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Financing Large-Scale Mitigation by Smallholder Farmers: What Roles for Public Climate Finance?

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There is increasing interest in accessing climate finance to support low-emission, climate resilient agricultural development, but little is understood about how climate finance can be deployed to catalyze large-scale adoption of mitigation practices by smallholder farmers. This study assesses the potential roles of public climate finance in enabling smallholder farmers in Kenya's dairy sector to adopt low-emission farming practices. Drawing on multiple studies conducted as part of the design of a nationally appropriate mitigation action for the Kenyan dairy sector, it examines financing needs, institutional arrangements for channeling climate finance, and appropriate financial instruments. The study finds that financially profitable investments can be made by dairy farmers, but credit financing on commercial terms is not viable for dairy farmers lacking off-farm income sources. Dairy farmers make little use of formal financial institutions for several reasons, and while financial institutions have a strong interest in increasing their finance to the dairy sector, they face a variety of capacity constraints. Climate finance may have roles to play in strengthening linkages between dairy farmers and financial institutions, building capacities of different actors in the dairy and finance sectors, and enabling both farmers and financial institutions to manage risks. Concessional loans, credit guarantee funds and grants are all relevant financial instruments. If agriculture is to attract climate finance in support of large-scale mitigation action, a diversified, demand-responsive approach to financial innovation is required that engages different types of financial institution to support access to both savings and credit services tailored to the varied needs of men and women dairy farmers and the dairy value chain actors they work with.

Keywords: agriculture, climate finance, dairy, finance, greenhouse gas mitigation, Kenya

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INTRODUCTION

Agricultural production contributed about 14.5% of global emissions between 2000 and 2010 (i.e., 5.0–5.8 Gt CO_2eq per year), more than half of which is from livestock emission sources (Smith et al., 2014; Tubiello et al., 2014). Global livestock emissions have risen at a rate of more than 1% per annum in the last two decades. With an increasing global population and dietary changes associated with urbanization and rising incomes, future demand for livestock products is projected to increase, particularly in developing countries (Alexandratos and Bruinsma, 2012). Greenhouse gas (GHG) emissions from livestock production are thus projected to increase significantly (Popp et al., 2010; Bajželj et al., 2014; Tubiello et al., 2014).

In recent decades, the GHG intensity of livestock production (i.e., GHG emissions per unit of livestock product) has been declining (Caro et al., 2014), mainly due to productivity increases. There is potential for further reductions in GHG intensity of livestock production through adoption of practices that increase livestock productivity and sequester carbon in livestock production systems (Gerber et al., 2013; Herrero et al., 2016; Mottet et al., 2017). Significantly, however, only a small proportion of these potential changes are financially profitable for producers (Herrero et al., 2016; Henderson et al., 2017). Promotion of productivity-enhancing mitigation measures will require financial support, in particular to make upfront investments in adopting improved practices (Lipper et al., 2014).

The majority of the world's food is produced by 300–400 million smallholder farmers operating farms of <5 ha (Samberg et al., 2016). Farmers in many developing countries face barriers to accessing finance. For example, in Africa, the majority of on-farm investments are financed through household savings and income from off-farm activities (Adjognon et al., 2017). This reflects multiple barriers to accessing formal credit faced by smallholders, including low returns, high risk, low trust of financial institutions, and lack of collateral, especially for women (Goldman et al., 2016). It has been estimated that financial institutions are currently only able to finance about a quarter of smallholder farmers' total investment need of $200 billion per year (ibid.). Existing public finance for agriculture is also insufficient (Benin and Yu, 2012). There is increasing interest in accessing climate finance to support low-emission, climate resilient agricultural development (Food and Agriculture Organization of the UN, 2013; Sadler et al., 2016; Bager et al., 2017).

Despite the mitigation potential in agriculture, and the overwhelming focus of climate finance on mitigation, agriculture has accounted for only 1–3% of the approximately US$ 1 trillion of climate finance pledged or delivered from 2012 to 2016 (Buchner et al., 2017). About two thirds of mitigation finance is from commercial or private sources, is available as market-rate debt, equity or balance sheet financing, and is delivered through private sector organizations. Since public climate finance is limited and should be used to fund the incremental costs of climate action (UNFCCC Article 4.3), the efficient use of public funds is important. Guidance for the Green Climate Fund, for example, indicates a preference for projects that leverage additional public or private finance and ensure reflows to the fund by limiting the use of highly concessional loans or grant (Green Climate Fund, 2015). To realize the potential for climate change mitigation in agriculture, there is a need to better understand the potential roles of public sources of climate finance in catalyzing increased financial capabilities of smallholder farmers for low-emission, climate resilient agricultural development.

In this article, we assess the potential roles of climate finance in enabling smallholder farmers in Kenya's dairy sector to adopt practices that can reduce the GHG intensity of milk production. Milk is Kenya's second most important livestock product after meat. An estimated 4.12 billion kilograms of milk worth KSh 182.9 billion (USD 1 ≈ KSh 100) were produced in 2015, mostly by about 2 million rural Kenyan households (Muriuki, 2011; Ministry of Agriculture, Livestock and Fisheries, 2017). National demand for milk is projected to double in the next decade (Food and Agriculture Organization of the UN and New Zealand Agricultural Greenhouse Gas Research Centre, 2017). About three quarters of Kenya's dairy cows are raised in extensive grazing and semi-intensive systems, in which cows obtain fodder through a combination of grazing and stall feeding (Bebe et al., 2003). Average annual milk production per cow on smallholder dairy farms is low, at about 1,800 L per cow, but the wide variation in yields among farms points to the strong potential to increase dairy productivity (Lukuyu et al., 2011; Migose et al., 2018). Common reasons for low productivity include poor management of the cow's lactation cycle, limited availability and poor quality of feed, and poor cow welfare (Biwott et al., 1998; Richards et al., 2015). Research has estimated that each kg of milk produced results in GHG emissions of between 2 and 37 kgCO_2eq, but that emissions intensity may be reduced by 7–45%, depending on the production system and practices adopted, while increasing milk production by 4–80% (Food and Agriculture Organization of the UN and New Zealand Agricultural Greenhouse Gas Research Centre, 2017; Brandt et al., 2018). Production practices that can increase milk yields and reduce the GHG intensity of milk production are generally well-known, and include using higher yielding breeds, increasing fodder production and improved feeding practices, and improving animal health and welfare through better housing and preventive veterinary practices (Muinga et al., 1993; Kahi et al., 2000; Kavoi et al., 2010; Food and Agriculture Organization of the UN and New Zealand Agricultural Greenhouse Gas Research Centre, 2017; Kathambi et al., 2018). Adoption rates vary considerably by technology and location, with reported rates ranging between 20 and 78% for improved breeds (Murage and Ilatsia, 2011), 8 and 65% for zero-grazing (Njarui et al., 2016), 88 and 91% for cultivation of Napier grass (Mutoko, 2014; Kiptot et al., 2015), 0 and 95% for fodder conservation (Njarui et al., 2011; Mwamuye et al., 2013) and 12 and 24% for use of chaff cutters (Kimenchu et al., 2014; Kiptot et al., 2015). Adopting these practices requires access to investment and operating capital. Changes in production practices are generally made gradually, with investments spread out over a period of some years.

About 45% of the milk produced is consumed on-farm by calves and household members, and the remainder is marketed. Of the marketed milk, more than 75% is sold through the informal market, either directly to consumers or through traders, and about one quarter is channeled to dairy processing companies, often via dairy cooperatives (Muriuki, 2011). Dairy cooperatives handle about 18% of the total marketed milk volume, and supply about 60% of the milk procured by dairy processors. The 412 registered dairy cooperatives have memberships ranging between 30 and 2,000 households. The cooperatives provide farmers with a reliable market outlet, and some also allow members to purchase inputs on credit. Some cooperatives are associated with Savings and Credit Cooperatives (SACCOs), which serve members' savings and credit needs. Many farmers are also members of self-help groups, where

members work together to improve fodder production, process feed or undertake joint marketing and processing. Access to extension services and their effectiveness in promoting adoption is variable (Zander et al., 2013; Mochama, 2015). Farmer groups and cooperatives also require investment and operating capital to provide and expand their services to members.

Kenya's dairy sector is fully liberalized, public investment in the sector has been limited, and current policy focuses on mobilizing private finance (Republic of Kenya, 2013). Kenya's dairy sector thus provides an important opportunity to investigate options for enabling access to climate finance to promote low-emission agricultural development. This study explores dairy farmers' and farmer cooperatives' needs for and access to finance, the needs of financial institutions (FIs) that serve them, institutional arrangements for linking smallholders to FIs, and appropriate financing instruments. The study identifies potential roles for public sources of climate finance and discusses the challenges in delivering financial support to the sector.

DATA AND METHODS

The operation of the dairy value chain and delivery of finance to the dairy sector both involve actors at multiple levels and cross-level interactions between them (Rousseau, 1985). A mixed method approach was used to understand finance needs, financing practices and perceived constraints on access to finance by actors at each level. Both primary and secondary data were used. While some of the data sources used are based on small sample surveys, analysis of multiple data sources is used to provide an understanding of constraints and opportunities at multiple levels in the finance and dairy sectors. Four surveys were conducted at farmer household, farmer cooperative and financial institution levels in Kenya. Two surveys targeted the farmer level, one aiming to quantify investment needs and one quantifying existing sources of finance for investments in household dairy enterprises. Another survey examined sources of finance at the dairy cooperative level, and one focused on the supply of finance by FIs. **Figure 1** shows the location of sites covered in each of these four surveys. All surveys were carried out in partnership with the World Agroforestry Centre, which has standing research clearance under the relevant Kenyan national laws. The research was conducted in accordance with national regulations and the policy of the World Agroforestry Centre on Research Ethics (2014), under which prior approval by an ethics committee is not required. All interviewees gave free, prior and informed verbal consent and all personal data has been anonymized.

An exploratory survey, conducted in 2015, focused on understanding the financial relationships, financing needs and access to finance of seven dairy cooperatives in central and southeastern Kenya (hereafter, "cooperative survey"). This study aimed to gain in-depth insights into financial management and constraints of dairy cooperatives. Seven cooperatives were selected, four in Meru county, a region with intensive production and strong linkages between individual cooperatives and a cooperative-owned processor, and three in Machakos county, where production is less intensive and value chains less strongly integrated. Semi-structured interviews were held with the chairman and financial manager of each cooperative, and covered the cooperative's history and current operations, organizational and financial management, use of credit, and perceived constraints on access to credit faced by each cooperative. Responses to closed and open-ended questions were coded and frequencies calculated. Interviews were also held with local branches of FIs, the results of which were used to inform design of a follow-on survey of financial institutions.

To understand the financial characteristics of investments by dairy farmers and farmer groups or cooperatives, 41 dairy farming households and five dairy cooperatives or farmer groups were surveyed in Nakuru County in 2016 (hereafter referred to as the "ex-post investment assessment"). The purpose of the survey was to undertake ex-post assessment of investments made by these farmers and cooperatives with support from the IFAD-funded Smallholder Dairy Commercialization Programme (SDCP). SDCP has supported individual farmers and farmer groups located in three project areas within Nakuru County. Through discussions with SDCP staff, typical investments supported by the project were identified. Purposive sampling was used to identify farmers in each of the project areas who had made at least one of the identified investments. Interviews with individual farmers collected data on dairy enterprise costs, revenues and actual investment costs in order to calculate gross margins, total revenue as well as cash income in with- and without-investment scenarios for each household. For investments made by farmer groups and cooperatives, focus group discussions with farmer group or cooperative members were used to collect the same data. Analysis of survey data used standard cash-flow models implemented in Microsoft Excel including capital and operating expenditures for the household dairy enterprise and farmer group's dairy operations to estimate financial rates of return by comparing cashflows between with- and without-investment scenarios, and to characterize feasible credit conditions (i.e., interest rate, grace period and repayment period) on the basis of cashflow characteristics of the investment scenario. A discount rate of 10% was used.

Informed by the results of the cooperative survey, in June-July 2016 a survey of financial institutions and SACCOs was undertaken (hereafter, "FI survey"). The survey covered five SACCOs, two commercial banks, two microfinance banks and one credit-only microfinance institution. This survey focused on understanding these financial institutions' current supply of credit to the dairy sector, current financial products, and their support needs if they are to increase financial services to the dairy sector. Using a pre-designed interview tool, staff in each FI responsible for agricultural lending were interviewed about their current loan portfolio to dairy farmers and cooperatives, perceived constraints on loans to actors in the sector, past involvement in international financial support initiatives, and their interest in and capacity building needs for expanding support to the dairy sector. For quantitative variables (e.g., volume of total loans and dairy sector loans, numbers of dairy loan clients and loan officers), averages and the ranges of responses were calculated. Frequencies were calculated for qualitative responses after coding (e.g., existence of training for

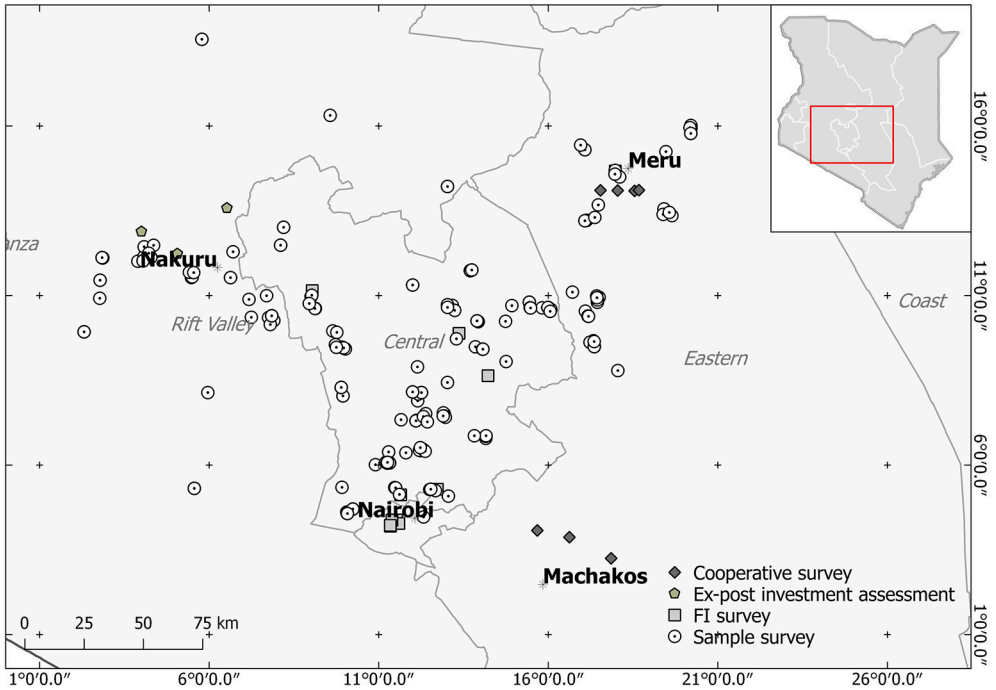

FIGURE 1 | Location of survey sites in Central Kenya.

loan officers, previous experience with international cooperation, perceived constraints).

A household survey was conducted in 2018 covering 429 milk producing households across eight counties in central Kenya (hereafter "2018 sample survey"). The survey used a stratified random sampling method to select households that are representative of households engaged in dairy production in the region. The questionnaire covered a variety of topics related to dairy production, including sources of funds for investment and operational costs of household dairy enterprises. Of the households interviewed, 66% raised cows in stall-fed production systems, 23% used a mixture of stall-feeding and grazing, and 11% used grazing systems. About 28% were members of a dairy cooperative or dairy farmer group. About 80% of households reported selling milk, and the average household sold 43% of its total milk yield. Dairy incomes accounted for almost 50% of reported total household income. Thus, the households in the 2018 sample survey had on average more intensive production systems, and were more dependent on dairy incomes than the average household reported in other recent regional surveys in western Kenya (Rao et al., 2016; Omondi et al., 2017). Descriptive statistics were calculated, and Chi-square tests run to identify associations between households' use of credit to finance dairy enterprise investments and operation costs and household characteristics (e.g., cooperative membership, income quartile). Analysis was conducted using IBM SPSS Statistics (IBM Version 1.0.0).

In addition to primary data, we analyzed a secondary dataset on Kenyan households' use of financial services (Central Bank of Kenya et al., 2016). The FinAccess Household Survey 2015 contains data on access to and demand for financial services by a nationally representative sample of 4,913 rural and urban households. For our analysis, we selected two sub-samples, one consisting of rural households owning a cow primarily for the purpose of selling milk (i.e., dairy farmers, $n = 608$), and an independent sub-sample consisting of all other rural households in the dataset ($n = 2{,}467$). These sub-samples are not nationally representative, but the dataset is the best available large-sample source of data with nationwide coverage. We analyzed this data to calculate the proportion of each sub-sample of households using different institutions for savings and loan services and performed Chi-square tests to investigate whether being a dairy farmer is associated with differences in the use of different institutions for savings and credit services. Analysis was conducted using IBM SPSS Statistics (IBM Version 1.0.0).

Qualitative and quantitative data from these primary and secondary data sources were supplemented by reviews of relevant literature.

RESULTS

Financial Characteristics of Dairy Sector Investments

The ex post assessment of investments made by households and farmer organizations with financial support from the SDCP in Nakuru County identified and assessed three investment projects at the household level: constructing housing for zero-grazing cattle, housing plus biogas, and housing and biogas with fodder production. Investment needs ranged between US$ 1457 and US $2875 per household. Farmer group investments ranged

from US$ 3800 for dairy meal processing machinery to US$ 254,000 for a milk cooler and pasteurizer. Analysis of cashflows in the with- and without-investment scenarios suggests that most investments at household and group levels achieved a reasonable rate of return (**Table 1**). However, characteristics of the resulting cashflows point to constraints on using formal credit to finance these investments. Several investments only break even after five or more years, and feasible repayment periods are even longer if repayments are made solely from income from the household dairy enterprise. Feasible interest rates (i.e., 8–12%) are also lower than the interest rates on many available credit products provided by formal financial institutions, which ranged between 10 and 16% for loans from SACCOs and 10–24% for FIs at the time of the ex post investment assessment. This conclusion remains unchanged even after the introduction of an interest rate cap at 4% above base rate (i.e., ca. 14%) through amendments to the Banking Act in September 2016. Therefore, although studies report positive benefit:cost ratios for dairy investments in Kenya (e.g.,Food and Agriculture Organization of the UN and New Zealand Agricultural Greenhouse Gas Research Centre, 2017; Kashangaki and Ericksen, 2018), they cannot necessarily be commercially financed.

Sources of Investment and Access to Credit

Sources of Investment and Access to Credit for Dairy Farmers

The 2018 sample survey identified the investments made in the past 5 years and operating expenditures in the past 1 year by a sample of households in central Kenya, as well as the sources of funds used to finance the investments and operating costs (**Table 2**). About a third of households had made investments in cattle housing and fodder preparation machinery. The majority had also incurred operating expenses for feed, breeding services and preventive veterinary services. General household income and savings were by far the most commonly mentioned source of funds for both investments and operating expenses. Dairy enterprise profits were mentioned as a source of funding for investments by about a quarter of households, and for operating expenses by a third of households. Many households relied also on non-dairy agricultural and non-agricultural income sources. Averaged across all expenditure items, credit was used by about 14% of households, but this was rarely from informal or formal financial institutions. Credit from input suppliers was used by 6% of households for all expenditures, but was more commonly used for making expenditures on cattle housing, AI services, curative veterinary treatment, and feed in the wet season. In some cases, inputs are supplied on credit by agrovet suppliers, vets or other service providers. In other cases, these services are either directly provided on credit by dairy cooperatives with repayment made by deductions from the value of milk supplied to the cooperative (known as the "check-off" system), or services are provided to cooperative members by interlinked third parties, with repayment facilitated through the check-off system. Where these services are provided by dairy cooperatives, repayment may be made by deducting costs from milk supply to the cooperative. Analysis using the Chi-square test of independence identified that whether a household used credit for investment in cattle, cattle housing or fodder processing machinery are not associated with cooperative membership, income quartile, non-farm income sources or gender of the household head. However, using credit for these investments was associated with whether the household had titled tenure of arable land [$\chi^2_{(1)} = 4.09$, $p < 0.05$], but a higher proportion (10.6%) of untitled households made investments using credit than titled households (4.8%). None of these household characteristics had a significant association with use of credit for operating expenses.

These findings are generally consistent with results of our analysis of the financial access dataset (Central Bank of Kenya et al., 2016). That dataset suggests that although about 70% of rural households use mobile money (e.g., M-PESA) for receiving and sending money with friends and family or for savings, only about a quarter of rural households have a bank

TABLE 1 | Analysis of feasible credit terms for selected group/cooperative and farmer investments.

Investment project	Investment costs (US$)	IRR 10 years(%)	IRR 20 years(%)	Years to break-even	Feasible interest rate(%)	Feasible grace period (years)	Feasible repayment period (years)
FARMER GROUP INVESTMENTS							
Dairy meal processing	3,800	20	24	2	10	2	8
Hay production	3,500 in year 1 plus 1800 in years 5 and 10	16	23	6	8	2	6
Milk cooler	174,000	1	10	6	10	4	10
Milk pasteurizer	80,000 (additional to the 174,000 for cooler)	16	23	7	10	6	10
ON-FARM INVESTMENTS							
Zero-grazing unit	1,457	25	29	5	12	2	8
Zero-grazing unit + biogas	2,125	31	34	5	12	2	6
Zero-grazing unit + biogas+ fodder production	2,875	28	31	5	12	2	6

IRR, internal rate of return. Source: Ex-post investment assessment.

TABLE 2 | Sources of finance for household dairy enterprise investment and operating costs.

Expenditure item	Number (%) of hh making expenditure (n = 429)	Sources of finance (% of households mentioning each source)[a]						
		General household savings or cash	Dairy enterprise income	Non-dairy agriculture income	Non-agriculture income	Supplier credit repaid in cash	Supplier cedit repaid in milk	Cash loan
INVESTMENTS[b]								
Cattle	70 (16)	37	18	27	17	7	0	7
Cattle housing	165 (38)	52	20	12	12	16	11	4
Machinery	123 (29)	55	26	6	11	2	0	2
OPERATING EXPENSES[c]								
Fodder								
Wet season	111 (26)	41	41	11	8	2	1	0
Dry season	156 (36)	46	37	10	10	4	2	0
Feed								
Wet season	257 (60)	44	45	6	9	9	7	0
Dry season	255 (59)	49	40	6	9	4	8	1
Breeding								
Bull service	66 (15)	47	42	2	8	6	3	0
AI	327 (76)	51	37	11	9	17	10	1
Deworming	368 (86)	62	28	6	5	2	0	0
Tick control	295 (69)	62	30	5	2	0	0	0
Vaccination	251 (59)	53	26	4	2	1	1	0
Curative treatment	207 (48)	72	18	6	5	27	40	3
Fodder production inputs								
Fertilizer	123 (29)	50	28	19	5	2	0	1
Seed	109 (25)	39	28	21	11	5	1	2

[a] *Figures in each row may not add up to 100% because household responses included multiple finance sources.*
[b] *Investments in the past 5 years.*
[c] *Expenditures in the past 1 year.Source: 2018 sample survey.*

account and about 80% have never had a loan from a formal FI (e.g., bank, mobile banking service, SACCO, micro-finance or government fund) (**Table 3**). Overall, access to formal financial institutions is limited among both dairy farmers and other rural households. However, compared with other rural households, dairy farming is associated with a greater likelihood of saving with a SACCO, microfinance institution and stocks and shares, as well as greater use of credit from SACCOs and goods suppliers. Informal institutions are more common means of both storing savings and obtaining loans, with more than half of rural households belonging to some kind of informal institution [e.g., accumulating savings and credit association (ASCA) or rotating savings and credit association (ROSCA)] to which they make monthly or weekly payments for savings to use in emergencies or for making lumpy investments. Among formal financial institutions, SACCOs are the most commonly used source of loans. Among informal institutions, family, friends, neighbors and credit from local shops or suppliers are the more common sources of credit, followed by loans from ASCAs and ROSCAs. Dairy farmers are more likely than other rural households to have loans from these informal sources. However, average loan volumes from these informal sources are likely to be much smaller than those potentially available from formal institutions.

Sources of Finance for Dairy Cooperatives

There are few previous studies of access to finance by dairy cooperatives. The cooperative survey conducted in 2015 found significant diversity among the small sample of cooperatives in their relationships with financial institutions and their capital investment decisions. Some cooperatives located in a major dairy producing area (i.e., Meru county) were relatively well integrated with financial institutions, which facilitate farmer payments for milk deliveries, and offer credit to cooperative members on the basis of their milk delivery records supplied by the cooperative (**Table 4**). Operating capital for the cooperatives was supplied by SACCOs, banks or advance payments from the processing company that buys their milk. Cooperatives in less intensive dairy production areas (i.e., Machakos) had not established such relationships. Where cooperatives had made capital investments, these funds mainly came from banks or SACCOs. Although processors sometimes provided a loan guarantee, lack of collateral or guarantees, high interest rates and the inability of cooperatives' financial records to meet banks' loan application assessment requirements were the main barriers to credit access perceived by cooperative managers. Thus, although two cooperatives stated that they had no investment need, in part this reflected their perception that obtaining loans would be extremely difficult.

TABLE 3 | Proportion of dairy farmers ($n = 608$) and other rural households ($n = 2,467$) using different institutions for savings and loans, 2015.

	Savings		Chi-square test statistic and *p*-value*	Credit		Chi-square test statistic and *p*-value*
	Dairy farmers(%)	Other rural households(%)		Dairy farmers(%)	Other rural households(%)	
Savings in secret hiding place	42	38	-	na	na	na
ROSCA/merry-go-round	43	32	24.4, <0.001	5	3	9.0, 0.003
ASCA	17	13	6.5,0.01	7	5	5.7, 0.017
SACCO	22	12	42.9, <0.001	10	4	29.5, <0.001
Mobile banking	11	11	-	4	3	-
Family or friends	8	8	-	8	7	-
Shares, stocks, mutual funds	9	5	20.6, <0.001	na	na	na
Microfinance	4	2	6.4, 0.01	2	1	-
Goods on credit from shop/supplier	na	na	na	13	9	5.5, 0.019
Bank loan	na	na	na	4	3	-
Government institution (e.g. Joint Loans Board, Youth Fund)	na	na	na	1	1	-
Credit from buyer of farm produce	na	na	na	0.4	0.8	-

**p-value reported for significant associations only, non-significant test results are shown by "-." "na" indicates that savings or credit are not available from this source. ASCA, accumulating savings and credit association; ROSCA, rotating savings and credit association; SACCO, savings and credit cooperative.*
Data source: (Central Bank of Kenya et al., 2016).

While in-kind lending solutions are important for some farmers' access to inputs, such as animal feeds or artificial insemination, many co-operatives are limited in their ability to provide these services. Provision of access to services on the check-off system ties up working capital in advances to members, while working capital is required for milk procurement, which is the cooperative's core business. Some cooperatives have linked up with financial institutions to enable payments for such in-kind lending. Processors also facilitate provision of these financial services by guaranteeing farmers' loans with financial institutions, supporting cooperatives to purchase inputs for their members in bulk, and by facilitating linkages between cooperatives and input suppliers. However, these arrangements are not yet widely adopted throughout the dairy sector.

Supply of Credit Finance

The FI survey found that for most non-SACCO FIs, the dairy sector accounted for 0.2–5.12% of their total loan book, compared to 10–100% for SACCOs. The SACCOs interviewed were mostly set up by farmer-based organizations and most of their members are farmers or individuals involved in agricultural production. However, the average size of loans to the dairy sector was higher for banks than for SACCOs. This is because SACCOs mainly serve smallholder farmers who typically borrow in small amounts, while banks mainly target medium to large scale farmers, small and medium enterprises and cooperatives. SACCOs and some microfinance institutions are thus better placed to serve smallholder farmers. Banks, on the other hand, are a key source of on-lending funds for SACCOs, with a few banks featuring prominently as providers of capital to SACCOs. It is also more attractive for banks to lend to cooperatives than to individual farmers, because of the higher cost of servicing smallholder farmers and banks' relatively limited staff and branch outreach.

Most banks and dairy-related SACCOs have one or more products targeting dairy farmers, such as loans for purchasing heifers, feed inputs, farm equipment and infrastructure, working capital and invoice financing. Typical credit amounts offered to farmers by the financial institutions ranged from KSh 10,000–KSh 5 million per loan (i.e., US $100-$50,925) with tenors between 6 and 60 months depending on the nature of financing, with working capital loans having shorter tenors. Banks however offered higher limits and longer tenors than SACCOs, because banks are able to access long-tenor lines of credit for on-lending, unlike SACCOs, which borrow from the banks.

However, SACCOs provide not only more affordable loans to farmers, but also have more flexibility in terms of eligibility criteria and lending terms. SACCO loan interest rates ranged between 10 and 16% while loans from non-SACCO financial institutions had interest rates of up to 24%. SACCOs are also less demanding when it comes to the level of contribution by clients to each investment, requiring 0–30% client contribution, compared to 15% and upwards for other FIs.

The FI survey also found that financial institutions face a number of constraints that reduce or limit their willingness or ability to lend to dairy farmers and cooperatives. The constraints mainly revolve around capacity needs of financial institutions, capacity needs of farmers and financing needs of financial institutions.

TABLE 4 | Financial relationships and investments by selected cooperatives (2015).

Location	Major dairy producing area				Minor dairy area		
	Coop 1	Coop 2	Coop 3	Coop 4	Coop 5	Coop 6	Coop 7
Has bank account	Y	Y	Y	Y	Y	Y	Y
Farmer payments facilitated by FI	Y	Y		Y			
Credit from FI available to members with milk delivery records		Y	Y	Y			
SOURCE OF OPERATION CAPITAL							
FI	Y		Y	Y			
Processor		Y	Y				
Own funds					Y	Y	Y
Capital investments in last 5 years	N	Y	N	Y	Y	N	N
Investment project:							
Milk transport		Y		Y			
Cooler					Y		
Processing equipment					Y		
Source of loan		Bank		Bank	Bank		
					SACCO		
PERCEIVED CONSTRAINTS TO CREDIT ACCESS							
Collateral or guarantee	Y			Y	Y		
Financial management records	Y	Y					
Interest rate		Y	Y	Y	Y		
No investment need						Y	Y

Source: Cooperative survey.

Capacity Needs of Financial Institutions

The FI survey found that non-SACCO FIs tend to have relatively few rural branches as a percentage of their total branch network. Although they all have agriculture loan officers working with farmers, the level of engagement with farmers is limited, as indicated by the ratio of agriculture loans to the total loan portfolio (i.e., 2–14%), compared to SACCOs for which the ratio is 27–90%. While SACCOs have worked with farmers for many years, engagement with agriculture for other FIs is more recent. SACCOs also have more staff per branch focused on agriculture lending than commercial and micro-finance banks. SACCOs are thus better placed to serve farmers. Although some banks and SACCOs do invest in training their agriculture loan officers in agriculture credit skills, both SACCOs and other FIs indicated a need for staff training in agriculture credit management and product development. As indicated by the feasible credit terms shown in **Table 1**, investments in the dairy sector tend to have relatively long repayment periods. There is thus a need to support financial institutions to design and deploy financial products that are farmer-centered and that address borrowers' credit needs. Both SACCOs and banks expressed interest in capacity development and support to develop targeted products as well as to explore the potential of digital and mobile technologies in the delivery of solutions to farmers.

Another capacity need expressed by both banks and SACCOs is improvement in management information systems (MIS). The majority of financial institutions interviewed has an MIS for the agriculture portfolio in general, and most mark dairy loans within their agriculture portfolio. However, the process of capturing and storing data is reportedly not fully reliable, indicating a need for support to develop better solutions for data capture, storage, retrieval, analysis and reporting. Financial institutions would benefit from being able to clearly disaggregate their agriculture portfolio because this visibility would enhance their risk management and enable them proactively manage problem loans or anticipate the impact of events in the dairy sector that have a direct impact on the loan book. For instance, if a region with dairy clients is affected by drought, the bank would be able to easily identify which clients might be affected and to what extent this may affect the loan portfolio, thus enabling them to be more proactive in portfolio risk management.

Capacity Needs of Farmers From Financial Institutions' Perspective

Financial institutions report a number of challenges at the farmer level that limit their ability to lend to farmers. The most common reason given for declining loan applications is the lack of a demonstrated financial track record by borrowers. Many farmers do not keep proper records of their dairy enterprises, and although some data on milk sales and input credit is held by cooperatives, this data is not visible to financial institutions. The issue of poor records was mostly reported by non-SACCO financial institutions, implying that SACCOs may be better able to access the financial profiles of farmers due to their affiliation to cooperatives.

Low productivity on smallholder farms as well as lack of structured off-take arrangements (e.g., long-term milk supply contracts) were also listed by financial institutions as limitations to lending to dairy farmers. Low productivity implies low

capacity of farmers to meet loan obligations when they fall due, as they may not generate sufficient cash flows from the dairy enterprise. The majority of institutions indicated that there was need for technical assistance to farmers to enable them to increase productivity, reduce fluctuations in milk yield and incomes, and hence increase their capacity to repay loans. Off-take agreements are seen by FIs as an assurance of the capacity of the farmer to repay the loans and to avoid diversion of funds. The risks and constraints to dairy sector lending as perceived by the financial institutions are summarized in **Table 5**.

Financing Needs of Financial Institutions

Most SACCOs interviewed in the FI survey mentioned inadequate funding for on-lending to members as a major constraint, while this was mentioned only by one non-SACCO FI. Only one SACCO had directly received international support, despite their much closer engagement with farmers. The main reasons for low SACCO engagement with international finance is their limited ability to attract such funds, restrictions due to funders' requirements, and their limited ability to absorb debt with external borrowing, since external borrowing by SACCOs is capped at 25% of total assets by the SACCO Societies' Act (2008).

Many non-SACCO FIs in Kenya have received international support for credit lines for agriculture on-lending. Some have received credit guarantees, and many have benefited from some form of technical assistance. These funds are usually provided for the entire agriculture portfolio, but in particular instances they have been extended to designated sectors or value chains in order to meet particular intervention outcomes.

DISCUSSION

Constraints on Access to Finance in Kenya's Dairy Sector

Increasing adoption by dairy farmers of farming practices that can increase milk yields will require upfront investment in items such as animals with higher yield potentials, better infrastructure for feeding, manure management and increased cow comfort, as well as fodder cultivation and fodder processing machinery. Working capital is also needed to cover ongoing farm costs, such as hired labor, feed and animal health interventions. Evidence that access to credit is associated with higher milk yields and higher net returns for dairy farmers highlights the importance of addressing liquidity constraints (Ngeno, 2018). Our analysis of survey data shows that the vast majority of dairy farmers currently finance investments and working capital from current income and savings. Small-scale surveys that include dairy farmers generally reflect these findings, although dairy farmers participating in the formal value chain may have higher rates of financial inclusion than other dairy farmers (Mburu et al., 2012; Zander et al., 2013). Similar to our 2018 survey, these other studies also find that own savings are by far the most common source of finance for farm expenditures and investments. Thus, loans from formal financial institutions are only used for on-farm investments by a small proportion of dairy farmers, while credit from input suppliers can be an important source of financing for some dairy farming households. These findings echo other reports on smallholders' investment sources in Sub-Saharan Africa, which note that credit-input linkages are common for some commercial crops, but less so for many food crops (Adjognon et al., 2017).

A significant proportion of farmers take part in informal savings and credit groups, but few make use of financial services from formal FIs. Low trust in FIs and unreliable services affect people's willingness to save with formal FIs (Dupas et al., 2012). Very few rural households report having applied for a loan from a formal FI. Lack of a perceived need for a loan, fear of loss of assets, inability to repay, and lack of records are the main reasons given by rural households for not applying for a loan (Central Bank of Kenya et al., 2016). Studies of formal credit applications suggest that refusal rates are between 40 and 60%, with a higher chance of success for male compared to female applicants, for households with a higher annual income, and for households owning land (Rambo, 2012). However, our sample survey indicated that a higher proportion of dairy farming households without land title made investments using credit. This may be due to fear of loss of assets, as there was no association with the households' income level. Limited or mixed evidence of the effects on land titling on access to credit in other developing contexts have been widely reported in the literature (e.g., Domeher and Abdulai, 2012; Lawry et al., 2017; Higgins et al., 2018). Our ex post assessment of investments supported by the IFAD SDCP indicates that while on-farm investments can be profitable, feasible loan repayment periods are longer than the tenor of most available loans, suggesting that farmers may be justified in not seeking to finance investments using loans. This finding has methodological implications, as many studies of the economics of mitigation or "climate smart" measures show negative abatement costs (i.e., $ per tCO_2e) or financial profitability (e.g., positive benefit:cost ratios or net present values) based on discounted net revenue over a given investment period (e.g., Food and Agriculture Organization of the UN and New Zealand Agricultural Greenhouse Gas

TABLE 5 | Risks and constraints to dairy sector lending as perceived by financial institutions.

Risks, constraints	Financial institutions' perceptions
Production risks	Weather, animal disease, poor management leading to low yields/fluctuations in yields impacting on repayment ability
Market risks	Market and price fluctuations impacting on repayment ability
Information risks	Poor record keeping, limited visibility of farmers' financial records
Constraints to expanding credit supply	Limited credit lines; multiple borrowing leading to default; high transaction costs of outreach to farmers; high cost of funding leading to high interest rates on loans; competition among FIs; inadequate funds for on-lending
Constraints to farmer access to credit	Insufficient collateral; income fluctuations impact on ability to repay; farmers' low literacy levels

Source: FI survey.

Research Centre, 2017; Henderson et al., 2017; Kashangaki and Ericksen, 2018; Lan et al., 2018), but without considering the time limit on loan repayments, which is critical for analysis of investment feasibility.

Farmer groups and cooperatives also require investments and operating capital for their business activities and to provide services to members. Investment needs of cooperatives vary considerably depending, for example, on whether they bulk and market milk only or also do value addition, and on the range of services they supply to their members. Most cooperatives use service providers for milk transport, but some invest in their own vehicle. Cooperatives that are able to provide financial visibility for their members also require an automated documentation system. Cooperatives also need financial services from financial institutions to run their day to day activities such as milk collection, payment for milk deliveries, and other operation costs. Given many cooperative members' limited funds for equity investment, access to appropriate and affordable financial services is an issue at the cooperative level in Kenya's dairy sector. Our cooperative survey suggests that all the cooperatives face constraints in their access to finance for longer-term investments. While there has been considerable research on the capital structure of cooperatives in developed countries (e.g., Barton et al., 2011; Li et al., 2015), there is a gap in related research in Africa.

On the supply side, formal finance sector lending to agriculture is <5% of total lending by FIs in Kenya (Tyson, 2016). This was also reflected in the small proportion of dairy lending in the loan portfolio of FIs surveyed. Some FIs are important sources of finance for cooperatives and their associated SACCOs. However, the FIs interviewed were all interested in further expanding their services to dairy farmers. The presence of constraints on access to finance by producers and cooperatives together with interest in expanded engagement with the dairy sector by FIs suggests a potential role for climate finance in supporting investment in the sector.

Potential Roles for Climate Finance

Climate finance is distinguished by its objective of promoting low-emission, climate-resilient development (United Nations Framework Convention on Climate Change Standing Committee on Finance, 2016). Many sources of public climate finance aim to support transformational change, also termed "a paradigm shift" (Green Climate Fund, 2014; Winkler and Dubash, 2016). Definitions of transformational change vary (GIZ, 2014). Common elements to different conceptualizations of transformational change include a high level of ambition (e.g., large emission reductions, or change in practices driving vulnerability by large numbers of people), addressing systemic barriers to change (e.g., policy or regulatory barriers, market failures), and leveraging significant levels of longer-term investment in low-emission, climate resilient pathways. Many of the financial mechanisms used by climate finance, such as loans, equity, guarantees or grants, are the same as those used in development and commercial finance. Sources of public climate finance may be able to provide credit or guarantees on better terms (e.g., lower interest rates, longer tenors) than commercial finance. There is thus likely to be a significant overlap between the modalities through which climate finance and other forms of finance are deployed. Furthermore, linking climate finance investments to other public investments would increase the leverage of climate finance, thus increasing the attractiveness of investment for climate funds. Where climate finance sources prioritize return to the fund (e.g., Green Climate Fund, 2015), other public funds could finance grant and other highly concessional investments, while climate finance is used for investments with a clear return. More generally, given the focus on transformational change, public climate finance investments should be targeted to supporting actions with demonstrated feasibility that have potential to fundamentally change the practices that drive GHG emission pathways. Deploying climate finance to overcome barriers to private investment in low-emission pathways also supports the longer-term transformation agenda (Patel, 2010). Dairy farmers' lack of access to finance for financing adoption of improved production practices is a systemic barrier with multiple causes. The following sections identify potential roles for climate finance in addressing this barrier by strengthening linkages between dairy farmers and FIs, and by enabling both farmers and FIs to manage risks.

Linking Dairy Farmers and Financial Institutions

Dairy farmers in Kenya mostly rely on own savings and current income sources for farm investments. Weak trust in FIs and poor service quality deter households from saving with FIs. They are also often unwilling to seek loans from formal financial institutions, fearing they may be unable to repay and consequently lose assets. Many households also have no documentation of their financial record with which to pass loan application assessments. To increase financial flows to the dairy sector, a prerequisite is that dairy farmers are linked to financial institutions (Sadler et al., 2016). There are many existing initiatives that have demonstrated a diverse range of institutional arrangements for strengthening such linkages.

Savings and credit groups

In some areas, dairy farmer groups have been established on the basis of informal savings groups, which may provide an institutional basis for linking farmers with formal financial institutions (Walton et al., 2016). Digitizing savings groups' records can help farmers document their credit record in a way that is visible to formal financial institutions, enabling a graduation from small-scale, informal loans to larger formal loans (Financial Sector Deepening Kenya, 2016). Lack of collateral is a constraint on access to credit for many farmers. Group lending models have begun to be adopted in Kenya, so that group members can guarantee each other's loans without the need for physical assets. Loan default rates are lower for loans to group members than to individuals, and some FIs also perceive that the group lending model fits with their strategies to expand the rural customer base (Kodongo and Kendi, 2013).

Cooperatives as intermediaries

Many farmers do not keep farm records, and their financial track record is not visible to FIs' credit officers for risk assessment. However, cooperatives and processors do keep data on milk supply by their members and suppliers. Some cooperatives provide inputs on credit and facilitate access to finance, but the capacity of cooperatives to provide these services varies. Automation of milk procurement systems is a broadly relevant intervention that can link cooperatives' receipt and payments systems with records of in-kind services, such as feed inputs, or artificial insemination services received by cooperative members (Onyiego, 2016). Participation of farmers in dairy hubs—farmer-owned milk bulking businesses that also link members to input suppliers and sometimes also credit providers—has been shown to have a positive effect on both participating farmers' milk yields and net returns (Ngeno, 2018). Making farmers' milk payment records visible to FIs can increase farmers' ability to demonstrate a financial track record and enable FIs to more accurately assess credit risks (Okech et al., 2017). Some companies have also developed apps and services to enable individual farmers to record their farm transactions and increase the visibility of their farm records to FIs[1]

Processors as intermediaries

One consortium of dairy, communications and financial sector partners has gone further, linking milk supply records with provision of a number of other services. Initially, the Agrilife Platform used data on farmers' financial status to enable provision of credit by a micro-finance bank, with milk receipts serving as collateral for the loans (Pambo, 2015). Subsequently, insurance companies, and service providers in animal health, breeding, feed, biogas and extension have joined the platform, enabling credit providers to link credit provision to a variety supporting services and thus reduce farmers' and banks' risks.

Linkages between financial institutions

Among formal FIs, SACCOs have the highest rate of engagement with farmers and are better oriented to serving farmers' needs. Some non-SACCO FIs provide capital to SACCOs for on-lending to members. These relationships can be further strengthened with additional finance.

Where proven models have been identified that are in line with FI's development strategies, climate finance can play a key role in supporting institutional development. There are significant transaction costs involved in identifying, piloting and upscaling institutional innovations to strengthen farmers' links with financial institutions. Climate finance could also support dissemination of knowledge of what works and what doesn't, strengthening networks among practitioners in the dairy and finance sectors. Covering these costs may require technical assistance grants to both FIs and their clients (i.e., farmers, cooperatives). Where there is insufficient evidence of the effectiveness of different institutional models, other forms of public finance may be more appropriate.

Managing Risks

Section Financial Characteristics of Dairy Sector Investments showed that many investments by dairy farmers and cooperatives may have positive returns, but the cash flow characteristics of these investments mean that current commercial credit terms are unviable if repayment depends on dairy enterprise revenues alone. Restrictive credit terms are often due to either real or perceived risks in the agriculture sector (Sadler et al., 2016). Climate finance may have several roles to play in managing these risks.

Linking credit to technical assistance

Low productivity and production risks are common in Kenya's dairy sector, and contribute to both farmers' fear of being unable to repay loans and FIs' reluctance to lend to farmers. Linking technical extension and dairy service provision to credit can support improvements in the productivity of dairy production and the stability of yields and incomes (Ngeno, 2018). Some credit providers have begun to tie their credit loans to use of cow insurance and technical support by dairy farmers in order to ensure farmers' ability to repay. However, value chain services lie beyond the remit of most financial institutions. Partnerships with other service providers are necessary to link finance to technical support. Some cooperatives provide technical extension services and other services such as input supply, artificial insemination and veterinary services. Several of Kenya's leading dairy processors have also begun to invest in dairy advisory services provision for their suppliers (Odhong' et al., 2018). Making data on provision of these extension services and uptake of good management practices visible to FIs can help indicate which farmers potentially have lower exposure to production risks. Similarly, some microfinance FIs link their loans to provision of financial literacy training for farmers.

Concessional finance and risk sharing mechanisms

In terms of financial instruments, concessional loans, risk sharing mechanisms (e.g., guarantee funds) and grants all have roles to play in Kenya's dairy sector. Concessional loans are critical because they can enable financial institutions to access capital for on-lending to the dairy sector while also delivering credit at affordable rates. Guarantee funds can also be used to offset part of an FI's risk to incentivize the FI to allocate its own funds to the dairy sector, and to overcome farmers' lack of collateral. Given the cash flow characteristics of dairy sector investments, blended grant-credit finance products may also be necessary to reduce loan repayment periods in line with financial institutions' credit policies.

Capacity building

Technical assistance, which is usually financed through grants, is relevant to the needs of farmers, cooperatives, processors, and FIs. Dairy advisory services and other forms of extension can increase farmers' knowledge of appropriate farming practices. The quality and effectiveness of extension services varies, and extension providers—whether private businesses, NGOs,

[1]e.g., https://farmdrive.co.ke/

TABLE 6 | Potential roles of climate finance in catalyzing investment in the dairy sector by financial institutions.

	Strengthening farmer-FI linkages	Managing credit risks	Leveraging private finance
Grants	• Supporting institutional innovation linking farmers with FIs (e.g., digitization of savings group, farm or coop records) • Strengthening dairy cooperatives' financial management capacities • Strengthening FIs MIS, credit staff dairy training, and capacities for product development	• Improving extension services • Developing systems to link farm and milk supply data to FI credit assessment procedures • Developing partnerships between FIs and dairy service providers	• Blending grant with credit finance • In-kind and own contributions by processors and FIs
Concessional loans	-	-	• Lowering the cost of dairy credit lines for FIs and farmers
Risk guarantee funds	-	• Partially offsetting dairy credit line risks	• Incentivizing allocation of FI own-funds to dairy sector

MIS, management information system.

cooperatives or processors—may need assistance with improving the services they offer (Odhong' et al., 2018). Developing linkages between farmers and FIs is also a knowledge intensive process of innovation that can be supported with technical assistance. SACCOs and non-SACCO FIs express demand for capacity building in a number of areas. SACCOs have a greater need for technical assistance to support finance and credit risk management, institutional governance, product development and information technology applications in their management and lending operations. Technical assistance is thus relevant to ensure the effective deployment of concessional loans and risk sharing funds.

Table 6 summarizes the potential roles of climate finance in building an enabling environment for private finance to support low-emission dairy development in Kenya. Public climate finance could have roles to play in covering the incremental costs of institutional innovations that enable farmers to access affordable financial services from FIs, in managing the risks faced by farmers and FIs, and in leveraging private finance from FIs and other actors in the dairy sector. Smallholder producers and farmer organizations in Kenya's dairy sector are both extremely diverse, and there will be no single mechanism to address farmers' financial constraints. Climate finance should be targeted to supporting access to a variety of financial services, including both savings and credit, and promote a wide range of financial institutions, models and delivery channels. Different financial institutions each have their own development strategies, strengths and constraints. Interventions supported by climate finance should be responsive to demand from the range of players involved in the market context.

CONCLUSIONS

This study suggests that, although financially viable investments can be made in Kenya's dairy sector, provision of climate finance through existing formal financial institutions at market rates would not be likely to reach a large number of dairy farmers and enable widescale adoption of low-emission dairy farming practices. The weak links between farmers and formal FIs; multiple causes of farmers' limited access to finance; the presence of production, market and price risks in Kenya's dairy sector; and capacity building needs of large numbers of actors illustrate the disadvantages in accessing climate finance that the agriculture sector faces relative to other sectors (Sadler et al., 2016). This study also indicates that there are often existing institutional innovations that can help overcome these constraints. If agriculture is to attract climate finance, a diversified, demand-responsive approach to financial innovation is required. In Kenya's dairy sector, climate finance should be targeted to supporting access to a variety of financial services (including both savings and credit), should promote a wide range of financial institutions, models and delivery channels, and utilize a mixture of financial instruments. Overcoming persistent barriers to financial inclusion for smallholder farmers is a long-term task that will require coordination between actors across the financial and dairy sectors. These multiple entry points are well suited to the focus of climate finance on supporting transformational change.

AUTHOR CONTRIBUTIONS

CO, AW, SvD, and MV: conceptualized the study and drafted the paper. CO, MV, SN, BS, and LK: implemented the surveys described and contributed to analysis.

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