows that if the farmer adopts diversification, their milk production will decrease by 42.6 or 88 litres according to nearest neighbour, radius or stratification method respectively. According to Table 4, the average land size for the dairy cattle farmers was 1-2 acres. If the smallholder dairy cattle farmer adopted diversification, their production would decrease since the land allocated for dairy cattle production such as fodder irrigation would be minimal. This interpretation is consistent with the findings of Wimmer and Sauer (2020), who discovered that big dairy farms gain more than small farms by co-producing milk and crops. Dairy farms with bigger herd numbers may use less labor-intensive technology (e.g., automated milking or feeding systems), freeing up more time for crop production. Small farms, on the other hand, may incur greater management expenses when engaged in two production sectors that demand unique sets of expertise, and hence do not gain from co-producing milk and crops.

Lastly, the current study also indicates that if the farmer adopted milk preservation methods, milk production would increase by 9.9 or 7.8 litres according to nearest neighbour or radius matching method, respectively. These findings are consistent with FAO 2023 findings, which show that when milk is chilled to between 15 and 20 °C, the lacto peroxidase system permits preservation of the milk, increasing the shelf life of milk and reducing milk losses associated to collection logistics and collecting costs.

CONCLUSIONS

In the study farmer's demographic information on age, land size, membership to dairy union, access to credit, household size, gender and market distance were statistically significant variables in explaining the adaption of risk management strategies. The findings further established that vaccination, insurance and milk preservation methods have an impact on milk productivity since they are statistically significant

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