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KENYA CROPS AND DAIRY MARKET SYSTEMS (KCDMS) ACTIVITY

Endline Methane Assessment of KCDMS Dairy and Fodder Value Chain Activities in Kenya

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RUMETH INTERNATIONAL, LTD SPECIALISTS IN RUMINANT METHANE ASSESSMENT

RTI INTERNATIONAL

Photo Caption
Front Cover: A dairy farmer milking a cow in Kenya. Credit: Far on Foot for USAID

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ACRONYMNS AND ABBREVIATIONS

AFCM	Annualized fat corrected milk
AI	Artificial insemination
Ca	Calcium
CH_4	Methane
CO_2e	Carbon dioxide equivalent
DFCM	Daily fat corrected milk
DIM	Days in milk
DM	Dry matter
DP	Digestible protein
EF	Annual methane emissions factor
FCM	Fat corrected milk (4%)
GHG	Greenhouse gas
ICI	Inter-calving interval
ILRI	International Livestock Research Institute
ISO	International Organization for Standardization
KCDMS	Kenya Crops and Dairy Market Systems
P	Phosphorus
RMA	Ruminant Methane Assessment
SEF	Specific emissions factor
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WCA	Wet chemical analysis

EXECUTIVE SUMMARY

The dairy industry is among the fastest growing agricultural subsectors in Kenya. Yet, national milk production is virtually unchanged in the last decade, increasing only slightly from 3.64 billion liters in 2010 to 3.98 billion liters in 2019. Sustained increases in dairy productivity require quantities and qualities of feed that provide essential macronutrients and minerals.

In 2019, the Kenya Crops and Dairy Market Systems (KCDMS) Activity funded by the United States Agency for International Development (USAID) contracted RuMeth International to carry out a baseline dairy animal nutrition study of the critical dietary and nutritional constraints to smallholder dairy productivity in its focus areas. The study centered on RuMeth's Ruminant Methane Assessment (RMA) methodology. The findings demonstrate that improved feeding and simple changes in the basal ration may greatly increase productivity and reduce the amount of methane (CH4) emitted per liter of milk produced.

KCDMS and USAID recognize that the relationship between animal productivity and enteric methane emissions offers significant opportunities for low cost greenhouse gas (GHG) mitigation. They also recognize the potential use of the RMA to assess and quantify methane emissions mitigation and productivity in livestock projects. The KCDMS baseline study offered a unique opportunity to demonstrate that potential.

Objective of the Assessment

The objective of this endline assessment was to measure the impact of KCDMS dairy and fodder value chain activities on methane emissions intensity and associated changes in productivity. The two key questions were:

> What has been the impact of dairy value chain activities on methane emissions intensity in those areas? and

> What has been the impact of those activities on smallholder dairy production?

Assessment Design and Methodology

The RMA integrated

1) detailed farm-level data from a sample of smallholder dairy producers who participated in KCDMS activities,

2) laboratory analyses of commonly used feed concentrates and supplements, and

3) published data on the nutrient profiles of common forages and fodders. We collected farm-level data from a sample of 127 smallholder dairy producers in three KCDMS geographic focus areas: Nyanza, Western, and Eastern regions.

Measuring Dairy Productivity and Methane Emissions

Producer operations are classified according to the intensiveness of operation and production herd genetics. Dairy productivity is measured using three factors which are combined to arrive at a calculation of annual fat corrected milk (AFCM):

(1) daily fat corrected milk (DFCM), days in milk (DIM), and inter-calving interval (ICI). AFCM is calculated as:

DFCM * DIM / (ICI / 365)

Methane emissions are calculated by analysing the basal diet of females using a United Nations Framework Convention on Climate Change (UNFCCC) methodology known as Strategic Supplementation in Smallholder Dairy Sector to Increase Productivity (AMS-III.BK).[1]

Results Overview

Dairy productivity

The assessment results showed significant changes in two of the three indicators of dairy productivity between the baseline and endline. DFCM and DIM increased in almost all operational categories as a direct result of amended feeding practices which improved the protein and energy content of the basal ration. ICI was virtually unchanged from the baseline in all zones because farmers fed improper amounts of mineral supplements and often fed the wrong products. Nevertheless, AFCM increased significantly due to increased DFCM and DIM.

Methane emissions

The assessment also showed significant improvement in methane emissions intensity, as illustrated by the Nyanza example in Table 1 below. This is the result of increased milk productivity combined with more nutrient dense and digestible feedstuffs.

Dairy productivity increased by an average of

43%

between 2019 and 2022 in the areas studied, and

Methane emissions intensity decreased by an average of

27%

between 2019 and 2022 in the areas studied.

TABLE 1

Methane Emissions Intensity, Nyanza County

Management/Genetics	AFCM (liters)		Annual Methane Emissions Factor (kgs)		CH4 emissions/liter SEF (kgs)	
Nyanza	2019	2022	2019	2022	2019	2022
Aa	1,625	2,690	85.4	90.4	0.053	0.034
Ab	824	1,581	66.9	63.9	0.081	0.040
Bb	842	1,180	63.6	61.2	0.076	0.052

A similar effort targeting 15,000 cows could increase total milk production by 7,706,020 liters, increase household income by KSh 270 million, and mitigate 11,175 tons of carbon dioxide equivalent (CO_2e) annually. This potential can be expanded even further by relatively simple changes: proper feeding of mineral supplements to bring the Ca:P balance to 2:1; eliminating poor quality feeds, such as maize stover, from the basal ration; and feeding high quality dairy meal.

1 "CDM Methodology Booklet Clean Development Mechanism." 2021. https://cdm.unfccc.int/methodologies/documentation/meth_booklet.pdf#AMS_III_BK.

Positive Observations

1) **Investment:** Smallholder dairy producers in KCDMS focus areas invested considerable effort and money to improve feeding practices and overall nutrition, particularly with respect to improved forages.

2) **Forage varieties:** We observed widespread adoption of the improved, more productive forage varieties promoted by KCDMS. This has increased protein, energy, and digestibility in the basal ration, resulting in increased AFCM.

3) **Dairy meal:** We observed an increased availability of dairy meal, the majority of which tested as fair to excellent in quality. These high-quality products improved rations and AFCM, while lower quality products negatively impacted animal productivity.

4) **Mineral supplements:** We observed an increased availability and use of mineral supplements. Almost all surveyed smallholders fed mineral supplements, but in inadequate amounts and with formulations which do not mitigate macro-mineral imbalances.

Negative Observations

1) **Macro-mineral imbalance:** There is a severe shortage of calcium (Ca) in the basal rations resulting in an overall imbalance of the Ca:P ratio, which greatly reduces fertility. The commercially available mineral mixes are improperly formulated for Kenyan forage conditions.

2) **Maize stover:** Significant producer investment in improved feeding and nutrition is compromised by the persistent, wide-spread practice of feeding maize stover to lactating cows. Maize stover in any form simply does not have the nutrient profile to effectively meet the nutritional needs of lactating cows.

3) **Dairy meal:** Dairy meal quality has improved since the baseline but there are still far too many sub-standard dairy meals on the market. This deficiency is a serious constraint to increasing productivity and improving methane emissions mitigation.

General Observations

1) **Feeding practices:** Farmers have materially improved their feeding practices, but still do not have access to professional nutrition advice to improve their rations. Most producers simply do not know how best to feed their dairy cows to maximize production.

2) **Dairy heifers:** The management and care of dairy heifers is woefully inadequate. The introduction of good genetics through artificial insemination (AI) is wasted because heifer calves are so commonly stunted before entering production, negatively impacting their overall lifetime production.

3) **Farm records:** Very few smallholders have any kind of production records and consequently are not in a position to make informed decisions. Production recordkeeping is required to improve nutrition and reproduction, as well as inform extension efforts and improve survey data collection.

Recommendations

1) **Feed supplemental calcium:** Simply balancing calcium in the rations would significantly improve fertility, increase productivity, and improve methane emissions intensity. Any mineral supplementation should focus on supplemental calcium to correct the Ca:P ratio imbalance.

2) **Stop feeding maize stover:** Replacing maize stover with readily available forage grasses will significantly increase annual milk production and improve methane emissions intensity.

3) **Establish laboratory testing services:** Without access to International Organization for Standardization (ISO)-certified wet chemical analysis (WCA) of feedstuffs, in particular dairy meal, both the manufacturers of the product and the farmer groups that use the products are severely handicapped. Laboratory facilities would give the dairy sector access to vital information to dramatically improve productivity.

4) **Train extension nutritionists:** Training extension nutritionists to advise producers in the best use of available feed to balance rations, along with proper mineral supplementation, can significantly improve productivity and methane emissions intensity. Note that the RTI training program and manuals on proper dairy feeds and feeding, available since early 2020, appear to not yet have been implemented in the field.

5) **Improve dairy heifer feeding:** Even in well managed operations, heifers are not fed what they need to maximize their genetic potential and allow good physical and reproductive development. Improving dairy heifer feeding will help them achieve closer to their genetic potential, increasing productivity and improving methane emissions intensity..

1. INTRODUCTION

1.1 Background to the Assessment

KCDMS is a five-year, $65 million Activity that seeks to improve the overall agricultural landscape in Kenya, specifically for horticulture and dairy, as well as other crops which contribute to the achievement of global food security strategy objectives, by supporting five priority areas:

1. competitive, inclusive, and resilient agricultural market systems
2. diverse agricultural production and improved productivity
3. improved policy environment for market systems development
4. integration of women and youth into agricultural market systems
5. collaborative action and learning for market systems change

> The goal of **KCDMS** is to transform agricultural market systems to enable intensification and diversification into higher value commodities and non-farm activities. This is done by facilitating market driven partnerships that bring together all players (agro-dealers, dairy and horticulture input suppliers, aggregators, processors, and exporters) to invest in higher productivity, quality improvements, and greater supply chain efficiency. In addition to enhancing productivity in the priority value chains across the project's zone of poverty alleviation, KCDMS is also working to increase the availability of safely produced food..

KCDMS is implemented by RTI International in the 12 focus counties of Nyanza, Western, and Eastern Provinces in partnership with the Busara Centre for Behavioural Economics, East Africa Market Development Associates, Farm Input Promotions Africa, International Livestock Research Institute (ILRI), Making Cents International, and Open Capital Advisors..

The dairy industry is among the fastest growing agricultural subsectors in Kenya, growing at an estimated rate of three to four percent annually[2] through 2010. Milk production is primarily undertaken by an estimated 1.8 million smallholder dairy farmers. However, during the past 10 years national dairy production has been virtually unchanged, increasing only slightly from 3.64 billion liters in 2010 to 3.98 billion liters in 2019.

Changes to Kenyan dairy production are largely a function of the number of cows being milked rather than changes in productivity. The estimated average annual milk production of 1,017 liters per milking cow[3] in Kenya is roughly the equivalent of 6 liters per day for a 270-day lactation with an ICI of 600 days. This performance is poor by any standard, and less than half of what should be expected from a reasonably nourished animal.

Smallholder farmers increasingly understand that improved feeding practices, with an appropriate balance of fodder and feed concentrates, help dairy cows increase performance and improve productivity.[4] Sustained increases in dairy productivity will require that rations have both the quantities and qualities of feed to provide a balance of essential macro nutrients and minerals (beyond what is needed to maintain normal body functions). Feeding a nutritionally balanced ration allows cows to consume as close to their actual energy requirements as possible and maintain the physical characteristics required for proper rumen function. Cows fed a balanced diet will be well-nourished, healthy, fertile, and able to manage the nutritional stresses associated with high milk production.

2 Kenya Ministry of Livestock Development, 2010.

3 1,187 liters per milking cow for improved breeds

4 The term productivity here refers to the ability of the animal to grow, reproduce, and produce milk

A baseline study of the critical dietary and nutritional constraints to smallholder dairy productivity in the KCDMS focus areas was carried out by RuMeth International in 2019 using its RMA methodology. The RMA is a tool for assessing the efficiency of developing country livestock production systems and development projects and is based on the UNFCCC methodology known as Strategic Supplementation in Smallholder Dairy Sector to Increase Productivity (AMS-III.BK). This methodology is designed to assess the nutritional efficiency and methane emissions from large ruminant production systems in the developing countries of Africa, Asia, and Latin America.

The final dairy animal nutrition study submitted to KCDMS on May 31, 2019, provided an indicative look at smallholder dairy farmer feeding practices, the nutritional status of their herds, available feeds and supplements, and production levels. It also considered the contribution of ruminant methane emissions to Kenya's GHGs and the potential to reduce their intensity. Finally, the report included a snapshot of the potential economic impact of improving smallholder feeding practices and overall dairy nutrition.

The baseline assessment findings showed significant potential impact of improved feeding practices on GHG emissions. The ration commonly fed to dairy cows in the study area result in between 50 and 100 grams of methane emitted per liter of milk produced. Simple changes in the basal ration could reduce methane emission intensity by over 50 grams per ration. Further improvements could potentially reduce emissions to as little as 20 grams per liter. RuMeth also quantified the potential impact on productivity of the nutritional changes needed for cows to produce an average of 8.5 liters of milk per day, extend lactation to 270 days, and decrease the ICI to 390 days.

KCDMS and USAID recognize that the relationship between animal productivity and enteric methane emissions offers significant opportunities for GHG mitigation. They also recognize the potential use of the RMA to assess and quantify methane emissions mitigation and productivity in livestock projects. The KCDMS baseline methane assessment offered a unique opportunity to demonstrate that potential..

1.2 Objective and Key Questions

The objective of this endline assessment is to assess the impact of dairy and fodder value chain activities in the KCDMS focus areas on methane emissions intensity, and associated changes in productivity. There are two key assessment questions:

1. What has been the impact of dairy value chain activities on methane emissions intensity? and

2. What has been the impact on smallholder dairy production?

The 2019 dairy animal nutrition study, which assessed the critical dietary constraints to dairy productivity for smallholder farmers, is the baseline against which change is measured. This endline assessment documented changes in productivity and methane emissions during the three-year period since the baseline. Specifically, RuMeth quantified changes in enteric methane emissions and dairy productivity and assessed the extent to which those changes are attributable to KCDMS interventions. RuMeth examined the following:

- forage, feed inventory, nutrient composition, and balance of the rations fed to dairy cows by smallholder dairy farmers in KCDMS zones
- nutritional weak links in smallholder dairy production systems
- changes in the overall quality of the rations (forages plus concentrated feeds and supplements) which farmers feed their dairy cattle as an outcome of KCDMS technical interventions, and their impact on productivity and methane emissions

The methodology integrates:

- detailed farm-level data from a sample of smallholder dairy producers who participated in the KCDMS Activity,
- laboratory analyses of the most commonly used feed concentrates and supplements, and
- published data on the nutrient profiles of common forages and fodders.

1.3 Assessment Design and Methodology

There are some nuances to the endline methodology given background and focus. The objective of the baseline study was to assesses the critical dietary and nutritional constraints in smallholder dairy productivity. It focused on feeding practices, nutritional status, available feeds and supplements, and production at the farm level. Secondarily, it considered the potential for reducing ruminant methane emissions intensity and their contribution to Kenya's GHGs.

In contrast, the focus of the endline assessment is twofold:

1) to quantify changes in methane emissions intensity and

2) to assess changes in smallholder dairy productivity and determine the extent to which those changes are attributable to KCDMS interventions.

The endline assessment uses the same RMA methodology as the baseline study. The endline assessment responds to the key questions by gathering and analyzing detailed farm-level measurements of production and information on what and how smallholder dairy farmers are feeding their animals. This information was used to calculate changes in methane emissions among individual cows.

1.3.1 Data Collection

KCDMS collected detailed survey data to undertake the analytical work for the study objective and tasks. RuMeth trained the enumerators, helped supervise the survey, observed interviews with key informants, and collected dairy meal samples for analysis. The information collected, the source, and the collection method are summarized below.

TABLE 2

Endline Assessment Data Collection Summary

Information	Source	Collection Method
Production data: cow genetics and weight, calving information, daily milk production, length of lactation, and calving interval.	Smallholder dairy producers	Producer survey
Feeding practices: Ration (forage types, amount fed, source, cost) fed to milking cows, dry cows, and heifers and concentrates and supplements (amount, type, source, cost) fed to all groups	Smallholder dairy producers	Producer survey
Nutrient profiles: Nutrient content of forages, concentrate feeds, and feed supplements being fed and/or currently available to producers	Laboratory analyses, published data	Collect samples of dairy meals and supplements, lab testing, desk review

The assessment was conducted across the KCDMS zones of influence. Activity staff selected the dairy cooperative societies and producer groups whose members participated in data collection and worked with them to identify the sample farmers to take part in the assessment. Following is a summary of the critical sampling parameters used to maintain comparability with the baseline study.

1. **Sample size and geographic location:** KCDMS collected farm-level data from a sample of 127 smallholder dairy producers representing 356 head of cattle in high-rainfall regions of Nyanza (Homa Bay, Kisii, Kisumu, Migori, and Siaya counties), and Western (Bungoma, Kakamega, and Vihiga counties), and semi-arid region of Eastern (Makueni, and Taita-Taveta counties)

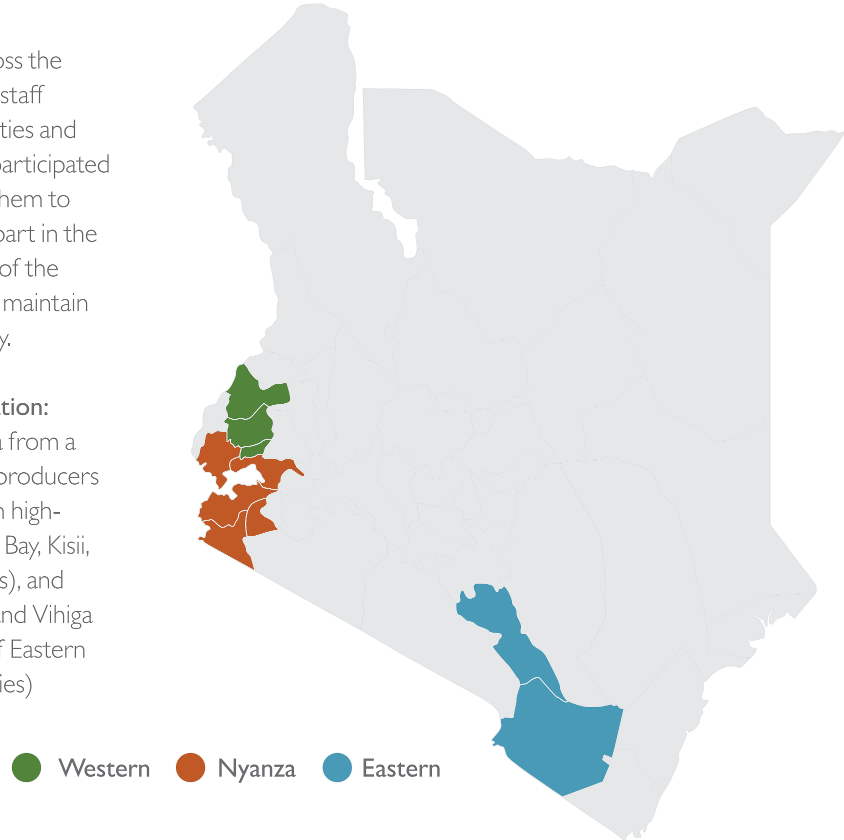

TABLE 3

Survey Sample Summary

County	Baseline # of Producers	Baseline # of Cows	Endline # of Producers	Endline # of Cows
NYANZA				
Homa Bay	7	19	7	40
Kisii	9	20	9	21
Kisumu	6	21	7	19
Migori	11	23	12	26
Siaya	4	9	4	13
Total Nyanza	**37**	**92**	**39**	**119**
WESTERN				
Bungoma	25	94	10	27
Kakamega	9	35	27	77
Vihiga	5	23	8	25
Total Western	**39**	**152**	**45**	**129**
EASTERN				
Makueni	20	82	22	61
Taita Taveta	20	56	21	47
Total Eastern	**40**	**138**	**43**	**108**
TOTAL SAMPLE SIZE	**116**	**382**	**127**	**356**

KCDMS contacted active farmer organizations from whose membership the producer sample was drawn and worked with them to randomly select a sample of producers currently participating in the Activity. Some of the producers who were sampled in the baseline study were selected for the endline assessment, but KCDMS was careful not to "cherry pick" participants with favorable outcomes. Table 3 shows the number of producers interviewed in each province and county as compared to the baseline, and the total number of cows represented.

2. **Operation classification:** RuMeth and KCDMS selected a sample of 130 dairy producers that mirrors the classifications from the baseline study as much as possible. Producer operations were classified according to the intensiveness of operation and the genetics of the production herd. The intensity of management in the respondent herd is separated into three categories:

    - Intensive, total confinement of productive females with all roughage provided, no grazing **(Category A)**
    - Semi-intensive, partial confinement of productive females with some roughage provided and some grazing **(Category B)**; and
    - Extensive, no confinement of productive females with no roughage provided other than grazing **(Category C)**.

The level of improved genetics is also separated into three categories:

- Purebred, productive females with more than 75 percent improved genetics **(Category a);**

Aa = Zero Grazing, >75% Exotic	Ba = Part grazing, >75% Exotic
Ab = Zero Grazing, 25% - 75% Exotic	Bb = Part grazing, 25% - 75% Exotic
	Bc = Part grazing, <25% Exotic

- Crossbred, productive females with between 25 and 75 percent improved genetics **(Category b)**;
- Native stock, productive females with less than 25 percent improved genetics **(Category c)**.

The distribution of producers from the baseline study is presented in Table 4. Note that matching operational classification in the sample, which can also vary over time, was not as important as geographic distribution and confirmed participation in KCDMS activities

TABLE 4

Survey Operation Classifications

Management/ Genetics	Baseline # of Producers	Baseline Percentage	Endline # of Producers	Endline Percentage
NYANZA	37		39	
Aa	7	19%	18	46%
Ab	4	11%	4	10%
Bb	26	70%	13	34%
Bc	-	-	4	10%
WESTERN	39		45	
Aa	8	21%	4	9%
Ab	6	15%	16	35%
Ba	4	10%	3	7%
Bb	21	54%	22	49%
EASTERN	40		43	
Aa	24	60%	15	34%
Ab	8	20%	14	33%
Bb	8	20%	14	33%


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044-0465

1.3.2 Measuring Dairy Productivity

Farm-level data collected on actual production parameters (genetics, weight, milk production, calving interval) and feeding practices (rations, dairy meals, supplements) at the operational level was combined with data on the nutrient profiles of fed rations to calculate dairy productivity.

Dairy productivity is most often reported as milk production per day. However, using DFCM as the sole indicator of productivity can badly skew reality. Instead, dairy productivity was measured using three factors, which are combined to arrive at a calculation of AFCM. These factors are:

- DFCM is the average amount of milk produced daily during the lactation period, expressed in liters per day
- DIM is the length of the lactation period, expressed in days
- ICI is the time that elapses between the initiation of two lactation periods, expressed in days

The formula for arriving at AFCM is:

DFCM * DIM / (ICI / 365)

To illustrate, Table 5 shows the impact of combining the same level of DFCM with increasing lengths of lactation and decreasing ICI to calculate AFCM:

TABLE 5

Impact of Combined Indicators

DFCM (liters/day)	DIM (days)	ICI (days)	AFCM (liters/year)
10	220	698	1,150
10	275	698	1,438
10	275	400	2,509

Note that the annual yield of the three producers, all of whom report an average of 10 liters per day of milk production, ranges from 1,150 to 2,509 liters per year.

This illustrates that substantial increases in productivity can be achieved by improved nutrition practices which extend lactation and reduce ICIs.

1.3.3 Measuring Methane Emissions

The methodology used to determine changes in methane emissions attributable to KCDMS is based on the small-scale clean development mechanism[5] methodology known as Strategic Supplementation in Smallholder Dairy Sector to Increase Productivity (AMS-III.BK). This methodology was developed by RuMeth International Ltd. And approved by the UNFCCC in May of 2014. AMS-III.BK is applicable to the productivity of large ruminants (i.e., dairy cows or buffalo) in the smallholder dairy sector for the purpose of increasing milk productivity and reducing methane emissions per unit of milk.

The feeding patterns of productive females in respondent herds were used to analyse the basal diet. Specifically, the roughage and non-roughage inputs (kilograms per day) of the animals' basal diets and the number of days occurring in each season (dry, wet) were compiled to later disaggregate the basal ration for seasonality and the stage of productivity of productive females (lactating versus non-lactating). Additionally, data for four specific animal production characteristics were required:

(a) animal weight (kilograms),

(b) daily milk production (liters),

(c) DIM per lactation (days), and

(d) the ICI (days).

The methodology uses this information to calculate specific emissions factors (SEFs) of methane emissions per liter of FCM, from which changes in methane intensity can be determined.

SEFs are calculated by dividing the annual methane emissions (EF) per animal by the AFCM developed for each production system[6] according to the following formula:

5 2022. Unfccc.int. 2022. https://unfccc.int/process-and-meetings/the-kyoto-protocol/mechanisms-under-the-kyoto-protocol/the-clean-development-mechanism?gclid=Cj0KCQiA4uCcBhDdARIsAH5jyUnWab0v8Ahf2RMTa8HauSskHR36i38StEifyyDH46jx-wnz8SGzK-oaArGqEALw_wcB.

6 A production system is defined as the group of large ruminants categorized based on level of management intensity and presence of genetics.

AFCM / EF = SEF expressed as kilograms/liter of CH_4

The complete formula for EF calculation is represented in AMSIII.BK as follows:

$$EF_{BL,r,y} = \frac{\sum_{u,n}(GE_{BL,u,n,r,y} \times SD_{BL,u,n,r,y}) \times Y_m}{55.65}$$

1.4 Report Limitations

Farm-level production and productivity data is specific to smallholder dairy producers in the KCDMS focus areas. The data is not representative of the Kenya dairy value chain as a whole, even though some of the results (such as average animal weight and daily milk production) are consistent with information in other reports. We used a very specific sampling methodology to calculate nutritional profiles for dairy cows in the smallholder operations surveyed.

Those profiles are indicative of ruminant methane emissions intensity in emergent smallholder dairy operations in the KCDMS focus areas and may not be representative of every operation in those areas. Nonetheless, our experience is that the indicative nature of the profiles generated will be consistent with what would be found in a broader survey.

2. FINDINGS

2.1 Results Overview: Dairy Productivity

The baseline study showed tremendous potential to significantly increase dairy production and productivity. In our opinion, it should be possible to increase annual milk production by two to four times the observed amount observed by:

1. Extensive training in basic dairy/nutrition management
2. Encouraging better forage utilization and basal rations
3. Increasing access to improved dairy meal formulations
4. Using appropriate salt and mineral supplements
5. Increasing access to nutrition advice

The endline methane assessment found significant changes in the major indicators of dairy productivity (DFCM, DIM, ICI, and AFCM) between the baseline and endline. Those changes are shown in Table 6. The impact indicator ranges for the baseline and endline are provided in Annex 1. Our observations regarding each indicator follow.

2.1.1 Daily Fat-Corrected Milk (DFCM)

Daily milk production in the survey area increased in almost all operational categories. The most significant changes were observed in operations practicing:

1. zero grazing with purebred animals (Aa). All increased daily milk production to 11+ liters per day. Increases were greatest in Western and Eastern Provinces
2. zero grazing with crossbred animals (Ab) in all three zones
3. partial grazing with crossbred animals (Bb) in Western and Eastern Provinces

Changes in daily milk production are most impacted by changes in the quantity and quality of feed provided in terms of protein and energy. The changes observed are a direct result of improved feeding practices. We found farmers fed their cattle more regularly and more often and provided full-time access to feed and water.

Farmers also fed less mature forages (such as Napier) and adopted the improved forage varieties that were promoted by ILRI. These changes improve the protein and energy content of the basal ration. Farmers fed better-quality feeds (i.e., not mature grass nor maize stover. Farmers are also feeding less poor-quality feeds (mature grass, maize stover). In combination, these changes led to marked general improvement in the basal ration and increased daily milk production.

2.1.2 Days in Milk (DIM)

DIM increased significantly in all but one operational category (Western, Bb). The most significant changes took place in Nyanza, the zone with the poorest DIM performance in the baseline study. Changes in the length of lactation (DIM) were most impacted by improvements in the quantity and quality of feed and improved mineral balance (macro and micro) in the ration. Increased DIM was a direct outcome of farmers feeding their cattle better, both in terms of quantity and quality, and their increased use of mineral supplements..

7 The number of days the cow should be milked based on her nutritional status.

TABLE 6

Dairy Productivity Indicators

Management/ Genetics	FCM (liters/day)		DIM[7] (days)		ICI (days)	
	2019	2022	2019	2022	2019	2022
NYANZA						
Aa	10.6	11.0	226	283	547	619
Ab	7.4	8.1	203	278	596	587
Bb	6.0	6.0	206	286	572	573
Bc	n/a	5.4	n/a	255	n/a	534
WESTERN						
Aa	8.8	11.6	249	270	620	686
Ab	7.1	7.6	228	277	777	585
Ba	7.9	7.7	213	205	642	654
Bb	5.8	7.3	180	207	620	582
EASTERN						
Aa	10.4	12.0	254	266	609	477
Ab	9.0	9.8	214	242	596	528
Bb	8.6	9.1	219	281	579	667

Aa = Zero Grazing, >75% Exotic blood

Ab = Zero Grazing, 25%-75% Exotic blood

Ba = Part grazing, >75% Exotic blood

Bb = Part grazing, 25%-75% Exotic blood

Bc = Part grazing, <25% Exotic blood

2.1.3 Inter-calving Interval (ICI)

The ICI was virtually unchanged in all zones. Changes in ICI are most impacted by the macro-mineral calcium: phosphorous (Ca:P) balance in the ration. Even when feeding enough energy and protein to support increased milk production, it is the mineral balance which most impacts fertility and reproductive function. During data collection, we frequently observed farmers feeding improper amounts of mineral supplements and often feeding the wrong products. In some cases, the feeding of the wrong product, such as those high in phosphorus (P), was akin to feeding a contraceptive. Those observations were confirmed by our analysis of the rations.

2.2 Results Overview: Methane Emissions Intensity

The endline methane assessment found significant changes in ACFM and EF, the major factors impacting methane emissions intensity. Those changes are shown in Table 7. The impact indicator ranges for the baseline and endline are provided in Annex 1. Our observations for each of those indicators follow..

2.2.1 Annualized Fat Corrected Milk (AFCM)

We observed dramatic increases in AFCM in purebred (Aa) and crossbred (Ab) operations in Nyanza and Western Provinces, with general increases across the board in all operational categories. Changes in AFCM are most impacted by the quantity and quality of feed provided to dairy cows in terms of protein and energy. Increases in DFCM and DIM translate directly into higher annualized milk production. The observed increase in AFCM is primarily due to improved feeding practices in terms of quantity and quality, particularly increased protein, and energy in the rations (higher quality feed).

2.2.2 Annual Methane Emissions Factor (EF)

Annual methane emissions per animal, expressed as kilograms of CH4, are a measure of digestive efficiency. EF is also directly impacted by the quantity and quality of the overall ration being fed. Improvements in EF are due to farmers feeding their cattle more nutrient dense and digestible feedstuffs. In those instances, a relatively greater amount of the total energy intake is converted by the cow into milk, even though her total methane emissions change very little.

TABLE 7

Methane Emissions Intensity Indicators

Management/Genetics	AFCM (liters)		EF (kgs)		CH4 Emissions/Liter SEF (kgs)	
	2019	2022	2019	2022	2019	2022
NYANZA						
Aa	1,625	2,690	85.4	90.4	0.053	0.034
Ab	824	1,581	66.9	63.9	0.081	0.040
Bb	842	1,180	63.6	61.2	0.076	0.052
Bc	na	932	na	41.4	na	0.044
WESTERN						
Aa	972	2,305	89.1	85.2	0.092	0.037
Ab	799	1,318	62.9	70.3	0.079	0.053
Ba	737	957	69.4	78.1	0.094	0.082
Bb	630	972	58.4	69.6	0.093	0.072
EASTERN						
Aa	1,925	2,271	97.7	99.9	0.051	0.044
Ab	1,409	1,736	88.9	93.5	0.063	0.054
Bb	1,460	1,503	82.4	73.3	0.056	0.049

2.2.3 Methane Emissions Per Liter (SEF)

Methane emissions per liter (SEF) are calculated by dividing the annual amount of methane emitted (EF) by the annual milk production. The SEF therefore represents how much methane it "costs" a cow to produce a liter of milk.

Per this endline assessment, the SEF decreased significantly across the board for all operational types to a range of between 0.034 kgs/liter and 0.082 kgs/liter. This is considerably less than the overall estimate for Kenya of 0.218 kgs/liter and is indicative of the potential for reducing emissions intensity in smallholder dairy operations in KCDMS focus areas. When applied to the 43,000 cows under the recommended feeding regime, RTI's Director of Resilience and Climate Adaptation estimated that KCDMS support abated 1,297 MT of methane (equivalent to 32,425 MT of CO_2).

As these improved practices are scaled to additional dairy cows, there is substantial to mitigate GHG while also improving dairy production. Table 8 illustrates the methane emissions for specific management and genetic combinations for a sample herd of 15,000 dairy cows.

TABLE 8

Annual Methane Emitted (15,000 head)

Management/ Genetics	Number of Cows	Annual Fat Corrected Milk (liters/year)		CH_4 Emissions (metric tons/year)	
		2019	2022	2019	2022
Aa	2,767	4,494,647	7,442,565	391	250
Ab	432	356,229	683,386	56	28
Bb	1,556	1,310,240	1,836,901	139	95
Aa	476	780,721	1,095,971	59	40
Ab	2,248	1,796,130	2,963,556	233	158
Ba	432	318,439	413,886	39	34
Bb	2,420	1,524,981	2,353,913	218	169
Aa	1,643	3,161,967	4,134,931	210	165
Ab	1,383	1,948,506	2,401,587	152	129
Ba	1,643	2,397,864	2,468,858	139	120
TOTAL	**15,000**	**18,089,244**	**25,795,554**	**1,636**	**1,188**

In summary, a program of this sample magnitude would annually increase total milk production by 7,706,020 liters, total producer income by KSh 270 million, and mitigate 11,175 tons of CO_2e. Furthermore, this potential can be expanded through relatively simple changes:

1. proper feeding of mineral supplements to bring the Ca:P balance to 2:1 in rations,
2. eliminating poor quality feeds, such as maize stover, from the basal ration, and
3. feeding high quality dairy meal.

2.3 Results Overview: Dairy Meal

Both the baseline study and the endline assessment included samples collected from commercially available Kenyan dairy meals used by farmers. These samples were taken to the U.S. and analyzed through WCA to arrive at their respective nutrient profiles. Availability and access to quality dairy meal has improved and smallholder farmers seem convinced that they should feed concentrates to their cattle.

However, effectiveness depends on the product purchased. While several of the available dairy meals are of quite high quality, others are of mediocre quality, and about one third are of inferior quality. Without a ration analysis, good quality dairy meal can be perceived as expensive, giving rise to less expensive dairy meals on the market including some of questionable quality.

TABLE 9

Kenyan Dairy Meals

Study Year	Dairy Meals Tested	Excellent	Mediocre	Inferior
2019	15	3	2	10
2022	22	8	6	8

The baseline study analyzed 15 commercially available Kenyan dairy meals using WCA in an ISO-certified laboratory in the U.S. Three were judged excellent, containing sufficient levels of protein and energy while two were judged mediocre, slightly deficient in protein, but sufficient in energy. The remaining ten samples were judged inferior, without a proper balance of protein and energy.

In the endline assessment, we analyzed 22 commercially available Kenyan dairy meals using WCA in the same ISO-certified laboratory. Eight were judged excellent, containing sufficient levels of protein and energy while six were judged mediocre, slightly deficient in protein, but generally sufficient in energy. The remaining eight samples were judged inferior, without a proper balance of protein and energy. A summary of the baseline and endline findings are presented in Table 9. The results of the analysis can be found in Annex 2..

3. KEY OBSERVATIONS

3.1 Positive Observations

- **Investment:** Field observations, collected data, and analysis all point to one notable positive production factor. KCDMS smallholder dairy producers expended considerable effort and money to improve feeding practices and overall nutrition of their dairy animals, particularly with respect to improved forages.

- **Feeding practices:** We observed great progress in improved feeding practices. In 2019 we often encountered confined livestock without access to feed and water. In 2022 we found the vast majority of farmers providing their cows with constant access to feed and water. Farmers were also providing less mature, and therefore higher quality and more digestible, forages.

- **Forage varieties:** Our survey found widespread adoption of improved, more productive forage varieties promoted by ILRI and KCDMS. This change increased protein, energy, and digestibility in the basal ration, and laid the foundation for increased daily milk production and days in lactation.

- **Dairy meal:** We observed increased access to and availability of dairy meals, the majority of which tested as good to excellent. Overall quality also improved, as manufacturers made efforts to improve their products. Almost all producers fed dairy meal to their lactating cows. Among those who fed the good- to excellent-quality products, the increased protein and energy supported higher daily milk and longer lactation. Those who fed the inferior quality products negatively impacted their animals' rations.

- **Mineral supplements:** We noted an increased use and availability of mineral supplements. Almost all the surveyed producers fed mineral supplements to their animals, but in inadequate amounts and with formulations which do not mitigate macro-mineral imbalances.

3.2 Negative Observations

- **Macro-mineral imbalances:** Almost all the surveyed producers fed mineral supplements to their animals. However, there was a severe shortage of calcium in the basal rations, resulting in an overall imbalance of the Ca:P ratio. This imbalance was compounded by the fact that commercially available mineral mixes are improperly formulated for Kenyan forage conditions. Specifically, the formulations and amounts being fed are inadequate to mitigate Ca:P ration deficiencies.

As a result, the almost universal imbalance in the Ca:P ratio greatly reduced fertility and worsened methane emissions intensity. Producers were unaware of the correct type or quantity of mineral product needed to provide an adequate and balanced amount of calcium in their rations to mitigate reproductive issues.

> Using adequate calcium has potential to highly increase annual milk production and reduce methane emission intensity.

The potential impact of balancing calcium in the rations among smallholders with partially confined crossbred cattle in the Eastern Province. This change, which is neither expensive nor difficult, has the potential to increase annual milk production by 850 liters/year, and reduce methane emissions from 48.7 grams/liter to 33.5 grams/liter. To summarize, a balanced Ca:P ratio greatly improves fertility, increases production, and reduces methane emissions intensity.

- **Maize stover:** Producers made significant investments in time, energy, and capital to improve feeding and nutrition. However, these efforts are compromised by the persistent, wide-spread practice of feeding maize stover to lactating cows. Feeding maize stover reduces daily milk productivity and lactation length, while worsening methane emissions intensity. Yet farmers continue feeding maize stover to lactating cows, even when higher quality fodder is available.

The myth persists that you can treat maize stover to make it a higher quality feed. Adding molasses and urea to maize stover improves palatability but does not improve the quality of the stover. For example, putting milk and sugar on sawdust can make it taste better, and some nutrients are provided by the milk and sugar. However, sawdust is not food, only a nutrient-deficient filler.

TABLE 10

Example Impact of Feeding Maize Stover

Eastern Production Zone Bb Producer			
Feeding Maize Stover	**Basal Ration (%)**	**AFCM (liters/year)**	**SEF (kgs/liters)**
Signal Grass, Cayman <40 days	60%	1,511	0.047
Maize Stover (Africa)	15%		
Napier Grass (40-80 days)	15%		
Couch Grass	10%		

Not Feeding Maize Stover	Basal Ration(%)	FCM (liters /year)	SEF (kgs/ liters)
Signal Grass, Cayman <40 days	60%	1,870	0.038
Maize Stover (Africa)	0%		
Napier Grass (40-80 days)	15%		
Couch Grass	25%		

Table 11 illustrates the impact of feeding maize stover. Our example producer has semi-confined crossbred cows in the Eastern Province. Fifteen percent of the basal ration he feeds his milking cows is maize stover. Simply replacing maize stover with readily available couch grass would increase AFCM from 1,511 liters/year to 1,870 liters/year, an increase of 359 liters. This substitution would also reduce SEF from 47 grams/liter to 38 grams/liter.

In summary, maize stover does not have the nutrient profile to effectively meet the nutritional needs of lactating cows. Its indigestibility limits feed intake and throughput. It reduces daily milk productivity and lactation length, while worsening methane emissions intensity. The question arises – what is the best use producers can make of their maize stover? Potentially, the best use is to incorporate it into the soil to increase organic matter and improve soil structure.

- **Dairy meal:** Access to and use of dairy meal in lactating cow rations substantially improved. Dairy meal quality also improved since the baseline, but was still lacking. There are still too many sub-standard dairy meals on the market. While it appears that quite a few participants in the feed milling industry are doing their best to comply with required standards, many manufacturers produce a decidedly inferior product.

> Feed manufacturers, notably, do not have ready access to the basic tool (ISO-certified WCA) needed to ascertain the nutrient profiles of their major ingredients or to formulate products. Producer groups do not have a way to confirm the quality of the dairy meal that they purchase. Access to WCA can improve product quality and consistency. Given the scale and importance of the dairy industry in Kenya, this deficiency constitutes a serious value chain weakness for continued expansion of this sector.

To demonstrate the persistent complaints regarding cost and effectiveness, the following analysis was developed. Table 12 illustrates the income impact of dairy meal quality. A cow fed a basal ration of Cayman Signal grass, Napier grass, and Macklick Dry mineral supplement is expected to produce 4.3 liters of milk per day (1,161 liters/year) and emit 60 grams of methane per liter produced. Net daily income from this cow would be KSh 151 (assuming a price of KSh 35/liter). Feeding the cow 2 kg/day of inferior quality Daima dairy meal has virtually no impact on production but reduces income by the cost of the feed to KSh 70/day.

However, feeding the cow 2 kg/day of high quality Unga dairy meal increases her production to 9.4 liters/day (2,538 liters/year), reduces methane emissions to 31 grams/liter, and increases net daily income to KSh 210. In effect, feeding the recommended amount of poorer quality dairy meal actually decreases producer income, thus creating confusion regarding the cost and effectiveness of dairy meals.

Feeding the cow with high-quality feeds increased production from

4.3 to 9.4

liters/day (1,161 to 2,538 liters/year); reduced methane emissions from 60 grams to 31 grams/liter produced; and increased daily income from Kshs.151 to Kshs. 210

TABLE 11

Income Impact of Dairy Meal

Ration	DFCM (liters)	AFCM (liters)	SEF (kgs)	Net Daily Income/ Cow (KSh)
Basal Ration	4.3	1,161	0.060	151
Basal + 2 kg Daima Dry Matter	4.2	1,134	0.061	70
Basal + 2 kg Unga Dry Matter	9.4	2,538	0.031	210

3.3 Potential for Improvement

The impact of KCDMS on individual cow performance has been described. The potential for further improvements through correcting the observed deficiencies is laid out. Several reviewers of the draft results questioned if it is indeed possible to have further substantial improvements under Kenyan conditions. In response, we listed the category averages followed by the best production indicators in that category according to the assessment. That comparison is shown in Table 13.

In all cases there is substantial room for additional improvement in annual milk production and SEF of the average cow. For example, AFCM in Aa operations in both Nyanza (2,690) and Eastern (2,517) could more than double without reaching the levels of the best cow in those areas (5,714 and 6,001), respectively.

TABLE 12

Performance Potential: Average Versus Best

Management/ Genetics	Average AFCM (liters/ cow)	Best AFCM (liters/ cow)	Average Methane Emissions (kgs/liter)	Best Methane Emissions (kgs/liter)
NYANZA				
Aa	2,690	5,714	0.034	0.028
Ab	1,581	2,320	0.040	0.035
Bb	1,180	2,558	0.052	0.031
Bc	932	1,657	0.044	0.031
WESTERN				
Aa	2,305	3,847	0.037	0.027
Ab	1,318	2,393	0.053	0.038
Ba	957	1,795	0.082	0.049
Bb	972	1,675	0.072	0.038
EASTERN				
Aa	2,517	6,001	0.040	0.022
Ab	1,736	6,595	0.054	0.027
Ba	1,503	2,634	0.049	0.033

3.4 General Observations

3.4.1 Feeding practices

Farmers materially improved feeding practices in terms of access to feed and feed quantity and quality. However, producers still do not have access to professional nutrition advice to improve their rations and feeding practices. Most producers simply do not know how to feed their dairy cows to maximize production.

3.4.2 Dairy heifers

The management and care of dairy heifers remains woefully inadequate. Underfed and stunted heifer calves are all too common. The most common age at which heifers give birth for the first time is 30-36 months; anything less than 24 months is exceptional. Smallholder operations that produce the most milk are more likely to feed their heifer calves better rations, but rarely is it enough for good physical and reproductive development. The introduction of good genetics through AI is wasted because heifer calves are so commonly stunted and will not reach their genetic potential.

3.4.3 Farm records

Very few producers have any production records, and among those who do, they are incomplete. Without a record of what they fed or what their cows produced, they are not in a position to make informed decisions. The most common records tracked AI service and calving dates. Improving nutrition and reproductive management will require more complete records of feeding practices and daily production. Encouraging record keeping using a simple farm record book for dairy operations would help inform extension efforts and markedly improve survey data collection and general information.

4. SUMMARY CONCLUSIONS AND RECOMMENDATIONS

4.1 Impact of Value Chain Activities on Smallholder Dairy Production

In this assessment, we found significant changes in the major indicators of dairy productivity, as shown in Table 6. DFCM improved in all but one of 11 operational categories, and increased to 11 liters per day or more in confinement operations with purebred dairy cows. The DIM improved dramatically in all but one of 11 operational categories, exceeding 270 days in five of those categories. ICI was virtually unchanged. However, the impact of increased daily production and increased length of lactation and AFCM across the board, with increases to over 2,000 liters per year in confinement operations with purebred cattle, and to over 1,300 liters in confinement operations with crossbred cattle.

4.2 Impact of Value Chain Activities on Methane Emissions

We found significant changes in the major factors impacting methane emissions intensity, as shown in Table 7. As noted in Section 4.1, AFCM increased across the board in all 11 operational categories. Annual methane emissions changed slightly, some increasing and some decreasing, influenced by feeding practices and improvements. These changes are shown in Table 7.

SEF decreased significantly across the board for all operational types, to a range of between 0.034 kgs/liter and 0.082 kgs/liter. This is considerably less than the Kenya national estimate of 0.218 kgs/liter, and indicates significant potential to reduce emissions intensity in smallholder dairy operations in KCDMS focus areas.

4.3 Recommendations

The following is a summary of the interventions which would most impact dairy productivity and improve methane emissions intensity.

4.3.1 Feed supplemental calcium

Farmers feed a wide range of mineral supplements without understanding their use in improving animal nutritional status. Mineral supplements in Kenya are not bad products but rather the wrong products. Some products, formulated for temperate climate forage conditions, have such high levels of phosphorus that feeding them is the equivalent of feeding contraceptives. A minimum Ca:P ratio of 2:1 in the diet is required to optimize the productive and reproductive health of dairy cows. Therefore, any mineral supplementation should feed supplemental calcium to correct the Ca:P ratio imbalance.

4.3.2 Stop feeding maize stover

The widespread belief that the quality of maize stover can be improved and should be included in a dairy ration is a myth. Maize stover does not have the nutrient content needed to support lactation, making it a nutrient deficient feed. Also, its low digestibility decreases rumen throughput of higher quality, more nutritious feeds. Treating maize stover with molasses and urea is like putting milk and sugar on sawdust; no matter how good it tastes it still has no nutrient value. The elimination of maize stover in dairy rations followed by the replacement of the stover with an alternate grass will increase annual productivity and improve methane emissions, as illustrated in Table 11.

4.3.3 Establish laboratory testing services

Quite a few manufacturers of dairy meal in Kenya are working to improve quality but without access to necessary testing services. Improving the productivity of the Kenya dairy value chain requires access to ISO-certified WCA capability to support the feed industry. Specifically, this capability will give the industry access to the information needed to manage their operations, determine the nutrient content of their raw materials, improve product quality, and monitor the consistency of their products. The availability of a certified WCA will also enable producer groups to randomly test the products on the market and inform their members which products will work best with their feeding programs. This type of assessment will allow the dairy industry to "weed out" those manufacturers of poor quality or spurious product.

4.3.4 Train extension nutritionists

Most producers simply do not know how to feed their dairy cows, or how best to improve their feeding practices. Trained extension nutritionists can improve productivity and methane emissions intensity by advising producers on best practices and how to make the best use of the available feed in formulating balanced rations along with proper mineral supplementation. RTI had access to a comprehensive program for training extension nutritionists and farmers in proper dairy feeds and feeding since March of 2020. However, we found no evidence that the training program and manuals available have been implemented in the field.

4.3.5 Improve Dairy Heifer Feeding

Most dairy heifers give birth for the first time at between 30-36 months of age, losing almost a year of their potentially productive life. High producing operations are more likely to feed their heifer calves better rations. However, even in these well managed facilities, heifers are not fed balanced rations to maximize their genetic potential and allow good physical and reproductive development. Improving dairy heifer feeding will allow those animals to achieve closer to their genetic potential, increasing overall lifetime productivity. Heifers are the future of any dairy operation and should be given careful attention.

Endline Methane Assessment of KCDMS Dairy 19
and Fodder Value Chain Activities in Kenya

Annexes

ANNEX 1

The following tables show the major production and productivity indicator ranges from the 2019 Dairy Nutrition Study, and from the 2022 Endline Methane Assessment.

TABLE 13

Impact Indicator Ranges 2019

Area	FCM/Day (liters)	Real Lactation (Days)	Calving Interval (days)	FCM/Year (liters)
Nyanza	2.5 – 12.5	105 – 300	395 – 1,065	398 – 3,206
Western	2.0 – 14.5	150 – 270	437 – 1,204	353 – 4,020
Eastern	3.8 – 16.1	165 – 300	397 – 1,023	541 – 3,007

TABLE 14

Impact Indicator Ranges 2022

Area	FCM/Day (liters)	Real Lactation (Days)	Calving Interval (days)	FCM/Year (liters)
Nyanza	4.0 – 35.0	160 – 300	366 – 1,129	314 – 5,712
Western	4.0 – 17.5	90 – 300	366 – 1,342	283 – 3,847
Eastern	4.0 – 30.0	120 – 300	365 – 1,098	598 – 6,001

ANNEX 2: KENYAN DAIRY MEAL ANALYSIS

The following is a table of WCA results of dairy meal samples collected in April and May 2022 during data collection for the Endline Methane Assessment. Laboratory analysis took place at an ISO-certified laboratory in Moses Lake, Washington, U.S.

Dairy Meal	Crude Protein	Digestible Energy	Net Energy for Lactation	Total Digestible Nutrients	Ca	P
UNGA	18.9%	4.38	2.31	99.4%	1.25%	0.81%
SIDAI	18.6%	3.77	1.97	85.7%	0.82%	1.18%
Empire	18.5%	3.62	1.89	82.1%	0.93%	0.95%
FUGO	17.8%	4.09	2.14	92.8%	1.54%	0.64%
Wonder Dairy Meal	17.8%	3.49	1.82	79.1%	1.20%	0.70%
BIDCO	16.3%	4.29	2.26	97.2%	0.73%	1.12%
Pembe	16.1%	3.89	2.04	88.3%	0.94%	0.82%
Nuru	16.0%	3.95	2.06	89.4%	2.89%	1.12%
Patandisho	14.6%	3.58	1.86	81.1%	0.55%	0.83%
Sakina	14.6%	3.84	2.00	87.1%	1.78%	1.03%
Kays	13.4%	3.43	1.78	77.7%	0.95%	0.76%
Faida	12.9%	3.98	2.08	90.2%	1.48%	0.69%
Victoria	12.4%	3.83	2.00	86.8%	1.56%	0.74%
Fair Deal	12.0%	3.40	1.77	77.1%	1.25%	0.71%
Jumbo	11.5%	3.67	1.91	83.2%	2.43%	0.93%
Tunza	10.9%	3.43	1.78	77.6%	3.02%	0.92%
TAI	10.0%	2.85	1.46	64.6%	1.78%	0.76%
SIMAGA	9.2%	3.23	1.67	73.3%	1.18%	0.86%
Turbo	8.6%	3.07	1.57	69.5%	3.13%	0.59%
Mikepa	5.5%	3.05	1.57	69.0%	2.69%	0.61%
Daima	5.4%	2.53	1.27	57.3%	5.86%	0.43%

Good feed   Marginal quality feed   Poor quality feed

ANNEX 3: ENDLINE ASSESSMENT FARMER SAMPLE

County	Dairy Cooperative Society/PO	Number of Farmers Interviewed
EASTERN		
Makueni	Kathonzweni Dairy Farmers Cooperative Society Limited	10
	Kaiti Dairy Value Chain Cooperative Society Limited	11
Taita Taveta	Tagho Dairy Farmers Cooperative Society Limited	21
WESTERN		
Kakamega	Luli Farmers Cooperative Union	12
	Sirikwa Dairies	8
	Sunrise Dairy Farmers Cooperative Society Limited	8
Vihiga	Vihiga Dairy Farmers Cooperative Society Limited	7
Bungoma	Kaptama Farmers Cooperative Society Limited	8
NYANZA		
Kisii	Bomabobo Dairy Farmers Cooperative Society Limited	9
Homabay	Kasbondo Aim Dairy Cooperative Society Limited	7
Siaya	New Yala Dairy Farmers Cooperative Society Limited	5
Kisumu	Kajulu Dairy Farmers Cooperative Society Limited	7
Migori	Nuru Social Enterprises Limited	7
	Cham Gi Wadu Dairy and Multipurpose Cooperative Society	7
TOTAL		127

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The U.S. Government's Global Hunger & Food Security Initiative